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2017-2018

सीएसआईआर-केन्द्रीय भवन अनुसंधान संस्थान, रुड़की

CSIR-Central Building Research Institute, Roorkee

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CONTENTS

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सीएसआईआर–केंद्रीय भवन अनुसंधान संस्थान, रुड़की का वर्ष 2017–2018 का वार्षिक प्रतिवेदन प्रस्तुत करते हुए मैं अत्यंत गर्व का अनुभव कर रहा हूँ। रिपोर्ट में वर्ष के दौरान संस्थान की प्रगति एवं उल्लेखनीय उपलब्धियों पर प्रकाश डाला गया है। लाखों भारतीयों के विकास हेतु उन्नत अनुसंधान और ज्ञान में इस निरंतर प्रगति से मैं उत्साहित हूँ।

निर्माण विज्ञान और प्रौद्योगिकी के सभी पहलुओं में एक अग्रणी संस्थान के रूप में सीएसआईआर–सीबीआरआई निर्माण क्षेत्र में सुरक्षा, स्थिरता, तन्यकता, तीक्ष्णता, आराम, कार्यात्मक दक्षता, गति, उत्पादकता, पर्यावरण परिरक्षण, ऊर्जा दक्षता व लागत प्रभावशीलता प्राप्त करने हेतु नवीन समाधान प्रदान करते हुए विश्वस्तरीय ज्ञान आधार बनने की दिशा में कार्यरत है। संस्थान अपने अनुसंधान, विकास और नवाचार द्वारा भवन नियोजन, अभिकल्पन, सामग्री, निर्माण, भवनों में आपदा न्यूनीकरण तथा क्षमता निर्माण से सम्बंधित सभी राष्ट्रीय चुनौतियों के समाधान प्रदान करने हेतु समर्पित है।

वर्ष 2017–2018, सीएसआईआर–केंद्रीय भवन अनुसंधान संस्थान, रुड़की के लिए एक सक्रिय वर्ष रहा है। संस्थान के भावी वर्षों के उद्देश्यों को निर्देशित करने हेतु हमने अपने लक्ष्यों को नवीन दृष्टिकोण के साथ पुनर्जीवित करने के उद्देश्य से एक नई रणनीतिक योजना तैयार की। यह योजना संस्थान के व्यापक मार्गदर्शक के रूप में आगामी वर्षों के प्रत्याशित प्रभावों को चिह्नित करेगी।

इसी दिशा में, संस्थान ने अपने मुख्य योग्यता क्षेत्र में Ng çe[k {k=k–आवास–संरचना एवं आधार, विरासत संरचनाओं का संरक्षण, अभिनव निर्माण सामग्री, ऊर्जा कुशल प्रणाली एवं भवन स्वचालन, आपदा शमन तथा निर्माण प्रक्रिया एवं स्वचालन–का शुभारम्भ किया। ßvkokl&l`jpuk ,o vk/kkjß परियोजना के सूत्रपात का उद्देश्य ^'kh?k] fVdkÅ vkj Åtk d`'ky tu vkokl fodkl ;kstuk^ पर ध्यान केंद्रित करना है।

जन आवास में आने वाली चुनौतियों से निपटने के लिए इंजीनियरी, वास्तुकला, शहरी एवं ग्रामीण तथा क्षेत्रीय नियोजन, सामाजिक विज्ञान तथा सूचना प्रौद्योगिकी की आवश्यकता है। सुरक्षा, कार्यात्मकता, स्थिरता, सुन्दरता, गति तथा मितव्ययिता के छह मूलभूत सिद्धांतों को पूरा करते नवोन्मेशों के माध्यम से अभ्यास में अंतर को पाटने के उद्देश्य से, संस्थान में 'राष्ट्रीय मिशन – सभी के लिए आवास' को सुदृढ़ करने हेतु समग्र अनुसंधान एवं विकास कार्यक्रमों को अपनाया गया है।

माड्यूलर समन्वय की संकल्पना का उपयोग करके निष्पादन मानदंडों अर्थात् स्थान दक्षता, जलवायु जवाबदेही, ऊर्जा दक्षता, आपदा की हलचल तथा लागत प्रभाव से आवासीय मानकीकरण की शुरूआत करने के लिए, संस्थान में 'स्टैंडर्डाइजेशन ऑफ डिजाइन एंड ले आऊट्स ऑफ प्रीफैब हाउसिंग यूनिट्स विद इम्प्रूव्ड थर्मल पर्फोरमेंस' पर कार्य किया गया।

संस्थान एक समग्र तरीके से आवास निर्माण क्षेत्र की तकनीकी चुनौतियों से निपटने के लिए एक इको–सिस्टम विकसित करने की इच्छा रखता है। आवास निर्माण क्षेत्र में पारंपरिक, संसाधन और ऊर्जा गहन प्रौद्योगिकियों से पर्यावरणीय रूप से टिकाऊ और सस्ते कुशल समाधानों की दिशा में एक निर्णायक बदलाव लाने के लिए–उन्नत संरचनात्मक एवं अग्निरोधक भवनों में शुष्क निर्माण, कोल्ड फोर्म्ड स्टील वॉल पैनल हाऊसिंग सिस्टम, परिरूद्ध चिनाई तथा सीबीआरआई द्वारा विकसित घटक आवास प्रणाली के साथ स्टील की दीवार पैनल आवास प्रणाली जैसी कुछ उभरती प्रौद्योगिकियों की दिशा में प्रयास किए जा रहे हैं।

सस्ते आवासों की गुणवत्ता तथा ग्राह्यता से संबंधित दीर्घकालीन समाधान प्रदान करने हेतु–प्रीफैब आरसी शियर वॉल सिस्टम के विकास, बीम–कॉलम जोड़ों के लिए दक्ष मैकेनिकल एंकोरेज का विकास, मिनी कलाइम्बिंग क्रेन, प्लास्टैरिंग मशीन, कंक्रीट के स्थायित्व में सुधार के लिए इको–फ्रेंडली कोरोजन इनहीबिटर, भवनों में उन्नत ऊर्जा दक्षता में सुधार के लिए सुरक्षित लेप, संधारणीय जन आवास के लिए बायो–आधारिक निर्माण सामग्रियों – पर अनुसंधान एवं विकास कार्यक्रमों की ओर ध्यान केंद्रित किया गया है। निर्माण उद्योग सभी देशों में सर्वाधिक अपशिष्ट पैदा करने वाला उद्योग है। निर्माण उद्योग में मांग और आपूर्ति के अंतर को कम करने के लिए अपशिष्ट से निर्माण अवसंरचना के लिए कृषि/औद्योगिक/ठोस अपशिष्टों के रीसाइक्लिंग तथा पुनरूपयोग की ओर ध्यान दिया गया है। जन आवास

परियोजना के लिए सीबीआरआई में विकसित निर्माण घटकों, अग्नि जोखिम सिमुलेशन अध्ययनों को परम्परागत निर्माण में रोबस्टनेस को सम्मिलित करके बहु–जोखिमों के लिए निर्माण ग्राह्य क्षमता पर अनुसंधान केंद्रित है। पहाड़ी क्षेत्रों में जन आवास योजनाओं में विभिन्न संदर्भों में अर्थात सुरक्षित भवन निर्माण के लिए लिक्विफिकेशन जोखिमों को कम करने हेतु भूमि सुधार तकनीक, ग्रेनुलर पाइल एंकर फाउंडेशन प्रणाली के उपयोग से भूमि सुधार, पाइल राफ्ट फाउंडेशन की संशोधित स्थैतिक तथा भूकंपीय अभिकल्प पद्धति, तथा निर्माण नींव प्रणाली हेतु डिजाइन एवं सुदृढ़ीकरण उपायों पर ध्यान दिया गया है।

विभिन्न वर्क पैकेजों के माध्यम से 'विरासत भवनों के संरक्षण और मरम्मत' पर ध्यान केंद्रित करने हेतु 'विरासत संरचनाओं के संरक्षण' परियोजना पर कार्य शुरू किया गया, जिसमें सीएसआईआर की सात प्रयोगशालाएं योगदान दे रही हैं। सात वर्क पैकेजों में, नोडल प्रयोगशाला के रूप में सीएसआईआर–सीबीआरआई उनमें से छह में योगदान दे रही है। इस परियोजना का मूल उद्देश्य विरासत संरचनाओं का संरक्षण तथा मरम्मत करने के लिए स्टेट ऑफ आर्ट प्रौद्योगिकियां विकसित करना है। परियोजना में, उनकी वास्तुकला, संरचना प्रणाली तथा सामग्री संरचनाओं के आधार पर Hkkjr e egRoi.k fojklr ljpukvk d oxhdj.k के साथ विभिन्न उद्देश्य सम्मिलित हैं। इसमें एक व्यापक डाटा बेस विकसित किया जाना प्रस्तावित है। Hkou foKku e ijEijkxr çkphu u,yt cl की महत्वपूर्ण विशेषताओं को पुनर्स्थापित किया जाएगा तथा उत्कृष्ट विशेषताओं पर एक पुस्तक जारी की जाएगी। विरासत भवनों के अंकीय संरक्षण को सुनिश्चित करने के लिए एक fjekV 3Mh opvy fj;fyVh flLVe Ýeod fon DykmM dufDVfoVh d fodkl पर कार्य किया जाएगा। ,frgkfld Hkou lkefx;k] Hkfexr ljx d dkj.k ljpukvk d /klu d fo'k"kdj.k d fy, ljpukRed fo'k"kdj.k fof/k] समुचित तकनीकों को स्थापित किया जाएगा। संरचनाओं की मरम्मत तथा रेट्रोफिटिंग के लिए विकास के fodYi rFkk uohu lkefx;k तथा संरचनात्मक अवनयन हेतु पर्यावरणात्मक मानदंडों के परिमाण को समुचित समाधान उपाय प्रदान करने के लिए कार्य किया जाएगा। चयनित विरासत Hkouk ij dod rFkk thok.k dh igpku ij vuqla/kku तथा समुचित उपचार उपाय करना एक अन्य उद्देश्य है। उन्नत एनडीई प्रौद्योगिकियों तथा आधुनिक अलगॉरिथम्स के उपयोग से संरचना की वर्तमान स्थिति के आकलन के लिए इस परियोजना में gkbfcM u,u fMLVfDVo boY;,'ku तकनीकों का विकास किया जाएगा। विभिन्न प्रकार के संरचनात्मक घटकों हेतु समुचित jVkfQfVx LVVth का विकास करने के लिए प्रयोगशाला आधारित अध्ययन किए जाएंगे। विकसित प्रौद्योगिकियों को चयनित विरासत संरचनाओं पर प्रयुक्त किया जाएगा तथा उनके निष्पादन मूल्यांकन हेतु एक विशेष समयावधि के लिए fuxjkuh की जाएगी। प्रस्ताावित अनुसंधान के परिणामों के आधार पर भारत में fojklr ljpukvk d ljf{k.k rFkk ejEer gr fn'kk fun'k तैयार किए जाएंगे। परियोजना के अंतर्गत विभिन्न सामाजिक क्षेत्रों में ज्ञान आधार (नॉलेज बेस) को d'kyrk fodkl dk;Øe@dk;'kkykvk rFkk çf'k{k.k dk;Øek के माध्यम से प्रचार–प्रसार करना भी इसमें सम्मिलित है।

ßvfHkuo Hkou fuek.k lkexhÞ परियोजना को ^flfydk uuksikfVdYl dh ik;yV Ldy r;kjh o lhesaV vk/kkfjr lkexh e mud vuç;kx*] ^io fufeZr Hkou ?kVdk e çkx gr fofHkUu ox d ¶ykb ,'k d lkFk ft;kikyhej dØhV dh çfØ;k çk|kfxdh dk fodkl*] ^dØhV mRiknu vkj vU; Hkou fuek.k mRiknk e lxejej vif'k"V dh iupØ.k {kerk*] ^io fufeZr Hkou ?kVdk gr lYQ&d,EifDVx iupfØr ,xhxV dØhV dk fodkl* तथा ^vkf'kd ok;q 'kk/ku x.kk d lkFk /ofu vo'kk"k.k gr ykxr çHkkoh lkexh dk fodkl* पर अनुसंधान के साथ शुरू किया गया है।

ßÅtk d'ky ç.kkyh ,o Hkou Lopkyuþ परियोजना ^d'ky lkj m".k lxkgd^ पर शोध हेतु शुरू की गयी है।

Þvkink 'keuÞ परियोजना विभिन्न कार्य पैकेजों के माध्यम से ^çk–frd o ekuo fufeZr vkinkvk d fo#) egRoi.k vf/k"Bkiuk dh ljf{kk^ पर ध्यान केंद्रित करने के उद्देश्य से शुरू की गई है। ^egRoi.k vf/k"Bkiuk gr vfXu ljf{kk mik;k dk vfHkdYiu vkj fodkl^ वर्क पैकेज के अंतर्गत वास्तविक अग्नि परिदृश्य में जोखिम मूल्यांकन हेतु प्रायोगिक और संख्यात्मक सिमुलेशन अध्ययन, अग्नि सुरक्षा संवर्धन के लिए अग्निरोधी/प्रतिरोधी सामग्री का विकास, आंतरिक सामग्री हेतु अग्निरोधी लेप का विकास तथा अग्नि संपर्क वाले प्रबलित कंक्रीट सदस्यों का विश्लेषण व रेट्रोफिट तकनीकों के विकास पर कार्य शुरू किये गए। ^çxfr'khy iru d fo#) ljf{kk gr ljpukRed ç.kkfy;k o Hkouk dk vfHkdYiu vkj fodkl ekuo fufeZr vkj çk–frd [krj^ वर्क पैकेज में संरचनाओं की प्रगतिशील पतन असफलता के विरुद्ध सुरक्षा हेतु अभिकल्पन–प्रभाव और विस्फोट भार पर अध्ययन किया गया। इसके अलावा, ^HkkL[kyu d fo#) egRoi.k vf/k"Bkiuk dh ljf{kk^ पर कार्य पैकेज भी शुरू किया गया।

ßfuek.k çfØ;k ,o Lopkyuþ परियोजना के अंतर्गत ^ukxfjd ljpukvk e tfVy dk;q i;koj.k gr ekckby lsfl;e ;= dk fodkl^ तथा ^LekVZ cl vyxko d mi;kx }kjk bekjrk d Hkdih; çn'ku e of)^ पर शोध शुरू किया गया है।

वर्ष के दौरान, संस्थान ने ßlh,lvkbvkj QkLV Vkd Vkly'ku ifj;kstukÞ के अंतर्गत तीन परियोजनाओं–^gYdh ljpukvk gr vk/kkj ç.kkyh^] ^dkVk LVku dVkbo xkj d vif'k"V dk mi;kx dj Hkou mRikn* और ^Vipy ç|kfxdh ij

vk/kkfjr ckfjx e'khu dk fodkl* पर कार्य किया। सीएसआईआर फास्ट ट्रैक ट्रांसलेशन परियोजना का उद्देश्य बहुत ही लघु अवधि में प्रयोगशाला से समाज तक नवीन प्रौद्योगिकी उत्पाद प्रदान कर तत्काल लाभ प्रदान करना है।

विगत वर्षों की भांति संस्थान ने अपने स्वयं के इन–हाउस आरएंडडी कार्यक्रमों और कई अनुबंध अनुसंधान परियोजनाओं को संभालते हुए स्थिरता के सभी पहलुओं पर ध्यान दिया है। वर्ष के दौरान, संस्थान ने 31 bu&gkml vkj,MMh ifj;kstukvksa] 3 vuqnku&lgk;rk] 17 ijke'k] 24 çk;kftr vkj 35 ijh{k.k ifj;kstukvksa पर कार्य किया। निर्मित रेत–प्राकृतिक नदी रेत के लिए एक वैकल्पिक; चूने आधारित हेम्प कंक्रीट का विशेषीकरण और विकास; स्टॉर्म जल नालियों से गाद, जल/मल उपचार केंद्र से कीचड़ तथा ऊर्जा केंद्र से राख अपशिष्ट का उपयोगी उत्पाद में पुनर्चक्रण; भू–तकनीकी जाँच व उपकरण निगरानी के आधार पर नरेंद्र नगर भूस्खलन क्षेत्र का विरूपण और सतह सरक अध्ययन; पंचायती राज ओडिशा के लिए ग्रामीण आवास; प्रधानमंत्री ग्रामीण आवास योजना के तहत ग्रामीण आवास; एक एकीकृत और सहयोगात्मक भारत–अमेरिका अनुसंधान कार्यक्रम : भवन ऊर्जा दक्षता में सुधार (आईबीईई); भारत में जीरो पीक ऊर्जा भवन अभिकल्पन पर भारत–यूके परियोजना (जेडईडी–आई); तुंगनाथ मंदिर, जिला रुद्रप्रयाग, उत्तराखंड के लिए ढलान स्थिरता आकलन और उपचारात्मक उपाय; बेसाल्ट फाइबर प्रबलित कंक्रीट का प्रदर्शन; फ्लाई ऐश उपयोग पर क्षमता संवर्धन कार्यक्रम; तथा संलग्नक आग में विभिन्न सामग्रियों का जलन व्यवहार–चार मंजिला रो भवनों तक प्रभावी अग्नि निकासी रणनीतियों के विकास पर अध्ययन किये गए।

संस्थान ने वर्ष 2017–2018 के दौरान सरकारी, सार्वजनिक और निजी क्षेत्र की एजेंसियों/संगठनों के लिए किए गए अनुबंध अनुसंधान एवं विकास, अनुदान सहायता, परामर्श कार्य और तकनीकी सेवाओं के माध्यम से लगभग 9.42 करोड़ का बाहरी नकदी प्रवाह प्राप्त किया। इस अवधि के दौरान, विभिन्न जर्नलों के साथ–साथ सम्मेलन की कार्यवाही में कुल 100 शोध पत्र प्रकाशित किये गए।

संस्थान वैज्ञानिक तथा अभिनव अनुसंधान अकादमी (एसीएसआईआर) के तत्वावधान में ^Hkou vfHk;kf=dh ,oa vkink U;wuhdj.k ¼chbMh,e½* के क्षेत्र में समन्वित स्नातकोत्तर–पीएचडी कार्यक्रम प्रदान करता है। कार्यक्रम के छठे बैच ने वर्ष के दौरान अपने शोध प्रबंध को पूरा किया। वर्तमान में सीएसआईआर–सीबीआरआई में कुल 14 पीएचडी विद्यार्थी एसीएसआईआर में नामांकित हैं।

प्रतिवेदन में चित्रित शोध उपलब्धियों के साथ ही, मैं वर्ष के दौरान संस्थान की अतिरिक्त विशिष्ट उपलब्धियों/गतिविधियों पर प्रकाश डालना चाहता हूँ। संस्थान को पीएमएवाई–जी के लिए विकसित आवास अभिकल्पन के प्रकारों की तकनीकी पुनरीक्षण में बहुमूल्य सहायता हेतु ग्रामीण विकास मंत्रालय के वार्षिक पुरस्कारों में ग्रामीण जनता के उत्थान हेतु योगदान के लिए पुरस्कृत किया गया।

संस्थान ने राष्ट्रीय प्रौद्योगिकी दिवस, विश्व पर्यावरण दिवस, सीएसआईआर स्थापना दिवस और 72वें सीएसआईआर–सीबीआरआई स्थापना दिवस को ओपन डे के रूप में मनाया। इसके अलावा, जन जागरूकता हेतु राष्ट्रीय महत्व के दिनों में प्रतिष्ठित एवं गणमान्य व्यक्तित्वों के व्याख्यानों, प्रतियोगिताओं और विभिन्न कार्यक्रमों का भी आयोजन किया गया। हिंदी भाषा प्रोत्साहन, भ्रष्टाचार के विरुद्ध युद्ध, स्वच्छता और आरोग्यता आदि जैसे महत्वपूर्ण जागरूकता वाले मुद्दों को हिंदी सप्ताह, सतर्कता जागरूकता सप्ताह और स्वच्छता पखवाड़ा के माध्यम से मनाया गया।

देश सेवा में 75 वर्षों का जश्न मनाते हुए सीएसआईआर ने देश भर में कैप्सूल प्रदर्शनी का आयोजन किया। इन समारोहों के एक भाग के रूप में, सीएसआईआर–केंद्रीय भवन अनुसंधान संस्थान, रुड़की ने 10–12 अगस्त, 2017 के दौरान संस्थान में विद्यार्थियों, शिक्षकों, जनता और उपयोगकर्ता एजेंसियों के लिए rhu fnolh; lh,lvkbvkj lyfVue tcyh dIlIy çn'kuh का आयोजन किया।

संस्थान ने सीएसआईआर योजनाओं–^lh,lvkbvkj ç;kx'kkykvksa }kjk ldk; çf'k{k.k] çj.kk ,oa Ldyksa vkj d,yt dk vfHkxg.k^ तथा ^ftKklk&mRlqdrk dh [kkst % fo|kFkh&oSKkfud l;kstu dk;ØSe^ के तहत संस्थान की प्रतिष्ठित प्रयोगशालाओं के माध्यम से विद्यार्थियों के कक्षागृह शिक्षा को सुनियोजित अनुसंधान प्रयोगशाला आधारित शिक्षा के साथ विस्तृत करने के उद्देश्य से शिक्षकों और विद्यार्थियों के लिए अनेक प्रेरक और शैक्षिक कार्यक्रम, मंथन सत्र, प्रदर्शनियों, प्रतियोगिताओं आदि का आयोजन किया। इस संबंध में, अन्य कार्यक्रमों के साथ, वर्ष के दौरान एक महीने भर का विद्यार्थी प्रशिक्षु कार्यक्रम और दो–दिवसीय राज्य स्तरीय शिक्षक कार्यशाला का भी आयोजन किया गया। आईआईएसएफ कार्यक्रम के अग्रगामी प्रसंग के रूप में 14–15 सितंबर, 2017 के दौरान एक विज्ञान उत्सव, जनसंपर्क कार्यक्रम और पत्रकार सम्मलेन का भी आयोजन किया गया।

प्रतिष्ठित सरकारी विभागों के सुझावों को समायोजित करने के साथ ही, संस्थान ने सहायक परियोजना निदेशकों, इंजीनियरों, अधिकारियों, प्रोफेसरों, वैज्ञानिकों और विभिन्न संगठनों के विद्यार्थियों के लिए विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय कौशल विकास कार्यशालाओं और प्रशिक्षण कार्यक्रम भी आयोजित किए।

संस्थान ने ज्ञान के इष्टतम प्रसार के लिए विभिन्न कार्यक्रमों में भी भाग लिया। देश–विदेश के लोगों के साथ नियमित संवाद और संचार बनाए रखने के क्रम में संस्थान ने भवन और निर्माण क्षेत्र की विभिन्न समस्याओं से संबंधित विभिन्न सवालों के उत्तर दिए।

वर्ष के दौरान त्रैमासिक द्विभाषी पत्रिका 'lhchvkjvkb U;t yVj&Hkofudk^ के अतिरिक्त सीएसआईआर प्लेटिनम जुबली सीरीज की दूसरी पुस्तक ^lhchvkjvkb fcfYMx fctu çkQkby&çkl uk&gkvk ,M VDuky, tht^] तथा ^lh, lvkbvkj&lhchvkjvkb fVIl Q,j xM dLVD'ku çfDVl t bu fcfYMXl^ पर दो संकलन सहित अनेक प्रकाशनों का विमोचन किया गया।

संस्थान ने दिल्ली स्थित अपने प्रसार केंद्र के साथ मिलकर केंद्रीय, राज्य, सार्वजानिक निजी क्षेत्रों के संगठनो के साथ संपर्क बनाये रखा। यद्यपि यह वर्ष हमारे लिए चुनौतियों तथा उपलब्धियों से भरा रहा, हम अपनी उपलब्धियों से आत्मसंतुष्ट नहीं है तथा हम भविष्य में आने वाली चुनौतियों एवं जिम्मेदारियों का सामना करने के लिए तत्पर हैं।

मुझे आशा है कि प्रतिवेदन के द्वारा आप संस्थान की गतिविधियों की गहरी जानकारी प्राप्त करेंगे। निदेशक के रूप में, मैं यह प्रतिज्ञा करता हूँ कि संस्थान बृहत्तर ज्ञान, बेहतर कार्यक्रमों और उन्नत अनुसंधान और विकास उत्पादन के लिए अपनी खोज जारी रखेगा। वर्ष भर की उपलब्धियां और भविष्य की हमारी परिकल्पना संस्थान के समर्पित कर्मचारियों के अमोघ समर्थन और योगदान का परिणाम है। मैं उन सभी व्यक्तियों और समूहों, साथी वैज्ञानिकों, तकनीकी अधिकारियों और प्रशासनिक कर्मचारियों के प्रति बहुत आभारी हूँ, जिनकी सकारात्मक ऊर्जा और समर्थन हमारा पथ प्रशस्त करता है।

gekjh vuqlU/kku ifj"kn d v/;{k vkj lnL;k d eY;oku ijke'k] ekxn'kZu vkj leFkZu d fy, eS viuh —rKrk 0;ä djrk gwA eS lh,lvkbvkj d egkfun'kd vkj lh,lvkbvkj e[;ky; d viu lkfFk;k dk mud fujrj leFkZu vkj ekxn'kZu d fy, lnHkkoiwoZd /kU;okn djrk gwA

मैं अपने साथियों का उनके सहयोग के लिए आभार व्यक्त करता हूँ जिन्होंने मुझे मेरे दायित्वों को निभाने में मेरी मदद की। वर्ष के दौरान सेवानिवृत्त साथियों का उनके योगदान के लिए मैं आभार व्यक्त करता हूँ और उनके भविष्य के लिए शुभकामनाएं देता हूँ। इस वार्षिक प्रतिवेदन की उत्तम एवं रिकॉर्ड समय में प्रस्तुति के लिए, मैं सम्पादक को हार्दिक धन्यवाद देता हूँ। अंत में, अपने मूल्यवान ग्राहकों, प्रायोजकों, शुभचिंतकों तथा सीएसआईआर–सीबीआरआई के सेवानिवृत्त कार्मिकों के सहयोग तथा सहायता का स्मरण करना मेरे लिए प्रसन्नतादायक पल है।

भवन निर्माण एवं अवसंरचनात्मक उद्योग में वृद्धि के साथ हम उज्ज्वल भविष्य की ओर अग्रसर हैं।

दिनांक : 20–11–2018

(डॉ. एन. गोपालकृष्णन)

From the Director's Desk

It is with great pride and accomplishment that I present the Annual Report of CSIR-Central Building Research Institute, Roorkee for the year 2017-2018. This report highlights many notable marks achieved by the Institute during the year. I am gratified to celebrate this continued progress in the pursuit of improved research and knowledge for the growth and development of millions of Indians.

As a leading R&D institute in all aspects of building science & technology, CSIR-CBRI aims to be a world class research & knowledge centre for providing innovative solutions to achieve safety, sustainability, resilience, smartness, comfort, functional efficiency, speed, productivity in construction, environment preservation, energy efficiency and economy. The Institute continues to dedicate its research, development and innovation in solving National challenges including, but not limited to planning, design, materials, disaster mitigation in buildings, capacity building and construction.

The year 2017-2018 marked an active year for CSIR-CBRI. To help direct the critical objectives over the coming years, we embarked on a process to formulate a fresh strategic plan to revitalize our existing goals with new vision. This plan will serve as a comprehensive road map for the Institute, marking the impacts we anticipate to achieve in the coming years.

In this regard, the Institute has initiated **six major thrust areas** - Housing-Structure & Foundations, Conservation of Heritage Structures, Innovative Building Materials, Energy Efficient System & Building Automation, Disaster Mitigation and Building Process & Automation; in core competency area of the Institute.

The **"Housing-Structure & Foundation" Project** has been initiated with focus on **'Development of Fast, Durable & Energy Efficient Mass Housing Scheme'.**

To meet the challenges being faced in Mass housing, a considerable leap in knowledge in many disciplines of engineering, architecture, urban, rural & regional planning, social sciences and information technology is required. With the explicit purpose to bridge the gap in practice through innovation that meet six basic tenets of *Safety*, *Functionality*, *Sustainability*, *Aesthetics*, *Speed* and *Economy*, well conceived holistic R&D programmes have been taken-up at the Instiute to reinforce the National Missions - *Housing for All*.

To introduce standardization in housing using the concept of modular coordination complying performance parameters e.g. space efficiency, climate responsiveness, energy efficiency, disaster resilience and cost effectiveness; a task deals with 'Standardization of designs and layouts of prefab housing units with improved thermal performance' at the Institute.

The Institute aspires to develop an eco-system to deliver on the technological challenges of the housing construction sector in a holistic manner. To facilitate the housing construction sector make a decisive shift from conventional, resource and energy intensive technologies and materials towards speedier, environmentally sustainable and economically efficient solutions, efforts are being made towards a few emerging technologies like – dry construction in buildings; cold-formed steel wall panels housing system with improved structural and fire resistance; confined masonry and CBRI developed prefab component housing systems.

To provide long-lasting solutions that can address the delivery, quality and accessibility of affordable housing, R&D programme on development of prefab RC shear wall system; development of efficient mechanical anchorage for beam-column joints; development of mini-climbing crane; plastering machine; eco-friendly corrosion inhibitor to improve concrete durability; protective coating for improved energy efficiency in buildings; bio-based construction materials for sustainable mass housing

are focused. The construction industry is one of the major waste producers in all countries. To reduce the demand supply gap in construction sector, recycling and reuse of waste arising from construction and demolition is addressed through studies on recycling of agricultural / industrial / solid wastes for building infrastructures. The research on building adaptive capacity for multiple hazards is addressed by incorporating robustness in traditional construction, improvement in CBRI developed prefab building components, fire hazard simulation studies for mass housing project. The geotechnical solutions for mass housing schemes are being explored from different perspectives viz. ground improvement technique to mitigate liquefaction hazards for safe building construction; ground improvement using granular pile anchor foundation (GPAF) system; modified static and seismic design methodology of piled-raft foundation; and design & strengthening measures for building foundation systems in hilly regions.

The "Conservation of Heritage Structures" Project has been initiated with focus on 'Conservation and Restoration of Heritage Structure' through different work packages where seven CSIR laboratories are contributing. Among the seven work packages, CSIR-CBRI as nodal laboratory is contributing in six of them. The basic aim of this project is to develop state-of-the-art technologies for conservation and restoration of heritage structures. The project includes different objectives beginning with **classification and characterization of important heritage structures of India** based on their architecture, structural systems and materials compositions. A comprehensive database is proposed to be developed. The superior features of **traditional ancient knowledgebase in building sciences** will be re-established and a book on superiority featured will be released. **Design and development of remote 3D Virtual Reality system framework with cloud connectivity,** ensuring the digital preservation of Heritage Structures, will be carried out. Innovative **structural analysis methods, appropriate techniques for characterization of historic building materials, settlement of structures due to underground tunneling** will be established. **Development of alternative, innovative materials** for restoration and retrofitting of the structures and quantification of environmental parameters for structural degradation will be carried out to propose appropriate remedial measures. Research on **identification of fungi and bacterial** on selected heritage structure and **development of suitable remedial measure** is another objective. **Hybrid Non Destructive Evaluation (HNDE)** techniques will be developed in this project for the assessment of current state of the structure utilizing advanced NDE technologies and modern algorithms. Laboratory based studies will be carried out to develop appropriate **retrofitting strategy** for different types of structural elements. The developed technologies will then be applied to selected heritage structures and will be **monitored** for certain period of time for their performance evaluation. Based on the outcomes of the proposed research, **guidelines for conservation and restoration of heritage structures in India** will be prepared. The project also includes dissemination of developed knowledgebase to different social sectors through **skill development programs, workshops and trainings**.

The **"Innovative Building Materials"** Project has been commenced with research on **'Pilot Scale Preparation of Silica Nanoparticles & Their Applications in Cement Based Materials'; 'Process Technology Development of Geopolymer Concrete with Varying Classes of Fly Ash for Use in Precast Building Components'; 'Recyclability of Marble Waste in Concrete Production & Other Building Products'; 'Development of Self-Compacting Recycled Aggregate Concrete for Precast Building Components';** and **'Development of Cost Effective Material for Sound Absorption with Partial Air Purification Properties'**.

The **"Energy Efficient System & Building Automation" Project** has been initiated for research on **'Efficient Solar Thermal Collector'**.

The **"Disaster Mitigation"** Project has been initiated with focus on **'Safety of Vital Installations against Natural & Manmade Disasters'** through different work packages. In the work package **'Design & Development of Fire Safety Measures for Vital Installation'**, work on experimental & numerical simulation studies for hazard assessment in real fire scenario; development of fire retardant/resistant materials for fire safety enhancement; development of fire retardant coating for interior materials; and analysis of reinforced concrete members exposed to fire & development of retrofit techniques; was initiated. In the work package **'Design & Development of Structural Systems & Buildings for Protection against Progressive Collapse: Manmade & Natural Hazards'**, study on design against progressive collapse failure of structures - impact & blast

loads was taken on. In addition, work package on **'Safety of Vital Infrastructures against Landslides (SOVIAL)'**, was also commenced.

The **"Building Process & Automation"** Project has been commenced with research on **'Development of Mobile Sensing Device for Complex Working Environment of Civil Structures';** and **'Seismic Performance Enhancement of Buildings using Smart Base Isolation'**.

During the year, the Institute accomplished three projects under the **"CSIR Fast Track Translation Projects"- 'Foundation System for Light Structures'**; **'Building Products using Kota Stone Cutting & Slurry Waste';** and **'Development of a Boring Machine Based on Trenchless Technology'**. The CSIR Fast Track Translation Projects aim to provide immediate benefits to the society by delivering products in short period by completing the last mile from lab to market.

As in the previous years, the Institute has handled a number of its own in-house R&D programmes and many contract research projects, giving due consideration to all aspects of sustainability. During the year, the Institute handled **31 in-house R&D projects, 3 grant-in aid, 17 consultancy, 24 sponsored and 35 testing projects**. Research on Manufactured Sand-An Alternative to Natural River Sand; Characterization & Development of Lime Based Hemp Concrete; Recycling of Silt from Storm Water Drains, Sludge from Water Treatment Plant/Sewage Treatment Plant & Ash from Waste to Energy Plant in to Useful Products; Deformation & Slip Surface Studies of Narendra Nagar Landslide Area based on Geotechnical Investigations & Instrumentation Monitoring; Rural Housing for Panchayti Raj Odisha; Rural Housing under PMAY-G; An Integrated & Collaborative India-US Research Program: Improving Building Energy Efficiency (IBEE); Indo-UK Project: Zero Peak Energy Building Design in India (ZED-i); Slope Stability Assessment & Remedial Measures for Tungnath Temple, District Rudraprayag, Uttarakhand; Performance of Basalt Fibre Reinforced Concrete; Capacity Enhancement Programme on Fly Ash Utilization; and Burning Behaviour of Various Materials in Enclosure Fires- Development of Evacuation Strategies for Fire Affected Up to Four Storeys Row Buildings; were also carried out.

The Institute registered an external cash flow of nearly **9.42 crore** during the year 2017-2018, earned through contract R&D, grant-in aid, consultancy assignments and technical services, carried out for government, public and private sector agencies/organizations. During the period, a total of **100 research papers** have been published in various journals as well as conference proceedings.

The Institute offers an integrated M. Tech. – Ph.D. (IMP) Programme under the aegis of Academy of Scientific & Innovative Research (AcSIR) in the area of **'Building Engineering & Disaster Mitigation (BEDM)'**. The sixth batch of the programme completed their dissertation during the year. Presently total 14 Ph.D. students are enrolled in AcSIR at CSIR-CBRI.

In addition to the many research accomplishments featured in the report, I would like to highlight additional distinguished activities of the Institute during the year. The Institute was awarded for the contributions made for the upliftment of the rural masses at the Annual Awards of Ministry of Rural Development, for its valuable assistance in technical vetting of house design typologies developed for PMAY-G.

Consistently, the Institute observed Open Days on the occasion of National Technology Day, World Environment Day, CSIR Foundation Day and the 72nd CSIR-CBRI Foundation Day. Apart from this, various programmes, competitions and lectures from eminent personalities were also arranged on days of national importance, for general awareness. Important awareness issues such as encouragement of Hindi language, fight against corruption, cleanliness and hygiene etc. were celebrated through the weeks during Hindi Week, Vigilance Awareness Week and Swachhta Pakhwada.

To celebrate the 75 years of service to the nation, CSIR organized capsule exhibitions across the country. As a part of these celebrations, CSIR-Central Building Research Institute, Roorkee organized a **Three-Day CSIR Platinum Jubilee Capsule Exhibition** for students, teachers, public, and user agencies at the Institute during August 10-12, 2017.

The Institute organized numerous motivational and educational programmes, brainstorming session, exhibitions, competitions etc. for teachers and students under the CSIR Schemes - **'Faculty Training, Motivation and Adoption of Schools and Colleges by CSIR Labs' and 'Jigyasa- Quest for Curiosity Student-Scientist Connect Programme'**, to extend

student's classroom learning with that of a very well-planned research laboratory based learning through the prestigious labs of the Institute. In this regard, along with other programmes, a month-long student apprenticeship programme and two-day state-level teachers' workshop were also organized during the year. As a prelude to the IISF event, a science fest, public outreach programme and press meet was also organized during September 14-15, 2017.

In addition to accommodate the requests from distinguished government departments, the Institute also organized various national & international skill development workshops and training programmes for assistant project directors, engineers, officers, professors, scientists and students from various organizations.

The Institute also participated in various programmes for optimal dissemination of knowledge. To maintain regular interactions and communication with the people of India and abroad, the Institute responded to various enquiries pertaining to various problems of Building and Construction sector.

Several publications were released during the year including the second book in the CSIR Platinum Jubilee Series 'CBRI Building Business Profile-Process Know-how and Technologies', and two compendiums on 'CSIR-CBRI Tips for Good Construction Practices in Buildings', apart from the quarterly bilingual 'CBRI Newsletter- Bhavnika'.

The Institute along with its extension centre at New Delhi continued to maintain liaison with Central, State, public/private sectors throughout the country. Though this has been a year of challenges and achievements, we are not complacent with our attainments but are ever keen to meet the forthcoming challenges and responsibilities.

As you read the report, I hope you will gain deeper insights of the Institute activities. As the Director, I pledge that the Institute will continue its quest for greater knowledge, better programmes, and enhanced research and development output. The accomplishments over the past year and the work ahead are the result of the unfailing support and contributions of the dedicated staff. I am immensely grateful to all the individuals and groups, fellow scientists, technical officers and administrative staff, whose energy and support sustains us.

To the Chairman and the Members of our Research Council, I express my deepest gratitude for their valuable advice, guidance and support. I extend my sincere thanks to the Director General, CSIR and other colleagues from CSIR Headquarters for their continuous support and guidance.

I wish to acknowledge with appreciation the unstinted co-operation of my colleagues who helped me conduct my duties to the best of my abilities. I express my gratitude to the members superannuating during the year for their contributions and wish the best for their future endeavours. I thank the editor for the efforts in bringing out this Annual Report in an elegant manner. Last but not the least, it is a happy moment for me to remember the support and co-operation provided by our valued customers, sponsors, well-wishers and ex-colleagues of CSIR-CBRI.

With unprecedented growth in building and infrastructure industry, we are looking forward to an exciting future.

Date: 20.11.2018

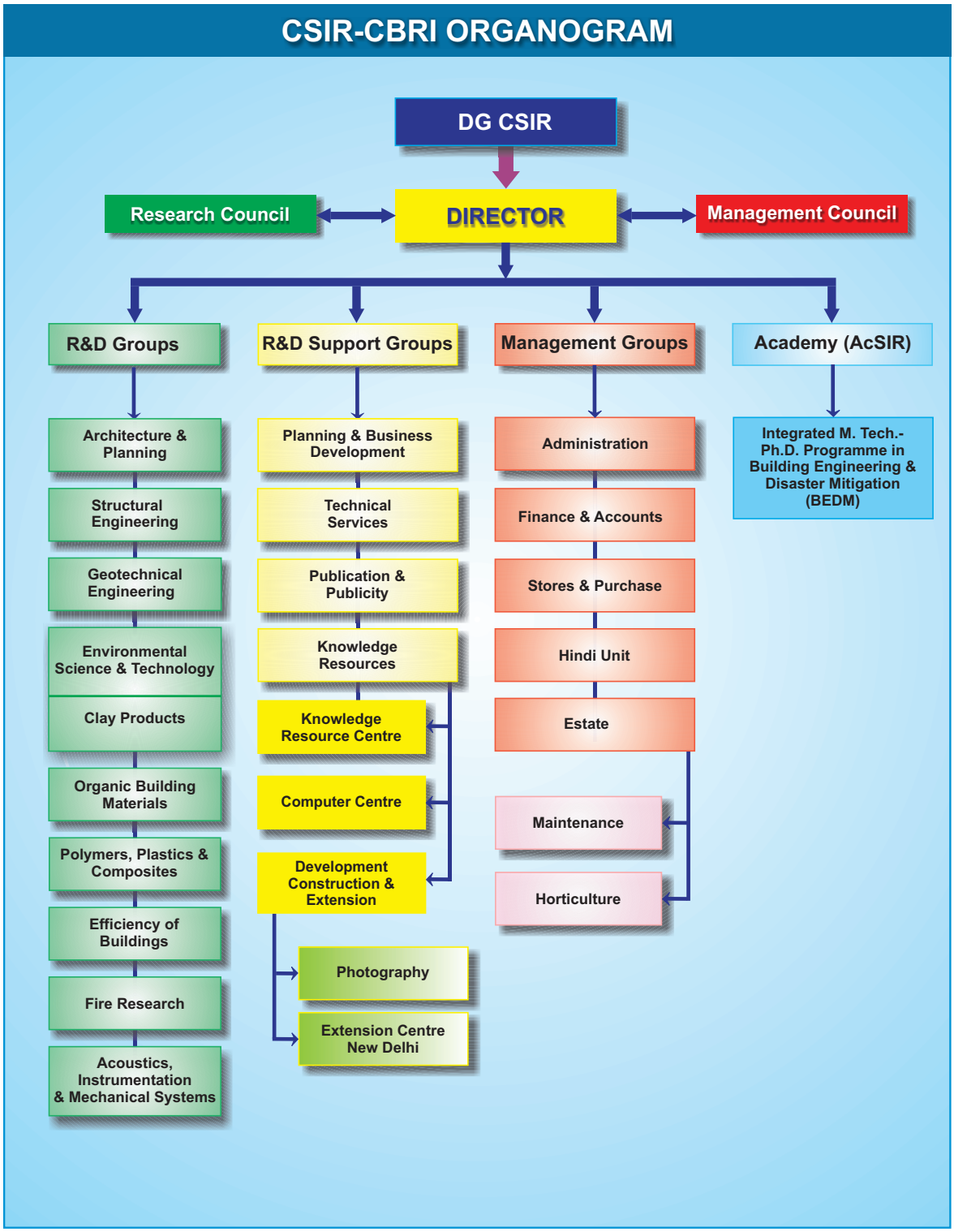
(Dr. N. Gopalakrishnan)

OUR VISION

To be a world class research & knowledge center of National importance for providing innovative solutions to all aspects of building science & technology.

OUR MISSION

Devotion to research, development and innovation (RD&I) in solving National challenges of planning, design, materials, capacity building and construction including disaster mitigation in buildings to achieve safety, sustainability, resilience, smartness, comfort, functional efficiency, speed, productivity in construction, environment preservation, energy efficiency and economy.



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Housing-Structure & Foundation

Development of Fast, Durable & Energy Efficient Mass Housing Scheme

Ajay Chourasia & Ashok Kumar

Development of Materials for Mass Housing Structural Elements

- Development of Cold-Formed Steel (CFS) Wall Panels Housing System with Improved Structural Performance & Fire Resistance
- Development of Bio-Based Construction Material for Sustainable Mass Housing

Performance Evaluation of Precast Panels & Framed Structural System

- Standardization of Designs & Layouts of Prefab Housing Units with Improved Thermal Performance
- Development of Prefab RC Shear Wall Systems & Evaluation of Their Lateral Load Resistance
- Development of Efficient Mechanical Anchorage Device for Precast Beam-Column Joint
- Performance Evaluation & Improvisation of Pre-Fabricated Building Systems
- Development of Dry-Construction Technology in Buildings

Reducing Resource Use in Housing Construction

- Recycling of Agricultural/ Industrial/Solid Wastes for Building Infrastructures
- Eco-friendly Corrosion Inhibition to Improve Concrete Durability
- Protective Coating for Improved Energy Efficiency in Buildings

Mechanization in the Housing Construction Sector

- Mechanization in Construction Process of Mass Housing
- Mechanization in Production of Prefabricated Building Components of Mass Housing

Disaster Resiliency in Housing Project

- Design Interventions for Enhancement of Robustness in Traditional Construction, Numerical & Experimental Investigation
- Design of Confined Masonry Construction using Different Types Units (Concrete Masonry Block, AAC Block)
- Improvement in CSIR-CBRI Developed Pre-Fab Technologies

Geotechnical Solutions for Mass Housing Schemes

- Ground Improvement Technique to Mitigate Liquefaction Hazards for Safe Building Construction
- Ground Improvement using Granular Pile Anchor Foundation (GPAF) System
- Modified Static & Seismic Design Methodology of Piled-Raft Foundation
- Design & Strengthening Measures for Building Foundation Systems in Hilly Regions

Science & Technology Intervention for Development of Safe & Sustainable Building Infrastructure in NE Region

M. Samanta & Soumitra Maiti

Sustainable Materials & Technologies

- Architectural & Structural Engineering Interventions in Housing Stock of NE Regions
- Development of Building Components using Locally Available Agro-Materials
- Development of Portable Energy Efficient Domestic Waste Water Management System
- Foundation Technology for NE

Development of Innovative Hybrid Connections for Pre-Cast Concrete Construction

Prefabricated Ferro Cement Sandwich Panel Based Housing System

Studies on Consolidation & Deformation Characteristics of Stone Columns with & without Geo-Synthetic Encasement in Soft Clay

Development of Materials for Mass Housing Structural Elements

Chanchal Sonkar

Development of Cold-Formed Steel (CFS) Wall Panels Housing System with Improved Structural Performance & Fire Resistance

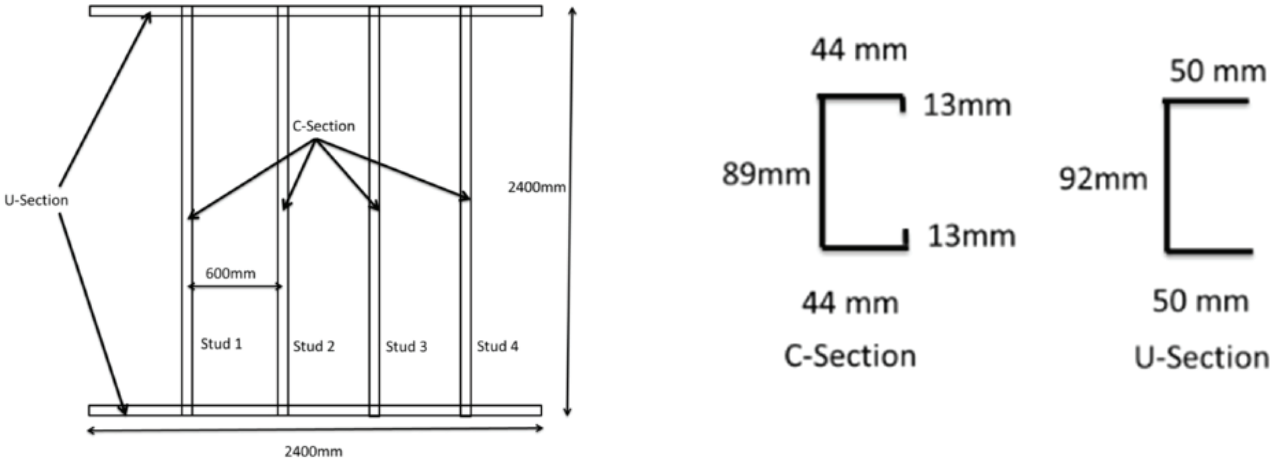
Chanchal Sonkar, A.K. Mittal, M.M. Dalbehera & Siddharth Behera

Objective

- Comparative studies on load carrying capacity & fire resistance rating of the innovative wall panels systems and conventional wall system at ambient and elevated temperature
- Connection strategies for different structural elements
- A demo prototype G+1 storey CFS building structure

Progress Highlights

Axial compressive load tests has been carried out on Cold-formed Steel (CFS) bare frame specimen fabricated using 4 nos. of C-section as vertical studs and 2 nos. of U-section as horizontal tracks. The dimensions of the test specimen are as shown in Fig. 1. The center-to-center spacing between the studs is 600mm.



(a) (b)

Fig. 1: Test Specimen Details (a) CFS Bare Frame Specimen (b) C-section and U-section

Fig. 2: Instrumentation using LVDT and LDS of CFS Frame

A test set-up has been developed for testing of CFS wall panels under compression on 300 Ton Instron UTM as shown in Fig. 2.

Loading Protocol

The loading protocol applied for testing is as shown in Fig. 3. The loading cycles consisted of four amplitudes of 2.5mm, 5mm, 7.5mm & 10mm. 3 nos. of cyclic displacement were applied for the first and second amplitude of 2.5mm and 5mm.

Only one cycle was applied for consecutive displacements of 7.5mm and 10mm. Loading rate was kept to be 0.5 mm/min and unloading rate was kept to be 1mm/min.

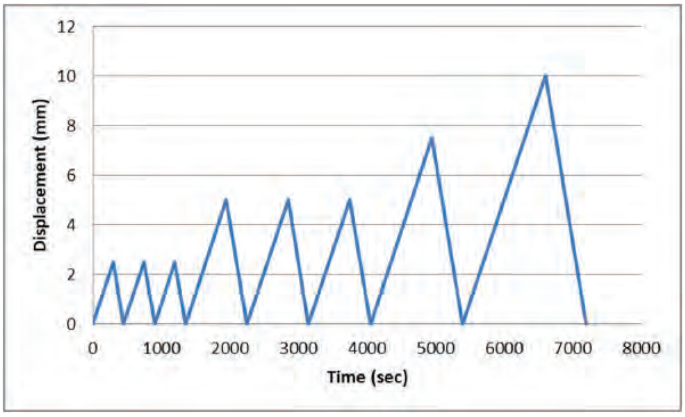


Fig. 3: Loading Protocol

Results & Discussion

As shown in Fig. 4, maximum load sustained by the specimen was 83.27kN during the seventh cycle of 7.5mm displacement. 1st drop was observed in the load vs time curve at the load 75.5kN due to flexural torsional buckling observed in the stud 2. Consecutively buckling took place in the stud 4 (2nd drop in the load vs time curve) and stud 3 respectively. Major failure mode for all the stud was basically observed to be flexural-torsional buckling mode. Local buckling was only observed on the lip of stud 1. Several drops were observed in the load vs time curve due to buckling in the studs of the CFS frame. Local buckling waves were observed in all the studs near the peak load. Initial stiffening of the specimen can be observed in load-deflection curve as shown in Fig. 5.

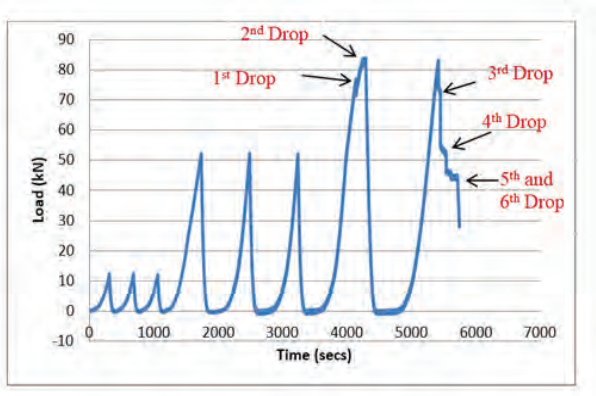


Fig. 4: Load vs Time Curve

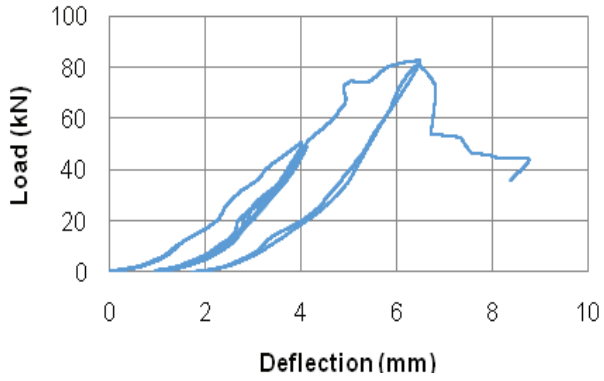


Fig. 5: Load vs Deflection Curve

Conclusion

The test demonstrated that studs in a full wall at 2.4m may fail in competing global buckling modes depending on the imperfections and redistribution of load within the walls. The analytical load carrying capacity of a single stud using AISI S100-96 depicts the load carrying capacity of the single stud to be approximately 21.79 kN, which if extrapolated to the wall should theoretically be able to carry 87.16 kN (4 studs x 21.79kN); however, the wall carried only 83.27kN. It is postulated that this lower result is because the wall fails when the weakest of 4 wall studs fails. As without the sheathing in place effective redistribution is nearly impossible. The difference between the predicted and experimental results is shown in Table 1. The ratio of the predicted load capacity and test is 1.05. Therefore, predicted result shows good agreement with the experimental result.

Table 1: Comparison of the Ultimate Load of Wall Specimen between the Experimental & Predicted Results

Specimen	Ultimate Load		Predicted/Test
	Experimental Test	Predicted	
CFS Bare Frame	83.27	87.16	1.05

Development of Bio-Based Construction Material for Sustainable Mass Housing

Leena Chaurasia

Objective

Development of Bio-based construction material for sustainable mass housing (Bio-bricks and Bio-concrete)

Progress Highlights

Studies on Bio-based Calcareous and Siliceous Construction Materials

The unprecedented growth in housing sector requires a huge quantity of building products causing the demand of natural resources far more than the supply in the developing countries like India. Worldwide advancement in bio-based materials over the last few years has led to the development of the biotechnology as a powerful tool. Adopting bacteria induced mineralization to fill the cracks is very innovative. The ability of these alkalophilic bacterial strains to tolerate highly alkaline environment may have important implications for remediation of cracks in building materials like brick and cement mortar/concrete. It is a new and promising method and the research in this aspect focuses more on durability aspect rather than on the mechanical properties. Although, the application of this technology and recent innovation is still in its experimental phases. Therefore, there are many future environmental designs and operational factors that still need to be assessed and practiced. It is possible that rebuilding with a self-healing bendable concrete would allow a more harmonious relationship between the built and natural environments by reducing the energy and carbon footprints in mass housing, so that the upcoming housing projects does not have to undergo the expensive repair and rebuilding process again in another 10 to 20 years.

Similarly there is abundant quantity of sand available in dessert area and this region is facing shortage of bricks in building construction. With the intervention of bio-technology, the dessert sand can be utilized for manufacturing of bricks with acceptable engineering properties and at reasonable cost. The present work is in its advanced stage for development of bio-bricks (Fig. 1) using dessert sand which will contribute to new building material/ product.

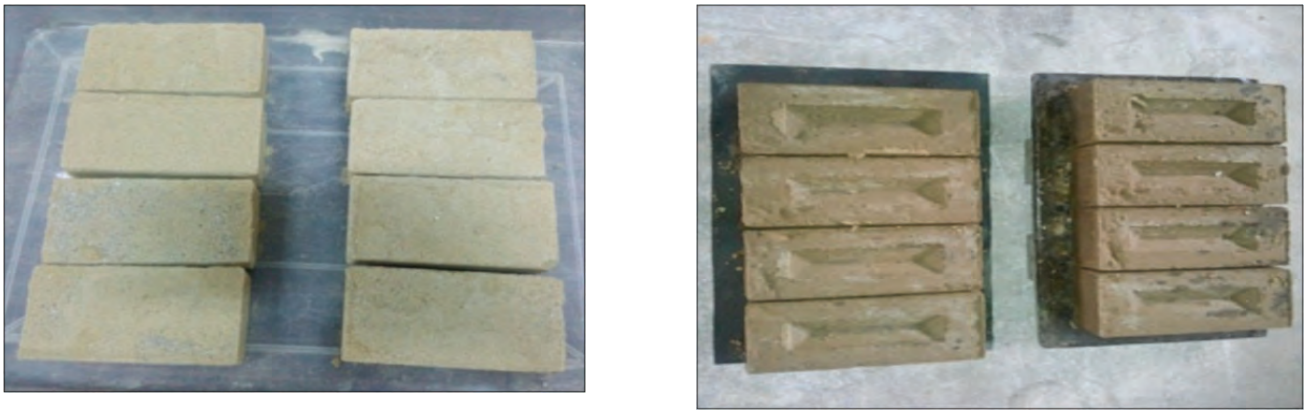


Fig. 1: Development of Bio-bricks using Dessert Sand and Bacteria

Performance Evaluation of Precast Panels & Framed Structural System

Sayantani Lala

Standardization of Designs & Layouts of Prefab Housing Units with Improved Thermal Performance

Shailza Singh, Ashok Kumar, Navjeev Saxena, Chandan Swaroop, Sayantani Lala & Kishor Kulkarni

Objective

i. To develop standardized type designs of houses with basic attributes such as space efficiency, climate responsiveness, thermal comfort, energy efficient etc.

ii. To develop optimum thermal characteristics for prefab housing components (i.e. wall, roof) for hot and dry, warm and humid and cold climatic conditions.

Progress Highlights

Design Layouts of Dwelling Units: Massing and Clustering

Twelve single design layouts have created considering the National Building Code requirement for minimum area requirements. In order to make clusters, each single design layout is grouped together to form massing or blocks. Fig. 1(a), Fig. 1(b), Fig. 1(c) and Fig. 1(d) illustrates the massing blocks created using each standardized single design layout. In total, four single design layouts are standardized and 13 massing blocks have been created.

Building Energy Modeling

The energy used by the buildings is mainly determined by the thermo-physical properties of building envelope. Thus, it is vital to control the rate of heat flow through the building envelope to maintain the zone temperatures within the comfort range. As the focus of the study is to develop standardized design layouts with improved thermal properties for different (hot and dry, warm and humid and cold) climatic regions, building energy modeling is done to carry the parametric analysis. Presently Building energy simulation is done for Unit 1 (Layout 1, 2 & 3) for Hot and Dry climatic condition of India.

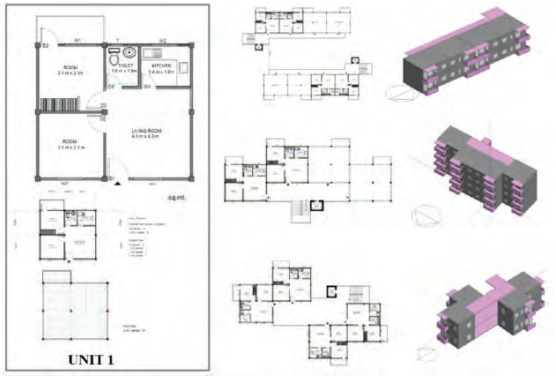


Fig. 1: (a) Single Design Layout and Massing of Unit 1

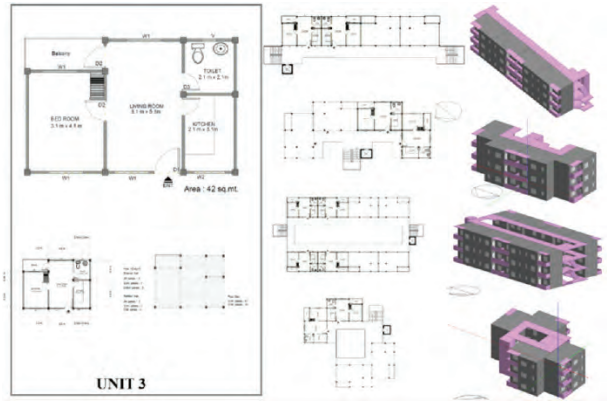


Fig. 1: (b) Single Design Layout and Massing of Unit 2

Fig. 1: (c) Single Design Layout and Massing of Unit 3

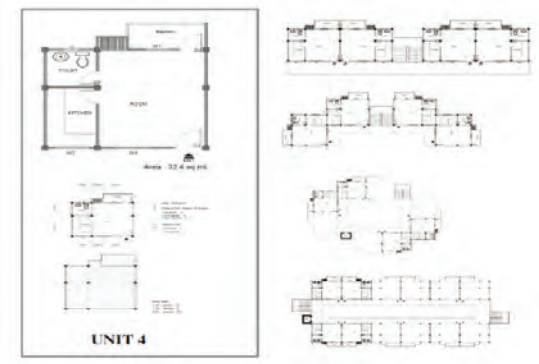


Fig. 1: (d) Single Design Layout and Massing of Unit 4

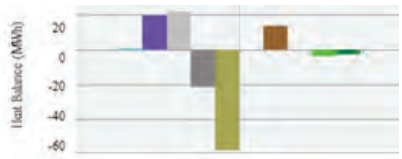
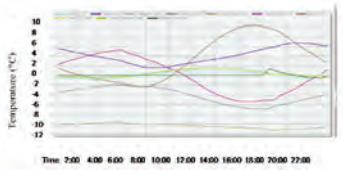
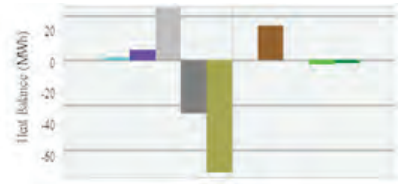
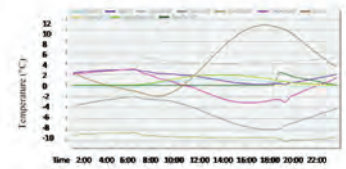
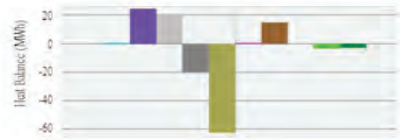
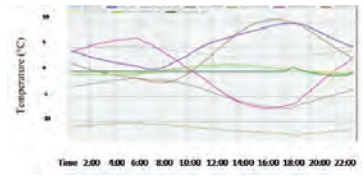
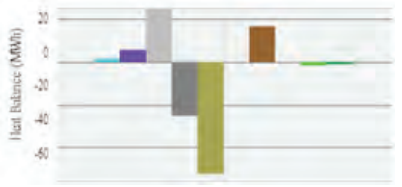
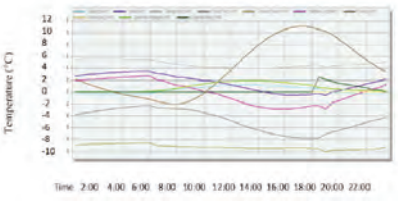
Results

The simulation results (using Design Builder v.1.6.9.003) have indicated that the source of heat gain/ loss can help in identifying the design parameters that needs to be focused to optimize energy use and thermal comfort. Table 1 gives a detailed summary of the thermal performance different building materials in Unit 1 in Hot and Dry climate. The simulation output shows that the annual heat gain through wall is minimum in Autoclaved Areated Concrete (AAC) wall and maximum in un-insulated Concrete wall and heat gain through roof is maximum in the late evening hours (16:00 – 18:00 hrs). Discomfort hours for a typical summer day is more in un-insulated concrete wall system and minimum in AAC wall system and heat gain through wall is maximum for most of the day (10:00 – 19:00 hrs). Table 2 gives the detailed summary of the simulation outputs to highlight the effect of built-form on heat gain/loss through wall and comfort. It is observed that annual heat gain through wall is minimum in Layout 3 with longer walls facing east west orientation and mutual shading due to offset. Discomfort hours are maximum in Layout 3 for a typical summer day with operative temperature reaching up to 42.4 °C.

Table 3 represents effect of Built form on daylighting for different orientations. As per ECBC for Residential Buildings 2017, minimum window to floor ratio (WFR)

for hot and dry climate should be 10%. The average Daylight Factor (DF) at the middle of the room is 0.9 as per Design Guidelines for Energy-efficient Multi-storey Residential Buildings Composite and Hot-dry climates, BEEP. Results show that, the daylighting factor DF is critical in living hall (in Layout 1, 2 & 3) and WFR has to be increased from 10% to ensure sufficient daylight.

Table 1: Thermal Properties of Different Wall Materials (UNIT 1)

Type of Walling Component	Total Energy (kWh)	Heat Gain /Loss through Building Envelope Typical Summer Day (15th July)	Heat Gain /Loss through Building Envelope Typical Summer Day (15th July)
Brick Masonry	Wall (kWh): 19575 Roof (kWh) : 13730		
AAC Wall	Wall (kWh): 4469 Roof (kWh) : 15647		
Concrete Wall	Wall (kWh): 24037 Roof (kWh) : 14901		
EPS Insulated	Wall (kWh): 5440 Roof (kWh) : 16460		
Summary		Annual Heat Gain through Wall is minimum in AAC Concrete Wall and maximum in Un-insulated Concrete wall.	Heat Gain through Roof is maximum in the late evening hours (16:00 – 18:00 hrs).
		Discomfort Hours for a Typical Summer day is more in un-insulated concrete wall system and minimum in AAC wall system: Heat Gain through wall is maximum for most of the day (10:00 – 19:00 hrs).	

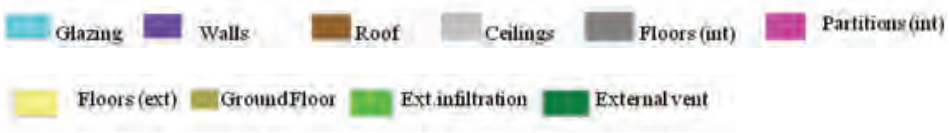
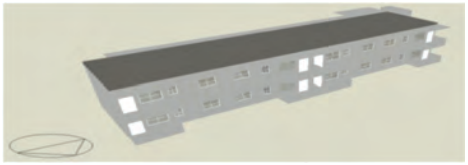
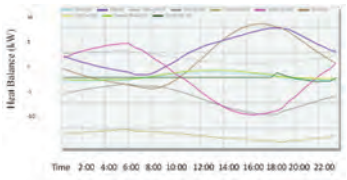
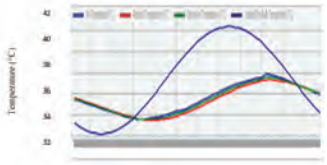
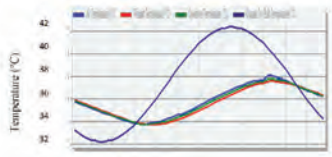
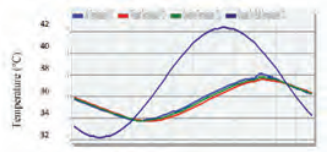
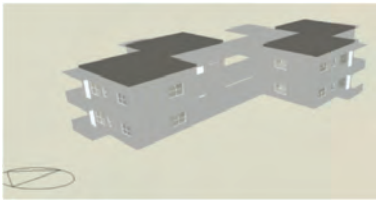
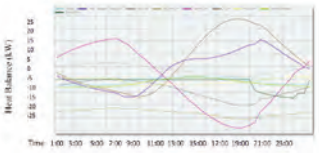
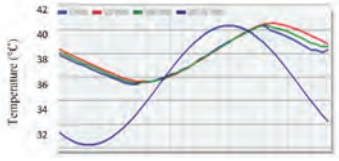


Table 2: Effect of Built-Form on Heat Gain/Loss Through Wall and Comfort (UNIT 1)

Built Form	Heat Gain /Loss through Building Envelope Typical Summer Day (15th July)	Indoor Air Temperature, Operative Temperature and Radiant Temperature vs Outdoor Air Temperature
Layout 1  Wall (kWh): 24037 Solar Gain Ext. Windows (kWh):23597		
Layout 2  Wall (kWh): 24901 Solar Gain Ext. Windows (kWh):19588		
Layout 3  Wall (kWh): 11110 Solar Gain Ext. Windows (kWh):20506.7		
Summary	Annual heat Gain through wall is minimum in Layout 3 with longer walls facing east west orientation and mutual shading due to offset.	Discomfort hours are maximum in Layout 3 in a Typical Summer Day with operative temperature reaching up to 42.4 °C.
Air Temperature (°C)	Operative Temperature (°C)	
Radiant Temperature (°C)	Outside Dry-Bulb Temperature (°C)	

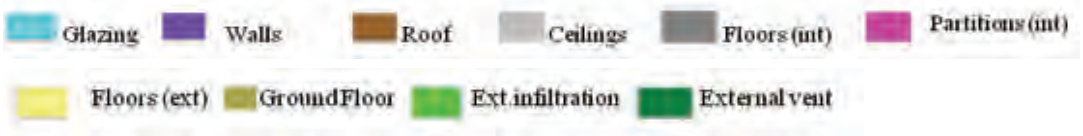
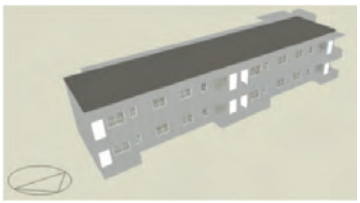
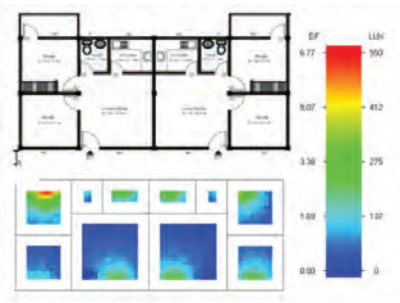
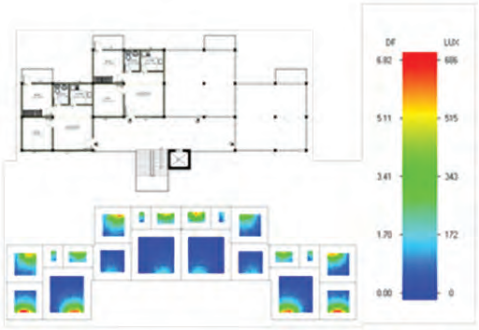
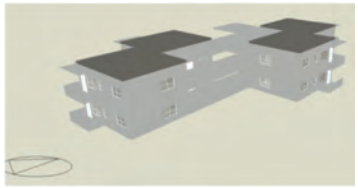
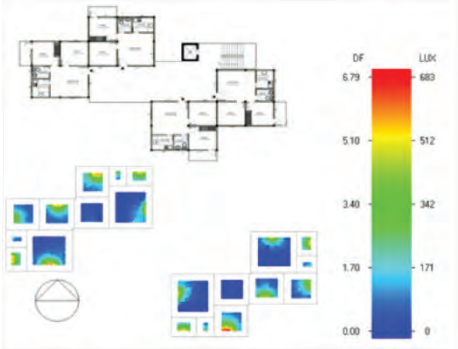


Table 3: Effect of Built-Form on Day lighting
(UNIT 1)

Built Form	Day lighting (Lux)	Remark
Layout 1 		Living Room (having WFR of 10% with minimum DF of 0). Bed Room 2 (with WFR of 18% with maximum DF of 4-6).
Layout 2 		Living Room (with WFR of 10% with minimum DF of 0).
Layout 3 		Living Room (with WFR of 10% with minimum DF of 0).
Summary	Analysis highlights the DF is critical in living hall (in Layout 1,2 &3) and WFR has to be increased from 10% to ensure sufficient daylight.	

Building Details: Dwelling Unit (DU) per floor = 4 No. of Floors = 2 Total DU in each cluster = 8 Orientation of each cluster = East-West	Minimum Window to Floor Ratio (Hot and Dry climate)= 10% (ECBC for Residential Buildings 2017) Recommended Average Daylight Factor (DF) at the middle of the room = 0.9 (Design Guidelines For Energy-efficient Multi-storey Residential Buildings Composite And Hot-dry Climates, BEEP)

Development of Prefab RC Shear Wall Systems & Evaluation of Their Lateral Load Resistance

Ajay Chourasia, Shubham Singhal, Shermi C. & Jalaj Parashar

Objective

To investigate the seismic behavior of precast RC shear wall systems and their connections with columns/ beam.

Progress Highlights

India is undergoing rapid urbanization and population rise, resulting in huge pressure on housing and urban infrastructure. Construction industry needs to address the technology that brings speed, quality and efficiency into construction, such as precast construction. Precast structures hold benefits over conventional RC structures in terms of quality, safety, economy, sustainability and pace in construction. Precast structures are highly effective in resisting gravity loads, while their efficacy in sustaining lateral forces has found to be irresolute due to inadequate joint connections. Tedious process of transportation and handling of precast components is another issue which restricts their acceptance in construction industry. Additional stresses may incorporate during transportation, handling, erection and assembling of precast panels, which may be more critical than the stresses generated due to service loads. The present research focuses on experimental investigation on precast hollow core shear wall, which has advantages such as easier transportation and handling, less shuttering requirement, improved bucking resistance, economical for large number of stories and higher lateral load resistance due to improved moment of inertia.

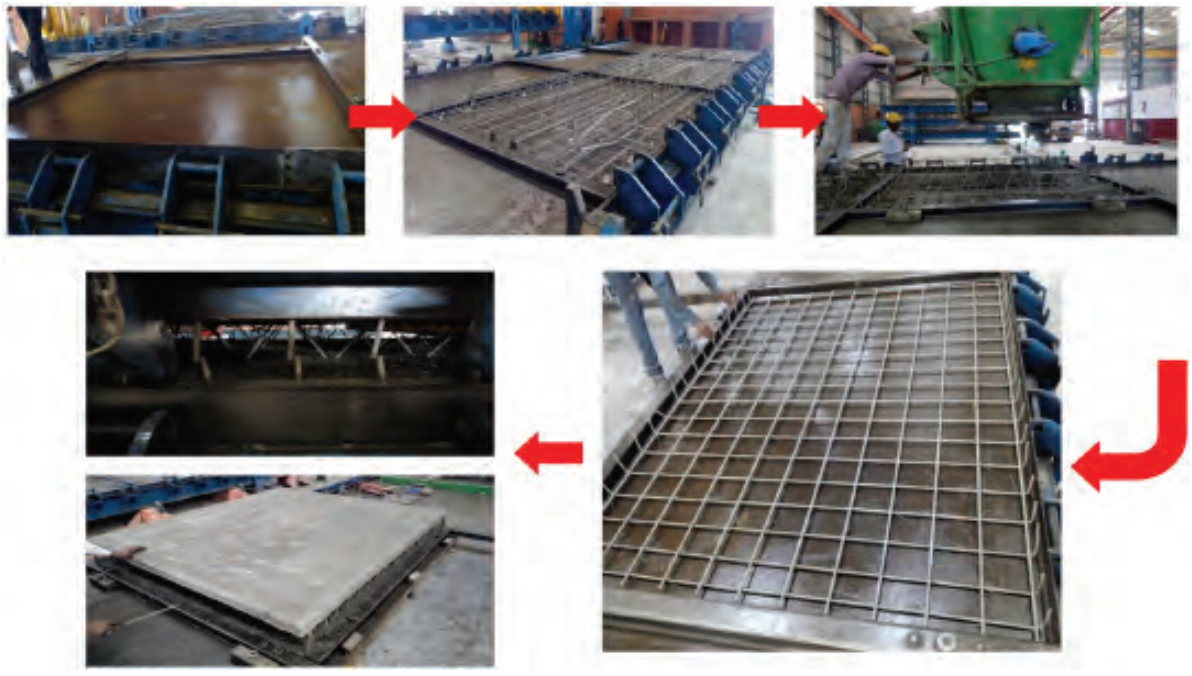


Fig. 1: Manufacturing of Precast Hollow Core Shear Wall

A 2.26 m high and 1.85 m wide precast RC shear wall having 0.3 m thickness was designed in accordance with IS 13920: 2016 for lateral load test. The shear wall was designed and developed as a precast RC double wall system consisting of two 70 mm thick precast RC wall panels confining 160 mm hollow core, which was later filled with the cast-in-situ concrete. An encompassing RC band was provided at the base of wall encompassing the wall from all the sides. Fig. 1 demonstrates construction process of the precast shear wall at the factory. Edge elements of the wall were strengthened with 3 - 8 mm ø longitudinal bars in hollow core which were embedded into the raft up to twice the development length of the bars. The precast RC panels were connected through three 8 mm ø - 215 mm long steel lattice girders along length of the wall, provided continuously throughout height of the wall. Longitudinal reinforcement required in the shear wall was critically distributed in hollow core and confining precast panels in order to comply with the design criteria as per IS 13920: 2016.

The precast hollow core shear wall system was tested under quasi-static reverse cyclic lateral load (Fig. 2). Seismic behaviour was investigated from the standpoint of damage pattern, lateral load capacity, stiffness, drift, ductility, response reduction factor, energy dissipation and equivalent viscous damping. Table 1 shows the experimental results of the test.

Fig. 2: Lateral Load Test of Precast Hollow Core Shear Wall

Table 1: Experimental Results

Parameter	Result
Maximum lateral load	353 kN
Displacement at ultimate load	63.50 mm
Roof drift at ultimate load	2.81 %
Effective Stiffness	83 kN/mm
Ductility	5.29

Development of Efficient Mechanical Anchorage Device for Precast Beam-Column Joint

Ajay Chourasia, Shubham Singhal, Siva Chidambaram, Shermi C. & Jalaj Parashar

Objective

To develop efficient mechanical anchorage system for beam-column joint

Progress Highlights

The exterior beam-column joint of RC structure are more vulnerable when subjected to lateral forces, hence needs proper design and detailing of joints. The bond between the reinforcing bar and concrete plays a major role in achieving the anchorage capacity of the joints. Normally reinforcement bars are bent into other element at joints by development length, causing congestion of reinforcement and may lead to honey combing. Similarly, the bending of large diameter bar is a cumbersome and expensive process in terms of cost and labour and also attracts possibility of corrosion. Mostly, architectural design constrains the dimension of structural member leading to insufficient development length ensuring inadequate shear and bond strength. These difficulties can be solved by use of headed bar, a bar with head anchor attached at its either end by attaching technique like welding, threading or forging. Headed bar is gaining attention over worldwide due to its simplified design and detailing, structural performance, reduced congestion, installation saving, shop fabrication, time and cost. The use of headed bar in the joints allows a very efficient construction process which eliminate the need of traditional bending and facilitating extremely rapid construction programme for the structure. The heads of the headed bar are capable to mobilize full bar strength in tension by bearing at the head without any contribution of bond strength of deformed bar.

These headed bars were experimentally investigated for bond behaviour and slip. Pull-out tests were conducted on headed bar specimens embedded in the M20 concrete cube. The headed bars of 27 mm gross diameter for 12 mm diameter of deformed bar fixed together by threading and welding technique. The test parameters considered were length of head (11, 19, 27, 35 and 43 mm), deformation over the length of head (plain, grooved and ribbed) and embedment depth of headed bar into the concrete (75, 100 and 125 mm). Fig. 1 shows different type of headed bars and Fig. 2 shows the experimental set-up for the pull-out tests.

(a) (b) (c)

Fig. 1: (a) Plain Headed Bars; (b) Grooved Headed Bars; and (c) Ribbed Headed Bars

Fig. 2: Experimental Set-up for Pull-out Test

Head bars proved to be effective enough when compared to conventional non-headed bars in terms of damage pattern and bond capacity. All the specimens with non-headed bars demonstrated pull-out failure, attributed to insufficient bonding and gripping of bar with the concrete. Whereas, specimens with headed bars demonstrated remarkably high bond capacity, owing to their better bonding property with the concrete, which prevented pull-out failure. Average bond capacity of welded headed bars was marginally better than that of threaded bars. Table 1 summarizes generalized observations of threaded and welded headed bars. Fig. 3 demonstrates the bond capacity of headed bar connected through threading, whereas Fig. 4 demonstrates the bond capacity of headed bar connected/attached through welding considering various types of bar mentioned in Table 1.

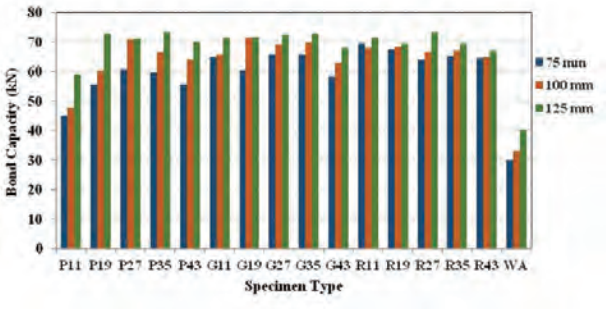


Fig. 3: Bond Capacity of Headed Bars attached through Threading

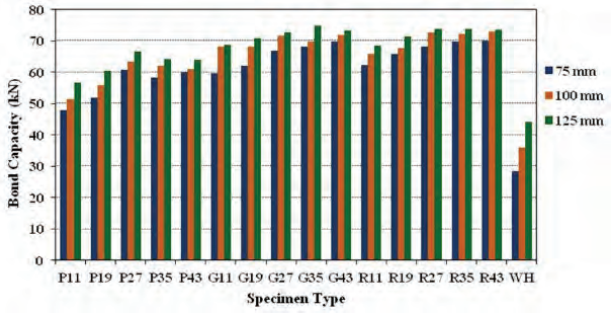


Fig. 4: Bond Capacity of Headed Bars attached through Welding

Table 1: Observations of Pull-out Tests

Type of Bars	Observations	
	Attached through Threading	**Attached through Welding**
Plain headed bar	• Concrete cone failure, concrete splitting failure • Yielding of bar for 125 mm embedment depth	• Concrete failure in lower embedment depth • Slip of bar failure in higher embedment depth • Lower bond capacity as compared to grooved and ribbed headed bar
Grooved headed bar	• Yielding of bar for 125 mm embedment depth	• Concrete failure in lower embedment depth • Slip of bar failure in higher embedment depth • Better bond capacity
Ribbed headed bar	• Slip of bar failure • Better bond capacity	• Slip of bar failure irrespective of embedment depth • Better bond capacity
Without head	• Lower bond capacity • Pull-out failure	• Lower bond capacity • Pull-out failure

Performance Evaluation & Improvisation of Pre-Fabricated Building Systems

Shermi C., Ajay Chourasia, Siva Chidambaram & Jalaj Parashar

Objective

To evaluate emerging housing technology for functional requirements in terms of thermal comfort, acoustics, water tightness, fire resistance, stability against vertical and lateral load

Introduction

Pre-fabricated structures have a vital role to play in the future of a more sustainable, efficient construction system. Though pre-fabricated structure have already made wave in the developed countries, the technology is still at a nascent stage in India.

"Pre-fabricated structure cannot transform poor design, but prefabricated structure can be transformed by good design and considered details"

Prefabricated components are used in practice as they speed up construction time, resulting in lower labor costs; the mechanization used in prefabricated construction ensures precise conformity to building code standards and greater quality assurance; there are less wasted materials than in-situ-built construction; worker safety and comfort level are higher than in-situ-built construction; computerization of the production process permits a high degree of customization, at an affordable cost. Due to these benefits, the construction industry is switching to pre-fabricated technology; as a result, a number of new pre-fabricated technologies are being introduced in the market. Though these techniques claim to be eco-friendly, energy efficient, disaster resistant, fire proof etc., their efficiency is not been properly evaluated as per the multi attribute evaluation methodology

Progress Highlights

As a first step for evaluation of emerging housing technology, demo houses are planned to be constructed at CSIR-CBRI premises for evaluation of various functional requirement. The plan, sectional elevation

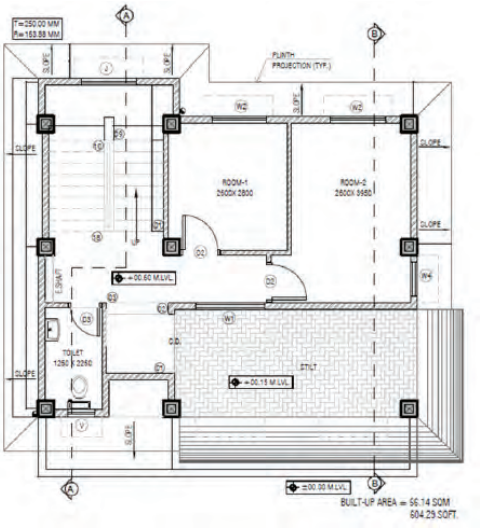


Fig. 1: Ground Floor Plan

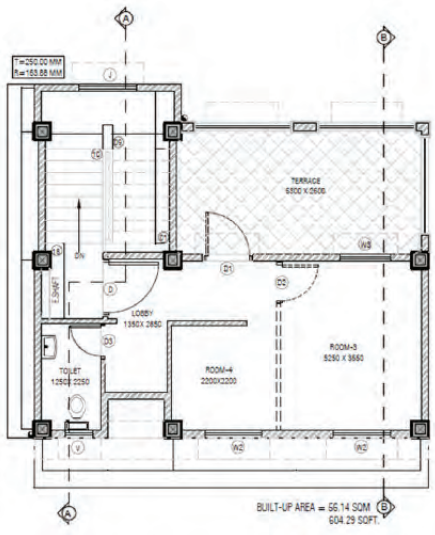


Fig. 2: First Floor Plan

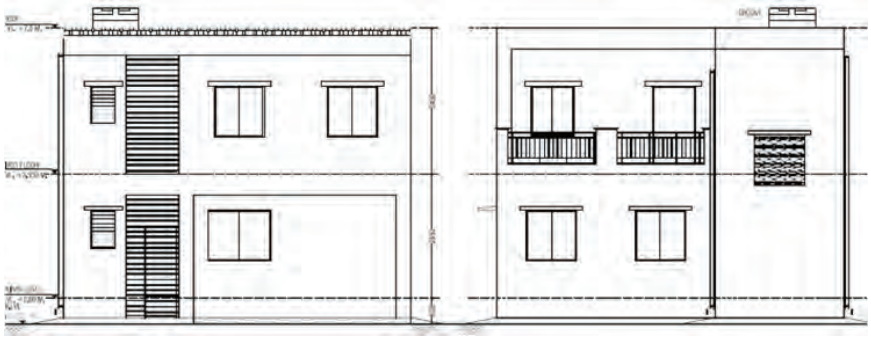


Fig. 3: Front and Rear Side Elevation

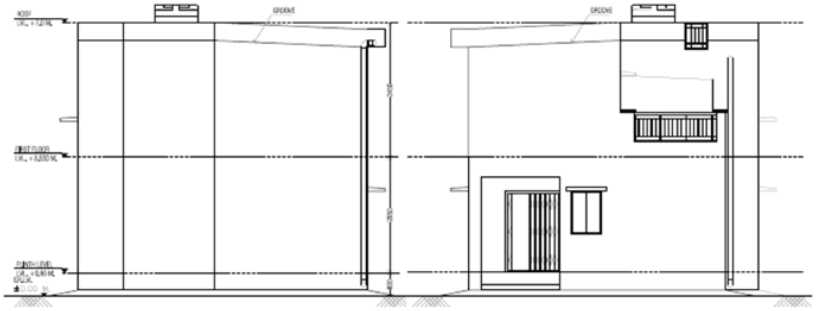


Fig. 4: Left or Right Side Elevation

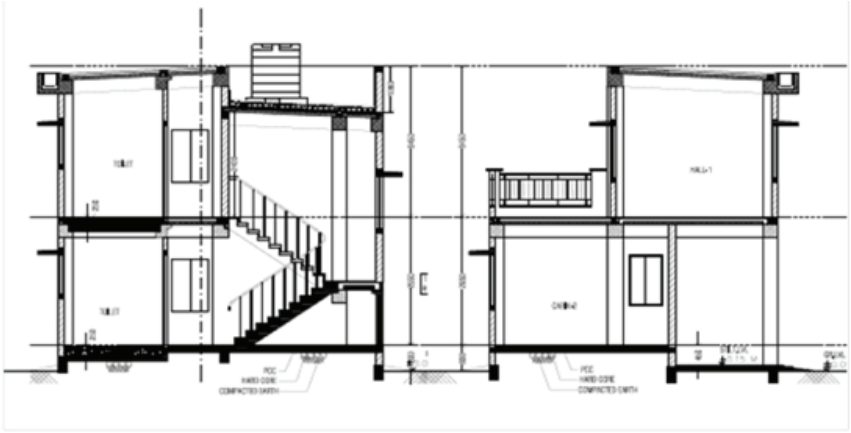


Fig. 5: Sectional Elevation

Fig. 6: 3D Front View of Demo Building

Fig. 7: 3D Back View of Demo Building

Table 1: Tests for Evaluating Emerging Housing Technology

S. No.	Name of the test	Standard Procedure
1	Thermal Conductivity/ Thermal Comfort.	IS: 3346: 1980 IS 3792:1978 ASTM C -177-13
2	Water Tightness	ASTM D 5957-98 ASTM E 2128-17
3	Stability against Vertical Load.	IS 875 (part 1) IS 875 (part 2) IS 875 (part 5) Chapter 27, ACI 318:2014
4	Acoustics	Sound transmission loss as per IS: 1950:1962 ASTM E 966-92 ASTM E 1332-9
5	Fire test	IS:3089:1979 ASTM E 119 ASTM E 2748 Fire rating as per National Building Code
6	Lateral load test	IS 875 (part 3) IS 875 (part 5) IS 1893 (part 1) ASTM E 2126-11

Development of Dry-Construction Technology in Buildings

Kishor Kulkarni, Sayantani Lala, Ashok Kumar, Navjeev Saxena, Tabish Alam & Naresh Gupta

Objective

To develop dry-construction technology addressing to the attributes: disaster resilience, thermally comfortable, energy efficient

Progress Highlights

1. Finalization of G+1 Building plan & Structural Design
2. Experimental setup finalized, fabrication of experimental setup is in progress
3. Identified various Beam column connector elements

Reducing Resource use in Housing Construction

Soumitra Maiti

Recycling of Agricultural/Industrial/Solid Wastes for Building Infrastructures

A.K. Minocha, Soumitra Maiti, Monalisa Behera, N. Jain, Santha Kumar G. & Team

Project Highlights

The issues of sustainability are of prime concerns these days as we use large amount of natural resources for producing materials such as concrete. Depletion of natural resources is one of such sustainability issues which needs to be addressed in an efficient manner. When properly done, recycling wastes as building materials is a convenient way to reduce the environmental impact of the construction industry. Recycling has several potential environmental advantages, such as it reduces consumption of natural resources, reduces the deposition of landfill, reduce energy consumption of material production and its associated pollution etc. Therefore, utilization of C&D wastes/ Baggase ash/ M Sand in construction sector is necessary to reduce the social and environmental problems against disposal of wastes and depletion of natural aggregate resources.

Sugarcane bagasse is used as fuel in the cogeneration process to produce steam and electricity in sugar industries. When bagasse is burnt in combustion boiler under controlled burning, reactive amorphous silica is formed in the residual ashes. After burning, bagasse ash is collected as a by-product from cogeneration boiler and directly dumped to nearest disposal area. Each ton of burned bagasse generates 25 kg of ash. India is producing around 67,000 tons/day sugarcane bagasse ashes. Disposal of bagasse ash is a critical issue for sugar industries because of environmental constraints and land requirement. In recent years, the building materials industry has become a promising alternative for the recycling of solid waste materials. it was found that bagasse ash (BA) contains high amounts of silicon and aluminum oxides in the amorphous state and can be used as a pozzolanic material in concrete. Because the volume of bagasse ash has increased every year, it would be beneficial to use this ash as cementitious materials. Bagasse ashes (BA) from nearby three sugar mill have been collected and their compositions are shown in Table 1.

Table 1: Composition of BA Samples & Renusagar Fly Ash

Compounds	Sample 1	Sample 2	Sample 3	Fly ash
Silica (SiO_2),%	78.3	70.4	72.5	56.7
Alumina(Al_2O_3) ,%	5.4	6.8	6.2	19.6
Ferric Oxide (Fe_2O_3) ,%	3.2	4.8	5.7	9.4
Calcium Oxide (CaO) ,%	6.2	8.9	6.8	4.1
Potassium Oxide (K_2O) ,%	2.1	3.4	3.2	2.9
Sodium Oxide (Na_2O) ,%	1.2	1.0	1.3	2.8
Loss on Ignition,%	3.0	3.6	4.2	1.1

It was found that SiO_2 is more than 70% in BA. The objective of the present investigation is to evaluate BA as supplementary cementitious material with reference to mechanical properties and permeability properties of hardened concretes and identify the optimal level of replacement. A two factorial three level Central Composite Design (CCD) was developed using Design Expert software (6.08, 2002, state-ease inc. Minnepolis) in RSM for this study. For statistical calculations, theses parameters (x_i) are coded as x_i according to the Eq. 1 and shown in Table 2.

$$x_i = \frac{(X_i - X_0)}{\partial x} \quad ...(1)$$

Where,
x_i is the coded value,
X_i is the actual value of i^{th} process variable,
∂x is the step change and
X_0 is the value of process variable at the center point.

The individual and interactive effect of the two process variables (Bagasse ash content, and W/B ratio) on compressive strength and slump are investigated using CCD model by conducting 18 experiments and presented in Table 3.

Based upon the calculation of regression co-efficient 28 days compressive strength of mortar and slump in terms of coded factor is modeled as:

Table 2: Experimental Range & Coded Levels of Process Variables

Variables	Coded value		
	Low level	Intermediate level	High level
A, Bagasse ash content (wt %)	10	20	30
B, W/B ratio	0.45	0.50	0.55

Table 3: Measured Value Based on CCD Matrix

Run	A:BA content (%)	B:W/B Ratio	CS (28 Day) MPa	Slump (mm)
1	10	0.5	33	215
2	10	0.55	36	225
3	20	0.5	36	190
4	30	0.5	34	160
5	30	0.55	29	170
6	10	0.45	36	205
7	20	0.5	36	190
8	20	0.45	40	180
9	30	0.45	34	155
10	20	0.55	32	210
11	30	0.45	34	155
12	10	0.45	36	205
13	30	0.5	34	160
14	20	0.45	40	180
15	20	0.55	32	210
16	10	0.5	33	215
17	30	0.55	29	170
18	10	0.55	36	225

CS (28 Day) = 35.78 -1.17A -2.08B - 2.17A^2 +0.083B^2 -1.25AB

Slump = 193.44 -26.83A+11.00B-6.67A^2 +2.33B^2-1.50AB

The compressive strength values of BA blended cement mortars are shown in Fig. 1. Comparison of the data for 28 days of curing time shows that the compressive strength increases with BA up to certain percentage replacement level and then decreases. The increase in strength may be due to the pozzolanic reaction as reported by many researchers and partially to high specific surface area of BA leading to number of nucleation sites for additional hydration products. At 25 and 30% BA, the strength decreases to a lesser value when compared to that of control specimens. Thus 16% replacement of BA to OPC is considered as optimal limit at W/B ratio of 0.5.

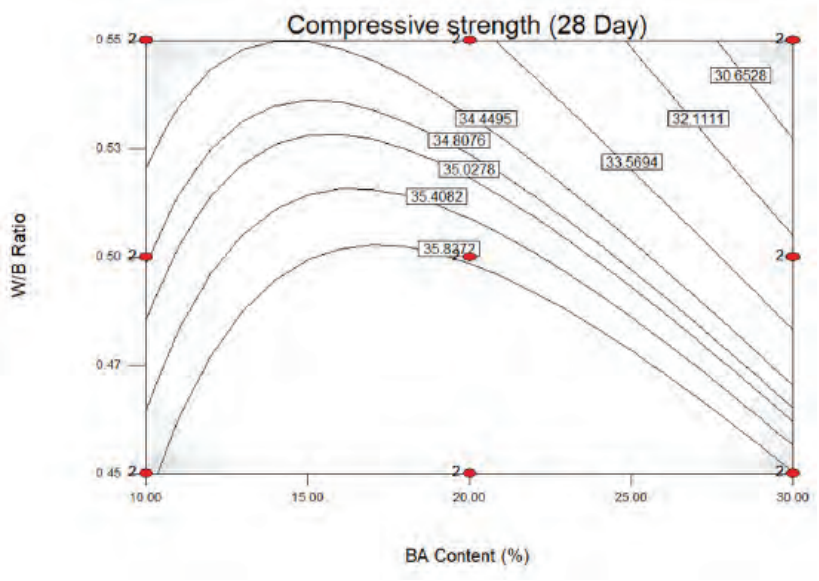


Fig. 1. Compressive Strength of BA Blended Mortar as Function of W/B Ratio

Eco-friendly Corrosion Inhibition to Improve Concrete Durability

S.R. Karade, P.C. Thapliyal, R.S. Chidambaram, Anujay Rawat & Jaipal Saini

Objective

To develop eco-friendly corrosion inhibitors to improve durability of RC elements/structures.

Progress Highlights

To overcome problem of corrosion of steel rebars in RC structures, one of the frequently used remedial measure is mixing corrosion inhibitors in the concrete. However, the commonly used inhibitors are costly and toxic in nature. Conventional corrosion inhibitors for reinforced concrete are generally manufactured from inorganic substances may have deleterious effects on concrete i.e. affect mechanical properties, hydration of cement etc. The use of green agro-forestry materials as corrosion inhibitors can be a potential solution for this problem, as most of them do not have deleterious effects on concrete as well as they have higher inhibition efficiency compared to conventional corrosion inhibitors. Because of their natural origin, as well as their non-toxic characteristics and negligible

negative impacts on the environment, agro-waste/ natural products and medical waste such as hina, neem, bamboo etc. seems ideal to replace traditional toxic corrosion inhibitors.

Based on an extensive literature survey, criteria for selection of plants to be used for extraction of corrosion inhibitors are given below:

- Ample availability of plant in India.
- Good crop yield of plant in several regions of India.
- Anti-oxidant activity of the compounds present in plant materials should be high.
- Low capital involvement in the collection and extraction process.
- Satisfactory performance during preliminary electro-chemical studies for screening of plant extracts.

On this basis, various plants identified for use are Phyllanthus emblica (Indian Gooseberry), Cynadon dactylon (Bermuda grass), Azadirachta indica (Neem), and Eucalyptus globulus (Eucalyptus).

Extraction from Plants

Of all the extraction methods, maceration is used in which water (polar solvent) is used for extraction. This method was selected to develop a cost-effective, non-energy intensive, environmental friendly process for the development of corrosion inhibitors. In maceration method of extraction, water was added to dried plant parts whose size had been reduced to increase the efficiency of extraction. The plant leaves were dried for at least 10 days in shade and then size reduction was done (Fig. 1 & Fig. 2). Water was allowed to stand in air-tight vessel for 7-10 days in a zero-light condition for extraction.

(a) Eucalyptus(Eucalyptus Globulus)

(b) Neem (Azardirachta Indica)

(c) Indian Gooseberry (Phyllanthus Emblica)

(d) Bermuda Grass (Cynodon Dactylon)

Fig. 1: Collection & Drying of Raw Materials

Extracts were filtered using an appropriate filter paper. The filtration process is shown in Fig. 3. To increase the concentration of extracts, slow evaporation of water from extract was done at a low temperature for which extracts were kept in oven to reach at an appropriate concentration at temperature lower than 40° C.

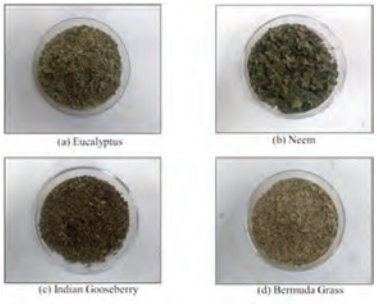


Fig. 2: Dried & Reduced Size of Various Tree Leaves

Fig. 3: Filtration of Extracts using Buchner Funnel

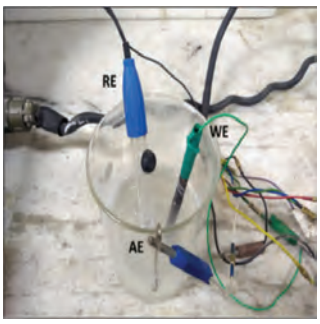


Fig. 4: Test Setup for Corrosion Tests

The measured concentration and pH afterwards is shown in Table 1.

Table 1: Concentration & pH of Various Extracts

S. No.	Plant	Concentration (g/l)	pH
1	Eucalyptus	2.70	4.85
2	Bermuda Grass	3.60	3.88
3	Fresh Gooseberry	6.20	3.26
4	Dry Gooseberry	3.06	3.60

Effect of Addition of Inhibitors on Cement Hydration

The preliminary studies on effect of addition of inhibitors on cement hydration was studied using a semi-adiabatic calorimeter in the laboratory. It has been observed that there is a reduction in the rate of heat evolution during hydration when extracts are added and the total heat of hydration is also reduced. This may result in the reduction of compressive strength of mortar or concrete which need to be further studied by casting mortar and concrete specimen.

Simulated Concrete Pore Solution (SPS)

For experimental studies, simulated concrete pore solution was prepared by adding calcium hydroxide in water. To imitate chloride induced corrosion when concrete is contaminated with chloride 3.5% NaCl (w/v) was added to the saturated solution. The setup for various corrosion tests is shown in the Fig. 4.

Corrosion Tests

Half-cell potential and linear polarization resistance tests are being carried out to assess the influence of various extracts on corrosion of steel rebar specimens. So far the results indicate that the presence of extracts in the SPS changes the electrochemical environment around the steel bar towards reduction in corrosion rate.

Completed/Ongoing Project Tasks

- Procurement of raw materials
- Processing of raw materials
- Collection of extracts from raw materials
- Electrochemical investigations for screening of extracts as corrosion inhibitors is afoot.

Protective Coating for Improved Energy Efficiency in Buildings

P. C. Thapliyal

Objective

To develop Eco friendly protective coating using renewable content for RC prefab building components with improved performance against corrosion, thermal heat transfer and better durability.

Progress

Literature survey was done to see any new development in this area and to get the state of the art. Designs of experiments (DoE) were completed. On the basis of results obtained from DoE, experiments were finalized to formulate the binder. Experimental work has been initiated and further work is in progress.

Mechanization in the Housing Construction Sector

S.K. Panigrahi

The project is aiming at mechanization in material handling, mechanization in wall plastering and machines for building components to bring speediness in construction process. The research team is developing mechanized system for light duty material handling used in construction process such as lifting, positioning, placing and alignment of pre-fabricated building components for mass housing development. The proposed mechanized system will be cost effective and portable for easy to assemble and dissemble features that is required in site specific use for ease in shifting from one floor/site to another. To bring speediness in mass housing, mechanization in development of building elements is really a challenging problem in India. Having expertise in building construction machinery, CSIR-CBRI may take this challenge by modifying the existing developed machine for casting building components as per the market requirement. Plastering of walls is a time consuming and skilled labour oriented work. Machines available for wall plastering are not successful in India due to its limitations in plastering the edges, at openings in walls and repeated fixing & alignment of the machine. The machine proposed to be developed under the project for wall plastering will be a semi-mechanized one and plaster the walls taking account the drawbacks of available plastering machines in market.

Mechanization in Construction Process of Mass Housing

R.S. Bisht, S.K. Panigrahi, Narendra Kumar & Team

Objective

Mechanization in construction process such as lifting, positioning, placing and alignment of pre-fabricated building components for mass housing.

Progress Highlights

- Prepared design concept of mobile crane for light duty range of material handling (up to 1-1.5 ton) required in mass housing development.
- Proposed concept design of mechanism for lateral movement of crane boom to improve workspace of the overall mobile crane.
- Prepared part design using SolidWorks CAD software and design validation using FEA ABAQUS software of mechanism for lateral movement of crane boom to improve workspace of the overall mobile crane.

Mechanization in Production of Prefabricated Building Components of Mass Housing

S.K. Panigrahi, R.S. Bisht, Narendra Kumar & Team

Objective

Modification of machine for prefabricated components in CBRI for production of pre-fab components as per market requirement for mass housing and Mechanization in wall plastering

Progress Highlights

- Identified suitable spraying components along with compressor, Motorized Planner and other accessories for developing wall plastering mechanized system.
- Prepared design concept of wall plastering machine for plastering of walls in mass housing development
- Developed new improved version of liver mechanism for up and down pressing mechanism of C-BRICK Machine for production of building components for mass housing

Disaster Resiliency in Housing Project

Swati Kulashri

Design Interventions for Enhancement of Robustness in Traditional Construction, Numerical & Experimental Investigation

S.K. Negi, Ajay Chourasia, Shermi C. & Ashish Pippal

Objective

Mechanization in construction process such as lifting, positioning, placing and alignment of pre-fabricated building components for mass housing

Progress Highlights

- S&T interventions provided to Panchayati Raj Dept., Govt. of Odisha for PMAY-G
- Till date S&T interventions provided by CSIR-CBRI has been utilized in the construction of 15000+ houses
- Technology park has been developed by Govt. of Odisha with technical inputs and know-how of CSIR-CBRI at Bhubaneshwar
- Previous version of Pre Cast RC Joist has been replaced by Steel Hollow box section to make it more convenient for use in rural areas
- Development of Bamboo truss & joint testing facility is under progress

Design of Confined Masonry Construction using Different Types Units (Concrete Masonry Block, AAC Block)

Ajay Chourasia, Shubham Singhal & Jalaj Parashar

Objective

- Material characterization of AAC (Autoclaved Aerated Concrete) and RBM (Round Boulder Mortar) units.
- Design of Confined masonry buildings using AAC/ RBM blocks.

Progress Highlights

Masonry construction is the most common construction typology for low to medium rise buildings. Masonry buildings have several advantages such as fire resistance, thermal insulation, simple and economic construction etc. Solid burnt clay bricks are the most prevalent masonry units, which are adopted worldwide. However, it is found that these units have varying material properties which depend upon the soil type and manufacturing methodology. Moreover, solid burnt clay units cause environmental pollution due to its manufacturing process, where the units are burnt. In order to overcome such hazards over the environment, alternate materials and eco-friendly manufacturing process shall be adopted. Autoclaved Aerated Concrete (AAC) units are other prevalent masonry units that are adopted on the grounds of being light-weight. However, it has been realized that AAC units are highly porous leading to higher water absorption capacity, which may subsequently lead to lower material properties. Further more, even this AAC unit being a lighter material, its initial cost per unit is higher than conventional solid burnt clay unit. Following the increasing use of AAC units for the construction purposes, relevant experimental investigations are required in order to determine their engineering properties. To overcome the drawbacks associated with the prevalent masonry units, Round Boulders Mortar (RBM) units were

developed which consist of round boulders confined in cement- sand mortar, thoroughly mixed with water with optimum utilization of materials. Fig. 1 shows the manufacturing process of RBM units. The RBM units were consolidated with vibro-compaction technique using CSIR-CBRI developed C-brick machine.

Experimental investigations in accordance with relevant Indian and ASTM standards were carried out on AAC and RBM units to determine their material properties. Dry density, water absorption, initial rate of absorption and compressive strength tests were conducted of such units. AAC and RBM masonry prisms (420 x 230 x 110 mm) and wallets (710 x 710x 110 mm) were casted (conforming to ASTM C1314-03b) and subjected to compressive and diagonal shear tests. Based on the obtained results, elastic constants for AAC and RBM masonry were determined. Average rresults of different type of units are tabulated in Table 1 along with the cost comparison. RBM units exhibited excellent material/engineering properties as compared to AAC and traditionally adopted solid burnt clay units, available in Roorkee.

The obtained material properties shall be adopted for the analysis and design of confined masonry buildings. The density of AAC units was determined in the the range of 551-650 kg/m^3 and average compressive strength of 3.78 N/mm^2, which is in agreement with IS 2185 (Part-3). While, usage of round boulders in RBM units resulted in approximately three times higher density as compared to AAC units. The water absorption capacity for RBM units was observed to be 5.56% which is reduced by 88.6% as compared to AAC units. This reduction in water absorption resulted in proper bonding between units and mortar, and thus increasing the compressive strength of masonry. Compressive strength of RBM units was found to be approximately 5 times higher as compared to AAC units. This makes evident that AAC units have inferior load bearing capacity. The present research concludes that RBM units are a better substitute for AAC units as well as burnt solid clay units especially in hilly regions where ingredients for their manufacturing are available in abundance. Similarly, the cost comparison shows that the cost for RBM units

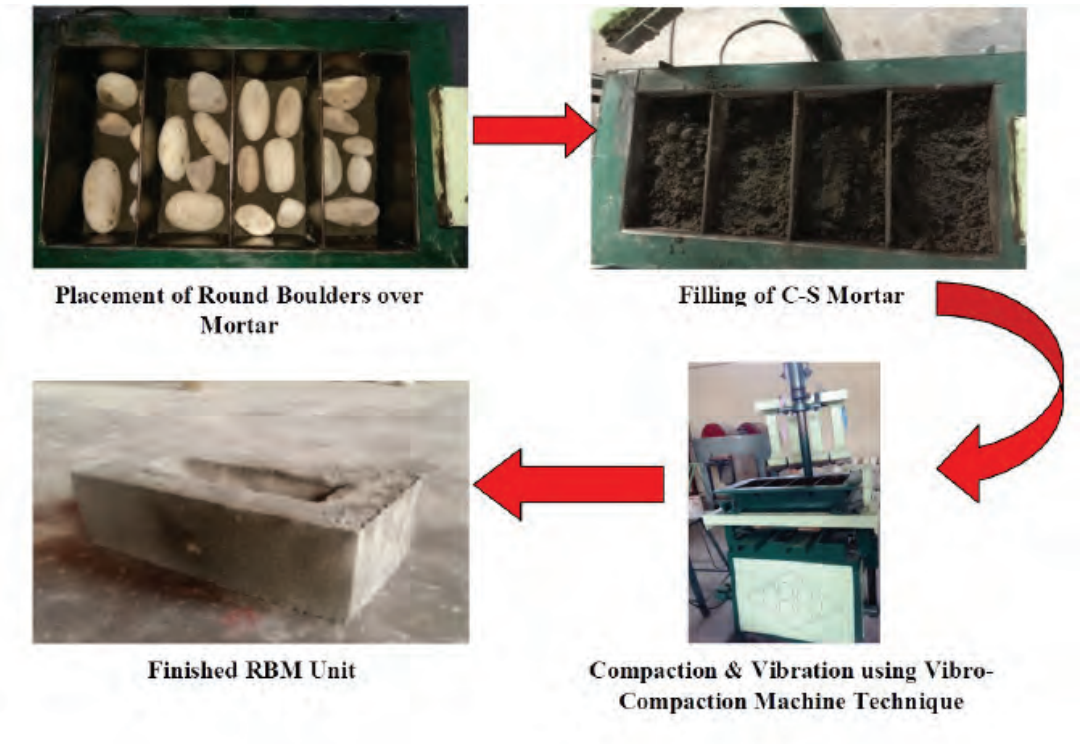


Fig. 1: Manufacturing Process of RBM Units

was reduced by 12% and 40% with respect to AAC units and burnt solid clay units respectively, which will impart economy in the masonry construction. Moreover, production of burnt solid clay bricks lead to air pollution due to their manufacturing process, while production of RBM units involves eco-friendly manufacturing process, thus preventing environmental pollution.

Table 1: Material Properties of Burnt Solid Clay Units, AAC Units & RBM Units

Parameters	Type of Units		
	Burnt Solid Clay Unit	AAC Unit	RBM Unit
Size (mm)	220 x 110 x 70	230 x 110 x 80	230 x 110 x 80
Water Absorption of Unit (%)	10.34	48.83	5.56
Dry Density of Unit (kN/m^3)	17.90	6.15	18.34
Compressive Strength of Unit, f_b (N/mm^2)	13.37	3.78	15.37
Compressive Strength of Masonry, f_m (N/mm^2)	3.311	2.670	6.909
Elastic Modulus of Masonry, E (N/mm^2)	1560	1386	3183
Relationship between E and f_m	E = 456 f_m	E = 531 f_m	E = 424 fm
Poisson's Ratio of Masonry, μ	0.260	0.260	0.110
Shear Strength of Masonry, τ (N/mm^2)	0.260	0.226	0.340
Shear Modulus of Masonry, G (N/mm^2)	227.25	320.00	665.00
Relationship between G and E	G = 0.150 E	G = 0.240 E	G = 0.220 E
Cost per unit (Rs.)	4.23	4.45	3.03
Cost per cum (Rs.)	2500	2200	1500
Percent Reduction in Cost w.r.t. clay unit	-	12%	40%

Improvement in CSIR-CBRI Developed Pre-Fab Technologies

S.K. Negi, Ajay Chourasia & Ashish Pippal

Objective

Development and modification of CSIR-CBRI developed technologies (Roofing/Flooring) for utilization as pre-fab building components

Progress Highlights

- Modification of RC Plank & Joist system has been achieved in terms of size & Net economy of the previous version
- Individual Planks have been designed, casted and tested. Results gathered are completely satisfactory
- This'll help in reducing time, improving net economy and reducing no. of joints, making it a more robust system

Geotechnical Solutions for Mass Housing Schemes

S. Ganesh Kumar

Ground Improvement Technique to Mitigate Liquefaction Hazards for Safe Building Construction

S. Ganesh Kumar & Anindya Pain

Objectives

i. To identify and develop engineering solution for soils susceptible to liquefaction in seismic prone regions.
ii. To improve the strength of natural soil by using encased stone columns

Progress Highlights

The purpose of the work is to use encased stone columns as a liquefaction remedial measure for sandy soils. The main objective is to study the load carrying capacity and pore- pressure dissipation in terms of spacing and area replacement ratio when the model ground is reinforced with encased stone columns. In addition, other parameters such as soil densification effect during installation, effect of volume compressibility and permeability also studied to understand the effect of reinforcement on liquefaction resistance.

During the research period, reduced scale 1-g model tests were conducted using uniaxial shaking table to study the behavior of loose saturated sand subjected to harmonic (sinusoidal) loading. Additionally, the response of saturated sand reinforced with stone column, with and without geotextile encasement is also studied and compared. The tests were performed in a rigid plexiglass tank with dimensions 1.4m×1m×1m, mounted over a uniaxial shake table. Fig. 1(a) shows the schematic diagram of the test assembly. The saturated sand sample was then prepared inside the plexiglass tank using water sedimentation technique to achieve a relative density of 25%. Initially, the height of sample inside the tank was fixed at 650 mm and corresponding dry weight of sand required to occupy the desired volume (at required relative density) inside the tank was calculated. The amount of water required to form saturated sand sample was evaluated and filled in the tank. Subsequently, dry sand was poured into the tank from a constant height from the water surface in three stages. The height was fixed after several trials. The sample was then left for 24 hours for complete saturation.

For the tests involving stone column and encased stone column, the saturated sample was prepared initially using a similar procedure. Thereafter, stone columns were installed in the saturated sand using a replacement technique. A hollow PVC pipe of outer diameter 111 mm was driven inside the prepared sand bed and subsequently, the sand inside the PVC pipe was removed. The bore hole (thus formed) was then filled with stone aggregates in three layers and compacted to achieve a density of 16+0.2 kN/m^3. Four stone columns of diameter (D) 111 mm were installed at a center-to-center spacing of 222 mm (2D). Fig. 1(b) shows the plan of the test assembly used for the tests involving saturated sand reinforced with stone columns. The entire assembly was then left for 24 hours.

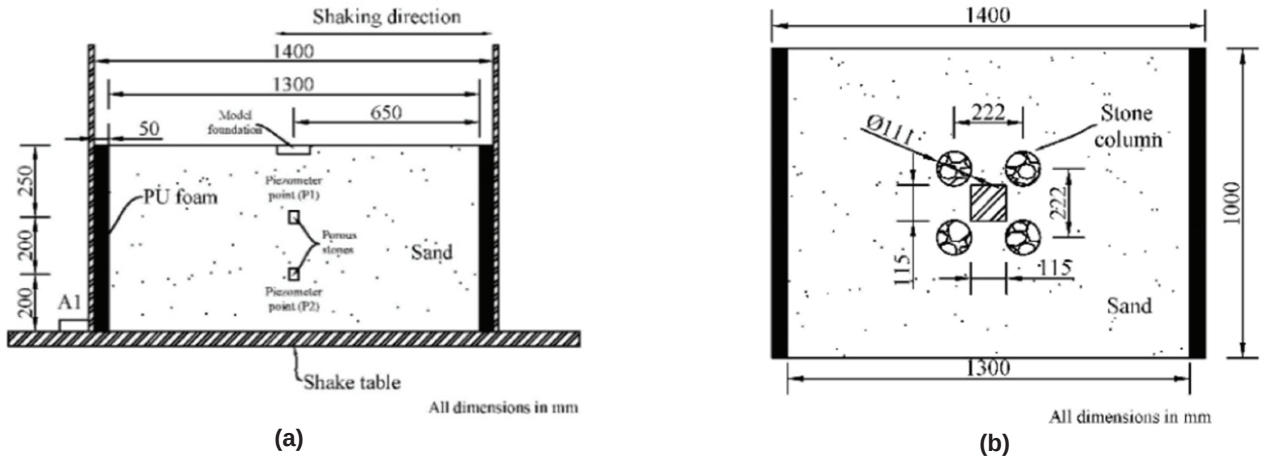


Fig. 1 (a) Schematic Diagram of the Test Assembly; (b) Plan of the Test Assembly for Test involving Stone Column

The test assembly was then subjected to a harmonic (sinusoidal) loading with acceleration amplitude ranging between 0.1-0.2 g and 5 Hz input frequency. The duration of shaking was fixed at 40s (i.e. 200 cycles) for each of the tests. Two tests were conducted for each sample i.e. unreinforced saturated sand (S), saturated sand reinforced with stone column (SC), saturated sand reinforced with encased stone column (ESC).

Fig. 2 compares the variation of excess pore water pressure ratio with time obtained from shaking table tests for unreinforced saturated sand (S), sand reinforced with stone column (SC) and sand reinforced with geotextile encased stone column (ESC) at 0.2 m from the base of the tank at an input acceleration amplitude of 0.1g. It can be observed that the excess pore water pressure ratio reduces significantly on installation of stone columns. The maximum value of ru for saturated sand sample is 0.48, however, on installation of stone column, the value reduces to 0.2 and on encasing with geotextile, the value further reduces to 0.1. This indicates that the stone column and geotextile encased stone column increases the liquefaction resistance of sand by 58% and 79% respectively at 0.1g.

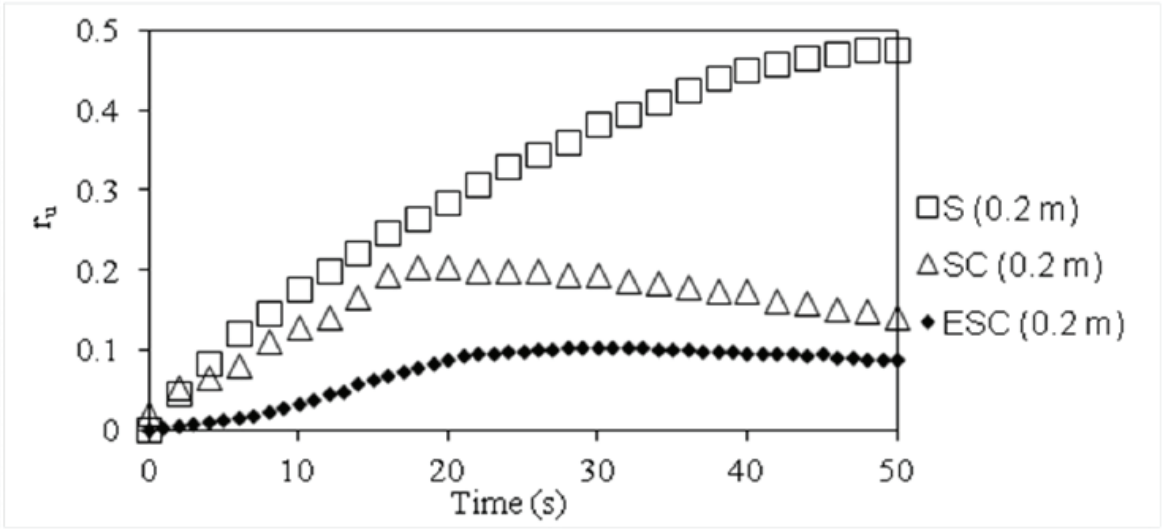


Fig. 2 Variation of Excess Pore water pressure Ratio (r_u) with Time at 0.2 m from Base of the Tank at an Input Acceleration Amplitude and Frequency of 0.1 g and 5 Hz respectively.

The construction of stone columns significantly increases the liquefaction resistance of saturated sand deposit. Moreover, the encasement of stone columns with geotextile further increases the liquefaction resistance. In the present study, the stone columns and geotextile encased stone columns increased the liquefaction resistance of loose saturated sand by 58% and 79% at 0.1 g input acceleration amplitude. Hence from preliminary experimental test results, it can be understood that presence of stone columns improves the liquefaction resistance and geosynthetic encased stone column in particular acts as an excellent drainage member dissipating pore water pressure effectively.

Ground Improvement using Granular Pile Anchor Foundation (GPAF) System

Pradeep Kumar & K. Pandit

Objective

To develop a holistic scheme for design, manufacture and construction of a granular pile anchor foundation system.

Progress Highlights

A state-of-the art report on different studies on granular anchor piles is being made, in which key design parameters have been identified. These parameters will be utilized for further testing and analysis. For its applicability in the field, two sites, one with sandy and another with clayey nature have been identified as weak foundation soils. A detailed soil characterization for these two kinds of soil will be carried out. The reason for choosing these two types of soil is the majority of land in India (more than 50%) are of sandy or clayey nature, like the one in the Indo-Gangetic flood plains, which also is home to a large number of population. Also, an alternative approach to the conventional cast in-situ GPAF construction is being explored. In this, a geotextile jacket wrapping the column of granular media is primarily selected for design and manufacture. This geotextile membrane will not only provide drainage to the sub-soil water to reduce settlement of the foundation on top of it, but also will provide confinement to the granular media and thus increasing its overall load bearing capacity, resulting in an improved design over the traditional GPAF systems. In addition to that, it will be tested in different site conditions to evaluate its performance and explore possibility of its transportation to the site as a pre-manufactured segmental unit which will speed up its speed of construction. Keeping the above points in view, the foundation technology will certainly achieve overall economy.

Modified Static & Seismic Design Methodology of Piled-Raft Foundation

Manojit Samanta & Ajay Dwivedi

Objectives

Incorporation of vertical load effect on lateral capacity of piled raft foundation and soil structure interaction on piled raft design method.

Deliverables

i. Improved static and seismic design methodology of piled raft foundation incorporating seismic amplifications
ii. Modified multiplier for pile group and piled raft foundation incorporating the influence of vertical load
iii. Economy and minimization of material from conventional practices

Progress Highlights

Fabrication of Test Set up

All the model tests were conducted in a specially designed mild steel (MS) tank of size

2000 mm×2000 mm×1500 mm. Fig. 1 shows the different components of the experimental setup and their functions. The test tank was uniquely designed to simulate the condition of combined loading. Vertical, lateral and simultaneous vertical and lateral loading can be applied through a specially designed vertical loading arrangement in the test tank. The MS tank was stiffened with steel channels all around at every 150 mm to eliminate the chances of volume change during the filling of sand and subsequent application of load during model tests. The vertical load at the top of the pile cap was applied using a dead load assembly. The test tank was marked inside all around at every 100 mm vertical interval to facilitate the filling of sand.

Fabrication of Pile and Raft

Model Pile

Hollow cylindrical aluminum pipe of 20 mm outer diameter and 1 mm thickness was used as model pile. The surface of all the cylindrical pile was smooth, uniform and machine finished. The lengths of the piles used in the present test are 500 mm, 750 mm and 1000 mm corresponding to a slenderness ratio of 25, 37.5 and 50 respectively. Maximum moment and shear resisting capacity of the pile sections are 41.05 N-m and 4.95 kN respectively. Five strain gauges were attached at equal intervals along the length of the pile to measure the bending strain during the loading process. Fig. 2(a) shows a typical instrumented model pile used in the present study. The bottom of the pile was closed with the help of a circular threaded cap.

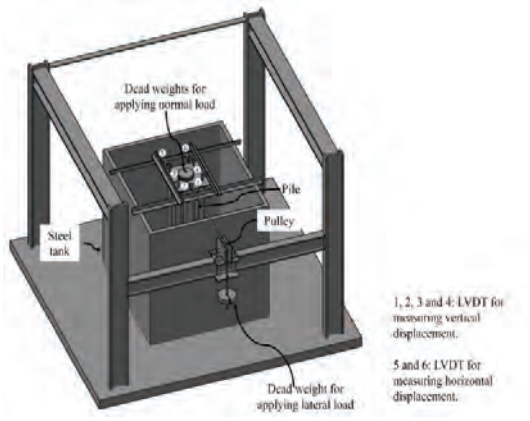


Fig. 1: Model Testing Set Up & Its Different Components

The top 10 mm of the pile was threaded to facilitate a nut and bolt connection with the pile cap. Fig. 2(b) shows a typical model pile cap having a central hole and nut-bolt connection to ensure a rigid connection between the pile and the cap.

The effect of pile roughness on the lateral response under combined loading was also investigated. Roughness on the outer surface of the pile was created by gluing the sand particles over it. It must be noted that identical sand was used for creating the rough pile and for conducting the model tests. Special care was taken to maintain a uniform pile surface after gluing of sand. Fig. 3 shows the different pile used in the present study. Fig. 3 shows a typical pile having the rough surface (numbered as 1).

Bending test was conducted to determine the elastic modulus of the model pile. Pile was clamped firmly to a mounting block at the end with the help of a U-clamp and bending strains were recorded through five strain gauges in response to known tip loading at the free end. Bending stresses were computed at the location of strain gauges. The elastic modulus of the pile material was computed as 82.7 GPa using the linear relationship between the induced bending moment and measured bending strain (Fig. 4). The elastic modulus was later used to determine the bending moment distribution along the length of the pile.

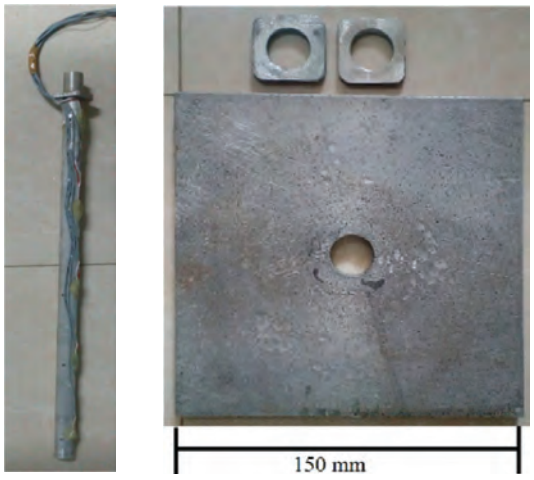


Fig. 2: (a) Instrumented Model Pile (b) Pile Cap with Central Hole

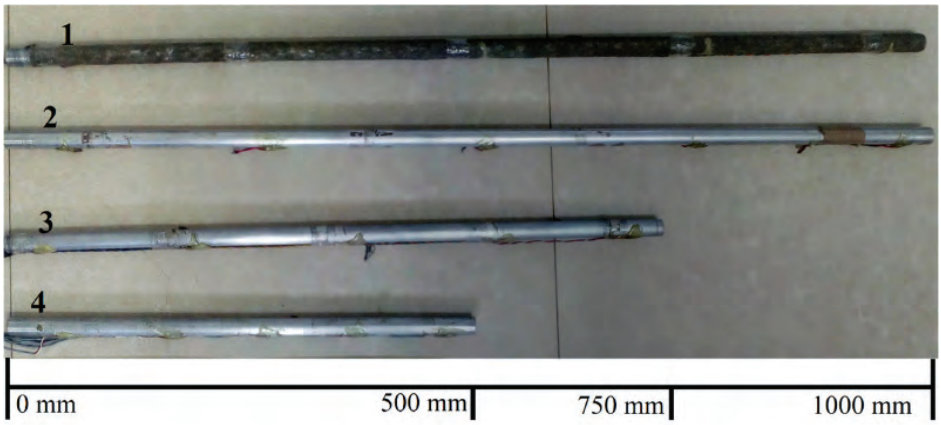


Fig. 3: Different Piles Used in the Present Study

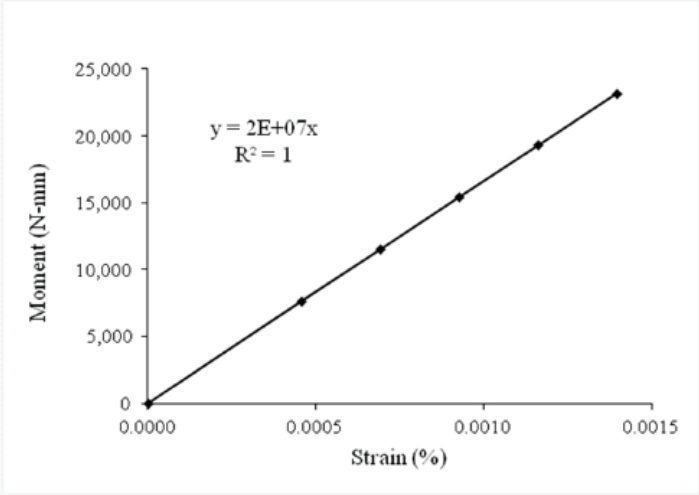


Fig. 4: Bending Moment Vs Strain Relationship of Pile

The entire test on the pile foundation was conducted keeping the pile at the center of the tank. The remote vertical boundaries of the tank were at a distance of more than 50 times the pile diameter from the pile, which was adequate to minimize the boundary effects on the model test results. The minimum distance between the tip of the pile and bottom of the tank was taken as L_m /2 (500 mm) to simulate the conditions of floating pile. Scaling factor for the present model piles was calculated using the following relationship proposed by Wood [2003].

$$E_p I_p / E_m I_m = n^5 \quad \ldots (1)$$

For 500 mm and 1000 mm diameter of the pile in prototype scale and M25 grade of concrete, the scaling factors were calculated as 23 and 13.2 respectively.

Model Raft

Square aluminium plates of size 150 mm×150 mm× 10 mm were used as pile caps. It was made of the same grade of aluminium alloy as of the pile. Pile was rigidly connected to the cap through a central hole in cap and nut as shown in Fig 5(a). The lateral load was applied on the cap through a string pulley arrangement. The string was connected to a circular ring on the pile cap (Fig. 5(a)). The circular ring has a threaded extended portion which is connected to the pile cap. The lateral displacement of the pile cap was measured with the help of two vertical plates attached to the cap through screw connection (Fig. 5(b)). Roughness on the base of the pile cap was created following the same method as described previously for the case of the pile. Fig. 5(c) shows a typical pile cap having a rough

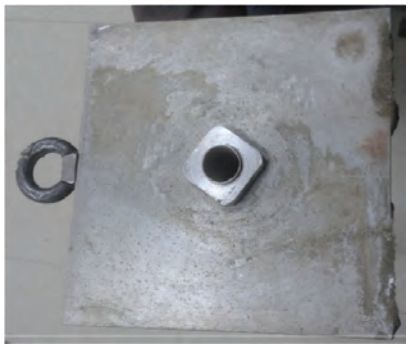


Fig. 5: (a) Pile Connected to Cap through Nut-Bolt Connections

Fig. 5: (b) Lateral Displacement Measurement Assembly of Pile Cap

Fig. 5: (c) Rough Surface (Sand Glued) of Pile Cap

surface. Interface direct shear test on the smooth and rough surfaces (representing smooth and rough surfaces of pile and cap respectively) was conducted to determine the shear strength parameters of these surfaces in direct sliding.

Filling of Test Tank

The test tank was filled with sand in several layer of 100 mm thickness. The amount of sand required in each layer to maintain a constant relative density of 75% was calculated and poured uniformly. The sand was then manually compacted in each layer to bring it to the marked divisions of 100 mm. To check the uniformity of the test bed, in-situ density was measured by sand replacement method at every 500 mm depth. Fig. 6 shows the variation of the average relative density with tank depth measured during filling. Maximum 4 % variation in the relative density was observed during filling. Thus, a uniform density was ensured during filling of the sand, which further ensures the consistency of the prepared sand bed.

After the sand was filled up to the level of pile tip, the position of the pile was located and imprinted on the sand with the help of plumb bob. The model pile was inserted in the prepared sand bed for about 10 mm. The verticality of the test pile during filling the rest of the tank was maintained with the help of a holding device. This method of pile installation simulates the state of stress in the surrounding soil similar to the bored pile installation, where the disturbance is usually small.

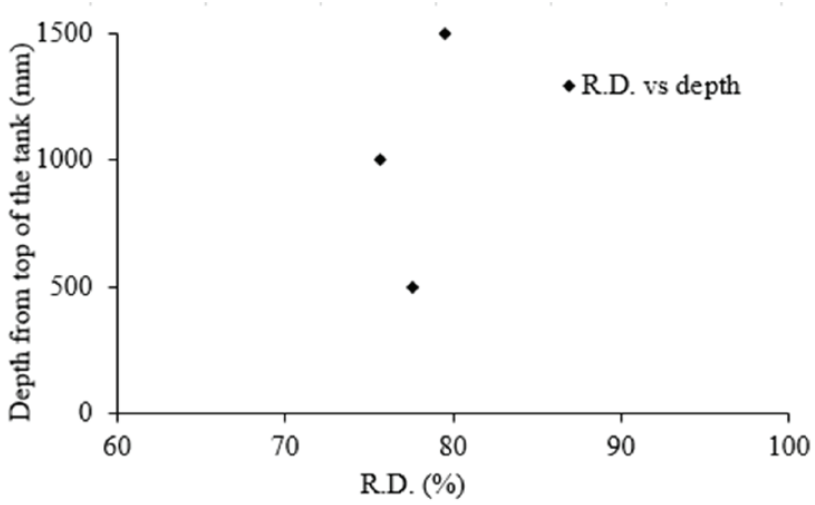


Fig. 6: Variation of Relative Density with Tank Depth

Evaluation of Interface Strength Parameters

Mobilization of interface shear strength at the base of the cap and around the pile primarily governs the response of the pile in purely lateral and combined loading case. Interface shear test has been conducted in the present study to evaluate the interface shear strength characteristics of the pile cap and pile during loading. The interface direct shear tests were performed on a direct shear box of size of 60 mm x 60 mm x 25 mm at 75% relative density of sand. The material used for the fabrication of the smooth pile cap and the pile has been used as the interface material. Fig. 7 shows the direct shear box with smooth interface material placed at the lower half of the direct shear box. The size of the interface material is selected in such a manner that it perfectly fits into the lower half of the direct shear box and allows the shearing of the sand at its face. The roughness on the interface material has been created using a procedure similar to the one followed to create rough pile and cap. Special care was taken to ensure that the top face of interface and top of the lower half of direct shear box are at the same level. A constant normal stress was then applied and the different interfaces were sheared against sand at a fixed rate of 1.25 mm/min. All the tests were conducted over the normal stress range of 25 - 125 kPa.

Mobilization of shear stress at the interface of pile cap-soil and pile-soil along with passive the resistance offered by the soil in front of the pile mainly contributes to the lateral response of the pile foundation. Fig. 8 shows the peak and residual shear strength vs. normal stress profile of the various surfaces over the tested range of normal stress. The ratio of the peak interface friction angle of the smooth and rough surface to the peak interface friction angle of soil is 0.5 and 0.9 respectively. The corresponding ratios of the residual interface friction angle of the two surface are 0.58 and 1 respectively. The results indicate that for the identical stress range, the mobilization of the shear strength at the cap-soil and pile–soil interface for the rough surface will be twice of the smooth surface.

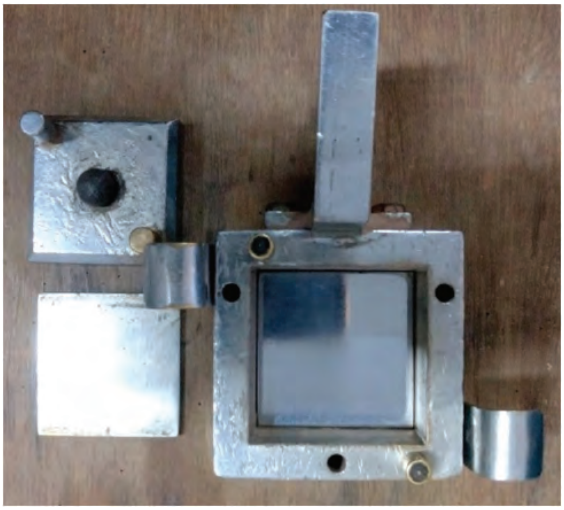


Fig. 7: Direct Shear Box with Interface Material

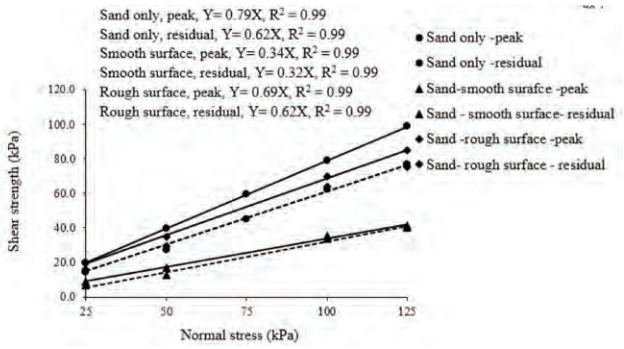


Fig. 8: Direct Shear Box with Interface Material

Design & Strengthening Measures for Building Foundation Systems in Hilly Regions

K. Pandit & S. Sarkar

Objective

To provide suitable design and strengthening measures for safety and stability of building foundations in hilly regions

Progress Highlights

At first, a literature review was conducted to know the state-of-the-art status on the analysis and design of multi-storey residential buildings on sloping grounds and some research gaps have been identified which have been attempted to be addressed in this present study. After literature review, analysis and design of a typical G + 3 residential building (Fig. 1 & Fig. 2) for earthquake zone V as per IS 1893: 2002 have been carried out in STAAD Pro. Subsequently, footing analysis for bearing pressure by various analytical methods (Yamamoto analysis for seismic bearing capacity on slopes, Meyerhof analysis, and Hansen analysis) have been performed followed by its design. Finally, a model slope has been analyzed to compute its factor of safety through: limit equilibrium methods (two dimensional: SLIDE) and finite element methods (three dimensional: Plaxis3D) (Fig. 3 & Fig. 4).

The natural ground level and road formation are at 8.71m from the lowest point of footing. Above the ground level, the building height is 12.4m including three storeys with presumed column size of 300 x 300 mm. Two footings are located below the ground level, at 3.71 m and 8.71 m each with column size of 400 x 400 mm. The beam dimensions are taken as 300 x 600 mm with slab thickness 150 mm and exterior wall thickness 230 mm and interior wall thickness 125 mm.

The results obtained from each the analysis methods; that is the Limit Equilibrium analysis from Slide and Finite Element analysis from Plaxis3D are evaluated and the following conclusions are arrived.

- The footing node at the extreme right and on highest elevation is the weakest in terms of normal stresses and settlement.
- The least global factor of safety occurs at the same footing node and for the loading case 4; that is after the complete application of footing reactions.

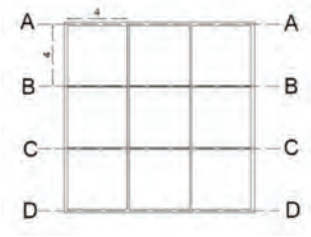


Fig. 1 Plan of the Building

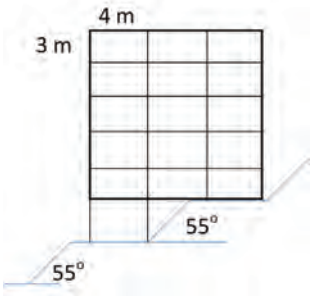


Fig. 2 Elevation of the Building with Slope Geometry

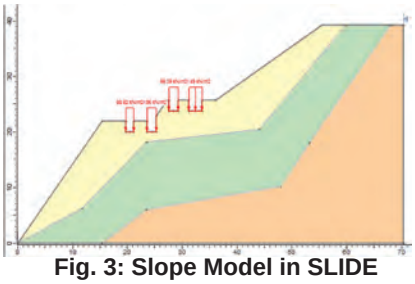


Fig. 3: Slope Model in SLIDE

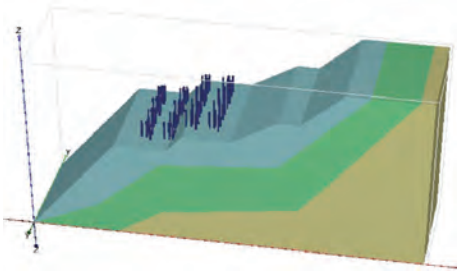


Fig. 4: Slope Model in Plaxis3D

Sustainable Materials & Technologies

Soumitra Maiti

Architectural & Structural Engineering Interventions in Housing Stock of NE Regions

Sayantani Lala, S.K. Negi, Ashok Kumar, Swati Kulashri & Kishor Kulkarni

Objective

S&T Intervention for Safe & Sustainable Building Infrastructure in NE Region

Progress Highlights

- Review of IS code 15912: 2017 (draft) is completed.
- Preliminary comparative study on the seismic performance of the different types of Bamboo stilt houses of North-East India
- Literature review on species used as a structural element, joints in Bamboo structure, foundation used for bamboo structures, work done by various organizations is under progress

Development of Building Components Using Locally Available Agro-Materials

Santha Kumar G., A.K. Minocha, Soumitra Maiti & Team

Introduction

Pozzolanic material like fly ash, silica fume and ground granulated blast furnace slag has been widely used in construction sector. Meanwhile, research on the use of micronized biomass silica as pozzolanic material in construction sector is very limited. The biomass silica (MBS) is produced by controlled burning of rice husk (500–600°C) in rotary furnace and afterwards, grinding in jar mill for few hours to reduce the particle size Thus, the main difference in rice husk ash and MBS is the presence of higher silica content and finer particles.

The oxides present in MBS and ordinary Portland cement (OPC) are presented in Table 1. The major oxides such as Sio_2, Al_2O_3 and Fe_2O_3 present in MBS is more than 90%, therefore, it act as the good pozzolanic material. The average size of MBS used in this study was 24µm. Preliminary experimental studies were conducted to assess the effect of using MBS as a pozzolanic material. Various properties on blended cement paste and blended cement mortar containing various replacement levels of MBS were studied. The specific gravity and standard consistency cement pastes incorporated with different MBS contents were found out using Le Chatlier flask as per IS 4031 Part 11:1988 and Vicat apparatus as per IS 4031 part 4 & part 5:1988. The specific gravity and standard consistency cement pastes incorporated with different

Table 1: Chemical Composition of MBS & OPC

Chemical composition (%)	Micronized biomass silica	OPC
SiO_2	92.85	14.82
Al_2O_3	0.41	6.82
Fe_2O_3	0.40	1.57
CaO	1.01	66.30
MgO	0.37	3.93
SO_3	0.25	2.13
K_2O	2.01	0.94

Table 2: Blended Mortar Containing Various Percentages of MBS

Cement Incorporated with MBS Content	Specific Gravity	Standard Consistency
0%	3.14	30
5%	3.10	32
10%	2.85	34
15%	2.80	38
20%	2.66	41

MBS contents were presented in Table 2. Various blended mortar containing different percentages (0, 5, 10, 15, and 20) of MBS, associated to fluidity of 130±2.5mm, were prepared to assess its behavior.

From Table, it can be observed that the specific gravity of blended cement paste decreases with increase in the replacement level of MBS. High consistency was observed on blended cement paste due to high fineness of MBS. The blended mortar corresponding to fluidity of 130±2.5mm, measured by flow table test, with respect to W/B ratio is presented in Fig. 1. From Fig. 1, it can be understood that the W/B ratio increases with incorporation of MBS increases when blended mortar associated to 130 of 130±2.5 mm. It is because the MBS incorporated in cement mortar makes the mix to be some what stiff.

The compressive strength of blended mortar with respect to age is presented in Fig. 2. The compressive strength of blended mortar for 7 and 28 days were increased to considerable level as compared to control specimen. From Fig. 2, it can be understood that there is substantial increase in compressive strength when MBS incorporation up to 15%. When mortar incorporated with 20% of MBS, the strength was slightly decreased.

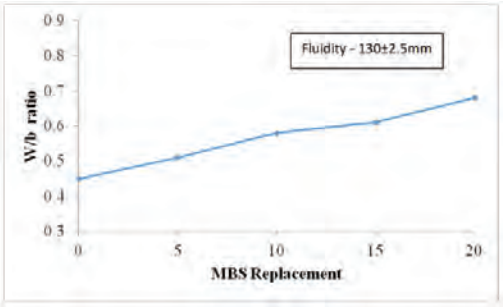


Fig. 1: Variation of W/b Ratio with respect to MBS Replacement

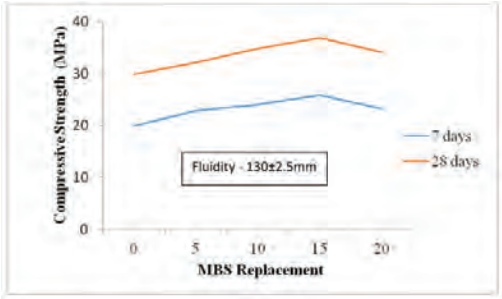


Fig. 2: Variation of Compressive Strength with respect to MBS Replacement

Development of Portable Energy Efficient Domestic Waste Water Management System

Soumitra Maiti & Team

Objective

To develop portable energy efficient domestic waste water management system for North East Region.

Disposal of waste water is a major public health problem in rural areas. Stagnant waste water smells bad and also acts as breeding place for mosquitoes resulting in spread of diseases like dengue, malaria, filarial etc. Proper disposal and also reuse of waste waster wherever possible will help in combating diseases as well as meeting water scarcity. It is estimated and experienced that about 75% to 80% of water supplied through piped water supply schemes comes out as grey water. The quantity of waste generated is increasing in rural areas as a result of increased population, consumerism and commercial activities. It is estimated that 15,000 to 18,000 million liters of gray water is generated each day in rural areas (DDWS-UNICEF, 2008). The treatment methodology should be such that it becomes pathogen free, does not promote insect breeding, and at the same time, this water could be recycled and reused. The choice of technology is a tricky issue. The high cost, high tech technologies will not be a solution for this problem under the prevailing conditions and situations in rural areas. These technologies will have to be affordable and manageable at village level and decentralized depending on the locations and spread of habitations. They have to be environment friendly, low-cost, hygienic, requiring intermediate or low level construction and maintenance skills available at village level. These can be either on-site or off site methods, depending on village level requirements. If grey water is managed at source, in a decentralized manner, by each household, it becomes a more appropriate proposition. The main objective of this project is to develop portable energy efficient domestic waste water management system for treatment of grey water.

Domestic waste water sample was collected from three different source of CSIR-CBRI, Roorkee campus one from CSIR-CBRI office canteen (Sample 1), one from guest hose canteen (Sample 2) and another one from CSIR-CBRI colony (Sample 3). The characterization of the raw domestic wastewater was conducted 3 times before starting to operate the wetlands constructed and results were presented in Table 1. The analysis of this water was performed immediately for pH, electric conductivity (EC) and temperature using a Hana multi-parameter. Chemical oxygen demand (COD), total nitrogen (TN), ammonium nitrogen (NH_4+ N) and nitrate nitrogen (NO_3− N) were determined according to the standard methods.

Table 1: Characterization of Influent Water

Parameter	Sample 1	Sample 2	Sample 3
pH	7.9	7.7	8.1
TSS (mg/l)	120	90	130
COD (mg/l)	140	160	185
BOD (mg/l)	75	75	95
NH_4+ N (mg/l)	15	14	25
NO_3-N (mg/l)	1.4	1.4	2.2
TN (mg/l)	28	26	38

Then this domestic waste water will be treated in the developed domestic waste water management system. Fig. 1 represents the schematic diagram of the water management system

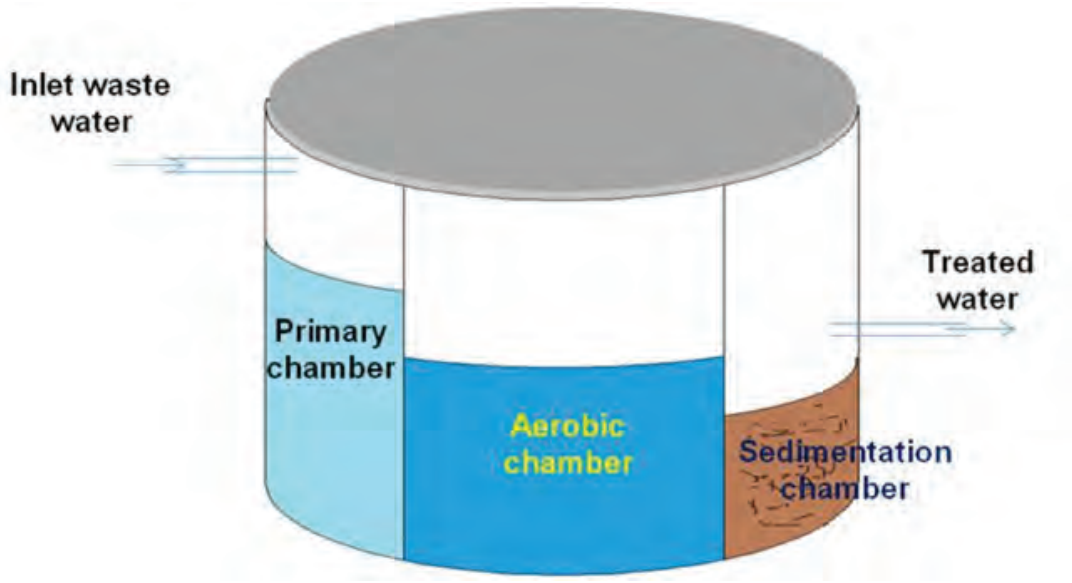


Fig. 1: Schematic Diagram of the Water Management System

Foundation Technology for NE

M. Samanta & Ganesh Kumar

Objectives

i. To study the behaviour of locally available bamboo and in-filled concrete tube as pile material on a sloping ground under vertical and lateral loading
ii. To evaluate the reduction in pile capacity due to the slope through experimentally and numerical studies
iii. To analyze the field behaviour of piles on sloping ground and to compare with experimental test results
iv. To develop design and installation guidelines for the developed piles on sloping ground

Progress Highlights

Main objective of the present study is to evaluate the reinforcing effect and performance behaviour of bamboo and in-filled concrete tube as a pile material on slope stability. Additionally influence of pile length, material property, effect of stiffness and its interaction on slope will be studied. The studies will be conducted both experimentally and will be validated using available numerical software. During the research period, collection of literature pertaining to the behaviour of pile on slopes was collected. Based on the literature studies, numerical model was developed and

analysed using PLAXIS 3D numerical software. To validate the numerical program, model studies on slope performed by Cai and Ugai (2000) was compared. The schematic details of the model slope adopted for the study is shown in Fig. 1 and its properties are given in Table 1. The, Slope stability analysis was performed using safety analysis i.e. using Shear Strength reduction method. The SSR method automatically determines the critical failure mode and evaluates its safety factor. Initially, the slope was analysed for estimating factor of safety to understand the stability of slope without any slope reinforcement. The factor of safety for the slope without any treatment was 1.12 which is in good agreement with Cai and Ugai (2000) numerical test results of 1.14.

After validation, the same slope was reinforced with bamboo as pile inside the slope to improve the safety factor for the slope. Since the diameter of the bamboo material is small, four bamboos together as a group is selected and installed. The selected c/c spacing between the row bamboo pile groups was 3.5 and 5 respectively. The schematic details of the model reinforced slope adopted for the study is shown in Fig. 2 and properties for the selected bamboo material are listed in Table. 2. With the installation of bamboo pile group, the factor of safety for the slope increased from 1.12 to 1.35 for 30° slope. Further analysis performed with different spacing of bamboo pile system and with different slope angle. The results are given in Table 2. With bamboo as pile material, the factor of safety increases for all the slope models. For initial tests, all the analyses were performed only with bamboo as pile material. Further, it is also planned to evaluate the performance of in-filled concrete tubes as pile system for slopes. The proposed work will be performed experimentally and will be validated using numerical studies. Finally, efficient, cost effective foundation system which can improve the stability of slope additionally will be developed.

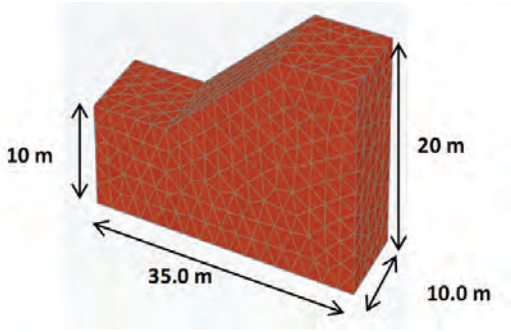


Fig. 1: Model Slope without Reinforcement

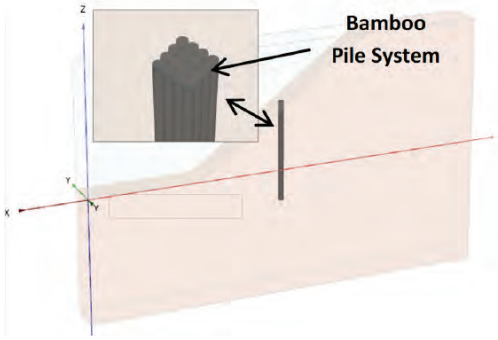


Fig. 2: Slope with Bamboo-Pile System

Table 1: Material Properties

Young's modulus	200 MPa
Poisson ratio	0.25
Unit weight	20 kN/m3
Cohesion	20 kPa
Friction angle	30°

Table 2: Material Property & Test Results

No	Material	Property	Values	
1.	Diameter	D	100 mm	
2.	Young's Modulus	E	20.6 GPa	
3.	Length	L	8 m	
		Factor of Safety		
	Slope Angle	Unreinforced Slope	c/c – 1.4 m	c/c – 2 m
1.	33.3°	1.12	1.35	1.29
2.	45°	1.10	1.28	1.24
3.	60°	1.08	1.24	1.19

Development of Innovative Hybrid Connections for Pre-Cast Concrete Construction

S.R. Karade, R. Siva Chidambaram & Jaipal

Objective

- To develop an effective and economical hybrid connection technique using fiber reinforced composites and mechanical splices at the pre-cast framed structures.
- To investigate the effectiveness of the hybrid connection in transmitting the force at beam-beam, column to column and beam-column joints subjected to cyclic loading.

Progress Highlights

The precast concrete framed structures are being constructed using different precast elements manufactured in industry and then assembled at the construction site. The structural components such as beam, slab, column, foundation units, and shear wall are separately made and fixed with each other using diverse techniques. There are wet, dry and wet-dry joint principles are used in connections. The reduced time limit, better workmanship and superior quality control increases the use of precast system across the world. However, failures of precast structures during natural and manmade disasters show the vulnerability of the elemental connection is and associated problems. In particular, the precast framed structure fails to behave like monolithic construction during earthquake. Thus, the precast connection is a potential risk zone during severe loading. The proposed project involves development of a novel connection technique for precast structure to resist earthquake forces. The proposed work is a combination of composite and mechanical contribution in resisting the forces.

In order to have a connection between the two distinct elements a rebar coupler is proposed in the study. The rebar coupler is a combination of mechanical and grouting. It will serve the purpose of connecting the rebars at any locations and also in transfering the forces. In the initial phase, rebar couplers have been developed for various diameter rebars and tested under tension to evaluate its tensile performance. Fig. 1 shows the tensile behavior of a rebar connected through coupler. Two types of failure pattern such as rebar rupture and rebar slip were observed during testing. Based on the Phase I test outcome, Phase II work is under progress.

Precast column with different confinement is also studied. An experimental study has been conducted to explore the possibility of different advanced materials instead of conventional confinement in precast columns and tested under axial compression. Promising test results have been observed and further detailed evaluation is going on. Fig. 2 shows the failure pattern of tested column specimen under axial load.

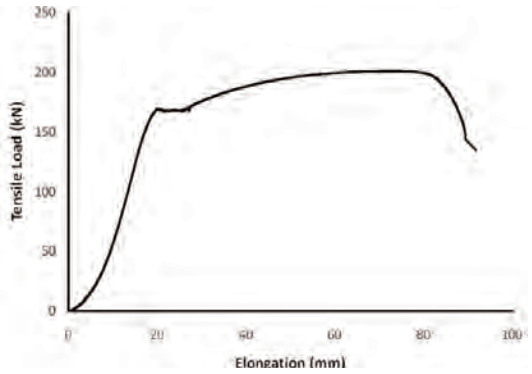


Fig. 1: Tensile Behavior of Rebar Connected with Coupler

Fig. 2: Failure Pattern of Column Specimens under Axial Compression

Prefabricated Ferro Cement Sandwich Panel Based Housing System

S.K. Singh, S.C. Gurram, & M. Surya

Conventional in-situ construction is a time-taking process that involves several tasks such as foundation preparation, casting of different building elements, and erecting walls etc. at the site. With ever-increasing population, the demand for housing and the necessity to meet the same in short duration cannot be over-emphasized. One such viable option is prefabricated construction system for mass housing.

Prefabrication, by definition, is a process of fabricating some or all components of a unit or structure, assembling and fitting them together on site where the structure is actually meant to be erected. The manufacturing process may be undertaken in a factory environment (factory prefabrication) or on the site under the open sky (site prefabrication). The first prefabricated structure is reported to be built in Cape Ann in 1624.

The primary cost benefits of prefabricated structures are derived from faster speed of construction and optimization of raw materials. In most countries, prefabrication is adopted in building construction to enhance productivity, improve quality, and cope with a shortage of skilled labour. Prefabrication system gives possibility to the designers for assembling their structures in a short period of time. It is emerging as attractive alternative to on-site construction. Government of India is adopting several innovative prefabricated construction systems developed within the country and abroad for its housing schemes. However, these technologies require expertise. Ferrocement-expanded polystyrene sheet (EPS)/ other coring material sandwiched panel based housing systems will not only provide speed, safety and sustainability but also can be constructed with locally available expertise.

Although panels can be cast in place, precast/ prefabrication is recommended to achieve greater quality control and faster construction. Thus, work related to construction of building with precast/ prefabricated ferrocement elements shall be taken up to reduce housing demand in India.

The present study objective is to develop a housing system using ferrocement sandwich wall panels including appropriate precast ferrocement roofing elements and foundation. An attempt will be made to study the joint behaviour numerically. The system will be used to construct a model house at CSIR-CBRI for demonstration of the technology. For casting the ferrocement sandwich panel, self-compacting mortar shall be used. Self-compacting mortar proportions with a target compressive strength of 38.25 MPa were finalized for flow spread of 220-240 mm. The mix proportioning is given in Table 1. The average flow diameter obtained varied between 230 – 240 mm satisfying the EFNARC guidelines. The average flow time obtained from V-funnel test varied between 8-11 seconds for different trial batches whereas the average compressive strength of mortar cubes at 7, 14 and 28 days were 25.58, 33.21 and 42.78 MPa respectively. Mixing and testing of self-compacting mortar and its cubes are shown in Fig. 1, Fig. 2, Fig. 3 and Fig. 4.

Fig. 1: Mixing of Mortar

Fig. 2: Mini Slump Flow Test

Fig. 3: V Funnel Test

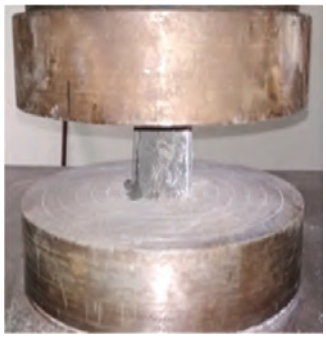


Fig. 4: Compressive Strength Test

Table 1: The Mix Proportions of Self-Compacting Mortar

Ingredients	Cement (Kg)	Fly-ash (Kg)	Fine aggregate (Kg)	Super plasticizer (Master Glenium SKY 8765) by wt.	VMA (TAMCEM by wt)	Water/ (c+m)
Mortar Mix proportion	0.80	0.20	2.5	2% of (c+m)	0.2% of (c+m)	0.36

The fabrication of ferrocement panels of 600 mm wide and 3000 mm in length with skin layers on both the sides and 50 mm/ 75 mm thick EPS as core material has been attempted for wall panels. The ferrocement layer was reinforced with galvanized woven wire mesh of 20 gauge and 1/2" x1/2" opening. Ferrocement layer were 20 and 25 mm thick for 90 and 100 mm thick panels, and reinforced with two and three wire mesh layers respectively. The reinforcement details are given in Table 2 while schematic diagrams of panels are shown in Fig. 5 and Fig. 6.

Table 2: Reinforcement & Ferrocement Layer Details of the Panels

Panel thickness (mm)	No of wire mesh layers	No of skeletal steel layers	Ferrocement wythe thickness (mm)	Cross-sectional area of wire mesh (mm^2) per layer	Cross-sectional area of skeletal steel (mm^2) per layer	Total cross-sectional area of steel per meter width (mm^2/m)
90	3	2	20	72.6	70.6	238.7
100	3	2	25	72.6	70.6	238.7
90	2	1	20	48.4	35.3	139.5
100	2	1	25	48.4	35.3	139.5
90	3	0	20	72.6	0	121.0
100	3	0	25	72.6	0	121.0
90	2	0	20	48.4	0	81.3
100	2	0	25	48.4	0	81.3

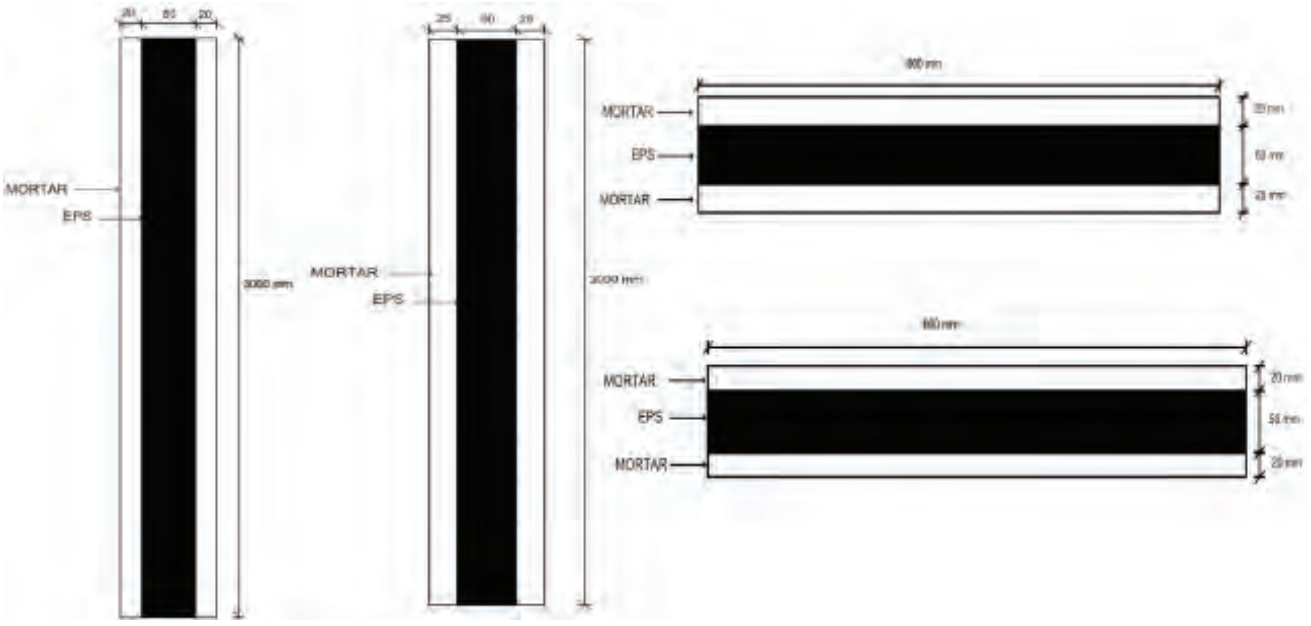


Fig. 5: Schematic View Panel indicating Core & Ferrocement Layers

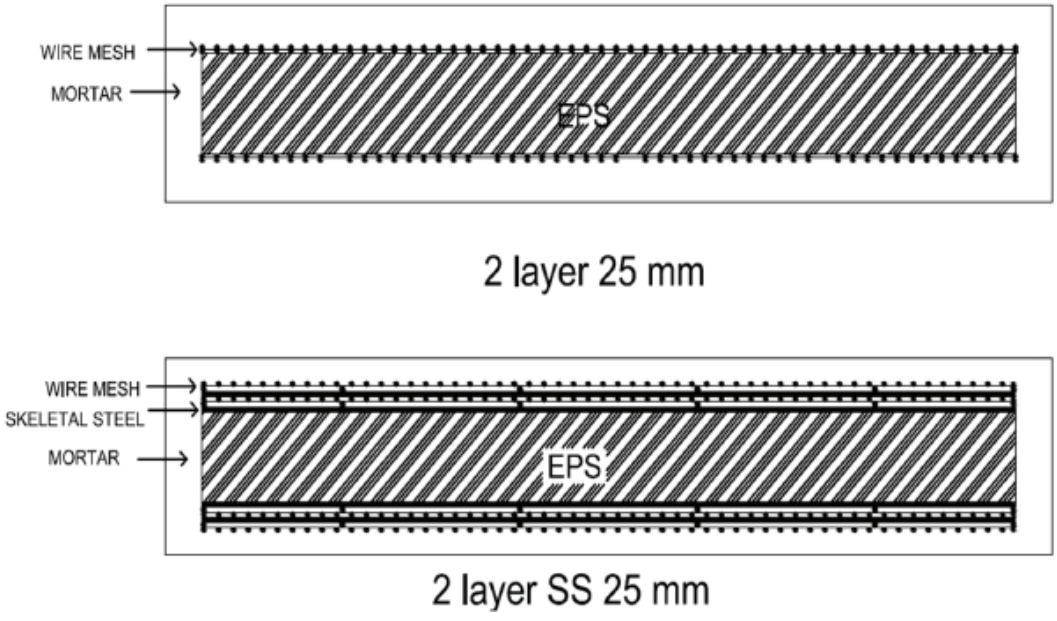


Fig. 6: Plan of 100 mm Thick Wall Panel having 2 Layers of Wire Mesh

3 mm steel was used as skeletal steel to hold the wire mesh in place in ferrocement layer. It was used also to make Z-shape shear connectors to keep skeletal steel layers on both sides of EPS as shown in Fig. 7. Casting of ferrocement sandwich panel with self-compacting mortar is shown in Fig. 8 and the panels after curing are shown in Fig. 9.

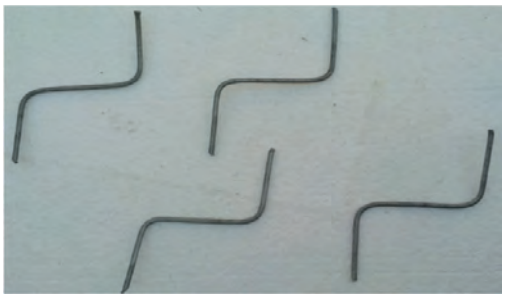


Fig. 7: Z-Shape Shear Connectors & EPS Core & Steel Mesh for Casting Panels

Fig. 8: Prepared Moulds with EPS Core & Cast Panels in Green State

Fig. 9: Ferrocement-EPS Sandwich Panels after Hardening

This housing system is found to be one effective alternative. Hence, there is a need for all government housing bodies, construction industry, research & academics and media to work towards to common objective of promoting pre-fab housing system in construction. CSIR-CBRI is in process of collaboration with industrial partners to demonstrate the technology.

Studies on Consolidation & Deformation Characteristics of Stone Columns with & without Geo-Synthetic Encasement in Soft Clay

Ganesh Kumar & M. Samanta

Objective

Evaluation of load-settlement and consolidation characteristics (compression index, recompression index, co-efficient of vertical consolidation, co efficient of radial consolidation and co efficient of compressibility) of ordinary and encased stone column improved soft soil.

Progress Highlights

Main objective of the present study is to improve the load carrying capacity of soft soil treated with ordinary and encased stone columns. In addition, the load sharing between the soil and stone column was also studied to evaluate the stress concentration ratio between the surrounding soil and stone column when subjected to external loading. The effect of stress concentration ratio will give the clear guidelines for predicting load improvement and settlement factors which makes the treatment method economically beneficial. The details of the progress during the period are given below.

Model Tests

Usually the stone columns are installed in triangular or square pattern in such a manner that each column influences certain area of soil, called unit cell. As unit cell is representative of an area treated with stone columns, it was decided to carry out unit cell experiments in the present study. The experiments were carried out to estimate the load carrying capacity of ordinary and encased stone column installed in soft clay. For this laboratory investigations, unit cell having inner diameter of 185 mm and height of 600 mm height was used.

Three stone column diameters having 63 mm, 76 mm and 88 mm diameter with an area replacement ratio of 11.6 %, 16.9 % and 22.6 % respectively were selected for evaluating the load carrying capacity of stone columns and stone column improved soft soil. The clay soil used for the study was classified as CL as per IS classification system. The liquid limit and plastic limit of the soil are 34.5 % and 23.5 % respectively. The stone aggregates used to form the stone columns are angular in nature and size of 2 to 10 mm and having uniform gradation. The stone aggregate in all the tests was compacted to a dry unit weight of 16.2 kN/m^3 corresponding to a relative density of 60 % representing the field conditions (60% - 80%).

Based on the unconfined compression tests on clay samples, water content of 28 % was selected for meeting the required shear strength of 15 kPa which simulates the soft clay characteristics in field conditions. The clay was dried for 24 hours and then pulverized and mixed with required quantity of water and finally filled in the test tank. The soil was then filled inside the test tank in 5 layers and each layer was properly compacted with a hammer of 4.5 Kg to achieve a compacted height of 120 mm with uniform density. After the preparation of clay bed, installation of stone column was performed. The installation procedure begins with bore-hole formation, which involves removal of soil from unit cell by placing a casing pipe having diameter equal to that of selected

stone column diameter. Then, the pipe was pushed vertically inside the prepared clay soil and the soil inside the tube was removed carefully leaving hole at the centre. Afterwards, the bore hole gets replaced with stone chips filled in stages to 120 mm thickness and compacted to achieve a dry unit weight of 16.18 KN/m3. The completed view of constructed stone column is shown in Fig. 1. For measuring load distribution mechanism two earth pressure cells were used. One earth pressure cell was placed at the centre of stone column and other one at soil surface. The position of earth pressure cells are shown in Fig. 2. After placing earth pressure cells, sand cushion having thickness of 30 mm was placed before starting load tests (Fig. 3). Then, load tests were performed to evaluate the load carrying capacity of stone columns.

Two types of tests were performed viz. Column alone loading where the stone column was loaded with a plate having diameter equal to that of column diameter and other one is surface loading in which the entire cell is loaded with a loading plate having diameter equal to that of cell diameter. Typical photograph showing the details of surface loading is shown in Fig. 4. Settlement during loading is measured using dial gauges having 0.01 mm accuracy. Fig. 5 shows the test results of column alone loading and Fig. 6 shows surface load test results for 63 mm, 76 mm and 88 mm respectively. At a settlement of 10 mm, the increase in load carrying capacity for the stone columns of 63 mm, 76 mm and 88 mm diameter is found to be 3.5, 6.0 and 8.99 times higher than clay soil without stone column. Also, the increase in load carrying capacity is about 2, 3.6 and 5.1 times for 63 mm, 76 mm and 88 mm diameter stone column than the untreated clay soil in case of surface load tests. It can be seen that both the load carrying capacity and stiffness increases with increase in diameter of stone columns.

Fig. 1: View of Stone Column & Unit Cell

Fig. 2: View of Stone Column & Location of Earth Pressure Cells

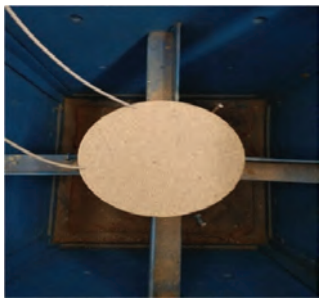


Fig. 3: Granular Blanket for Load Distribution

Fig. 4: View of Complete Load Test Set-Up

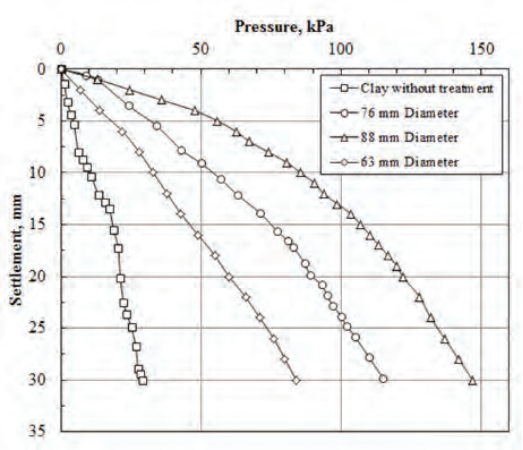


Fig. 5: Load Test Results for Different Stone Columns (Column Alone Loading)

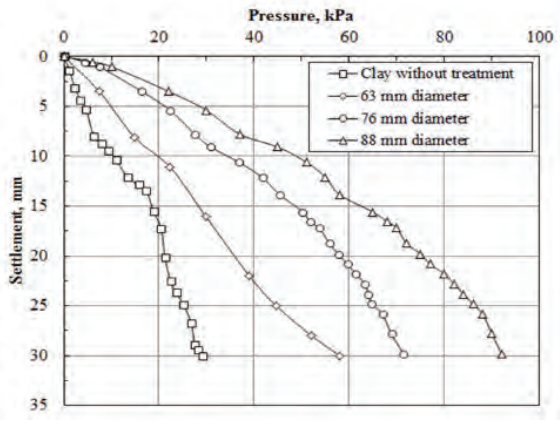


Fig. 6: Load Test Results for Different Stone Columns (Surface Loading)

In addition to the above tests, load test were performed on column alone loading tests by varying the material property of the column material i.e. changing the reinforcing member inside the clay soil. Columns was installed with Ennore sand and Solani river sand to compare the reinforcing and consolidation effects of reinforcing material. The effect of load carrying capacity for the above parametric studies is shown in Fig. 7. For comparison, all the columns were installed with 76 mm diameter. At 10 mm settlement, the load carrying capacity of stone columns is 7.3 times higher than Solani river sand and 1.5 times higher than that of Ennore sand. The difference in load carrying capacity of both Solani river sand and Ennore sand is mainly due to the effect of internal strength parameter of reinforcing material. Ennore sand is angular in shape which develops and improves the load carrying capacity when subjected to loading whereas Solani river sand, the grain size is more or less finer which shows reduction in load carrying capacity. Numerical studies also performed to evaluate the reinforcing effect of stone column on soft ground.

Analyses of experimental and numerical test results are in process. Finally design guidelines incorporating the effect of stress concentration ratio for different diameter of stone column, different column material under different loading conditions will be developed.

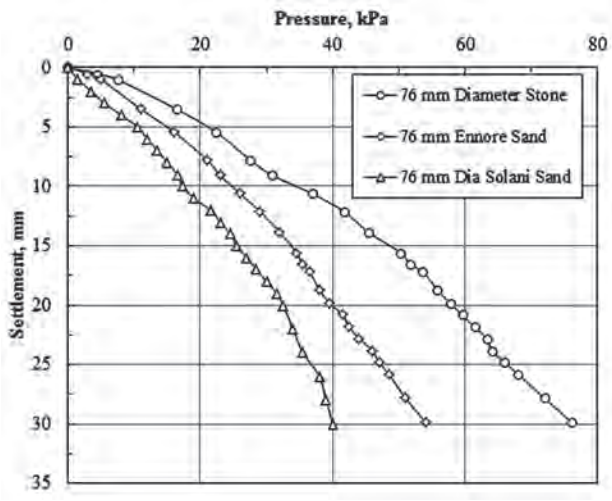


Fig. 7: Test Results for Column Alone Loading by Changing Material Property

Conservation of Heritage Structures

Conservation and Restoration of Heritage Structure

A.K. Mittal

Classification, Analysis & Restoration Technologies

- Classification of Important Heritage Structures & Extracting Superior Features of Indian Traditional Knowledge of Building Science
- Development of Novel & Simplified Analysis Procedure for the Structural Systems
- Effect of Construction Activities Adjacent to Heritage Structures & Remedial Measures for Strengthening of Foundations for Heritage Structures
- Development of Innovative Structural Restoration & Retrofitting Strategies for the Heritage Structures
- Structural Analysis of Heritage Buildings Pre & Post Retrofitting

Non-Destructive Evaluation

- Development of Hybrid Non-Destructive Techniques & Signal Processing Algorithms for Multi-Wave Imaging
- In-Accessible Foundation Studies of Cultural Heritage Sites using Non-Invasive Techniques

Material Development

- Identification of Fungi on Select Heritage Structure & Development of Suitable Anti-Fungal Chemical from Medicinal Plants

Classification, Analysis & Restoration Technologies

Hina Gupta, Debdutta Ghosh, Aswathy M.S. & Siddharth Behera

Objective

Activity 1.1.: Classification of important heritage structures and extracting superior features of Indian traditional knowledge of building science.

Activity 1.2.: Development of novel and simplified analysis procedure for the structural systems.

Activity 1.3.: Effect of construction activities adjacent to heritage structures and remedial measures for strengthening of foundations for heritage structures

Activity 1.4.: Development of innovative structural restoration and retrofitting strategies for the heritage structures.

Activity 1.5.: Structural analysis of heritage buildings pre and post retrofitting.

Progress Highlights

- Collection of data, web designing in JSP and data structure using MySQL
- Studies on Specialty/Superiority features is being carried out
- The simplified analysis technique is used to analyze a live heritage building (Old Delhi Railway Station, Main Building)
- Experimentation on monitoring of steel structures under compression and tension is performed using Vibrating Wire Strain Gauges (VWSG) and Electrical Resistance Strain (ERS) sensors
- Settlement prediction of structures due to tunneling and open excavation using PLAXIS 3D

Non-Destructive Evaluation

Debdutta Ghosh

Development of Hybrid Non-Destructive Techniques & Signal Processing Algorithms for Multi-Wave Imaging

Debdutta Ghosh, P.K.S. Chauhan & Hina Gupta

Objective

- Evaluation of material properties of heritage structures (moisture content, density, elastic modulus, poisons ratio etc.)
- Imaging / detection of internal voids, cracks, and discontinuities using existing individual techniques
- Development of multi wave based imaging techniques

Progress Highlights

- Development of Passive thermography technique for imaging of heritage structures
- Experimental set-up for thermography and contact ultrasonic setup
- Signal processing algorithms for ultrasonic based imaging

In-Accessible Foundation Studies of Cultural Heritage Sites using Non-Invasive Techniques

P.K.S. Chauhan, D.P. Kanungo & Abha Mittal

Geophysical survey is employed within archaeology as a non-invasive, non-destructive aid to understanding sub-surface features and conditions. No physical interventions (such as trenches or pits) are required to conduct a survey, since the geophysical information can be collected remotely from the ground's surface. Geophysical survey thus plays a vital role in the evaluation of archaeological areas - allowing the archaeologist to assess a feature like foundation or site without risking damage to the heritage structure.

Due to the variety of complex features that may be found below the ground surface, a wide variety of techniques and equipment are available to the surveyor. The table below highlights the main techniques applied to archaeology.

The objective of the project is to study the in-accessible foundations of heritage sites and develop a guideline for foundation studies.

Technique	Features Detected	Appropriate Application
Ground Penetrating Radar (GPR)	• Ditches and pits. • Walls, foundations and rubble spreads Made surfaces. • Metalled roads and trackways. Stone coffins, cists and graves . Drains and gulleys. • Depth of peat i.e. mapping of palaeo-landscape Depth to bedrock • Location of voids	GPR is ideally suited to sites where depth information is required. It can be applied to a variety of even ground conditions and can detect to a wide range of depths making it the most versatile technique available, but not the most time or cost effective.
Electrical Imaging (ERT)	• Ditches and pits. • Walls, foundations and rubble spreads. • Made surfaces. • Depth of peat i.e. mapping of palaeo-landscape. • Depth to bedrock • Location of voids	As with GPR, ERT provides accurate depth information. However this is often at the expense of lateral resolution. It is ideally suited to locating large scale archaeological or environmental features, especially where soil conditions e.g. high clay or salt content, limit the efficacy of GPR

Material Development

L.P. Singh

Identification of Fungi on Select Heritage Structure & Development of Suitable Anti-Fungal Chemical from Medicinal Plants

Rajesh K. Verma & Neeraj Jain

Objective

- Identification of deteriorating fungi from Indian heritage structures.
- Development of eco-friendly and durable anti-fungal chemical for management of fungal growth on heritage structures.

Progress Highlights

a) Collected live fungal spore from concrete and brick masonry surfaces of Solani aqueduct, Roorkee (Fig. 1). Culturing of collected fungal specimens is under progress.

b) FRI, Dehradun heritage site identified for collection of fungal spores (Fig. 2).

Fig. 1: Brick Masonry and Concrete Surface with Algae and Fungi Infestation

Fig. 2: Fungal Infestation on Exterior Surface of FRI, Dehradun.

Innovative Building Materials

- **Pilot Scale Preparation of Silica Nanoparticles & Their Applications in Cement Based Materials**
- **Process Technology Development of Geopolymer Concrete with Varying Classes of Fly Ash for Use in Precast Building Components**
- **Recyclability of Marble Waste in Concrete Production & Other Building Products**
- **Development of Self-Compacting Recycled Aggregate Concrete for Precast Building Components**
- **Development of Cost Effective Material for Sound Absorption with Partial Air Purification Properties**

Pilot Scale Preparation of Silica Nanoparticles & Their Applications in Cement Based Materials

L.P. Singh & Team

Nanotechnology in construction sector is gaining widespread acceptance and is one of the suitable alternative to fulfil the present need of sustainable construction without compromising the strength and cost of the concrete. Keeping in view the same, the applications of silica nanoparticles (SNPs) in cementitious system have been widely explored during last one decade resulting in three major advantages i.e. (1) Higher early stage strength, yielding to speedy construction; (2) Improvement in microstructure leading to higher performance against environmental constituents and (3) Modification in C-S-H structure, thereby resulting in enhanced durability. Although, extensive research during the last one-decade or so has demonstrated the beneficial role of silica nanoparticles (SNPs) in cement based materials. However, commercial applications of SNPs in cement-based materials is still limited due to the cost constraints of the SNPs. There is a definite need to develop a cost effective, facile and eco-friendly process for the preparation of SNPs for applications in cement-based materials. In past a process has been developed (Patent submitted) at laboratory scale but for the successful commercialization need has been realized to develop a process know how at a pilot scale (Capacity: 2-2.5 kg/day) which can be further scaled up.

The layout of the pilot plant can be better understood by the figure mentioned below (Fig. 1):

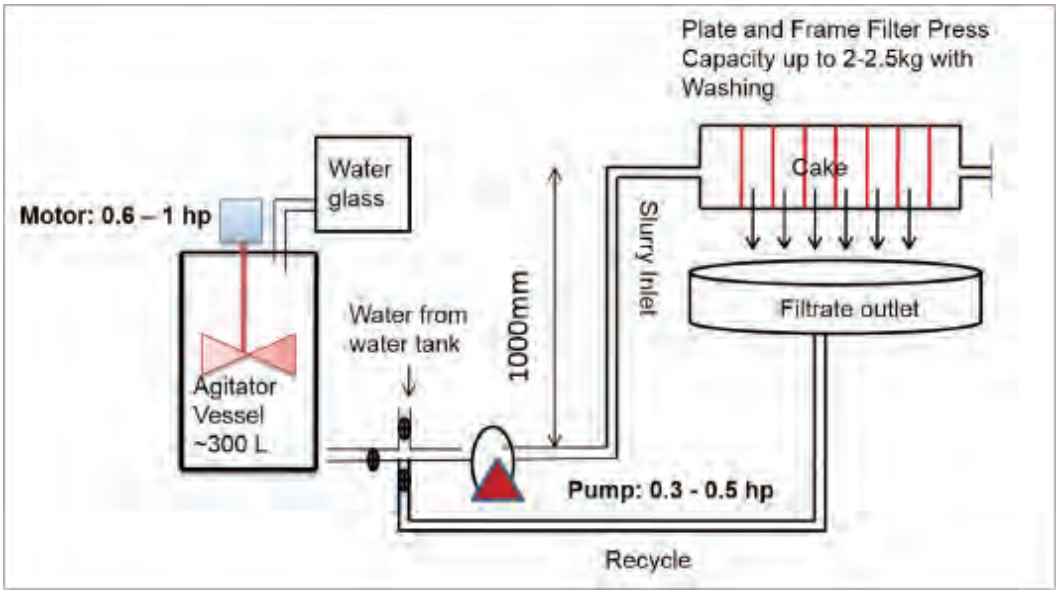


Fig. 1: Flow Chart of Pilot Scale

Process & Product Specifications

The developed method is cost effective, improved, facile and scalable to the construction industry requirements. In addition to this, it is eco-friendly (as non-hazardous chemicals are used) and energy efficient (as steps like multiple washing and calcination) are now eradicated as compared to the processes/methods presently available in the market. In terms of reaction precursor, we are using very cheap inorganic source i.e. water glass, insubstantial amount of mineral acid and additive. The steps involved for the cost effective preparation of SNPs can better be understood with the help of flow chart (Fig. 2).

Further work on reaction protocol for optimizing the concentration of the reactants and effective parameters is in progress in order to enhance the yield up to 2-2.5kg/day, which can be further scaled up as per the industry requirements.

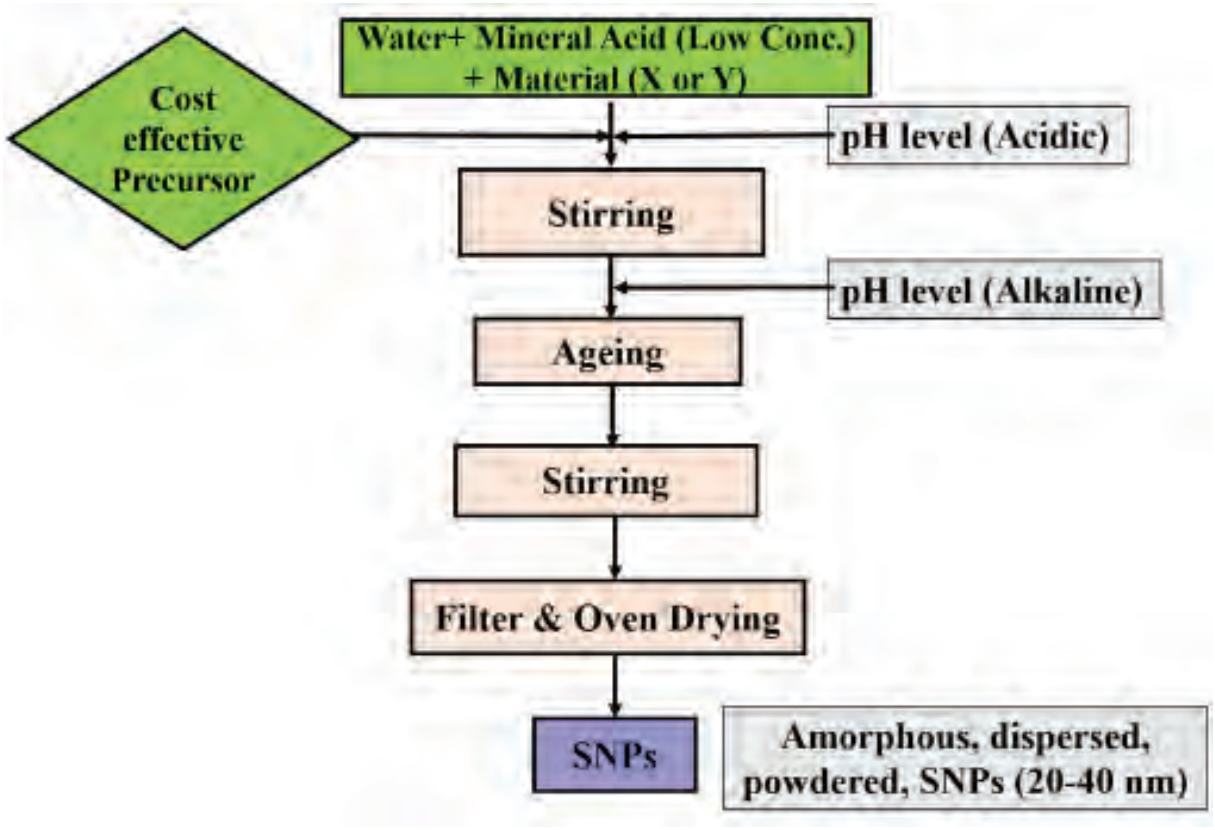


Fig. 2: Improved Process for the Preparation of Silica Nanoparticle

Process Technology Development of Geopolymer Concrete with Varying Classes of Fly Ash for Use in Precast Building Components

Md Reyazur Rahman, Rakesh Paswan, Jeeshan Khan & Ishwarya G.

Objective

i. Development of manufacturing process for producing geopolymer cement/concrete using varying classes of fly ash
ii. Design and development of precast reinforced geopolymer concrete components

Progress Highlights

Fly ash, ground granulated blast furnace slag (GGBS) and alkaline activator required to carry out study of geopolymer were procured. Fly ash (class F) and GGBS were characterized for chemical composition, mineral phases, morphology, Particle Size Distribution and Blaine's surface area. Silica and alumina contents in the fly ash were ~57% and 31% respectively. Chemically, raw and ground fly ash was same as per XRF analysis. The SiO_2/Al_2O_3 ratio in fly ash and ground fly ash was 1.87 and 1.83 respectively. The raw fly ash has a hump between 15° and 35° 2θ while the ground fly ash has an extended hump between 20° and 40° 2θ showing more amorphousness. This hump is directly related to the presence of glassy content in fly ash. The presence of crystalline phase quartz, mullite and hematite were also identified (Fig. 1).

The particle size distribution of raw fly ash is in the range of 0.4 – 400 micron contrary to this, the ground fly ash is in the range 2 - 280 micron. This shows that ground fly ash is more uniform in particle size than the raw fly ash. The mean size of raw ash and ground ash were 69.49 µm and 37.25 µm respectively. The mean size of the slag particles was 19.18 µm. About 90.68% of the particles were smaller than 45µm. The Blaine surface area of raw ash was 258 m^2/kg which was less than the required value (320 m^2/kg) mentioned in IS: 3812. Contrary to this, the fineness of ground fly ash was 350 m^2/kg. This benefits the ground fly ash to become more reactive in the alkaline medium than raw ash. Blaine's surface area of slag was 514 m^2/kg and LOI was found to be 0.7%.

Heat flow rate during alkaline activation of fly ash/slag was measured using Isothermal conduction calorimeter (ASTM C 1702) using alkali solution of different molarities (8, 10, 12, 14 & 16). Activator-binder ratio of mix was 0.4. The emergence of first initial peak is mainly attributed to the early stage dissolution of fly ash/slag particles and the second small accelerated peak in the heat flow curve addressed to the formation of alkali aluminosilicate gels as a result of condensation reaction between silicate and aluminate species. As the activator concentration increased, the peak of acceleration increased from 1.60 mW/g for 8 M activator to 2.26 mW/g for 16 M activator and the time required for evolution of the peak shortened. 16.74% increase in total heat for 16 M activated paste was observed as compared to 8 M and was responsible for rapid setting/hardening at 16M concentration. But, the total heat released at higher activator concentration was nearly closer to each other. The lack of induction time for 16 M activated mix favours an option for use of activator concentration upto 14 M

only. The effect of fly ash to slag ratio (1:1, 2:1, 3:1) on geopolymerisation reaction has also been studied using isothermal conduction calorimetry (Fig. 2). The addition of GGBS enhanced dissolution–precipitation reaction with an increase in peak intensity as well as heat of reaction. Of all the mixes fly ash GGBS mix of 2:1 showed peak position that supported increased setting time and low workability loss.

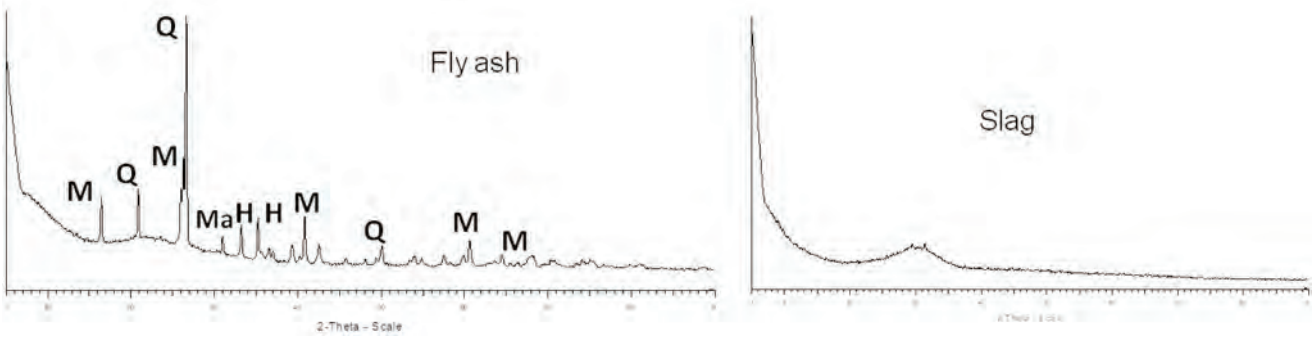


Fig. 1: XRD of Fly Ash and Slag

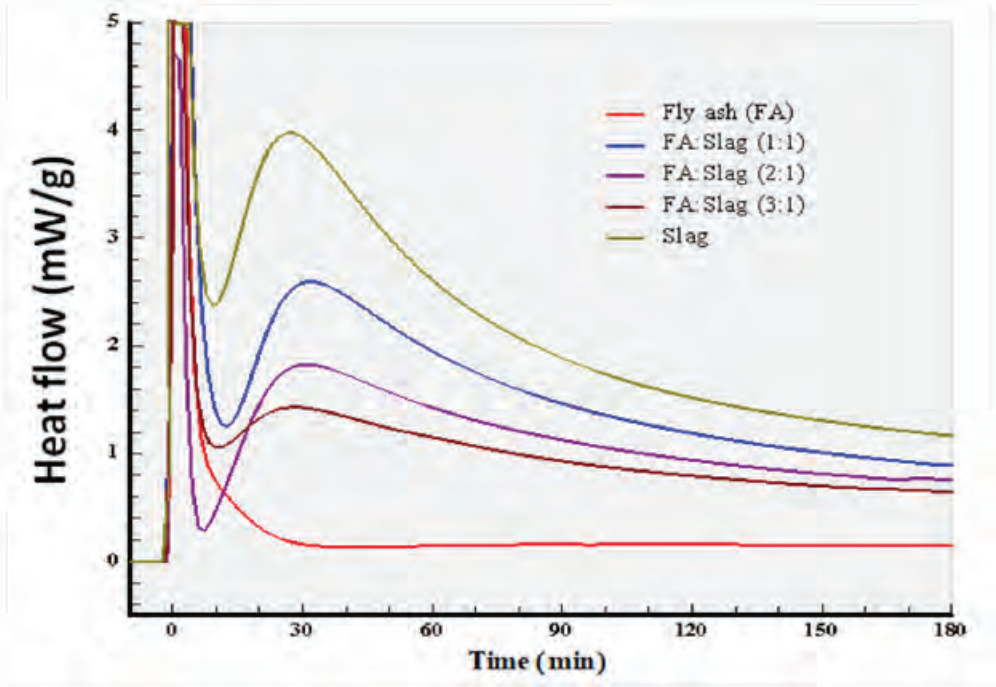


Fig. 2: Heat Flow Curves of Geopolymerization Reaction at Various Fly Ash and Slag Ratio

Recyclability of Marble Waste in Concrete Production & Other Building Products

Rajni Lakhani, Rajesh Kumar & Koushik Pandit

Objective

- To develop the formulation for light weight blocks i.e. Autoclaved aerated concrete and Cellular concrete blocks using marble cutting & slurry waste
- To develop the formulation for tiles (flooring/wall) and paver blocks
- Scale up of the developed process up to pilot level

Progress Highlights

Introduction

Commercially, marble is a crystalline rock composed predominately of calcite, dolomite, or serpentine that has hardness of 3 to 4 on Moh's scale and capable of taking good polish. Chemical impurities may be present in marble in the form of Silica (SiO_2) ; as free quartz or silicates, iron oxides as hematite (Fe_2O_3), Limonite ($2Fe_2O_3.3H_2O$), Manganese oxide (MnO_2), and Alumina (Al_2O_3) in form of aluminium silicates. Presence of impurities generally imparts decorative patterns and colours to marble. Rajasthan, the largest state in India in terms of area also holds the largest share in the Indian stone industry. As a result of setting up of thousand of marble cutting units in Rajasthan, huge amount of marble slurry dust (MSD) is being produced every year. These accumulated heaps of MSD besides, occupying large areas cutting units cause environmental pollution. About 6 MT of marble sludge waste is generated in Rajasthan annually. Makrana, Jaipur, Kishangarh, Rajsamand, Chhitorgarh, Udaipur are the major places, where marble waste are found in abundance. Marble ranks the largest produced natural stone in the world and it accounts for 50% of the world's natural stone production. Approx. 85% of production of marble in India is from Rajasthan state shown in (Fig. 1).

Fig. 1: Marble Stone Waste (MSW) Sites in Rajasthan

Marble occupies a unique position among other dimension stones because of its aesthetic value. In terms of geological definition, it is a metamorphosed limestone produced by re-crystallisation under condition of thermal and also regional metamorphism. The total production value of marble decreased to 1541.91 crore in 2013-14 from 1912.99 crore in 2012-13. Rajasthan alone accounted for about 88% output value followed by Gujarat (10%) and remaining 2% shared by Madhya Pradesh, Andhra Pradesh and Jammu & Kashmir (Table 1).

Characterization of the Raw Materials

The main raw materials that will be used to make sustainable concrete are as follow:

1. Cement (OPC)
2. All-in- aggregate from MSW

These raw materials with their physical and chemical properties are discussed below:

Cement

Ordinary Portland Cement (M/s Ultratech Vikram Premium) was used as the main binder. The physical and chemical properties of cement were tested as per IS: 4031(ii) and 4032 are given in Table 2, Table 3 & Table 4; which confirms to IS: 8112-1989. Cement was stored properly in plastic bags to prevent moisture penetration and subsequent deterioration. Laser particle size analysis was done using HORIBA laser scattering particle size distribution analyser and grading curve is given in Fig. 2.

Table 1: Value of Production of Marble (in Rs. x000)

Country and State	2011-2012	2012-13	2013-14
India	**16012403**	**19129861**	**15419081**
Andhra Pradesh	81534	13744	37
Gujarat	399729	1945115	1607500
Jammu & Kashmir	295	537	310
Madhya Pradesh	358015	54565	262388
Rajasthan	15172830	17115900	13548846

Table 2: Physical Properties of Cement Tested as per IS 4031(ii)

Parameters		Value	IS:8112-2013 Recommendation	Code for experiment
Std. consistency (% of water by wt. of cement)		26%	-Not specified-	IS 4031 (iv):1988
Setting time (min.)	Initial	120	30 (Min.)	IS 4031 (v):1988
	Final	47	600 (Max.)	
Compressive strength (MPa)	3 Days	27.50	23(Min.)	IS 4031 (vi):1998
	7 Days	36.30	33(Min.)	
	28 Days	48.40	43(Min.)	
Soundness (By Le Chatelier method, mm)		1.9	10 (Max.)	IS 4031 (iii):1998
Fineness (m^2/kg)		355	225	IS 4031 (ii): 1999
% retained on 90 µm sieve		2%	<10%	IS 4031 (i): 1996
Bulk specific gravity, Gc (SSD)		3.15	-Not specified-	IS 4031 (xi):1988

Note: As per physical test value, cement qualifies for OPC-43 G.

Table 3: XRF Analysis of cement

Chemical compounds	Value (%)
CaO	63.81
SiO_2	19.53
Al_2O_3	05.78
Fe_2O_3	05.05
MgO	00.85
SO_3	02.48
$K_2O + TiO_2$	01.27
C_3S	65.24
C_2S	6.78
C_3A	6.77
C_4AF	15.37

Table 4: Chemical Properties of Cement Tested as per IS 4032

Parameters	Value	IS 8112-2013 Recommendation
Ratio of % of lime to % of silica, alumina and iron oxide	0.95	0.66 (Min.)
		1.02 (Max.)
Ratio of % of alumina to that of iron oxide	1.14	0.66 (Min.)
Insoluble residue, % by mass	1.05	4.00 (Max.)
Magnesia, % by mass	0.85	6.00 (Max.)
Total sulphur content calculated as sulphuric anhydride (SO_3), % by mass	2.48	3.50 (Max.)
Chloride content, % by mass	0.80	5.00 (Max.)
Loss on ignition, % by mass	0.08	0.10 (Max.)

Note: As per chemical test value, cement qualifies for OPC-43 G.

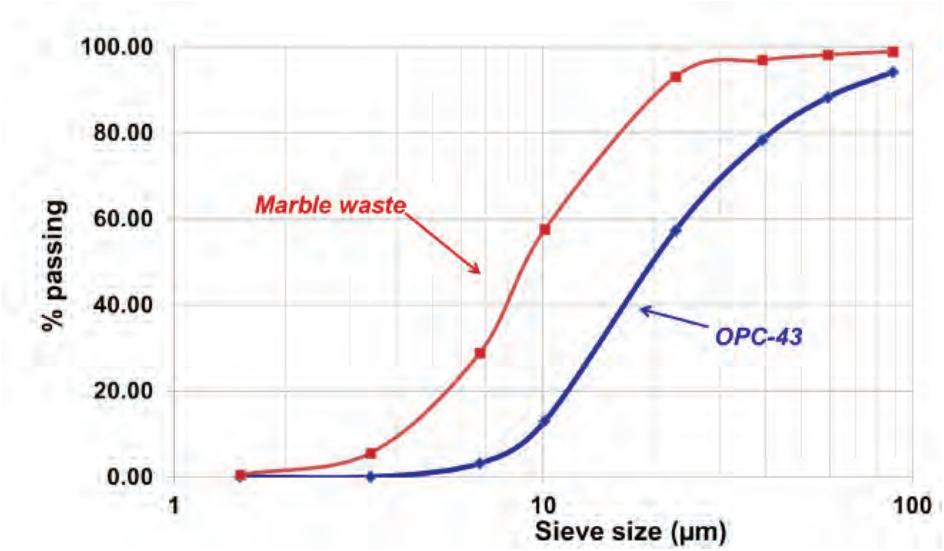


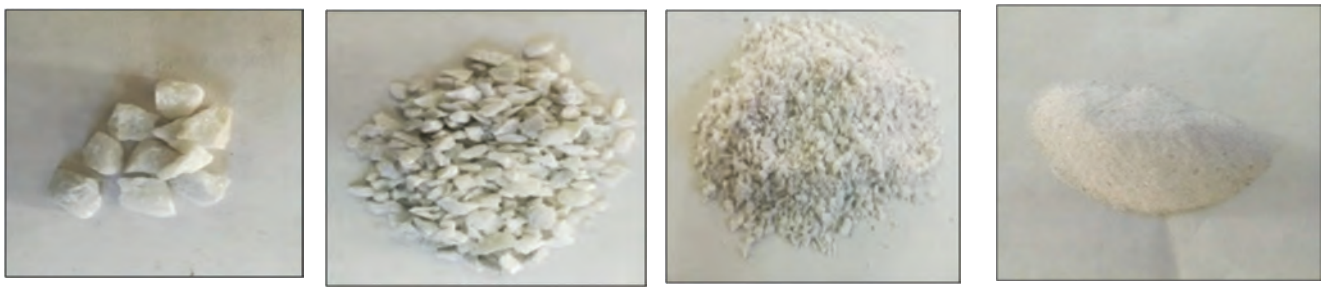
Fig. 2: Laser Particle Size Analysis of MSW & OPC-43G (All-in-Aggregates)

Marble Stone Waste

The result of sieve analysis of marble waste is shown in Table 5. The particle gradation fractions and particle size distribution is shown in Fig. 3 & Fig. 4. Other physico-mechanical properties viz.- specific gravity, water absorption, impact value, Los angels abrasion value, bulk density etc. were determined as per IS-code (Fig. 5 & Fig. 6) and the results are shown in Table 6. Chemical composition of marble waste is shown in Table 7.

Table 5: Sieve Analysis of MSW

Sieve size (mm)	Wt. retained in each sieve (g)	% on each sieve	Cumulative % retained	% passing
12.5	0	0	0	100
10	11.6	2.32	2.32	97.6
4.75	140	28	30.32	69.6
0.60	245.6	49.12	79.44	20.5
0.15	63.3	12.66	92.1	7.9
Pan	39.3	7.86	99.96	0.04



Size 12.5-10mm | Size 10-4.75mm | Size 4.75- 0.150 mm | Size <0.150 mm

Fig. 3: Particle Size Fractions of MSW

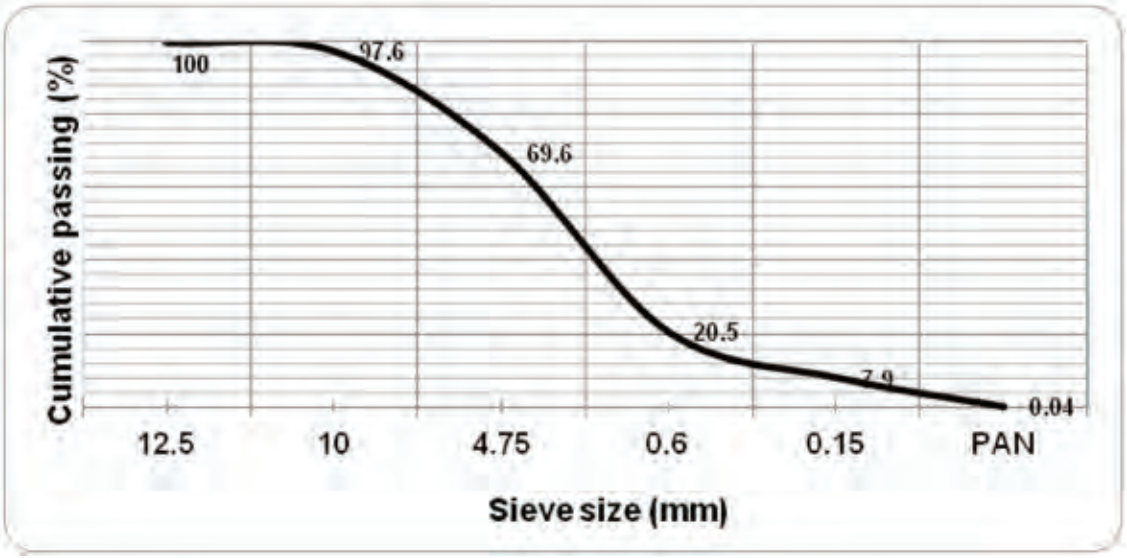


Fig. 4: Grading Curve for MSW- AiA (All-in-Aggregates)

Fig. 5: Bulk Density Test

Fig. 6: Impact Value Test

Table 6: Physical Properties of MSW Tested as per IS-code

Characteristic		Value	Code/Method
Colour /Appearance		White	Visual inspection
Bulk density	Loose	1.69 kg/l	IS 2386 (iii): 1963
	Rodded	1.83 kg/l	
Specific gravity, Gk (SSD)		2.70	IS 2386 (iii): 1963
Water absorption		0.05 %	IS 2386 (iii): 1963
Impact value		22%	IS 2386 (iv): 1963
Los angeles abrasion value		34.87%	IS 2386 (iv): 1963
Porosity		45%	----------

Table 7: Chemical Composition of MSW

Chemical compounds	CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	K_2O
Value (%)	45.40	1.73	1.11	1.42	4.41	0.01

Development of Self-Compacting Recycled Aggregate Concrete for Precast Building Components

Monalisa Behera, A.K. Minocha, Santha Kumar G. & Md. Reyazur Rahman

Shrinkage Characteristics of Recycled Fine Aggregate Mortar

The objective of this study is to investigate the influence of recycled fine aggregate (RFA) on the drying shrinkage characteristics mortar and concrete and how to mitigate the negative influence of RFA. Drying shrinkage is a very important phenomenon in all cementitious system as it is related with the volume reduction caused due to the evaporation of capillary pore water developed due to volume gradient. Drying shrinkage causes internal stresses due to the multidimensional contraction or volume reduction. The drying shrinkage depends upon various parameters such as chemical composition, w/b ratio, type and size of aggregate, relative humidity etc. In self compacting concrete, drying shrinkage is a very crucial parameter as self compacting concrete is prone to shrinkage due to high powder content and high flowability. Apart from that, RFA has high water absorption value (11.5%) as compared to natural sand (1.5%). Thus, it may also contribute to more shrinkage. The presense of filler material such as Fly ash (FA) or fine aggregate helps in substantial reduction of total shrinkage. Therefore, the drying shrinkage of mortar samples have been evaluated for various mixes incorporating RFA and along with supplementary cementitious substances.

The particle size distribution and the zoning of both the types fine aggregates was done as per IS 383:2016 and it was found the particle size distribution of RFA lies within the specified limit of IS standard showing a good particle distribution. The particle size distribution curves of various aggregates are shown in Fig.1. The particle size distribution of RFA shows a good size distribution followed by a more inclined sigmoid curve as compared to NFA. The sieve analysis result showed that the RFA lies in zone I and NFA lies in zone II, confirming that the RFA is coarser than NFA. However, the fine content below 75 micron was found to be more in case of RFA.

A total number of ten mixes were developed with a water/binder (w/b) ratio of 0.3. The binder to sand (b/s) ratio was kept constant at 1:3 by mass for all the mixes. Ten series of mixes were casted differing in the amount of water added depending on the water absorption value of NFA and RFA In order to see the effect of FA and silica fume (SF) with RFA, the cement was replaced with FA from 0 to 30% and SF from 0 to 10%. Each mix was casted with both NFA and RFA. The mixes were designated as MX-Y-Z, where X denotes the type of fine aggregate used in the mix (N- for NFA ad R- for RFA); Y indicates the replacement level of FA and Z denotes the replacement level of SF.

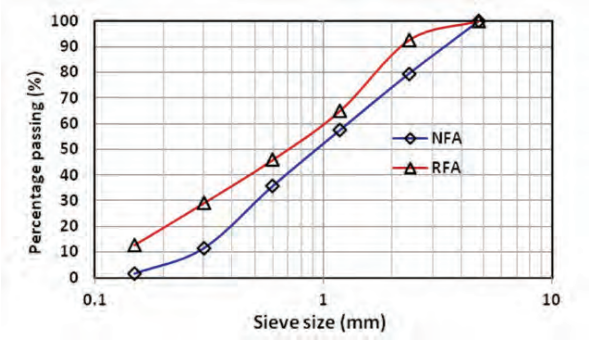


Fig. 1: Particle Size Distribution of NFA & RFA

For example, MN-20-5 represent a mix with NFA in which cement is replaced by 20% FA and 5% SF. A control mortar has been used as reference for this study made with only OPC and NFA designated as MN-0-0. Samples of size 25mm X 25mm X 285 mm were casted to determine the drying shrinkage of mortar specimens as per ASTM C596 at various ages, as shown in Fig. 2. The readings were taken at a regular interval of time.

As RFA shows high water absorption and contains hydrated and unhydrated cementitious substances, it may show higher shrinkage phenomena. The shrinkage stress basically develops near the vicinity of $Ca(OH)_2$. Fig. 3 shows the drying shrinkage curve of control mortar with NFA and RFA made with only cement. From the curve, it is observed that the samples showed rapid increase in drying shrinkage up to 7 days as the slope of the curve is steep. The control samples experienced higher early shrinkage up to 7 days than the samples with RFA. However, the control samples showed low shrinkage than RFA samples at later stage. The shrinkage value for samples with RFA continues to increase at higher rate for later stage after 7 days as curve shows a steep slope. The initial lower shrinkage in RFA samples may be due to the higher water absorption value of RFA from the cementitious system which restrains the shrinkage stress. In later stage, water present in the capillary pores of RFA added advantage towards the shrinkage value of RFA.

The influence of cementitious substances such as FA and SF on drying shrinkage mortar samples with the replacement of cement along with NFA and RFA at 90 days is presented in Fig. 4. It is clearly visible from the figure that the addition of RFA suffered a remarkably high drying shrinkage value than that of NFA. In case of NFA samples, the addition of FA reduces the drying shrinkage value than that of control samples. Ths may be due to the formation of secondary hydration products due to addition of FA which reduces the spacing of CSH particles, thus making the microstructure denser and restraining towards shrinkage. At the age of 90 days, the pozzolanic reaction of FA helps in pore refinement. The similar phenomena are observed in case of RFA sample containing FA. However, the addition of SF has more influence towards the increase of drying shrinkage and the higher percentage replacement of SF exhibited considerable increase in drying shrinkage. The addition of SF contributes towards the autogenous shrinkage or self-desiccation caused due to the formation of cohesive and adhesive solids as a result of chemical reaction between the cementitious substances and water. The cohesive solids are formed during the reaction of $Ca(OH)_2$ and SiO_2 present in SF. Thus, the combined effect of FA and SF has a positive response towards drying shrinkage resistance of mortar specimen with RFA than mortar sample made with RFA and only cement.

Fig. 2: Casted Samples & Testing for Length Change of Specimen

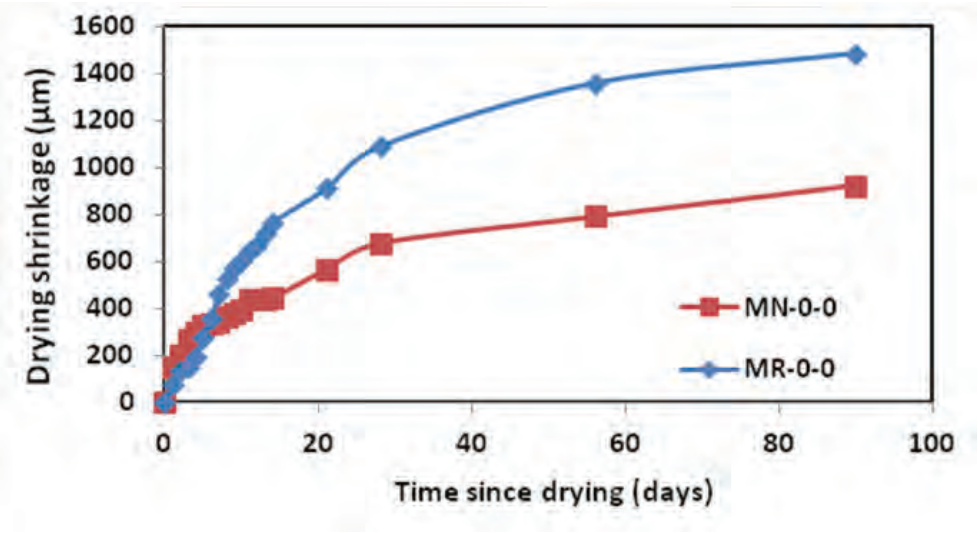


Fig. 3: Drying Shrinkage of Mortar Bar with Respect to Time for NFA & RFA

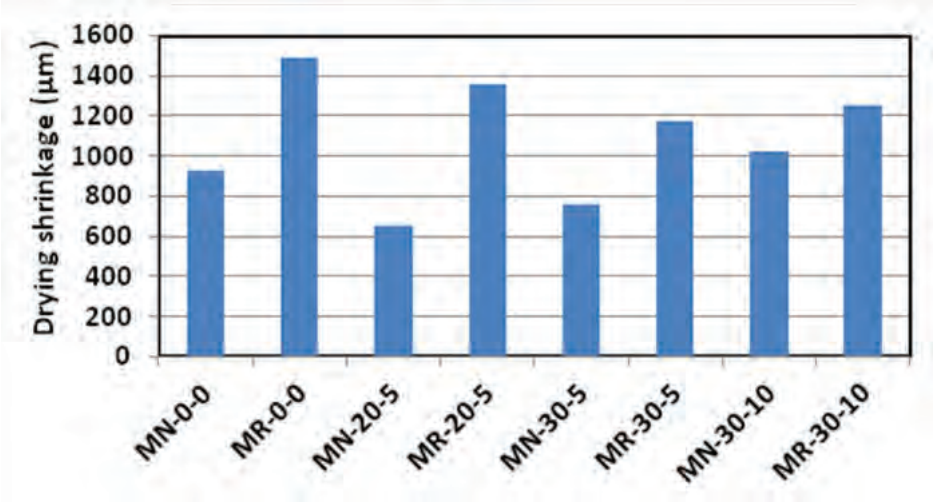


Fig. 4: Drying Shrinkage at 90 Days for Different Replacement Levels of Cement with NFA & RFA

Development of Cost Effective Material for Sound Absorption with Partial Air Purification Properties

Siddharth, Soumitra Maiti & Team

Industrial revolution and modern lifestyle in today's scenario has brought a major impact on our daily life. Various industrial pollutants irrespective of its nature, whether solid, wastewater or toxic gases have caused serious health issues. For example, the industrial waste water contains large amount of heavy metals like Cr, Pb etc. If these metal ions are not removed properly before discharging the waste, they will contaminate our natural water sources. These pollutants have severe consequences on human health as well as disrupt the ecological balance. Similarly, air pollution caused by industries, road transport, evaporation of paints, smoke and by volatile organic compounds (VOCs) has degraded the air quality of the ambient atmosphere. According to a survey conducted by Central Pollution Control Board (CPCB) New Delhi, NO_2, PM_{10} have crossed the safe limits. For the removal of heavy metal from water and air pollutants form atmosphere, many techniques like ion exchange, chemical precipitation and adsorption have been explored. Among these techniques, adsorption has been proved more effective because of its efficiency and simplicity. Some common used adsorbents used for heavy metal removal are activated carbon, alumina and silica. In this regard, zeolite, a low cost material synthesised from fly ash, which itself is a waste from coal industry has been proved a good adsorbent for removal of heavy metal ions from waste water and is also effective in adsorption of harmful air pollutants from atmosphere. Flourogypsum, a waste of hydrofluoric acid and fertilizer industries can be utilised in false ceiling tiles or in the panel form as sound absorbing materials with certain modifications.

Objective

Development of cost effective material for sound absorption with air purification and fire retardant properties (zeolite/gypsum based).

Progress Highlights

- Synthesised zeolite from flyash as an effective air purifier.
- Detailed experimental studies synthesised zeolite material.
- Synthesis of gypsum samples for acoustic testing in the frequency range of 150-4400 Hz
- Fig. 1 showing XRD pattern of synthesized zeolite from fly-ash. Appearance of two zeolite phases can be seen from the XRD pattern.
- Fig. 2 shows FE-SEM images of synthesized zeolite with fly-ash & NaOH in ratio 1:1.2
- Fig. 3 represents XPS analysis of air pollutant treated zeolite samples confirming the presence of N_2O, NO, NO_2, CO & carbonate.

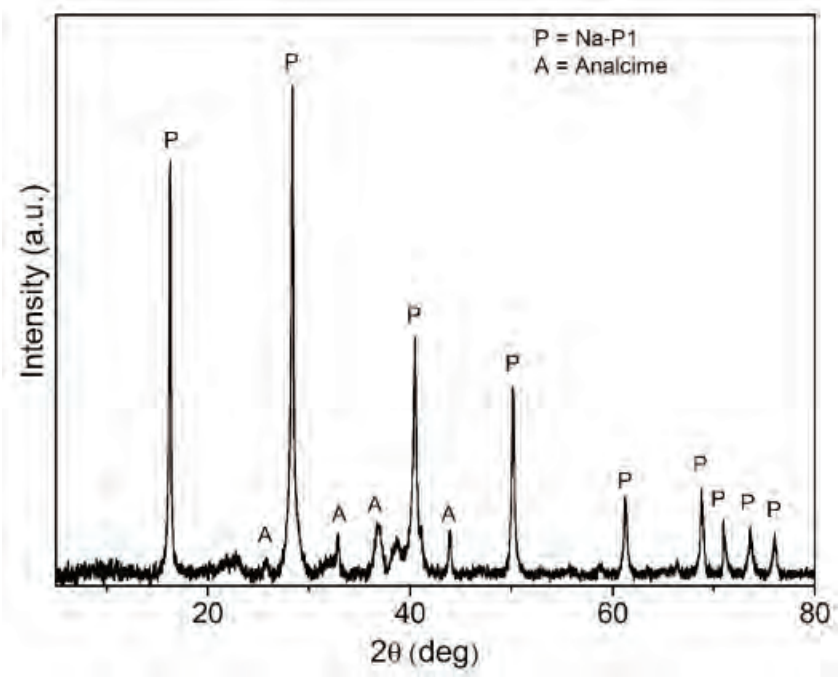


Fig. 1: XRD Pattern of Synthesised Zeolite For Fly Ash and NaOH Ratio 1:1.2.

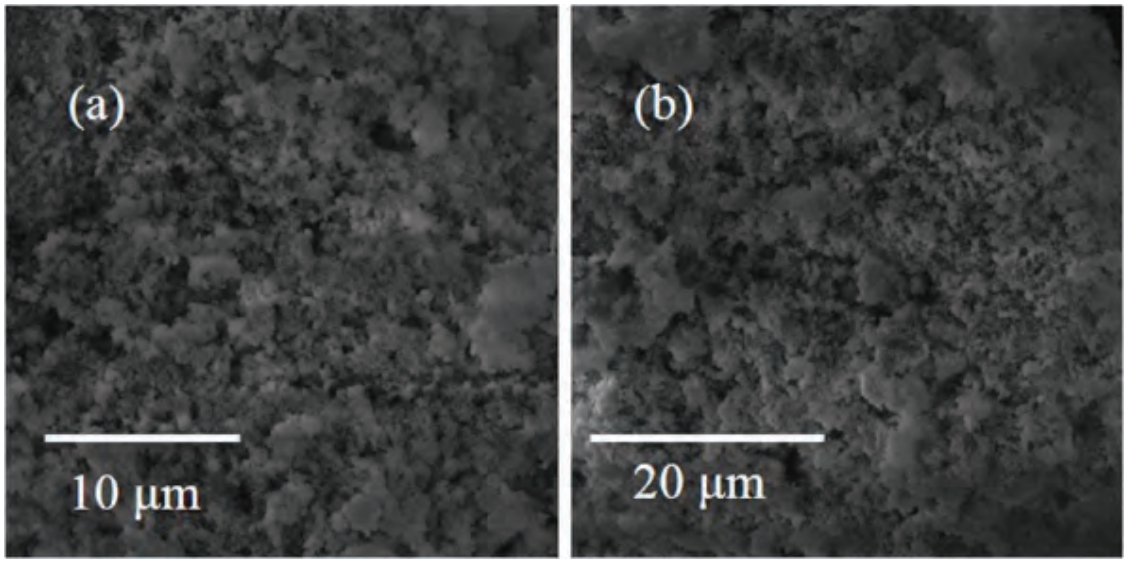


Fig. 2: FE SEM Images of Zeolite with Fly Ash and NaOH Composition

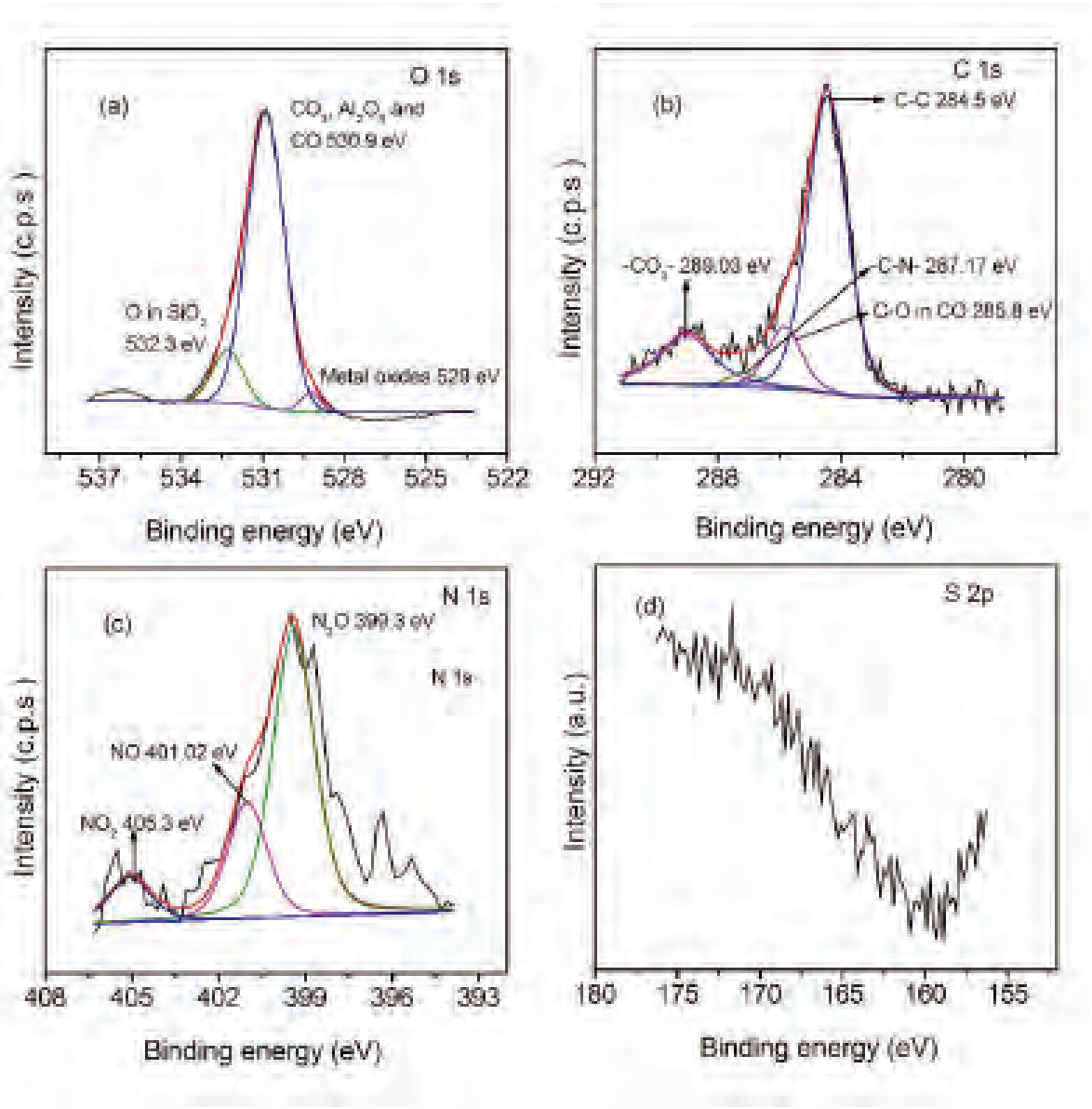


Fig. 3: Core Level Spectra of (a) O 1s, (b) C 1s, (c) N 1s and (d) S 2p
The De-Convolution of Respective Spectrum shows the Presence of NO_x and Co and Other Pollutants Adsorbed on Zeolite Surface

Energy Efficient System & Building Automation

- **Efficient Solar Thermal Collector**

Efficient Solar Thermal Collector

Nagesh Babu Balam, Tabish Alam & Chandan Swaroop Meena

Flat plate solar collector (FPSC) converts solar radiation into thermal energy of fluid when it is exposed to sunshine. Solar radiation absorbing capability of collectors depends on many factors such as types of absorber, collector designs, working fluids and heat losses etc. The advantage of FPSC's over others collectors is, it can absorb diffuse radiation along with direct radiation. The major drawback of FPSC has been its inability to operate with significant efficiencies at a temperature over 70°C, thus limiting its applications largely to provide space heating and hot water. Due to high temperature of absorber, significant heat goes waste to the environment from the top side of collector by convection losses. This problem can be overcome by implementing double glazing which leads to a advantages of minimizing the top heat losses. Double glazed FPSC offer several advantages over other collectors which include excellent thermal characteristics and optical properties due to a combination of their wide surfaces area and high insulation.

Major heat loss from the glass covers to ambient, influence the performance of FPSC. In order to reducing this heat loss is to reduce the convection by transparent convection barrier using a second glass and another way is to reduce thermal conductivity by using a more suitable gas than air. The use double glaze filled with inert gas (iron) which reduces the thermal losses drastically, leading to achieve higher efficiency.

Thermal analysis of double glaze FPSC has been carried out using thermal network as shown in Fig. 1. Some typical location of absorber and glass cover has been presented. Solar energy is absorbed which is distributed into useful heat gain to fluid, top heat loss, bottom heat loss and side edge heat loss.

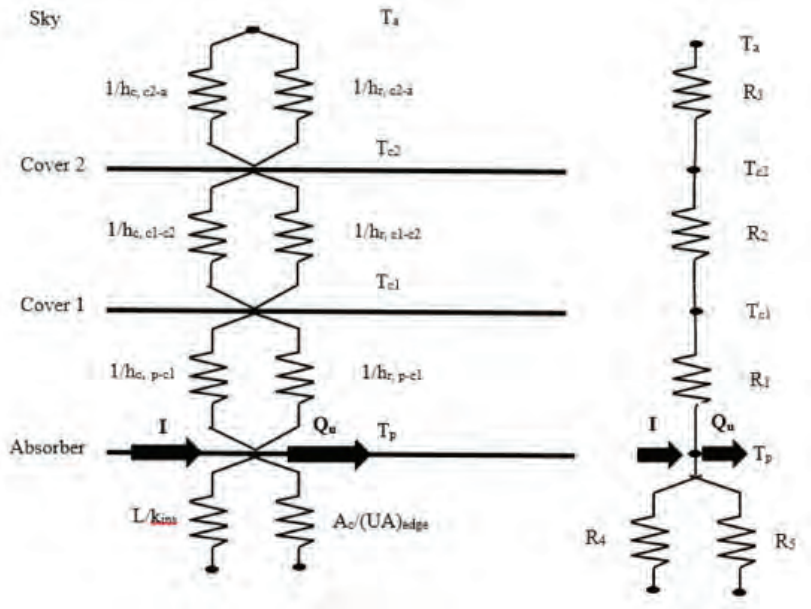


Fig. 1: Thermal Network of Two Cover FPSC

The side and bottom losses have been minimized using glass wool. The energy loss through the top cover by convection and radiation which have been minimized using double glazing.

The following equation has been used to determine the thermal efficiency.

Efficiency of the collector,

$$\eta_{th} = \frac{Q_u}{A_c . I} = \left[(ia) - \frac{U_o (T_p - T_a)}{I} \right]$$

The efficiency has been determined and graphs of efficiency and plate temperature of single and double glaze collector have been presented in Fig. 2. There is significant difference in the single and double glaze collector efficiency. Higher efficiency of double glaze flat plate solar collector is due to lower top heat loss through double glaze as presented in Fig. 2.

It is found by analysis that due to absorption of solar radiation in glass cover of a single glazed flat plate collector the increase in glass cover temperature which leads to high thermal losses to environment. In comparison to single glazing, the temperature of outer glass in double glazing is much lower. The resulting effect of absorption of solar radiation in glass covers on heat transfer coefficients in a solar collector with double glazing is significantly more than in a solar collector with single glazing.

The efficient flat plate solar collector can be used in wide applications such as domestic purposes, solar air conditioners, air dryers and heat process in industries. Their major purpose is to collect as much solar energy as possible at the lower possible total cost. The collector should also have a long effective life, despite the adverse effect of environment.

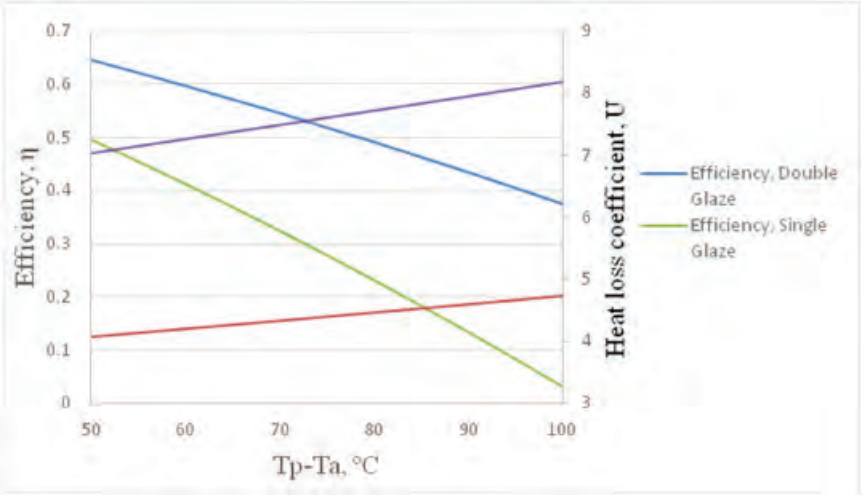


Fig. 2: Comparison of Efficiency and Heat Loss Coefficient of Single and Double Glaze Collector with respect to Plate Temperature

Disaster Mitigation

Safety of Vital Installations against Natural & Manmade Disasters

Suvir Singh & S. Sarkar

Design & Development of Fire Safety Measures for Vital Installation

- Experimental & Numerical Simulation Studies for Hazard Assessment in Real Fire Scenario
- Development of Fire Retardant/Resistant Materials for Fire Safety Enhancement
- Development of Fire Retardant Coating for Interior Materials
- Analysis of Reinforced Concrete Members Exposed to Fire & Development of Retrofit Techniques

Design & Development of Structural Systems & Buildings for Protection against Progressive Collapse: Manmade & Natural Hazards

- Design against Progressive Collapse Failure of Structures - Impact & Blast Loads

Safety of Vital Infrastructures against Landslides (SOVIAL)

Design & Development of Fire Safety Measures for Vital Installation

A. Aravind Kumar

Experimental & Numerical Simulation Studies for Hazard Assessment in Real Fire Scenario

A. Aravind Kumar &. Rajiv Kumar

Introduction

The fire safety of buildings in vital installations such as hospitals, power plants, and Nuclear, oil and gas industries attracted people's attention over years, due to their unique challenges, such as long evacuation time, smoke movement and fire department accessibility. Fire protection features are provided to ensure safety of these buildings in case of a fire. In recent years, more residential building fires were reported prompting concerns over fire safety in this type of buildings. In residential buildings, large amounts of combustibles materials are stored in units of small area. The fires reported are from the materials used in the buildings from the furniture, electronic items and ceiling and wall ling materials.

The assessment of the fire behaviour of ceiling and wall ling materials often requires large scale testing. The use of small or intermediate scale test can be questioned for such type of products. Testing in full-scale is often the most appropriate solution. This project has aimed to develop a full-scale test procedure which fully allows the end-use mounting of the panels but retains the philosophy of the room corner test scenario as ISO 9705. The experimental fire facility of ISO 9705 room fire is shown in Fig. 1.

The objective of this project is to characterize the ceiling and wall lining materials in reals scenario as per standard test method of practise. The characterization of the materials is based on the parameters of flashover condition, heat release rate, ceiling temperatures, species concentrations and smoke production rate in full scale experimental fire facility results in single burn room fire facility. The safe evacuation time will be determined experimentally for these materials in two storey experimental fire facility as shown in Fig. 2. The test results will be validated numerically with computational fluid dynamic tool and further the predictions will be carried out for different ventilation conditions.

Fig.1: Single Room Experimental Building Fire Facility

Fig. 2: Two Storey Experimental Building Fire Facility

The progress so far achieved are computational study has been carried out for predicting the behaviour of a corner ignition fire source for a reported experimental data using a field model based code Fire Dynamics Simulator (FDS). Time dependent temperature is predicted along with the resulting changes in the plume structure. The analysis has been carried out with the correct value by performing a grid sensitivity study. The predicted temperatures of the two scenarios at two points by the current analysis are in very good agreement with the reported experimental data and numerical prediction for two different burner cases as shown in Fig. 3. The studies have extended the utility of field model based tools to model the particular separate effect phenomenon like corner for one such situation and validate against experimental data. The present approach uses the advanced Large Eddy Simulation (LES) based CFD turbulence model. The geometry and boundary condition details are given in Table 1.

Table 1: Geometry & Boundary Conditions of the Single Room

Room size	2.4 m(W) × 3.6 m(L) × 2.4 m(H)
Doorway	0.8 m(w) × 2.0 m(H) (Open)
Experiment Time	15 min
Burner size & type	0.3 m × 0.3 m × 0.3 m sand burner
Fuel source	Methane Gas.
HRR Input	100 to 300 kW (Part A), 40 kW to160 kW (Part B)
Data measured	Heat release rate and Temperatures at room corner, room centre at ceiling height 0.05 m and at top of the door centre 0.1 m just below.

Source: Webb, A. K.; Dowling, V.P.; and Mc Arthur, N. A., Fire Performance of Materials, Internal CSIRO report by Fire Science & Technology, Nort Ryde, CSIRO,1999.

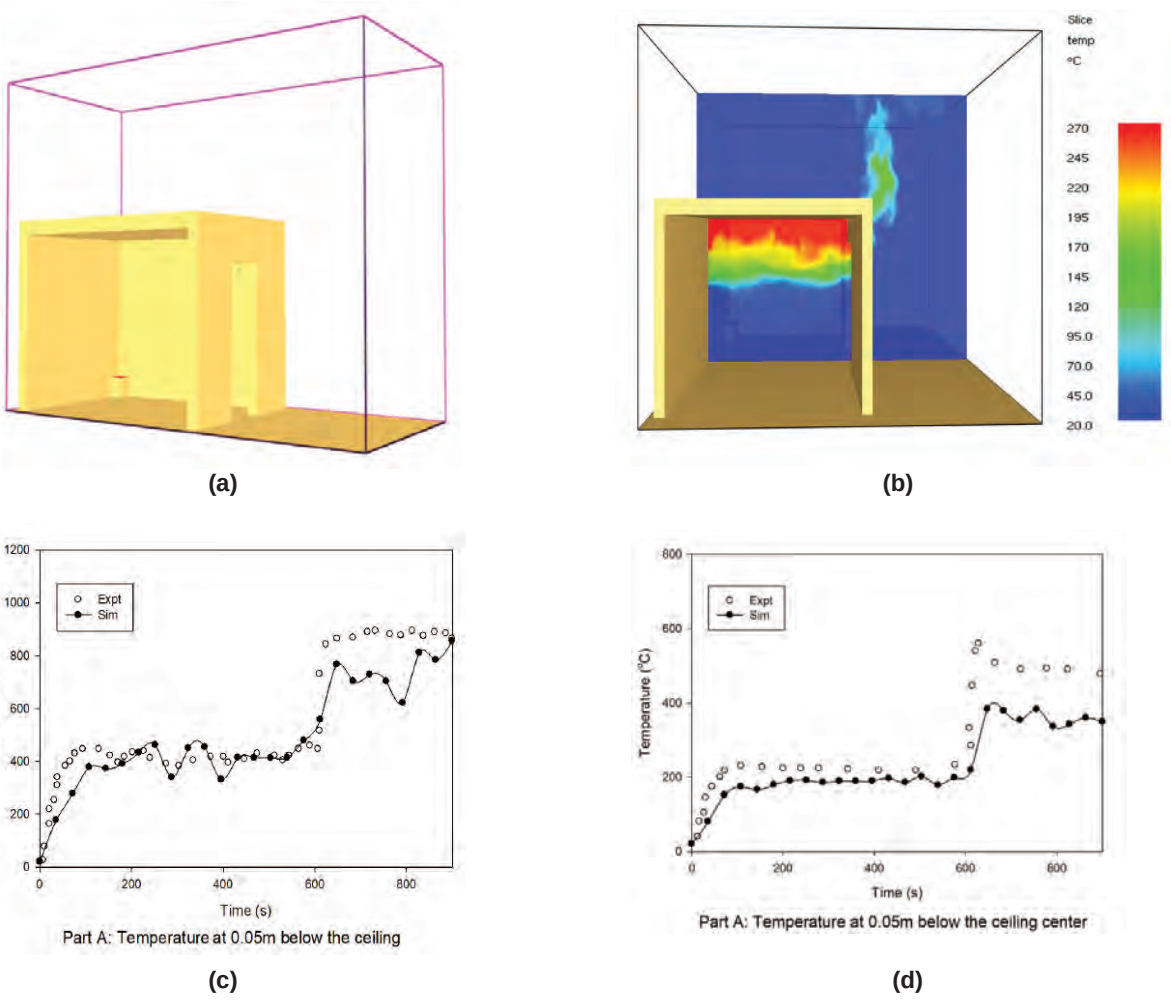


Fig. 3: (a) Geometry of Single Burn Room (b) Slice Temperature at 900 s of Part A (c) Temperature at Room Corner (d) Temperature at Ceiling Centre

Development of Fire Retardant/Resistant Materials for Fire Safety Enhancement

Harpal Singh

Objective

Durable fire retardant/resistant materials with reduced smoke and low toxic combustion products to mitigate fire hazard in hospitals and telecom-shelters

Progress Highlights

There are various furnishing materials including fabrics used in built environment however, flammability limits their application. The behaviour of the most common natural fibres when exposed to fire are separated into two categories: lignocellulosic fibres, like cotton and flax, which are easy to ignite and flammable, and; protein fibres, such as wool and silk, in which is more difficult to start the flame. The response of the fibres to heat depends on mainly of their chemical composition and can be divided into: thermoplastic, which soften

and melt above certain temperatures, and; non-thermoplastics, which tend to carbonize and embrittle at high temperatures. The variation of the flammability characteristics of the fabrics can be influenced by their construction (woven, knitted or nonwoven) and the chemical nature of their constituent fibres. Such characteristics range from highly flammable (in the case of cellulosic fibres and common synthetic fibres) to inherently flame retardant. Catching of fire and its progress in fabrics is mainly due to the formation of various gases and liquids during burning of fibre. Burning of material is a complex phenomenon. It involves processes such as heat transfer, thermal decomposition etc. For synthetic fibres, the thermoplastic behaviour adds to the effect. Material like fabrics made of cellulose fibres when bum, combustible vapour is generated and char is formed. When the flash point is reached, run away exothermic reactions are triggered. This is accompanied by appearance of flame or glowing zone. This phenomenon is known as ignition. Fabric made of synthetic material exhibit melting and surface involved in afterglow is different than in flaming. Prevention method of afterglow is also different. Afterglow is mainly due to the burning of remnant char, which forms due to lack of oxygen in surrounding atmosphere. Carbon and oxygen react to form carbon monoxide through exothermic reaction. The char becomes ash in afterglow process by conversion of carbon monoxide to carbon dioxide in presence of excess oxygen. Fires resulting from upholstered furniture, floor coverings, curtains, and drapes are more frequent, which result in significant rate of fatalities. The flame spread rate observed after ignition of cellulosic, common synthetics and blended fabric apparels is heavily dependent on fabric areal density, with the highest danger with lightweight fabric. Apart from low areal weight fabrics, raised-surface apparel is also of concern from the point of view of high flammability hazard, because of easy ignition and fast flame spread. In order to reduce the flammability risks of a textile material, considers three approaches: (i) using inherently flame-retardant textiles such as high-performance fibers; (ii) using chemically modified textiles; (iii) incorporating flame-retardants into natural and synthetic fibers or make surface treatment. The fabric should meet flammability standards and customer expectations regarding performance, cost, aesthetics and maintenance care.

Fire performance of various natural and synthetic fabrics was investigated through standard vertical flammability test method. Natural fabrics burn fast whereas, synthetic fabrics comparatively burn slow with shrinking, melting and dripping. These results are shown in Table 1.

An aqueous chemical composition was formulated based on acid catalyst, spumific agent, nitrogen based additive and methanal compound. The chemical composition and its ingredients per moles are shown in Table 2. Samples of natural fabric were treated with prepared composition at the ambient condition.

Table1: Fire Performance of Natural & Synthetic Fabrics under Standard Flammability Test

Properties	Fabrics					
	Cotton	Silk	Rayon	Nylon	Polyester	Acrylic
Exposure Time, sec	12	12	12	12	12	12
Char length burn, sec	52	68	59	41	37	45
Char area, mm^2	BEL	BEL	BEL	BEL	BEL	BEL
After flame, sec	45	59	52	34	26	38
After glow, sec	98	63	87	52	54	57
Shrinking, sec	00	00	09	04	05	08
Melting, sec	00	00	00	12	15	18
Dripping, sec	00	00	00	13	18	00
Weight loss, %	96.23	97.16	96.54	97.86	96.89	97.22

Table 2: Fire Retardant Chemical Composition

Chemical ingredients	Quantity per mole
Acid catalyst	0.75
Spumific agent	0.25
Nitrogen based additive	1.0
Methanal compound	3.0
Water	5.0

The fire performance of chemically treated and untreated natural fabrics was evaluated as per standard vertical flammability test in terms of char length, char area, after flame, after glow, shrinkage, melting, dripping and weight loss. Fire performance of samples was also evaluated after first, second and third washing. The results of fire performance of natural fabric chemically treated, untreated and after washing are shown in Table 3.

The results showed that natural fabric samples become fire retardant after chemical treatment. The fire performance of fabric samples was satisfactory up to second washing however; it was decreased significantly after third washing. Therefore, it can be concluded that the results are promising however; more experiments are needed to improve the fire performance of natural fabric to desired level.

Table 3: Fire Performance of Untreated & Chemically Treated Natural Fabric under Standard Flammability Test

Properties	Fabric		Washing		
	Untreated	Treated	Ist	IInd	IIIrd
Exposure Time, sec	12	12	12	12	12
Char length, mm	BEL	35	37	42	64
Char area, mm2	BEL	475	477	486	524
After flame, sec	45	00	00	02	08
After glow, sec	98	00	00	00	15
Shrinking, sec	00	00	00	00	00
Melting, sec	00	00	00	00	00
Dripping, sec	00	00	00	00	00
Weight loss, %	96.23	4.61	4.84	4.97	9.43

Development of Fire Retardant Coating for Interior Materials

A.A. Ansari & Rakesh Kumar

Importance

New& existing building materials such as wood & wood based materials are being used in building interiors, however their fire performance is poor or not up to the desired level of fire safety. It is proposed to provide solutions to these by developing fire retardant coating which improves overall 'Reaction to fire' behavior up to the normally accepted levels. Materials will be

studies for their fire performance in a comprehensive manner which is lacking so far.

Objectives

Development of fire retardant coating for wood based materials which improves surface spread of flame classification, low fire propagation index / low heat release rate, retard the generation of dense smoke & toxicity.

Deliverables

Development of fire retardant coating for wood based materials.

Scope of Work

Studies on fire behaviour of existing and new wood based interior materials.

Development of non-toxic, non-hazardous fire retardant coating which do contain lead, asbestos.

It is desired to render wood based materials fire retardant so that these do not get ignited easily, do not spread flames over their surfaces rapidly, do not generate significant heat, smoke & toxic combustion products as they burn, so that they would not cause extensive damage in case of fire.

Progress

Development of fire retardant coating which improves surface spread of flame classification, low fire propagation index / low heat release rate, retard the generation of dense smoke & toxicity to provide desired level of fire safety.

Table 1: Surface Spread of Flame Classification of Plywood & Rice Husk Particle Board

MATERIAL	Observations	Surface Spread of Flame Classification
Rice Husk Particle board, 12 mm	Ignites easily & continues to burn with flame spread on its surface rapidly	Class-4
Rice Husk Particle board, 12 mm (Treated with FR Coatings)	No ignition No flame spread	Class - 1
Plywood, 12 mm	Ignites easily & continues to burn with flame spread on its surface rapidly	Class-3
Plywood, 12 mm (Treated with FR Coatings)	No ignition No flame spread	Class - 1

Developed chemical formulation in form of clear/ transparent coating. This coating is a reaction product of amide with phosphoric acid and Boron compounds. When exposed to fire it releases nitrogen, phosphorous and boron, hence effective in fire retardancy. This coating was applied on the specimens of Plywood & Rice husk particle board to study ignition barrier as well as resistant to surface spread of flame.

Fire experiments on surface spread of flame classification of untreated and FR treated Plywood & Rice Husk Particle Board specimens as per BS 476: Part 7 was carried out .The experimental evaluation results are summarized in following table (Table 1). While behavior specimens of plywood (untreated & treated) during the experiments are given in Fig. 1(a) and Fig. 1(b) respectively.

(a) Untreated Plywood

(b) FR Treated Plywood

Fig. 1: Surface Spread of Flame Classification of Untreated & FR Treated Plywood

Analysis of Reinforced Concrete Members Exposed to Fire & Development of Retrofit Techniques

Banti A. Gedam, Suvir Singh, H. C. Arora, Rajeev Bansal, Sushil Kumar, Narender Kumar, I.A. Siddiqui & Bharat Bhushan

Objective

- Design aid for RC beam at elevated temperature.
- Rehabilitation (strengthening and repairing) technique of the fire damaged RC beam.
- Databank generation of fire damaged RC beam to robust the developmental model.

Progress Highlights

- Moment resistance prediction model for RC beam has been developed.
- This model capable to predict the moment resistance of RC beam based on the material properties at elevated temperature condition.
- Preparation and characterization of physical, chemical and mechanical properties of HPC have been done.
- The casting of RC beams for experimental study has been done.
- Comparative appraisal of existing temperature prediction models and experimental data of RC beam have been done.

Design & Development of Structural Systems & Buildings for Protection against Progressive Collapse: Manmade & Natural Hazards

M.M. Dalbehera

Design against Progressive Collapse Failure of Structures - Impact & Blast Loads

M.M. Dalbehera, A.K. Mittal, S. Behera & Chanchal Sonkar

Objective

Design guidelines for precast RCC buildings against progressive collapse failure subjected to impact and blast loads.

Scope of Work

- Development of precast RCC beam column joints for mitigating progressive collapse in precast RCC buildings
- Experimental study on scaled specimen of beam column sub assembly.
- Numerical study of composite beam – column joints for progressive collapse analysis.
- Design guidelines for precast RCC buildings against progressive collapse failure subjected to impact and blast loads.

Progress Highlights

1. Physical tests and numerical modeling are two main means to investigate structural resistance against progressive collapse. Due to the high cost of physical tests, progressive collapse modeling is used for tracing the collapse sequence of the structures.
2. Four kinds of modeling approach, namely linear static analysis, nonlinear static analysis, linear dynamic analysis and nonlinear dynamic analysis are applied to study the responses of buildings during progressive collapse.
3. Static analysis procedures such as pushdown analysis are usually load-history independent as they ignore the effects of service loading. In addition, most static analysis procedures do not model the impact effects of failed members after the initial partial collapse.
4. Nonlinear dynamic analysis is capable to model the progressive collapse accurately, they are complex to implement and require expensive computational cost.
5. Two types of pushdown analysis i.e. uniform pushdown and bay pushdown are used to study progressive collapse resistance of the building. In the uniform pushdown analysis, gravity loads on the damaged structure are increased proportionally until the ultimate limit occurs. The failure may occur outside the damaged bays, and thus it is not possible to estimate the residual capacity of the damaged bay. In the bay pushdown analysis, however, the gravity load is increased proportionally only in the bays that suffered damage until the ultimate limit is reached in the damaged bays.
6. Present modeling procedure does not consider:
   - Catenary action of beams at large deformation
   - Effect of service loads on the structure before column removal (heavy service loads on intact structure may produce non-ignorable effects on the structure's performance after column removal).

- Effects of impacts from failed members (Both vertical impact force due to free fall of members and tangential impact forces due to oblique impact will be taken into account)

7. A nonlinear static modeling procedure for progressive collapse analysis of 2D RC frames considering all the above scenarios and comparison has been made with pushdown analysis approach.
8. 1 x 2, 2 x 2 and 4 x 5 two-dimensional RC frames have been taken up for study with different column-removal scenarios such as side-column removal, middle-column removal and two-column removal scenario.
9. One - third scale specimen of Beam column sub assembly has been casted and will be tested under static loading conditions to study the effect of progressive collapse.

Safety of Vital Infrastructures against Landslides (SOVIAL)

S. Sarkar, D.P. Kanungo, M. Samanta, A. Pain, S. Ganesh & K. Pandit

Objective

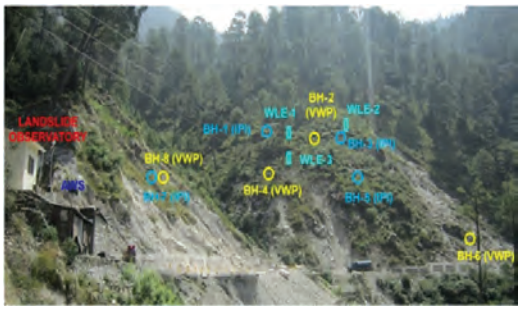
The objective of the ongoing study is to design and develop efficient slope stabilization measures to mitigate landslide hazards for the safety of vital infrastructures in Himalayan region.

Instrumentation & Monitoring

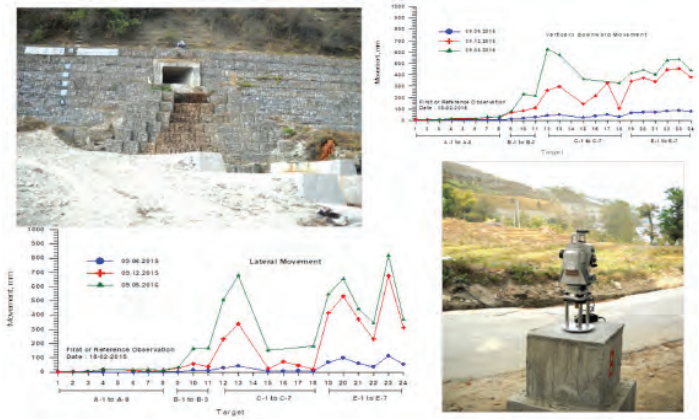
Acquisition of real time instrumentation data for landslide monitoring from the Landslide Observatory established at Pipalkoti Landslide, Garhwal Himalaya is being continued (Fig. 1(a)). Monitoring of soil reinforced structure at newly constructed Greenfield Airport, Pakyong, Sikkim is also being continued (Fig. 1(b)).

Geo-Synthetic Reinforcement Solution for Slope Protection

A study has been initiated to evaluate the reinforcing effect of anchored geosynthetic system on slope stability. Additional influence of anchor length,



a



b

Fig. 1: (a) Landslide Observatory at Pipalkoti &; (b) Monitoring of Re Wall using Total Station at Pakyong Airport

material property, effect of geosynthetic stiffness and its interaction on slope will be studied. The study will be conducted both experimentally as well as numerically using available numerical software.

A numerical model has been developed and analysed using PLAXIS 3D numerical software. To validate the numerical program, model studies on slope performed by Cai and Ugai (2000) was compared. The slope stability analysis was performed using safety analysis i.e. using shear strength reduction method. Initially the slope was analysed for estimating factor of safety without any slope reinforcement. The factor of safety for the slope without any treatment was 1.12 which is in good agreement with Cai and Ugai (2000) numerical test results of 1.14.

After validation, the slope was reinforced with anchored geosynthetics to improve the safety factor. With the installation of anchored geosynthetic system, the factor of safety for the slope increased from 1.12 to 1.57 for 30° slope. Further analysis was performed with differential spacing of anchorage system and with different slope angles. The results are given in Table 1. With anchored geosynthetic reinforcement, the factor of safety increases for all the slope models. Fig. 2 shows a typical anchored geosynthetic scope system. For initial tests, all the analyses were performed under dry conditions. Further, it is proposed to conduct the performance of anchored geosynthetic slopes subjected to rainfall conditions. The proposed work will be performed experimentally and will be validated using numerical studies. Finally, design and installation procedures for anchored geosynthetics for slope stability will be established.

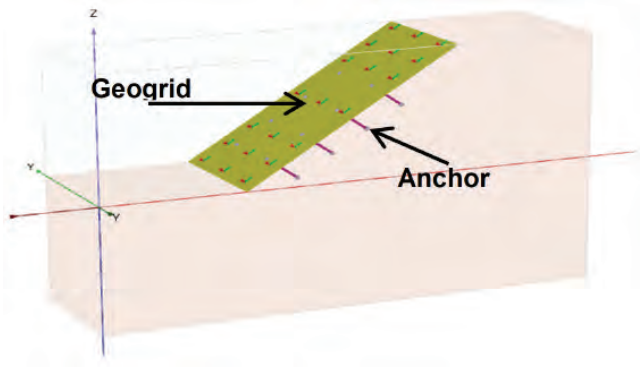


Fig. 2: Anchored Geo-Synthetic Slope

Table 1: Material Property & Test Results

Material	Property	Values	
Geosynthetics	EA	500 kN/m	
Anchor	EA	6.5×10^5 kN	
Anchor length	L	5 m	
Anchor Installation angle	degree	45°	
	Factor of Safety		
Slope Angle	Unreinforced Slope	c/c – 2.5 m	c/c – 5 m
33°	1.12	1.57	1.43
45°	1.10	1.49	1.39
60°	1.08	1.44	1.33

Seismic Active Earth Thrust on Rigid Retaining Wall using Strain Dependent Dynamic Properties

An analytical model is being developed for the evaluation of seismic active earth pressures on rigid retaining wall that satisfies the boundary condition and overcomes the shortcomings of the earlier theory. The methodology is applied for a retaining wall resting on sand. Consider a vertical rigid retaining wall with cohesionless backfill and foundation soil as shown in Fig. 3. Governing differential equation of vertically

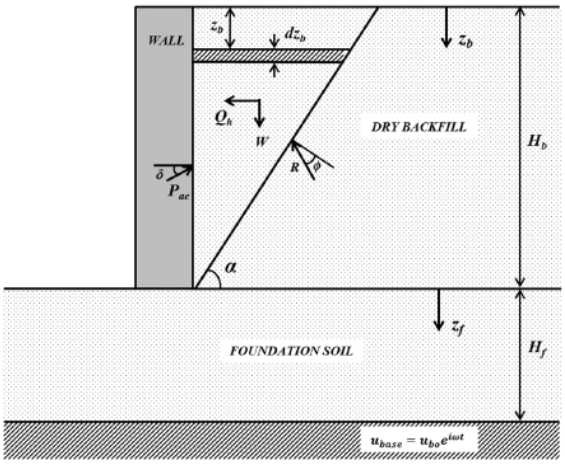


Fig. 3: Model Retaining Wall with the Forces acting on Soil Wedge

propagating shear wave in visco-elastic medium is solved by maintaining the displacement continuity and stress compatibility at the interface between backfill and foundation soil. In Fig. 4 the amplification ratios obtained from the present method are compared with the dynamic centrifuge experiment data of Jo et al. (2017) for different values of kh. Acceleration distribution in the foundation and backfill soil is consistent with dynamic centrifuge experimental results available in literature. For certain combination of input parameters, present method gives higher values of seismic active thrust as compared to other available methodologies. The estimated acceleration distribution from the present study is accurate and comprehensive for design purpose.

Landslide Control Measures

Soil nailing as a possible measure to control sliding on the uphill part of the newly constructed Greenfield Airport at Pakyong, Sikkim has been designed (Fig. 5). In-situ reinforcement by soil nailing was adopted to increase the factor of safety of the slope keeping long term stability and importance of the stability of the slope in smooth and effective functioning of the airport. The factor of safety of the slope improved substantially after nail reinforcement.

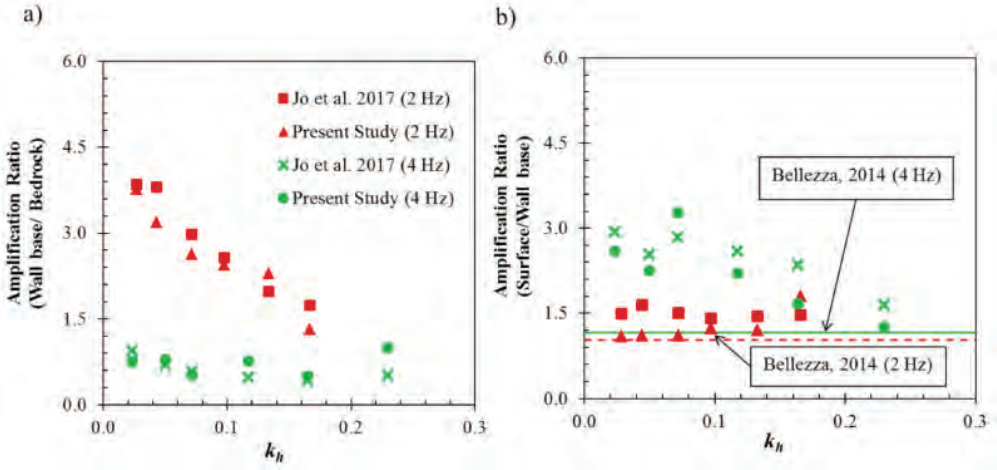


Fig. 4: Comparison of Present Method with the Centrifuge Experiment of Jo et al. (2017); (a) Amplification Ratios (Wall Base/Bedrock); (b) Amplification Ratios (Surface/Wall Base) for the Input Frequencies of 2 & 4 Hz.

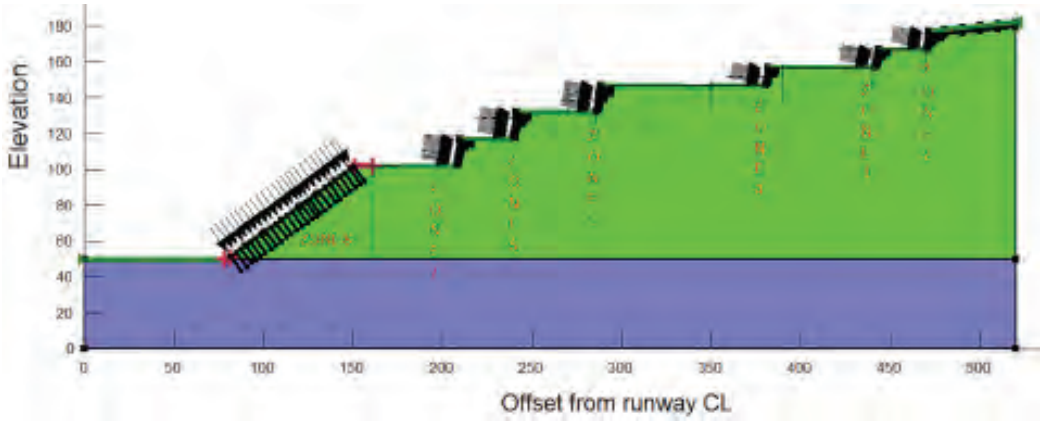
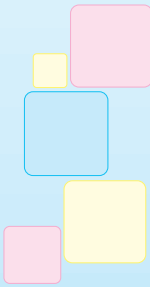


Fig. 5: Soil Nail Reinforcement at Different Zone of the Slope



Building Process & Automation

- **Development of Mobile Sensing Device for Complex Working Environment of Civil Structures**
- **Seismic Performance Enhancement of Buildings using Smart Base Isolation**

Development of Mobile Sensing Device for Complex Working Environment of Civil Structures

Ravindra Singh Bisht, S.K. Panigrahi & Team

Currently, nondestructive testing (NDT) of civil structures is mostly performed manually. Direct access to remote locations of these structures is often difficult and expensive for human operators. They have to use conventional inspection methods by using complex access devices to reach remote locations. Conventional inspection technique requires installing a number of sensors on the civil structure to be monitored. This requires huge instrumentation in order to acquire data to the remote control station for monitoring. On the other hand, mobile sensing techniques can move and manipulate with these sensors to various locations even in unreachable locations of structures in a cost-effective manner by reducing number of sensors. This will lower the required instrumentation cost for structural monitoring.

Mobile sensing techniques for routine inspection along confined, complex and hard-to-reach locations of civil structures have the potential to detect internal and external infrastructure cracks, corrosion and damage using advanced sensors. This can provide more information to inspectors and agency decision makers to improve safety of habitants and asset management in various ways. Mobile sensing techniques in structural health assessment can also reduce workplace injuries by accessing areas of the infrastructure that put even highly trained inspectors at risk. In the proposed project, the mobile sensing device will have a stable locomotion on complex working environment without sacrificing its holding capacity by providing enough traction force while manoevering. Development of various control strategies for stable movement of the device for safe locomotion requires further research in this area.

Objective

1. Development of mechanism and control strategies for device locomotion in complex working environment
2. Design and development of mobile sensing device
3. Field implementation by deploying both contact and non-contact based NDE sensors

Progress Highlights

- Prepared mechanical design of the proposed sensing device (mechanism and assembly design of the device) and developed wheel mechanisms for laboratory testing.
- Comprehensive experimental studies on these developed wheel mechanism have been performed and investigated.
- Developed mathematical model of the sensing device (kinematic and dynamic) under wheel locomotion and arm locomotion mode
- Developed motion control strategies of the proposed mobile sensing device under obstacle avoidance and wall-to-wall transitions situation

Seismic Performance Enhancement of Buildings using Smart Base Isolation

Soju J. Alexander, S.K. Panigrahi, R.S. Bisht, Subhash C. B. G. & Sameer

Objective

To mitigate the effect of external excitation on buildings using base isolation system incorporated with semi-active device and newly developed control algorithm.

Progress Highlights

The team is currently involved in the development of Damper Characterization facility for evaluating the dynamic characteristics of RD 8041-1. The existing shake table facility available with GE group shall be utilized as actuator for the evaluation. After discussions with BiSS, the supplier of shake table, the experiment has been planned to work under the prescribed limits of loading, stroke length and operating frequency. To mount the damper for the experiment, certain attachments are to be made which has been outsourced for fabrication.

CSIR Fast Track Translation Projects

- **Foundation System for Light Structures**
- **Building Products using Kota Stone Cutting & Slurry Waste**
- **Development of a Boring Machine Based on Trenchless Technology**

Foundation System for Light Structures

Manojit Samanta & Ajay Dwivedi

Objective

A pre-engineered foundation system with better compressive and tensile load capacity with faster erection time and minimum soil disturbance

Introduction

Foundation systems for light structures are usually isolated footing which need excavation and minimum curing period for strength gain to support the structures. The foundation system proposed for light structures (Immediate/intermediate and transit shelter for post disaster shelter, canopy structures, storage structures etc.) will be helpful to construct the foundation within hours and without any excavation. The proposed foundation scheme will minimize the excavation cost and construction time. The present developed anchors system contains openable leaf which remains close during installation, and after installation to a required depth, the leaf can be opened from the top. The advantages of the proposed foundation system is that, it requires less installation energy compare to final leaves open conditions, creates minimum disturbance to surrounding soil, easy to use in limited access sites, high water tables and installed in any weather conditions.

Progress

The conceptual foundation system is shown in Fig. 1. Fig. 1 shows a helical anchor presently design and fabricated to support the lightly loaded structures. Fig. 1(a) shows the leaves closed conditions during installation and Fig. 1(b) shows the leaves open condition after installation to a required depth. As the foundation system are installed in leave close condition, it required less installation torque. Opening of leaf after installation to desired depth increases the

(a)

(b)

(a) Leaf Close Condition during Installation (b) Leaf Open Condition after Installation
Fig. 1: Fabricated End Openable Helical Anchor

area and provide greater uplift/compressive/lateral load capacity. Various model foundation system based on the same mechanism and principle have been designed and fabricated as shown below in Fig. 2. A field pullout test setup has also been designed (Fig. 3) and fabricated to carry out pullout test of these anchor system to prove the efficacy of design. Fig. 4 shows the installation of anchors in the field. Fig. 5 shows the field pullout test of developed foundation system.

Fig. 2: Various Model Developed as Foundation System for Lightly Loaded Structure

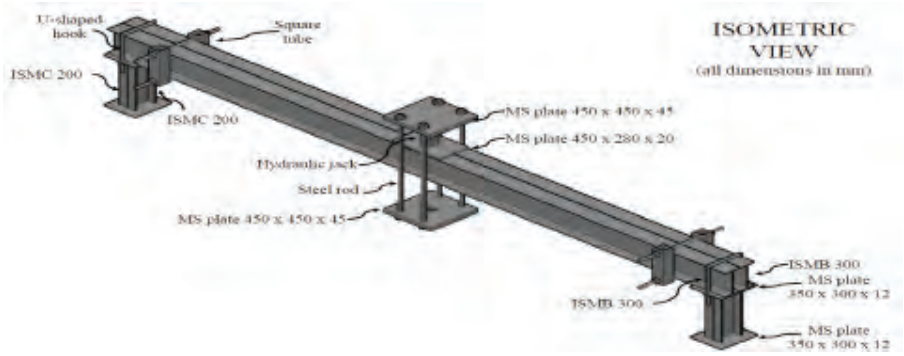


Fig. 3: Experimental Setup for Fabricated Foundation System

Fig. 4: Installation of Openable Helical Foundation System

Fig. 5: Pullout System of Openable Foundation System in Progress

Soil Properties

To assess the physical and engineering properties of the test site, field and laboratory investigation was carried out earlier which includes Dynamic cone penetration test, drilling of borehole along with SPT, UDS and DS sample collection has been reported here. Laboratory investigation was also carried out on the samples collected during field investigation.

Dynamic Cone Penetration Test (DCPT)

Dynamic cone penetration tests 6 nos. have been carried out to cover entire area of proposed sites. DCPT's were carried out as per IS: 4968 (Part-I) 1976. A steel cone of 62.5 mm diameter and 60° apex angle was attached to the bottom of the drill rod and driven into the sub-soil with the help of standard weight hammer of 63.5 kg freely falling through 75 cm. The number of blows required to penetrate cone by 15 cm were recorded. The number of blows per 30 cm penetration was designated as N_C values. The tests results thus obtained have been plotted i.e. Nc values versus depth and shown in Fig. 6.

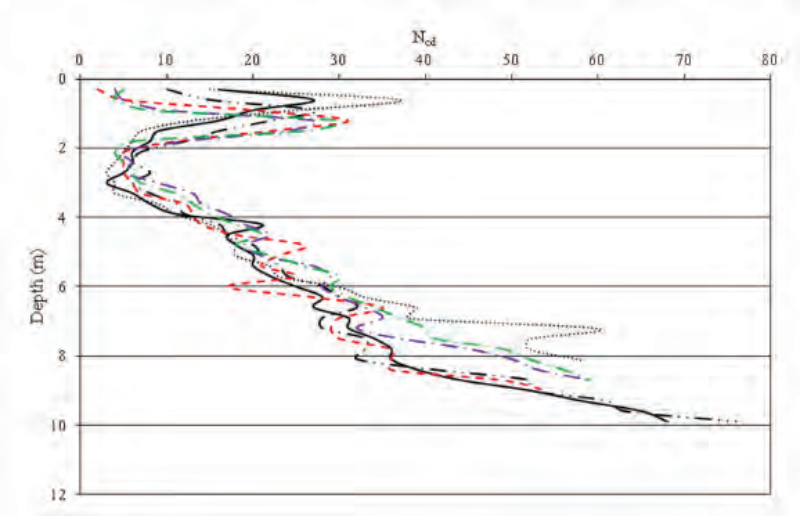


Fig. 6: Dynamic Cone Penetration Resistance vs. Depth

Standard Penetration Test (SPT)

The SPT were conducted in the boreholes at specified interval as per IS 2131-1981. The borehole was cleaned upto the desired depth, standard split spoon sampler attached to the lower end of drill rod and lowered into the borehole at location of the test. The sampler was driven penetrating 45 cm into the soil as per IS specifications and number of blows per 15 cm penetration were recorded. The number of blows for first 15 cm penetration was not taken into account. This was considered as seating drive. The number of blows for next 30 cm penetration was noted as SPT value (N-Value) and is presented in Fig. 7. The samples obtained in the SPT were collected in polythene bags with proper tagging i.e. number, depth of sample, number of borehole, its location and N-values. The collected samples were properly sealed, recorded and carefully transported for laboratory investigation.

Test Results

The designed system behaved in the same manner as envisaged. The result obtained after field experimentations show that the designed system provides better resistance than conventional system. Fig. 8 & Fig. 9 show the field experimental results. In the test results, load improvement factor has been defined as ration of load in open condition to close conditions for same displacement. Other tests i.e. efficiency in lateral load, group anchor tests, torque determination in progress.

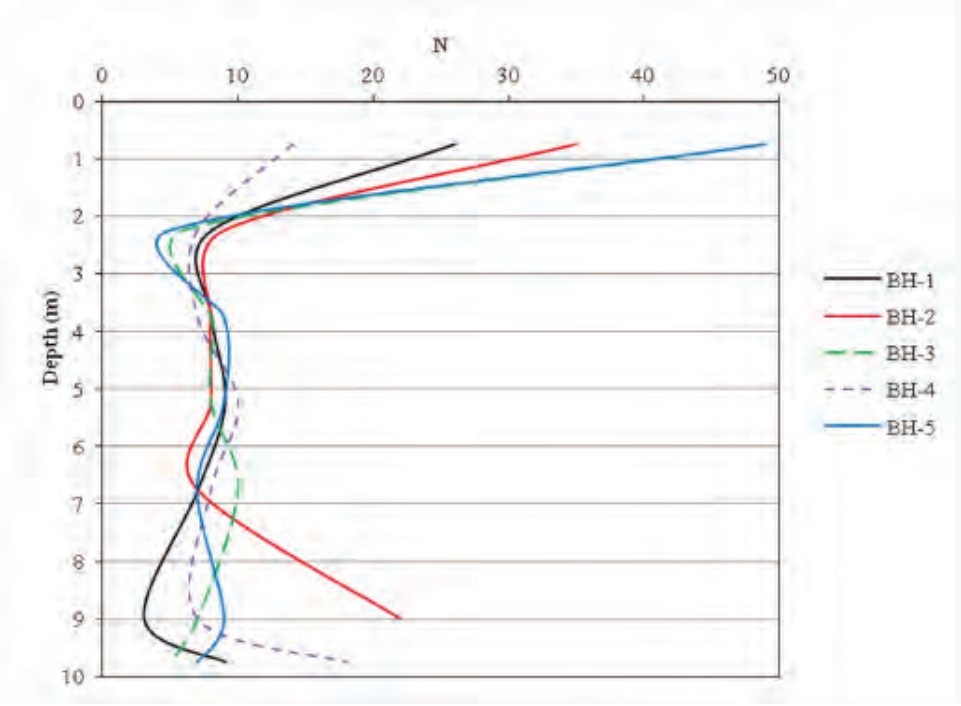


Fig. 7: Standard Penetration Test Results

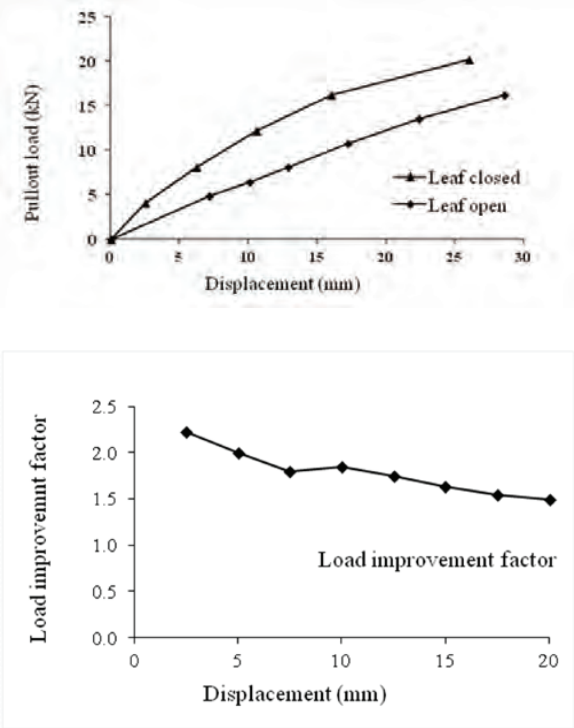


Fig. 8: (a) Experimental Pullout Displacement Test Results of 4 Leaf Anchor (b) Load Improvement Factor Vs Pullout Displacement

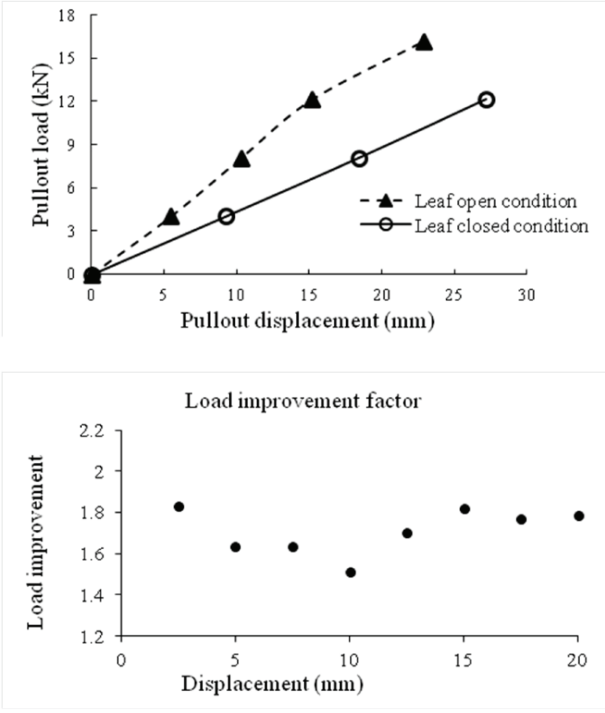


Fig. 9: (a) Experimental Pullout Displacement Test Results of 8 Leaf Anchor (b) Load Improvement Factor Vs Pullout Displacement

Building Products using Kota Stone Cutting & Slurry Waste

Rajni Lakhani, Rajesh Kumar, S.K. Panigrahi, Shahnavaz Khan & Rajat Kumar

Objective

- To develop the formulation for tiles/paver block using Kota stone cutting/slurry waste
- To develop the formulation for Light weight Blocks and its optimization
- Scale up of the developed process up to pilot level

This is in continuation of the ongoing work on the utilization of Kota stone waste for the development of value added products.

The following recommended grades of paver blocks were targeted, to be used for construction of pavements having different traffic categories as per IS:15658 (Table 1).

Optimization of Mix Proportions & Results for Paving Blocks

Total 50 mix proportions and trials have been made to develop concretes paver blocks of grade M30, M35, M40 and M50. Utilization of slurry up to 50% of total inert aggregates (using mix design method as per IS: 10262) was done. Three types of curing were adopted i.e. water, moist and ambient curing. Compressive strength test set up is shown in Fig. 1.

Table 1: Recommended Grades of Paver Blocks for Different Traffic Categories

S. No.	Grade Designation of-Paver Blocks	Specified Compressive of Paver Blocks at 28 Days, N/mm^2	Traffic Category (Million standard axles)	Paver Block Thickness mm	Traffic Examples of Application
1.	M-30	30	Non-traffic (No vehicle)	50	Building premises, monument premises etc.
2.	M-35	35	Light-traffic (<0.5)	60	Pedestrian plazas, shopping complexes ramps, car parks etc.
3.	M-40	40	Medium-traffic (0.5-2.0)	80	City streets, small and medium market roads etc.
4.	M-50	50	Heavy-traffic (2.0-5.0)	100	Bus terminals, industrial complexes etc.

Fig. 1: Compressive Strength Test Set Up & Determination of Peak Load for M40 Paver Block

Some of the selected mix proportions with their 28 days compressive strength are given in Fig. 2.

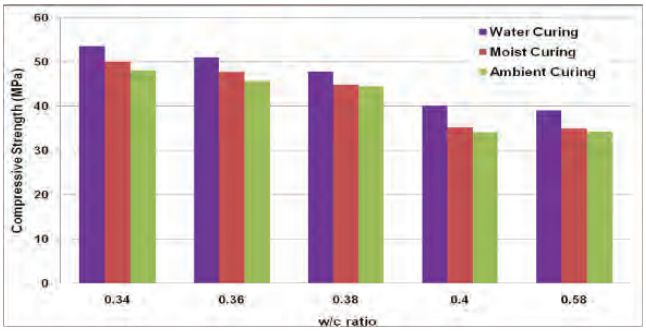


Fig. 2: Compressive Strength vs. w/c Ratio at Different Curing Conditions

Following observations were made:

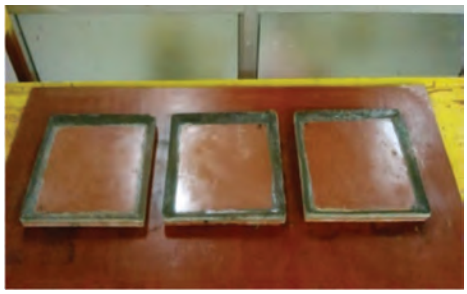
1. For M30 Grade, at 14.3% cement and w/c ratio of 0.58; CS was 39.10 MPa. While for M35 Grade at w/c ratio of 0.40 and 14.4% cement; CS was 40.11 MPa. This was due to the decreased w/c ratio, which resulted in less capillary pores in paste system. Therefore, further optimization of w/c ratios, superplasticizer and binder content are required.
2. CS_{28d} results after adding 10% Kota stone slurry, was 49.36 MPa. at w/c ratio of 0.38 and OPC content of 21.2%.
3. CS_{28d} results after adding 50% Kota stone slurry, was 22.49 MPa. at w/c ratio of 0.40 and OPC content of 15.62%.

Acid Resistance Studies of Developed Products:

Concrete is a susceptible material to acid attack. Concrete can be attacked by acids both internally and externally. The existence of different kinds of acid in the environment around the concrete causes a great reduction in the pH of the concrete, and the reaction between the acids and the hydrated and unhydrated cement finally leads to the deterioration of the concrete. The primary effect of any type of acid attack on concrete is the dissolution of the cement paste matrix. This research aimed to study the acid resistance properties of concrete paving block and tiles samples (Fig. 3(a)). The concentration of the acid solution

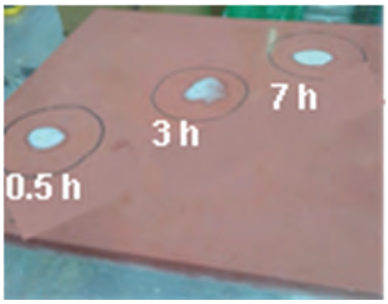
was kept constant at 5% (pH: 1.5-1.75) as shown in Fig. 3(b). Sulphuric acid and hydrochloric acid attack tests were conducted on hardened concrete samples up to 7 h (Fig. 3(c)). Three samples were immersed in sulphuric and hydrochloric acid solution for 7 h at a temperature of 23 ± 2°C (Fig. 3(d)). Thereafter, the samples were taken out and assessed visually. Also, flexural strength of specimens was measured. After leaving specimens in the oven at 100°C for 24 h, the samples were weighed to measure the mass loss.

After visual inspection; it was found that after 0.5, 3 and 7 h; no scar to mild white scar was observed (Fig. 3(e) & Fig. 3(f)). However, after drying the specimen; mild white scar was disappeared (Fig. 3(g)) and flexural strength set up as shown in Fig. 3(h).

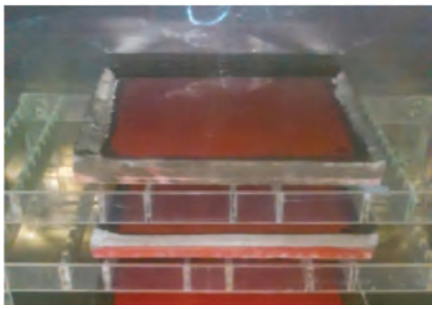


(a) Preparation of Concrete Specimen

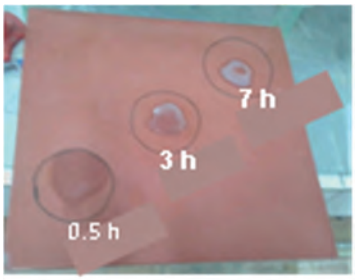
(b) Adjustment of pH using Digital pH Meter



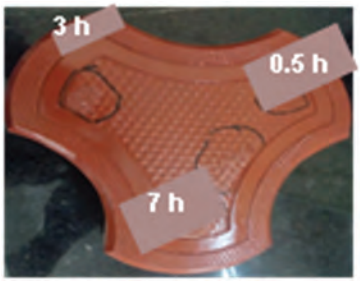
(c) Placing of Sulphuric/ Hydrochloric Acid



(d) Placement of Specimens in the Chamber at 23 ± 2°C

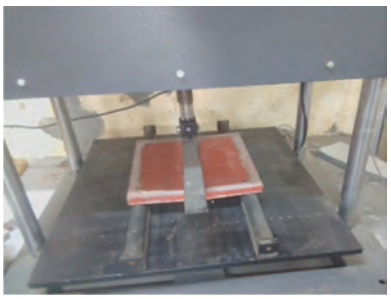


(e) Tile Specimen up to 7 h



(f) Paver Block up to 7 h

(g) Tile after drying in Ambient Condition after 7 h



(h) Flexural Strength Test Set Up for Dried Tile Sample

Fig. 3: Set up to Observe the Effect of Acid on Concrete Tiles

Flexural Strength Test & Weight Loss

The strength loss of various specimens was calculated by using the Equation 1.

$$\text{Strength loss} = \frac{(S1-S2)X100}{S1} \quad (1)$$

Where, S1= Strength of specimen cured in tap water

S2 = Strength of specimen immerged in acidic solution

To determine the change in mass, mass of one specimen was measured from each sample before immersion in acidic solution and tap-water. After immersion in acidic solution, mass was measured.

The mass loss of specimens was calculated by using the Equation 2.

$$\text{Mass loss} = \frac{(M1-M2)X100}{M1} \quad (2)$$

Where,

M1= Mass of the specimen before immersion in acidic solution

M2= Mass of specimen after immersion in acidic solution

Developed concrete paver blocks and tiles have insignificant changes in strength and weight loss, as shown in Table 2.

Table 2: Flexural Strength & Weight Before & After Acid Treatment

Sample	Flexural Strength			Weight		
	Before	After	% Δ	Before	After	% Δ
A	4.70	4.63	-1.48	4.810	4.695	-2.30
B	5.03	4.97	-1.19	4.815	4.740	-1.55
C	4.63	4.56	-1.51	5.160	5.055	-2.03

Development of a Boring Machine Based on Trenchless Technology

S.K. Panigrahi, Narendra Kumar, R.S. Bisht & Sameer

Trenchless construction is a method of laying underground facilities without disturbing the surface structure. It limits the amount of excavation and the surface repairs needed after trenching operations. The upcoming regulations in different parts of India prohibiting the open cut installations and environmental issues encourage the trenchless construction.

Big capacity crawler mounted underground drilling rigs are available in international level costing more than 1.00 crore. In India, available imported machines are of large capacities, very costly and are being used in big projects. Therefore, the available machines are not suitable to cater the needs of small / medium class contractors engaged in building and allied construction activities.

To fulfill the requirements of construction industry as mentioned, a small-capacity boring machine capable of making horizontal bores under the ground at required depth economically and effectively has been developed at CSIR-CBRI. The machine is suitable to make bores for installation of sewer pipelines, conduits, electrical cables, water lines, other transmission products under the buildings, roads and allied constructions.

Fig. 1: Developed Boring Machine on Working

The salient features of the developed boring machine are as follows:

Boring diameter	:	Up to 160 mm
Boring length	:	Up to 14.0 m
Depth of Boring	:	Up to 1.0 m (under surface)
Required Pit Size	:	1m X 0.75m
Power requirement	:	3 HP

The license for its commercialization has been transferred to M/s. Techno Industrial Marketing, Kashipur.

R&D Projects

- **Manufactured Sand-An Alternative to Natural River Sand**
- **Characterization & Development of Lime Based Hemp Concrete**
- **Recycling of Silt from Storm Water Drains, Sludge from Water Treatment Plant/Sewage Treatment Plant & Ash from Waste to Energy Plant in to Useful Products**
- **Deformation & Slip Surface Studies of Narendra Nagar Landslide Area based on Geotechnical Investigations & Instrumentation Monitoring**
- **Rural Housing for Panchayti Raj Odisha**
- **Rural Housing under PMAY-G**
- **An Integrated & Collaborative India-US Research Program: Improving Building Energy Efficiency (IBEE)**
- **Indo-UK Project: Zero Peak Energy Building Design in India (ZED-i)**
- **Slope Stability Assessment & Remedial Measures for Tungnath Temple, District Rudraprayag, Uttarakhand**
- **Performance of Basalt Fibre Reinforced Concrete**
- **Capacity Enhancement Programme on Fly Ash Utilization**
- **Burning Behaviour of Various Materials in Enclosure Fires- Development of Evacuation Strategies for Fire Affected up to Four Storeys Row Buildings**

Manufactured Sand-An Alternative to Natural River Sand

S.K. Singh & S.K. Kirthika

Conservation of natural resources and preservation of environment is the essence of sustainable development. Boom in infrastructure development led extensive extraction of natural river sand that physically alters rivers and coastal ecosystems. In addition, stringent guidelines of National Green Tribunal (NGT) and Hon'ble Supreme Court of India have forced the construction industry to choose an alternative to river sand without compromising the quality in construction. To overcome these issues, researchers have started to explore the use of manufactured sand in construction.

Manufactured sand is fine aggregate manufactured from other than natural sources, by processing materials, using thermal or other process such as separation, washing, crushing and scrubbing. It can be classified as natural crushed rock sand (CRS), recycled fine aggregates (RFA) and industrial by-products. These sands can be used either full or partial replacement of natural sand in construction. It is cost effective and eco-friendly solution. A schematic representation of benefits of the manufactured sand over the natural sand is shown in the Fig. 1. The natural crushed rock sand (CRS) is produced by crushing rock deposits to obtain a well-graded sand, which is generally more angular and has a rougher surface texture than naturally weathered sand particles. Diorite, metamorphic siltstone, granite, limestone, sandstone, feldspathic quartzite etc. are some of the parent rock that is used for CRS production. The properties of crushed rock manufactured sand depends on their lithological character, composition and production process. Recycled fine aggregates, produced from the re-processing of C&D waste can be used in concrete. Recycled brick fine aggregate, recycled glass fine aggregate, recycled bitumen aggregate etc. are some other major used recycled fine aggregate. Large-scale recycling of demolished concrete will contribute not only to the solution of a growing waste disposal problem, it will also help in conserve natural sand. Researchers have also reported on utilization of industrial by-products such as blast furnace slag, waste foundry sand (WFS), coal bottom ash (CBA), cement kiln dust (CKD) and wood ash (WA) as fine aggregate in concrete. Indian standard, IS:383-2016, has also allowed copper slag, iron slag and steel slag as partial replacement of natural sand up to 30%. The major advantage of utilizing these industrial by-products unlike crushed rock sand, no further process is needed and it is energy saving material.

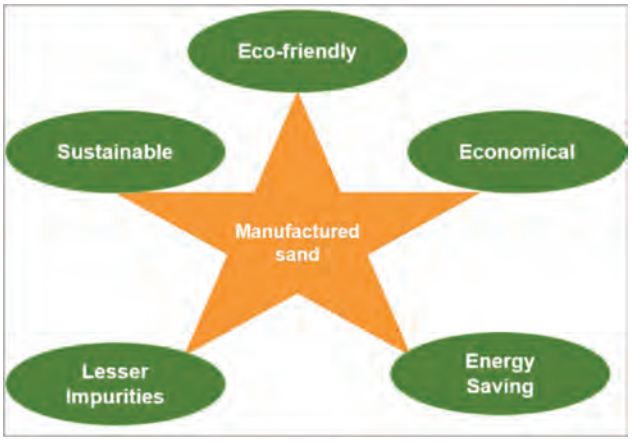


Fig. 1: Benefits of Manufactured Sand

In this regard, CSIR-CBRI has initiated a project on "Studies on Manufactured Fine Aggregate as Alternative to Natural Sand for Production of Sustainable Mortar and Concrete".

Fig. 2: Schematic Production Process of CRS

An exploratory experimental investigation on natural crushed rock sand (CRS) is initiated to characterize and to compare the mechanical properties of the concrete with control having natural sand. A schematic description of production of CRS is given in the Fig. 2. It was observed that the fineness modulus of river sand was 2.31 and that of CRS was 2.60. In addition, CRS was found confirming to Zone II of IS 383:2016. Fig. 3 shows the sieve analysis graph drawn for CRS and river sand. Concrete of M30 grade was proportioned in accordance with the Indian standard IS: 10262-2009 as given in Table 1.

Compressive strength tests were carried as per IS: 516. Test results of concrete cubes (150x150x150 mm) after 3, 7 and 28 days of curing tested in Universal Testing Machine (UTM) of capacity 1000 kN and with 0.5 mm/min loading rate and shown in Fig. 4. It was found the CRS concrete have 14.08% higher strength than control concrete at age of 28 days. Flexural tensile strength or modulus of rupture of c oncrete has been determined by applying the failure load on prismatic specimen (100x100x 500 mm) after 7, 28 and 56 days of curing in UTM under four point loading and with rate of 0.5 mm/min. The flexural strength for the control concrete and CRS concrete is shown in the Fig. 5. It was observed that the flexural strength of the CRS concrete was 15% higher than the control concrete after 56 days curing.

Sand is a rudimentary material that is required for construction. Society's increasing dependence on natural sand has led to river ecosystem disruption and environmental imbalance. Thus, finding an alternative to natural sand has become a mandate not only for construction industry but also for environmental protectors. In last few years, developed countries have been maintaining their global position in production of alternative sand and its adaptations. However, it is the need of hour for developing country like India.

Table 1: Mix Proportion used for M30 Grade Concrete

Material	Cement (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)		Water (kg/m^3)	Superplasticizer Dosage (kg/m^3)
			10 mm	20 mm		
RS	380	720	729.6	486	171	1.9
CRS	380	720	729.6	486	190	0.5

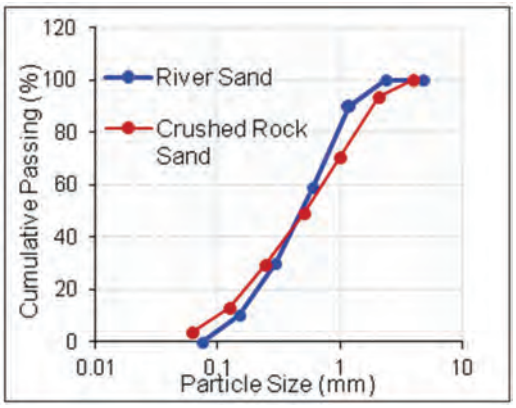


Fig. 3: Sieve Analysis of CRS & River Sand

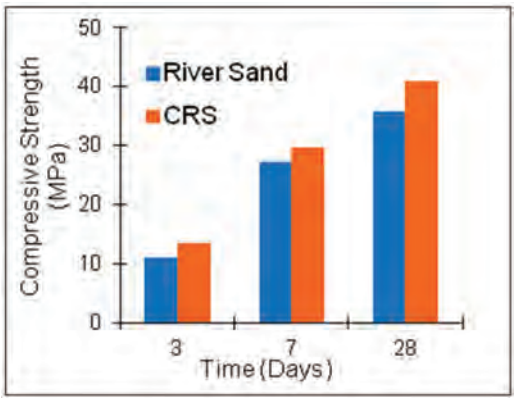


Fig. 4: Compressive Strength of Concrete with CRS & River Sand

Manufactured sand is found to be one such alternative, but lack of awareness and a kind of aversion is noted in its usage in place of natural sand. Hence, there is a need for all government bodies, construction industry, research& academics and media to work towards to common objective of promoting its use in construction by executing their specific responsibilities allied towards the objective. CSIR-CBRI is in process of collaboration with industrial partners to assess its suitability and efficacy in construction. In addition, based on the evaluations, modifications shall be suggested/ recommended for IS 383, IS 2116 and IS 1542.

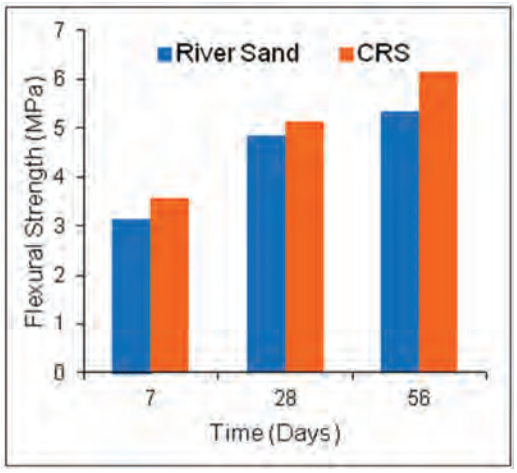


Fig. 5: Flexural Strength of Concrete with CRS & River Sand

Characterization & Development of Lime Based Hemp Concrete

S.R. Karade, L.P. Singh & Tarun Jami

Objective

- To develop a lime based concrete from the particles of the hemp plant for non-load bearing applications as a sustainable alternative for conventional materials such as bricks, AAC blocks, concrete blocks, etc.
- To develop the material into a market-ready product that shall have favorable hygrothermal behavior, low weight, carbon negativity and, adequate strength and durability
- To construct a working prototype structure

Progress Highlights

Current stage of the project is at procurement of raw materials for research and characterization studies.

With the global greenhouse gas emissions reaching the 50 billion tonnes mark, it is imperative that technologies, which are carbon negative or utilize such materials that are a result of carbon dioxide consumption, processes need to be developed and adopted rapidly to achieve the targets, set by the global leaders at the Paris Climate Accord, 2016. In construction industry that accounts for about 10% of the global emissions often looked upon as a hopeless case of carbon emissions, lies potential for not just carbon neutrality but also for carbon negativity in the form of bio-aggregate building materials. However, the construction industry is also arguably the least flexible in terms of adaptability and welcoming new technologies save for an exception in the form of hemp concrete. Hemp concrete belongs to a new age category of building materials called bio-aggregate concretes which has been steadily gaining popularity, due to the increasing acceptance of the controversial plant – hemp, also popularly known as cannabis. The Fig. 1(a) shows hemp plants grown in the wild and the Fig. 1(b) shows the leaves of a wild hemp plant.

Bio-aggregate concretes are exceptionally good for the construction industry in the carbon emissions context, since these involve the usage of biomass which are sinks for carbon dioxide. The production of biomass involves natural photosynthesis by the plants, which is a process that actively consumes carbon dioxide and storing it in the form of organic plant matter. Bio-aggregate concretes also utilize lime, which is considered to be a very low carbon footprint material for construction. With advances in the preparation of lime to match the speed and strength of Portland cements, bio-aggregate concretes are a very sustainable choice of building materials.

Studies from existing cultivations have shown that the usable biomass yield from a hemp field is about 4 times that of an average forested land, making the per unit land sequestration of carbon dioxide higher and also yielding greater amount of feedstock. This utilization of biomass in a form that does not release any sequestered carbon dioxide dovetails with a geoengineering mechanism called carbon dioxide removal (CDR), which is being put forth by researchers and political scientists to achieve the targets set at the Paris Climate Accord, 2016, thereby strengthening the stand of hemp concrete as a first choice for sustainable building materials.

The magazine Popular Mechanics had reported in the late 1930s, when the prohibition of cannabis was coming into effect, that the plant has over 25,000 applications, in a bid to prevent its prohibition. Historical evidence of hemp in construction can be dated back to over 1,500 years ago in the Ajanta Ellora Caves in India. Globally, hemp has been found in constructions in France and China. In the current times, hemp constructions are gaining popularity in the European Union, United Kingdom, United States of America, Canada, Australia, New Zealand and China. The most common variety of hemp construction is casting a hemp-lime mix around a timber frame. This application of hemp concrete is always intended to be non-load bearing, but the material does extend some mechanical support to the timber frame, thus establishing a potential for hemp concrete to be manufactured for partially load bearing applications as well. Apart from this, hempcrete blocks are being successfully used for construction in USA. Fig. 2 shows the hemp stalks and its various products useful for hemp construction.

(a) (b)

Fig. 1: (a) Hemp Plants Grown in the Wild; (b) The Hemp Leaves

Fig. 2: Various products of the (a) Hemp Stalk; (b.) Shivs with Fibre; (c) Shivs without Fibre; (d) Hemp Fibre

Besides hemp concrete, the major thrust areas for hemp are medicine, textiles and food. The commercial success of hemp concrete depends on the availability of the hemp shivs, which are a by-product of the hemp medicine, hemp textiles and hemp foods industries, which are all interconnected at some level. Considering the growing interest in hemp in India, with private investments from industry, active medicinal hemp research and the changing implementation of a hemp policy by the Uttarakhand Government, it can be concluded that a hemp industry is primed for a rapid expansion in India. Therefore, recognizing the need for a construction technology to utilize the hemp shivs that are a guaranteed byproduct from these industries, and the availability of large quantities of hemp owing to the growing number of entrepreneurs entering the hemp industry, GreenJams Infrastructures LLP sponsored a research project at CSIR–Central Building Research Institute, Roorkee for the development of hemp concrete and generation of related technical knowledge to sustainably benefit the Indian market. So far, the raw materials have been collected and experimental work on characterization and composite properties evaluation is in progress.

Recycling of Silt from Storm Water Drains, Sludge from Water Treatment Plant/Sewage Treatment Plant & Ash from Waste to Energy Plant in to useful Products

A.K. Minocha, Neeraj Jain, Soumitra Maiti & R.K. Verma

In addition to the municipal solid wastes, urban areas in Delhi generated million tonnes of various other wastes such as silt from storm water drains or nallah cleaning, sludge from municipal water/sewage treatment plant/ Industrial effluent treatment plants, ash from waste to energy plants etc. These waste get mixed up with MSW at collection or disposal points leading to many problems during their disposal. As a disposal option, landfills are also becoming increasingly expensive because of the rising costs of construction and operation. The recycling of industrial solid wastes as substitute for building materials is not only environment friendly but also cost effective alternative way to sustain a cleaner and greener environment. Therefore, a project was formulated by Department of Environment, NCT Govt. of Delhi and sponsored to CSIR-CBRI, Roorkee for utilization of these waste for development of construction materials like road paving blocks and bricks.

Development of Paver Blocks Using Bottom Ash

In Delhi there are three "Waste To Energy" (WTE) plants in Delhi for the management of municipal waste (Table 1) and bottom ash is generated as by products causing disposal problems. Samples of bottom ash were collected from M/s. East Delhi Waste Processing Company Ltd., Ghazipur and characterized for physical and chemical analysis. The results of analysis are shown in Table 2 & Table 3 respectively, which show that it can be utilized as building material. In the present studies bottom ash has been utilized as a replacement of natural fine aggregates. Mix compositions used for development of road paving blocks as per Indian Standard 15658 are given in Table 4. After 28 days of curing period, engineering properties like water absorption and compressive strength were determined of the paving block developed (Fig. 1) and results are shown in Table 5.

Table 1: Status of Waste to Energy Plants in Delhi

S. No.	Name and location of the site	Designed Capacity	Ash generated
1.	M/s Timarpur- Okhla Waste Management Company Pvt. Ltd., Okhla, Delhi	1950 MT/D (operated by JITF ECOPOLIS), 16 MW Electricity	350-400 MT/day
2.	M/s East Delhi Waste Processing Company Ltd., Ghazipur, Delhi,	1300 MT/day (operated by ILF&S), 12 MW Electricity	230-250 MT/day
3.	M/s Delhi MSW Solutions Ltd. Narela Bawana Road, Delhi	3000 MT/day (operated by Ramky Group), 24 MW Electricity	580-620 MT/day

Table 2: Physical Properties of Bottom Ashes Collected

S. No	Properties	Bottom Ash Ghazipur WTE Plant
1.	pH	10.30
2.	colour	Light grey
3.	Specific gravity	2.52
4.	Water absorption	23.74%
5.	Compact Bulk Density	1.86 g/cc
6.	LOI	5.4 %
7.	Particle size 10 mm 4.75mm 2.36mm 1.18mm 600 µm 300 µm 150 µm	Passing (%) 100 99.45 94.14 82.56 90.10 86.98 77.57
8.	Fineness modulus	1.77

Table 3: Chemical Composition of Bottom Ash

S. No.	Parameters	Values (%)
1.	SiO_2	41.18
2.	Al_2O_3	15.01
3.	Fe_2O_3	2.95
4.	CaO	24.50
5.	MgO	7.59
6.	P_2O_5	2.91
7.	Na_2O	----
8.	K_2O	3.66
9.	Cl^-	----
10.	MoO_3	0.05
11.	BaO	0.93

Table 4: Mix Proportion of Paving Blocks using Bottom Ash

Mix designations	Cement (%)	Stone dust (%)	Bottom ash (%)	Coarse aggregate (%)	Water (%)
Top Layer	33.33	66.67	----	----	9.00
A0 (Control)	**25.00**	**37.50**	**----**	**37.50**	**8.00**
A1	25.00	18.75	18.75	37.50	10.60
A2	25.00	15.00	22.50	37.50	10.90
A3	25.00	11.25	26.25	37.50	11.20
A4	25.00	7.50	30.00	37.50	11.50
A5	25.00	3.75	33.75	37.50	11.80
A6	25.00	----	37.50	37.50	12.00
B0 (Control)	**22.25**	**33.25**	**----**	**44.50**	**7.5**
B1	22.50	16.63	16.62	44.00	9.60
B2	22.50	13.30	19.95	44.00	10.00
B3	22.50	10.00	23.25	44.50	10.50
C0 (Control)	**20.00**	**30.00**	**----**	**50.00**	**7.0**
C1	20.00	15.00	15.00	50.00	8.75
C2	20.00	12.00	18.00	50.00	9.25
C3	20.00	9.00	21.00	50.00	9.75
D1	15.00	17.50	17.50	50.00	8.75
D2	10.00	20.00	20.00	50.00	8.75

Fig. 1: Road Paving Blocks Developed using Bottom Ash

Table 5: Physical & Mechanical Properties of Paving Blocks

Mix designations	Water absorption (%)	Compressive strength (MPa)	Remark
A0 (Control)	**2.0**	**62.50**	
A1	2.80	46.60	Recommended
A2	3.75	42.50	Recommended
A3	3.75	42.00	Recommended
A4	3.75	41.60	Recommended
A5	3.80	41.10	Recommended
A6	4.00	40.00	Recommended
			Recommended
B0 (Control)	**2.80**	**50.50**	
B1	2.90	45.20	Recommended
B2	3.50	42.00	Recommended
B3	3.75	40.00	Recommended
C0 (Control)	**3.20**	**45.00**	
C1	3.50	42.00	Recommended
C2	3.80	40.20	Recommended
C3	4.30	38.50	Recommended
D1	4.20	36.80	Recommended
D2	4.80	27.00	Recommended

Observations

After receiving the results of blocks and bricks development utilizing bottom ash, following observations were made:

1. It is observed that with increase in bottom ash composition as a replacement of stone dust (50-100 %), compressive strength decreases in the development of blocks.

2. Bottom ash was used 15-37.50 % of the total mix with various cement dose (10-25 %) in the development of blocks. All the mixes (A1-A6, B1-B3, C1-C3 and D1-D2) are recommended for development of blocks as strength is more than 20 MPa in each case and water absorption is less than 6.0 % as per IS: 15658. Maximum strength of 46.60 MPa was observed with A1 mix having 18.75 % of bottom ash and 25.0 % of cement.
3. TCLP studies are not required as no hazardous heavy element is present in the chemical composition and product can be used in fields.

Deformation & Slip Surface Studies of Narendra Nagar Landslide Area based on Geotechnical Investigations & Instrumentation Monitoring

R. Dharmaraju, S.K. Negi & Ashish Pippal

Objectives

- Instrumentation and monitoring of surface and subsurface movements of the slide area.
- Evaluation of geotechnical parameters based on disturbed/undisturbed/ borelogs soil/rocks samples collected from different horizons.
- Assessment of traffic vibration and deep-seated movement using micro seismic sensors for landslide warning.
- Slope stability analysis and development of the suitable model for slope failure based on the rainfall patter.

Introduction

The Himalayan terrain is prone to landslides due to its adverse geological framework, physiographic condition, seismicity (Zone-IV and V), intense rainfall, deforestation and anthropogenic activities. In Uttarakhand, landslides are commonly occurring natural hazards in all districts except the flat lying area covered by younger alluvium. The landslides are active because they vary in extent, scale, activity and occurs over time due to environmental changes and human encroachment. Every year occurrence of landslides are accountable for the huge loss of lives and properties, therefore, the early warning system (EWS) will prove to be an efficient tool for preventing and mitigating the risks associated with landslides occurrence.

Defence Terrain Research Laboratory, Delhi (DTRL) has taken up a research project on 'Development of Early Warning System for Landslides by Integration of Different Technologies and its Forecasting Mechanism' (DEWSLIT-FM) and has entered into collaboration with Central Building research Institute, Roorkee for the study of Narendra Nagar landslides near Rishikesh in Uttarakhand. CSIR-CBRI has taken-up a sub-project entitled "Deformation and Slip Surface Studies of Narendra Nagar Landslide area based on Geotechnical Investigations and Instrumentation Monitoring" on the request of DTRL, New Delhi under CARS. This collaborative project aims to understand the surface and subsurface movements in different climatic conditions based on the geotechnical parameters, instrumentation monitoring and to establish the Early Warning System (EWS) on real-time based on the instrumental data of in-situ sensors.

Present Status

A thorough understanding of the behavior and mechanism of the problematic landslide sites are very essential for establishing early warning system and the evaluation of control measures for stabilization of the landslide area (Fig. 1). The detailed field investigation on geological, geomorphological, hydrological and laboratory assessment for geotechnical parameters

of soil/rocks mass of the slide area reveals the site conditions. In addition to this, instrumentation and monitoring gives the surface and subsurface movements of the slide area. The brief details of the studies conducted on account of geotechnical, instrumentation and monitoring of Narendra Nagar site have been elaborated in this report.

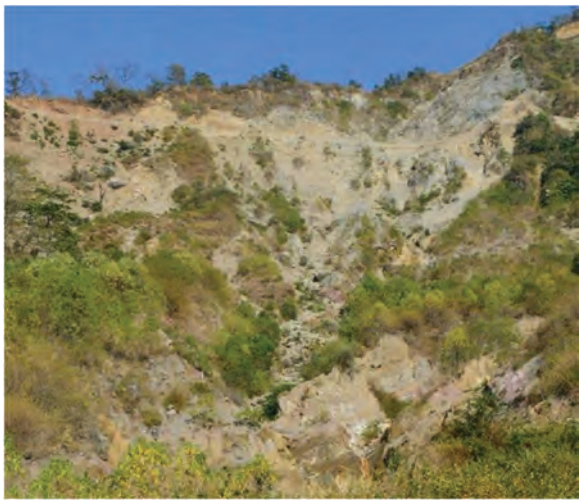


Fig. 1: View of Narendra Nagar Slide Area

- A detailed survey on slope morphology, rocks exposed areas, micro sliding zones, drainage pattern, vegetation cover and debris accumulation zones etc. have been studied considering the different base maps prepared by the Geological Survey of India for establishing the monitoring of surface movement.
- A scheme of instrumentation and monitoring setup has been designed and installed about 120 steel markers and constructed 06 permanent benchmarks in the landslide site (Fig. 2) for recording the periodical observations using the Total Station to assess the potential areas of surface movement within the landslide area. Three sets of

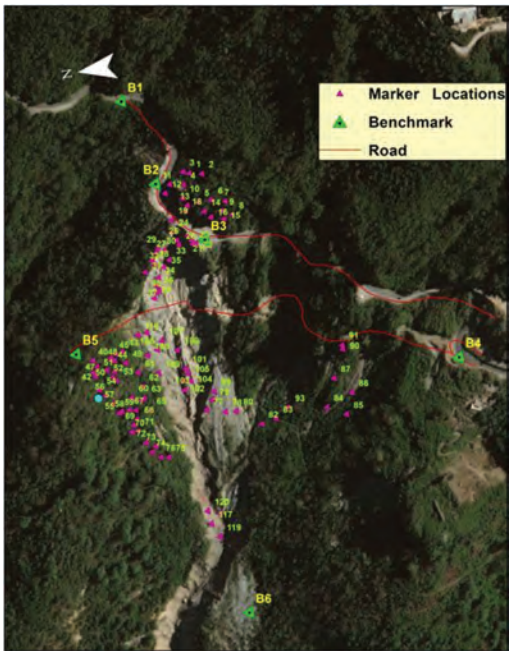


Fig. 2: Locations of Steel Markers (On Arc GIS Word Imagery)

observations of steel makers from the different permanent benchmarks have been recorded in the first week of January, February & March 2018 with the help of Total Station instrument.

- Further, it is proposed to take all these parameters repeatedly on 1st week of every month, so that after collecting sufficient data sets and seasonal observations will help in assessing the surface deformation within the landslide area. Also, undisturbed soil/rock samples have been collected at different locations for the evaluation of geotechnical parameters responsible sliding phenomenon.

Rural Housing for Panchayti Raj Odisha

S.K. Negi, R. Dharmaraju & Swati Kulashri

Technical Assistance, Support & Guidance to Panchayti Raj Department Odisha for the Implementation of Rural Housing Programmes

Objective

- To develop architectural design with alternative technologies improving upon conventional designs of PMAY-G, Biju Pucca Ghar Yojna and other rural housing schemes implemented by Odisha Govt.
- To train and demonstrate the technical staff of Panchayati Raj Department, go up on use of various sustainable alternative materials and technologies for better implementation of schemes qualitative and quantitatively.
- To provide practical guidance to execution, construction supervisory staff during the period of construction in Bhubaneswar and on selected sites.

Introduction

Govt. of Odisha is committed to convert all the kutcha houses (Fig. 1) to pucca houses by the year 2019. With a view to achieve this objective, the state government has launched its own flagship programme "Biju Pucca Ghar Yojna".

The Odisha Govt. has constructed 10 lakh Pucca houses under various rural housing schemes in the past two years. Odisha has become a role model for other states and bagged several awards of excellence in rural housing sector.

CSIR- Central Building Research Institute (CSIR-CBRI), Roorkee was approached by PR Department to provide technical assistance, support and guidance on housing designs and to suggest improvements based on Institute's vast research experience in areas like economy, design, material, energy efficiency, comfort, safety against disasters etc. In the past CSIR-CBRI had been associated with Odisha Housing Board in the design and construction of thousands of houses under Kalinga Kutir Programme and establishment of chain of building centers.

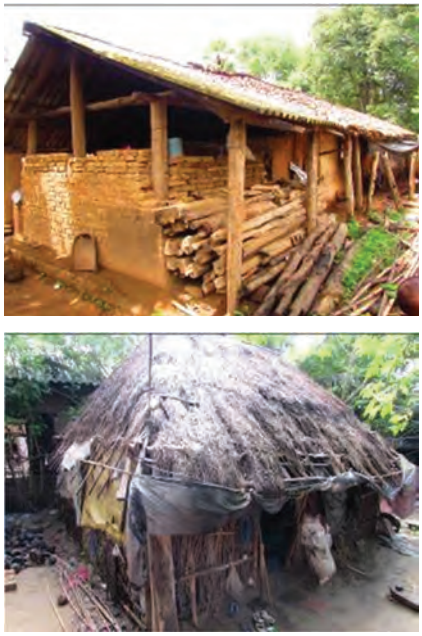


Fig. 1: Existing Kutcha Houses in Odisha

Scope

- To study various designs of housing typologies from different regions of Odisha developed by the State Government and other agencies and to suggest appropriate affordable building materials

and technologies for overall improvement in the construction cost, functional efficiency, comfort, energy efficiency and durability against prevalent natural disasters like cyclones, floods, earth quakes etc., by the use of possible alternate and local materials.

- To provide architectural, structural drawings and necessary technical details and support as per the requirements of the State Government for the specific area or problem.
- To train stakeholders involved in implementation of Rural Housing schemes in the training programs organized by CBRI.
- To visit construction sites during the project period for providing on-site training-cum-guidance on execution and construction to supervisory staff.
- To provide technical support to CBOs/ Entrepreneurs willing to manufacture alternative affordable building components and materials which are considered useful and feasible for the specific regions of the Odisha state.

Deliverables

- To develop architectural designs with alternative affordable and locally built materials and technologies improving upon the conventional designs of PMAY-G, Biju Pucca Ghar Yojana (BPGY) and other Rural Housing Schemes implemented by Odisha Government (Fig. 2).
- To train and demonstrate the uses of various sustainable alternative affordable materials and technologies for better implementation of Rural Housing Schemes qualitative and quantitatively.
- To provide practical guidelines regarding execution and construction to supervisory staff during the period of training and construction on selected sites.
- Currently the team has had several training programs for the technical and administrative staff of PR department.
- The team is also in the process of developing a rural technology park in Bhubaneswar with the compliance of state government for efficient dissemination of rural technologies relevant to all districts of Odisha (Fig. 3).

Envisioned Outcomes

- Mass adaptability of rural housing designs suggested and developed by CSIR – CBRI in the state of Odisha.
- Dissemination of appropriate region specific rural housing technologies at grass root level.

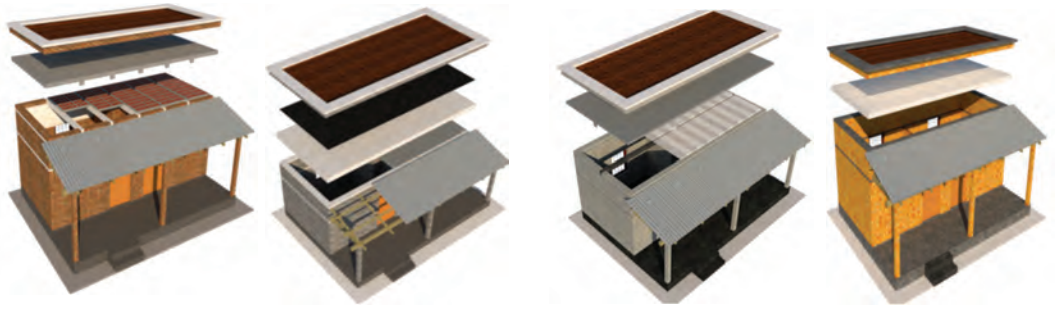


Fig. 2: Technologies Suggested Based on the Various Locally Available Materials in Odisha

Fig. 3: Layout Plan/Construction Stage of Demonstration Houses at SIRD Campus Bhubaneswar

Rural Housing under PMAY-G

S.K. Negi, R. Dharmaraju & Swati Kulashri

Design & Development of Rural Housing Typologies for Thirteen States under PMAY-G

Objective

To develop designs by suggesting appropriate building techniques and construction technologies as S&T interventions to make houses more durable, resistant to natural disasters and comfortable to live in using locally available materials and skills within the financial assistance provided under PMAY-G across 13 states of India.

Introduction

The rural population account for nearly 68.33 percent of the country's total population and are the backbone of the country's economy. However, the quality of rural housing as also the volume of rural housing shortage in the country is emerging as a critical and unique challenge considering the varied dimensions of the rural landscape and lifestyle. As per the working group on rural housing for the 12th five year plan, the total housing shortage in rural areas is estimated at 43.67 million units. A full-fledged rural housing program Indira Awaas Yojana (IAY) was launched in June, 1985. There still exists a huge gap in rural housing scenario in view of the limited scope of coverage under the scheme.

To address the gap in rural housing and in view of Governments' commitment to provide "Housing for All" by 2022, the scheme of IAY has been re-structured into Pradhan Mantri Awaas Yojana – Gramin (PMAY-G) w.e.f. 1st April, 2016.

While ensuring quality of the houses it also focus on the basic amenities such as access to drinking water, toilets, electrification and general sanitation.

CSIR- Central Building Research Institute (CSIR-CBRI), Roorkee was approached by MoRD & UNDP to provide technical assistance, support and guidance on housing designs prepared by the various agencies under PMAY-G and to suggest improvements based on Institute's vast research experience in areas like economy, design, material, energy efficiency, comfort, safety against disasters etc.

Envisaged Deliverables

- Review of plans submitted by UNDP in terms of architectural and structural validation of drawings
- Development of housing designs with appropriate rural technologies and construction techniques
- Suggesting alternatives using locally available materials
- Suggesting technologies developed by CSIR CBRI for mass applicability
- Detailed Rural housing report for 13 states of India.

Design

Over 130 housing designs have been reviewed to meet the provisions of National Building Code (NBC) where ever needed regarding dimensions of spaces, ceiling heights, fenestration, thermal comfort and anthropometric requirements maintaining the original design.

Developed details of over 130 housing typologies for 13 states (floor plans, sections, elevations &w building details) along with the suggested specifications for foundations and super structure (walling, roofing, flooring, joinery) for the suitable zones/districts.

Fig. 1: Digital Prototype for Chhattisgarh

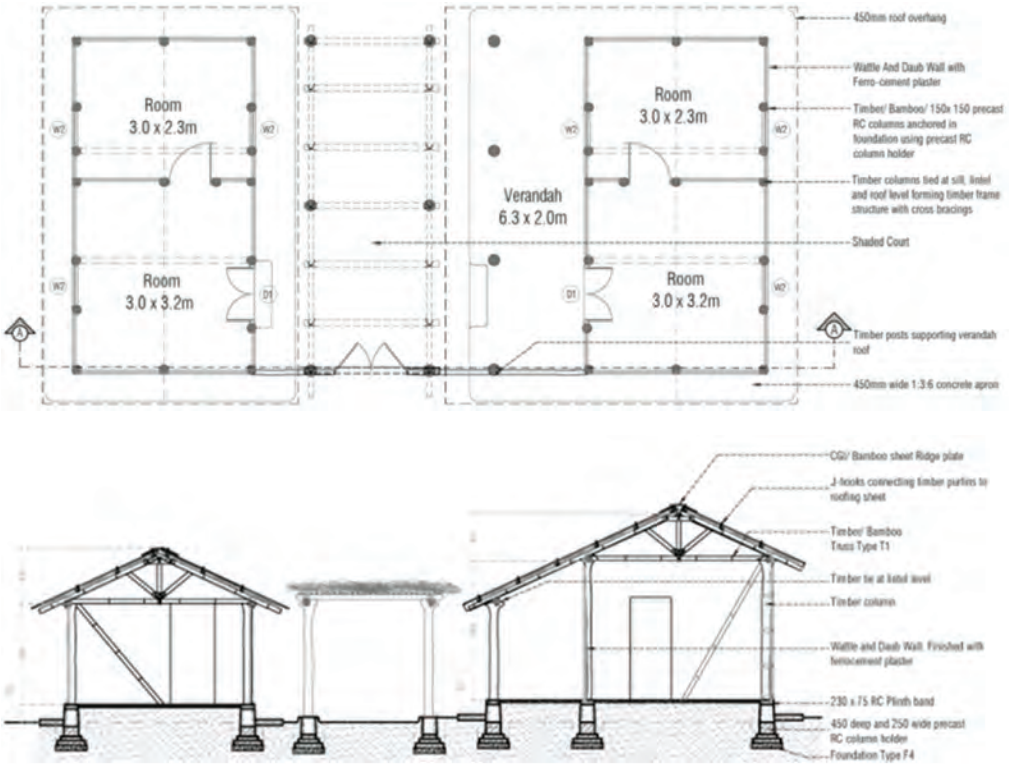


Fig. 2: A Prototype detailing for Zone A- Chhattisgarh

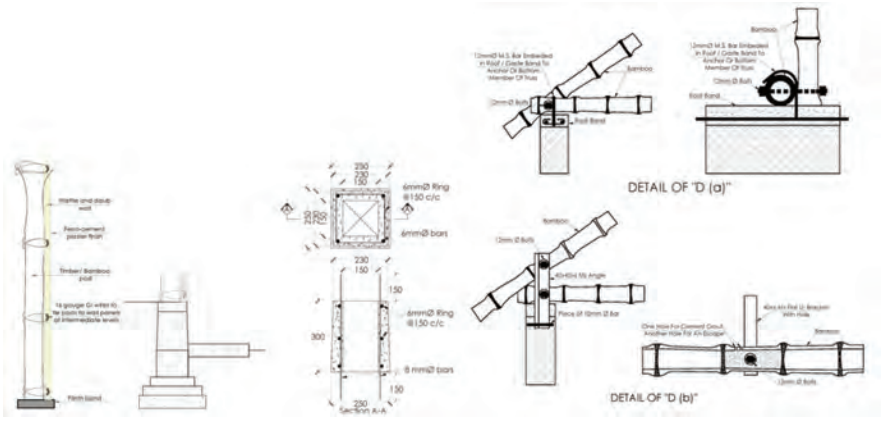


Fig. 3: Proposed Fixing & Jointing Details

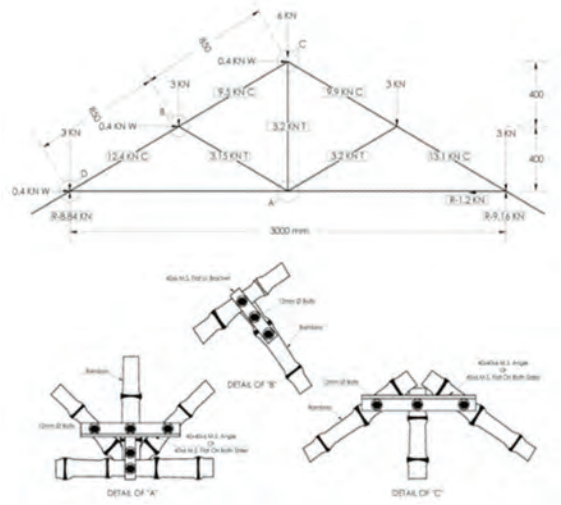


Fig. 4: Typical Bamboo Truss Details

Deliverables

Development of architectural, structural designs, construction details and disaster resilient technologies for over 150 rural typologies in 13 states across India covering Assam, Bihar, Chhattisgarh, Jharkhand, Maharashtra, Madhya Pradesh, Manipur, Meghalaya, Odisha, Sikkim, Tripura, Uttar Pradesh and West Bengal.

Salient Features

The following techniques have been incorporated in the designs which were found appropriate to reduce cost and time of construction, and to improve durability, safety and living comfort;

1. Stone Masonry Blocks*
2. Solid Concrete Blocks*
3. RC Plank and RC Joist roof*
4. Brick Panel and RC Joist*
5. Precast Channel Unit roof*
6. C-bricks*
7. Confined Masonry*
8. L Panels*
9. Pyramidal roofing*
10. Under reamed piles*
11. Nail jointed trusses*
12. Protection of mud walls*
13. Two pit latrine systems*
14. Waste water disposal system*
15. Rat-trap Bond
16. Ferro-cement Channels
17. MCR Roofing tiles
18. CSMB blocks

*Technologies developed by CSIR-CBRI

The typical detailing on prototype, fixing & jointing, Bamboo truss of Chhattisgarh is given in Fig. 1, Fig. 2, Fig. 3 & Fig. 4.

Envisioned Outcomes

- Mass adaptability of rural housing designs suggested and developed by CSIR CBRI.
- Knowledge proliferation by detailed State wise Rural housing report developed by CSIR-CBRI.

An Integrated & Collaborative India-US Research Program: Improving Building Energy Efficiency (IBEE)

Ashok Kumar (PI), N. Gopalakrishnan, S.K. Negi, Nagesh B. Balam, L.P. Singh, Rajni Lakhani, Anuj Kumar, Kishor Kulkarni, Sayantani Lala, Tabish Alam, Chandan Swaroop, Navjeev Saxena, Rajesh Deoliya, Srinivasrao Naik, Rajesh Kumar, Kshitij Jain, Akanksha Singh, Neha Goyal, Baldev Krishan, Neha Rawat & Team

Objectives

- Development of Low-energy Design Guides for Commercial Buildings in Indian Climatic Zones.
- Modular Thermally Activated Solar Cooling and Ventilation Systems.
- Identification, Study and Development of Building Materials, Novel Insulation Systems and Components.

Progress Highlights

- Energy Efficient Lighting Systems in Commercial Buildings.
- Technology integrated design and construction of an energy efficient demonstration building.
- Develop Technology Transfer, Training and Sensitivity Plans for Generating Awareness on Energy Efficient Buildings.

Activity	Highlights of the Progress
Development of Low-Energy Design Guides for Commercial Buildings in Indian Climatic Zones (Ashok Kumar, Kishor Kulkarni, Sayantani Lala, Kshitij Jain & Team)	• Conducted statistical analysis of the climatic data of 425 stations for last 50 years (1960-2010) collected from IMD, Pune. • Map the historic data of IMD and compared with existing climate data handbook of CSIR-CBRI. • Conducted statistical grouping of cities as per NBC and Koppen climate zones and analysed the impact on building performance. • Carried out cluster analysis, criteria for climate zoning and thermal performance criteria based on the revised climate zones.
Development of Solar Thermal Air Conditioner (Nagesh B. Balam, Tabish Alam, Chandan Swaroop & Team)	• Fabricated 4 prototypes of vacuum type solar collector • Fabrication of Double glazed high temperature solar collector in progress. • Silica gel type Desiccant wheel is fabricated • An environmental simulator test setup created to test the performance of desiccant cooling system is fabricated

Activity	Highlights of the Progress
Development of Phase Change Material & Its Incorporation in Building Components (L.P. Singh, Srinivasrao Naik & Team)	• Microencapsulated Phase Change Material (MPCM) has been prepared by in-situ polymerization technique. • Thermo-physical characteristics of MPCM have been determined. • Compressive strength and thermal conductivity of MPCM Mortar have been determined
Development of Cost Effective & Durable Masonry Blocks having High Thermal Insulation Properties using Industrial / Agro Industrial Waste (Rajni Lakhani, Rajesh Kumar, Neha Rawat & Team)	• Raw materials used in this study were Light Expanded Clay Aggregate (LECA) of different sizes 0 - 2, 2 – 8 and 8 – 15mm. These aggregates were purchased from Ahmedabad and used for the experimental work after physico-chemical characterization. The characterization of the aggregates includes particle size distribution, specific gravity, water absorption, bulk density, aggregate crushing value, fineness modulus and moisture content test as per IS 2386 (Part 1, 3 and 4) - 1963 and IS 383 -1970. • The sieve analysis, grading curve and fineness modulus of three different sizes of LECA were measured in which different proportions of LECA content were taken for the experiment. • The bulk density of an aggregate is affected by several factors including the amount of moisture present etc. The loose bulk density of LECA was 580kg/m^3, 430kg/m^3 and 390kg/m^3 for 0-2mm, 2-8mm and 8-15mm aggregates, respectively. • The specific gravity of three different sizes of LECA varied from 0.8, 0.6 and 0.7 for 0-2mm, 2-8mm and 8-15mm aggregates, respectively. The water absorption ratio, referred to the oven-dried aggregates; was 61% for 0-2mm, 30% for 2-8mm and 25% for 8-15mm sizes of LECA aggregates. Further studies are under progress to make energy efficient building components.
Energy Efficient Lighting Systems in Commercial Buildings (Anuj Kumar, Ashok Kumar, Nagesh B. Balam, Abhishek Singh, Kshitij Jain & Team)	• Prepared state of the art report on daylighting and energy efficient lighting systems in commercial buildings. • Based on the existing knowledge available in the public domain, developed an Android App for integrating daylight with artificial lighting for buildings in all climates of India.
Develop Technology Transfer, Training and Sensitivity Plans for Generating Awareness on Energy Efficient Buildings (Ashok Kumar, Navjeev Saxena, Rajesh Deoliya, Kishor Kulkarni, Sayantani Lala, Kshitij Jain, Nagesh B. Balam, Tabish Alam & Chandan Swaroop)	• Kickoff meeting with all the Consortium Partners and team members on 25th April, 2017 at CSIR – CBRI, Roorkee. • Meeting of Consortium Partners to monitor the 6 months progress chaired by Director, CSIR – CBRI during July, 2017 • A meeting held on 26th September, 2017 with the Executive Director of Indo-US Science and Technology Forum (IUSSTF). • Review meeting chaired by Director, CSIR-CBRI during January, 2018.

Indo-UK Project: Zero Peak Energy Building Design in India (ZED-i)

Ashok Kumar (PI), N. Gopalakrishnan, L.P. Singh, Anuj Kumar, Kishor Kulkarni, Sayantani Lala, Rajesh Deoliya & Team

Objectives

- To produce a comprehensive set of building simulation weather files for India that include climate change and extreme events.
- To undertake detailed post-occupancy evaluation of a range of building types in different climates to gain knowledge of current building practices and discover peak demand driven failure modes. Also generate zero-peak demand solutions for the buildings including materials/ components.
- To validate selected strategies via field testing under real weather.
- To develop field-validated dynamical interaction models to enable peak demand elimination.
- To create a new proto-standard for zero peak energy design for India.

Progress Highlights

The project of three years duration brings together world-leading academic expertise in the fields of architecture, civil engineering, computer science, mathematical sciences, environmental psychology, mechanical engineering, electrical engineering, hydrology, climate science and advanced materials to tackle the problem of climate change driven peak energy demand in buildings.

The project has started in February 2018. The Indo-UK consortium is working on addressing the problem of peak demand reduction by aiming to eliminate peak demand of power in buildings. The overall aim of the project is to decouple building energy use from economic growth in India through a new science of zero peak energy building design for warm climates. This will provide “thermal stress free” living conditions whilst minimizing mean and peak demand.

The project focuses on improved building designs, low-energy cooling & heating, social practices of adaptive thermal comfort, a range of materials / technological solutions and post-occupancy evaluation in order to bring about peak demand reduction. It will also look at providing support through research to urban planning, and integration of information, communication and renewable energy technologies at building level. The other aim of the project is on delivering a method of construction that is compatible not only with the Indian climate but also its building practices and social customs, thus avoiding the trap of an “imported” standard.

Slope Stability Assessment & Remedial Measures for Tungnath Temple, District Rudraprayag, Uttarakhand

Manojit Samanta, Ajay Dwivedi & S. Sarkar

The project on "Geotechnical investigation and slope stability assessment and remedial measure for Tungnath temple, Rudraprayag" was taken up at the request of the Uttarakhand Tourism Department. Tungnath temple is situated at a height of approx. 3680 m from MSL near Chopta, Ukhimath, in Rudraprayag district. The temple is approximately 1000 years old and is the highest Shrine dedicated to Lord Shiva. During the site investigation, it was observed that there are some indications of slope instability and the temple looks to be slightly tilted (Fig.1). There is a differential settlement at the base of the temple and distress at the retaining structure around the temple. It was inferred from the field observation that the poor drainage at the base of the temple and seepage of water towards the base of the temple could be the primary reason of the continued distress of the temple and retaining structures.

Fig. 1: Tungnath Temple

Geotechnical Investigation & Stability Analysis

The insitu density test was conducted at site and soil samples were characterized at the laboratory. Different laboratory investigations such as grain size analysis, moisture content, specify gravity, bulk density, dry density and direct shear tests were carried out.

Slope stability analysis was performed using different methods for stability evaluation. The laboratory test was conducted at various degree of saturation and drainage conditions. The parameters obtained from the laboratory testing and field observation were taken as input for slope stability analysis. The stability of slope with and without control measures for various sections were evaluated under static and pseudo static conditions. The computed Factor of safety (FOS) obtained from different methods are comparable and not differ significantly. Factor of safety values in the static condition indicate that the slope is stable. Under pseudo-static condition the factor of safety decreases significantly and drops below 1.0 for few sections. Fig. 2 shows the stability analysis of & critical failure of surface of two typical section under static & pseudo-static conditions.

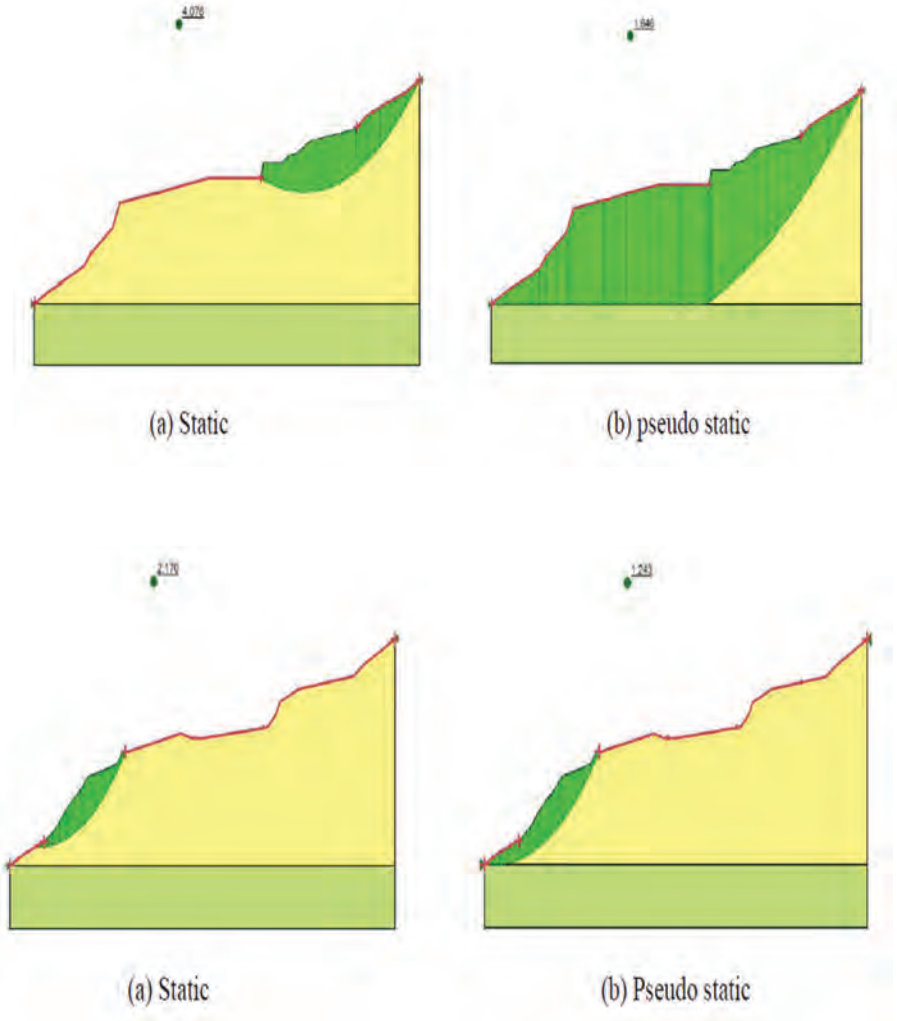


Fig. 2: Slope Stability Analysis of Two Sections

Control Measures

As can be seen from the result of stability analysis that the few sections are unstable as the values of factor of safety are close to or less than 1 in pseudo static case indicating a potential failure zone. A field signature of failure in existing retaining wall was also observed. Therefore, an integrated scheme of control measures was designed for long term stability of the slope vis a vis the temple. The control measure consists of gabion structures, drainage measure, and design of impermeable member to prevent seepage of water and drains (Fig. 3). A 3D view of the temple area and measures are shown in the Fig. 4.

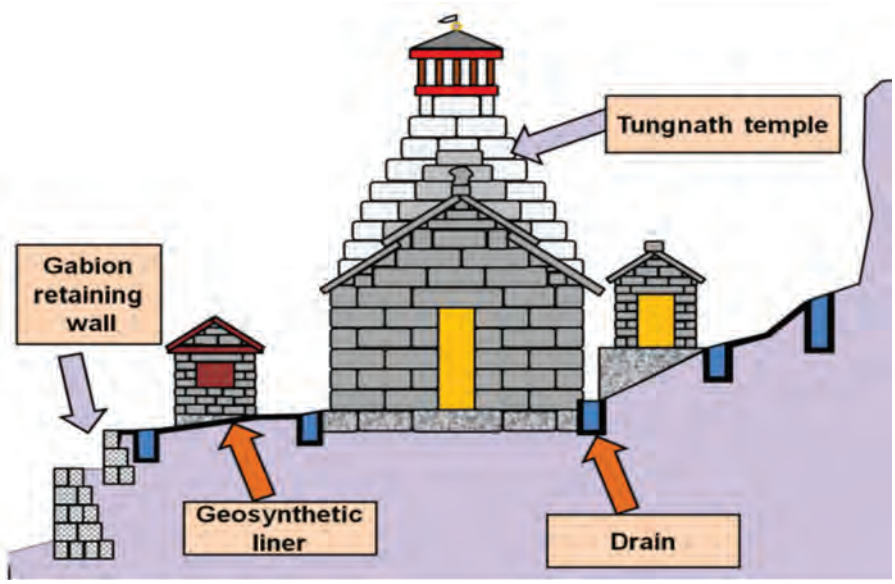


Fig. 3: Scheme of Suggested Measures

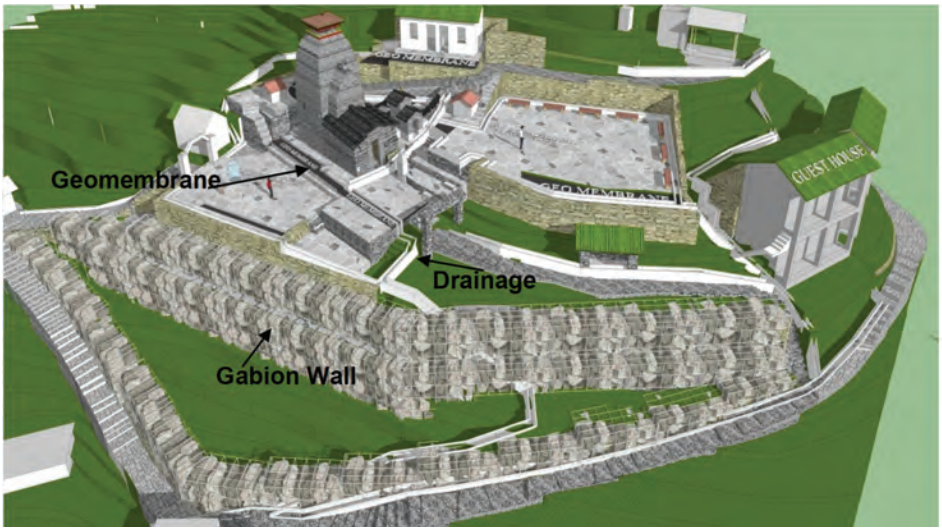


Fig. 4: 3D View of Tungnath Temple Site with Suggestive Measures

Performance of Basalt Fibre Reinforced Concrete

S.K. Singh & S.K. Kirthika

Fibres are used in concrete to improve its structural integrity. Nowadays among all, basalt fibres, an inert mineral fibre is gaining more importance due to its exceptional properties like resistance to corrosion and chemicals having low thermal conductivity. Basalt fibres are produced from basalt rocks which is an igneous, extrusive rock (volcanic magma which solidifies in open air) is generally found near East-Asian countries among which Russia has abundant basalt reserves. In India, these rocks are found near Deccan plateau (Fig. 1). Only those basalt rocks which have about more than 46% of SiO_2 content are considered suitable for fibre production especially for concrete construction industry. The brief schematic representation of the manufacturing process by Junkers method is given in Fig. 2. Basalt fibres in concrete exhibits higher ultimate strength, young's modulus and adds stiffness to the concrete. Basalt fibres also have excellent insulating properties, resistance to heat and chemicals as compared to other fibres. Basalt fibre, which is typically a ceramic fibre gets dispersed easily when mixed in concrete or mortar. The cost of basalt fibre is relatively higher than polypropylene, nylon and other organic fibres, but, it is lesser than the carbon and S-glass fibres. Basalt fibres can be used in variety of concrete structures including nuclear power plants, highways, bridges and runways. It is also more stable than organic & synthetic fibres under a radiative ambiance.

An experimental investigations to characterise basalt fibre (Fig. 3) and to investigate its mechanical properties of basalt fibre reinforced concrete (BFRC) was carried out. The properties of the basalt fibre tested are given in the Table 1. In addition, it was observed that basalt fibre contain mainly oxygen and silicon content and it was amorphous in nature. The TGA/DTA analysis of basalt showed that the mass loss of fibre was only 1.6% up to 1000°C. This is due to high melting point of the basalt fibres (about 1400°C). Contact angle of the basalt fibre made by both water (polar) and foramide (non-polar) were less than 90° which implies that basalt fibres are hydrophilic. Characterisation of basalt fibre are shown in the Fig. 4.

Concrete of M30 grade was proportioned in accordance with the Indian standard IS: 10262-2009 and dosage of basalt fibre were varied as 0.50%, 0.75% and 1.00% volume fraction and concrete were designated as BFRC1 BFRC2 and BFRC3 respectively. Basalt fibre reinforced concrete (BFRC) with 0.5% volume fraction showed better compressive and flexural strength at age of 28 days. The increase in strength are of order 32.5% and 46% respectively than control concrete, whereas BFRC with 0.75% vol. fraction improved 45% more splitting tensile strength than control concrete. This is due to bridging effect of basalt fibres in the concrete mixes. A slight reduction in the hardened properties of the concrete is observed as percentage volume fraction of fibre increases due improper mixing. The hardened properties of BFRC is given in Table 2.

Fig. 1: Location of Basalt Rock in India

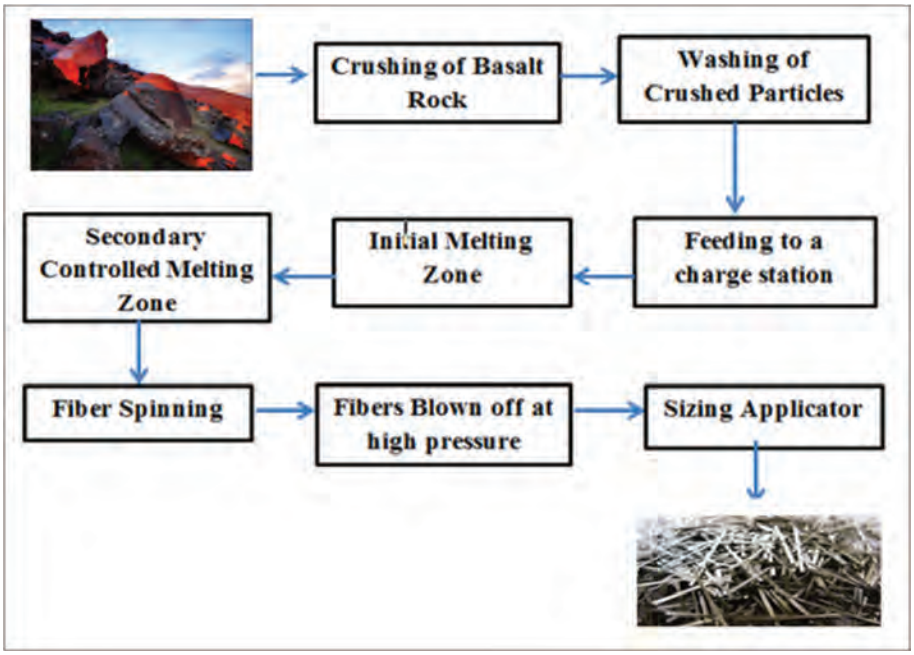


Fig. 2: Junker's Method of Manufacturing of Basalt Fibre

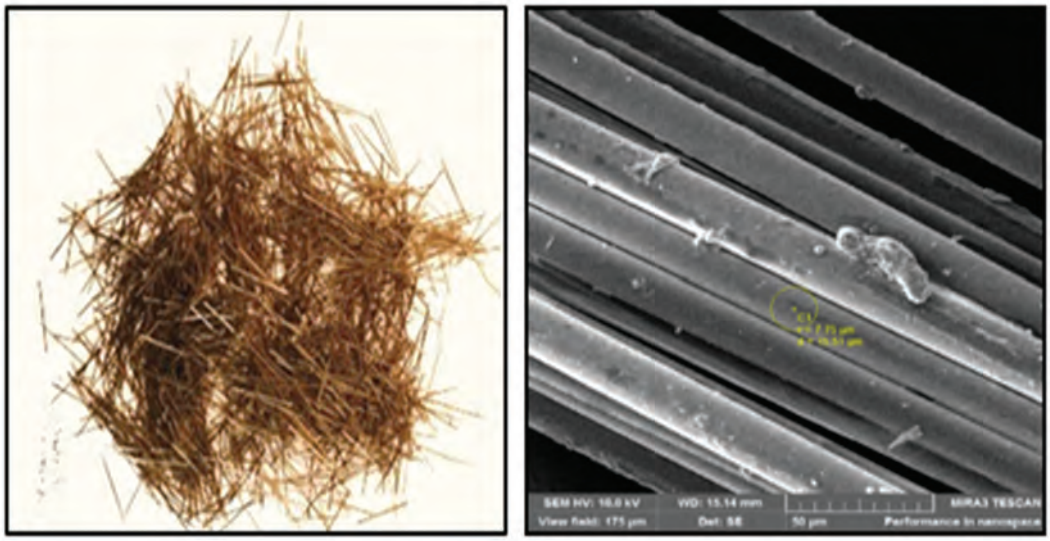
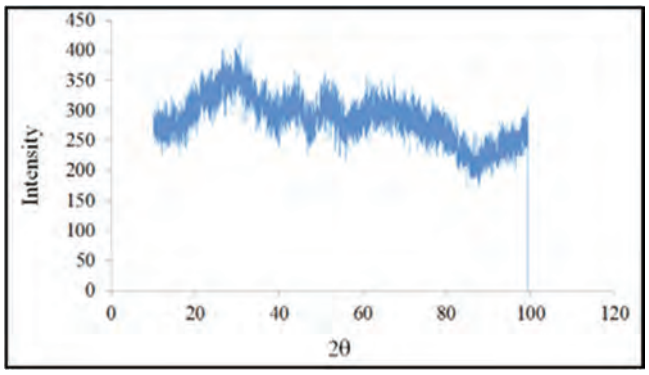


Fig. 3: (a) Basalt Fibre (b) SEM of Basalt Fibre

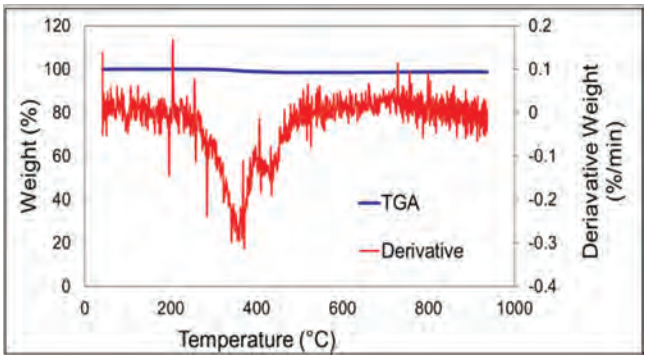
Table 1: Properties of Fibres

Properties	Basalt Fibre
Form	Monofilament
Colour	Brown
Length (mm)	24
Diameter (µm)	16±0.5
Aspect ratio (l/d)	1500
Specific gravity	2.60
Tensile strength (MPa)	3200
Elastic modulus (GPa)	110
Elongation at break (%)	3.5
Melting Temperature (°C)	1400

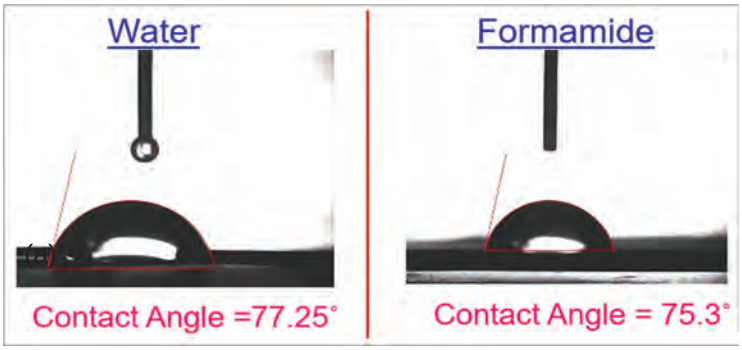
A study to understand the efficacy of basalt fibre in concrete when exposed to elevated temperatures of 200°C, 400°C, 600°C, 800°C and1000°C in a muffle furnace was carried out. Residual mechanical properties and microstructural studies were studied. It was observed that the reduction in strength in control specimens exposed to 1000°C was found nearly 75% whereas in BFRC (0.5%V_f) was only 48.14% (Fig. 5). In addition, the reduction in residual elastic modulus of BFRC (0.5% V_f) was only 47.88% as shown in Fig. 6 but in control concrete, it was 74.40%. SEM images reveals that in BFRC, basalt fibres were found closely bound with C-S-H crystals. BFRC even after exposing to 1000°C, dense formation of C-S-H and no voids were formed (Fig. 6) because of good bonding of fibre as shown in Fig. 7. The durability studies like carbonation and rapid chloride penetration (RCPT) were carried out for optimized BFRC and compared with control concrete. The reduction in carbonation depth of BFRC is about 70% to control concrete at 56 days probably due to improvement in micropore structure of concrete.



(a)



(b)



(c)

Fig. 4: Characterisation of Basalt Fibre (a) XRD (b) TGA/DTA (c) Contact Angle

Table 2: Hardened Properties of Concrete Mixes at Ambient Temperature

Concrete Specimen Designations	Compressive Strength (MPa)	Tensile Strength (MPa)	Flexural Strength (MPa)	Elastic Modulus (GPa)
Control	38.25	3.00	4.63	28.21
BFRC 0	48.50	4.20	6.70	35.25
BFRC 2	46.54	4.50	6.45	36.01
BFRC 3	40.28	4.00	6.30	35.75

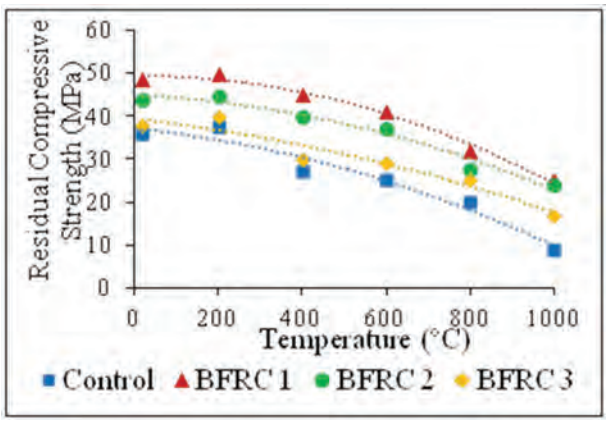


Fig. 5: Residual Compressive Strength of Concrete Mixes

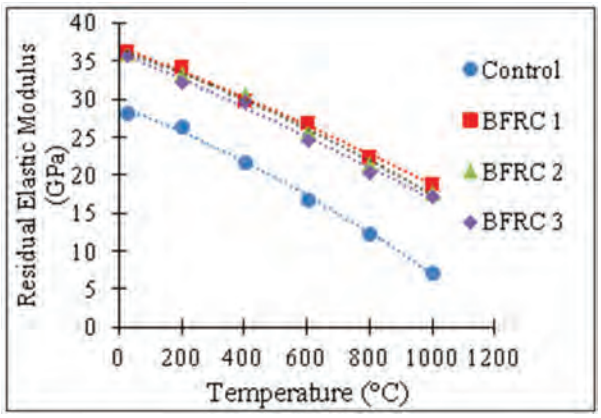


Fig. 6: Residual Elastic Modulus of Concrete Mixes

The accelerated carbonation test results are shown in Fig. 7. RCPT test results are shown in the Fig. 8. The chloride ion permeability of the control concrete was 49% more than BFRC1 at the age of 56 days.

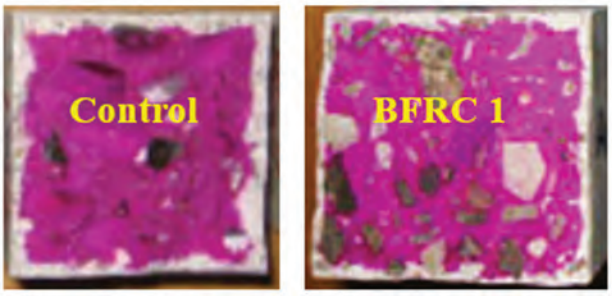


Fig. 7: Carbonation Test at 56 Days

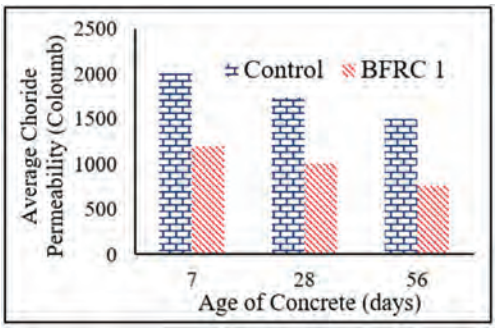


Fig. 8: Chloride Permeability of Concrete

The chloride ion penetrability in BFRC1 was found very low (765 Columb) at the age of 56 days. This is due to dense structure formation of concrete by C-S-H gel that fills the voids that inhibits ingress of chloride ion.

Basalt fibers in concrete outplay other fibers as it exhibits higher ultimate load, higher young's modulus and higher stiffness to the concrete. It also improves compressive strength and flexural strength of concrete.

From the study, it is evident that utilization basalt fibre reinforced concrete is a smarter choice and a potential material for construction industry especially in the nuclear or thermal industries. In addition, utilization of basalt fibre makes concrete sustainable and eco-friendly. Though, lot of information are available on the utilization of basalt fibers in concrete, the utilization of the basalt fibers incorporated concrete is scarce due to its non-availability in many places in the globe. Hence, further studies on developing BFRC is needed in order to make it available and used in construction practices.

Capacity Enhancement Programme on Fly Ash Utilization

L.P. Singh & Team

In order to enhance the utilization of flyash, the Ministry of Environment, Forest and Climate Change MOEF&CC has identified CSIR-Central Building Research Institute, Roorkee (CSIR-CBRI) to collect, collate and disseminate information relevant to flyash generation and utilization in the country.

As a result CBRI ENVIS Centre on Flyash was established in the year 2003.

CSIR-CBRI ENVIS Centre has its own website. Website includes details of flyash generation and utilization. Moreover all information regarding publications (newsletters, books, research articles, technical bulletins), latest news, upcoming events, major activities, expert data, kids centre, notifications and standard codes related to flyash etc. are available on website (Fig. 1).

Fig. 1: Home page of ENVIS Centre Website

Apart from website, CBRI-ENVIS Centre on flyash also published a newsletter entitled "The Built Environ" with subject as "Flyash". Till date 25 issues have been published and in order to ensure the maximum dissemination of flyash information, CBRI-Centre on Flyash is also involved in several minor and major activities as a part of project activity. Some glimpse of the different outreach of the minor/major programes are as follows (Fig. 2(a), Fig. 2(b)).

Fig 2: (a) Outreach of the ENVIS Team Members in Nearby Areas for Dissemination of Information about Swachh Bharat Abhiyan

Fig. 2: (b) ENVIS Team Members conducting Cleanliness Drive in Campus

Burning Behaviour of Various Materials in Enclosure Fires- Development of Evacuation Strategies for Fire Affected up to Four Storeys Row Buildings

Rajiv Kumar, Aravind Kumar & Narendra Kumar

A two storey building (Fig. 1 & Fig. 2) has been constructed for studying the behavior of fire in built multi-storey environment. The experimental building has been fully instrumented to monitor temperature profile, burning rate of fuels, heat release rates, toxic gases (CO, CO_2 and O_2) generated and opacity of the smoke generated due to fire during pre-flashover period. The experiments are being conducted as per plan in project proposal. In Burn Room (Room No 1 in Fig. 1), Benzene & Heptane are burned to check the functioning of the experiments at two locations in two different ventilation conditions. In Ventilation condition 1, the two windows of the burn room are closed and door is opened while in Ventilation condition 2, the both the windows are opened in addition to the door. In other rooms & stair cases, all the doors are opened while windows are closed for both the ventilation conditions of the burn room. The location of the fuel is changed from Platform No 1 & Platform 2 for each set of ventilation condition. One set of experiment is conducted when fuel is placed on both Platform No. 1 and Platform No. 2 and fuel is burned on one Platform and effect is observed on the fuel on another platform whether it ignites or not, Same experiment is repeated by changing the position of source fuel. These experiments are conducted for both the ventilation conditions.

Experimental Building has been instrumented for measurement of the following parameters

1. Temperature
2. Fuel burning Rate
3. Heat Flux
4. Species Concentrations
5. Smoke Density

One sprinkler fire extinguishment system is installed in the experimental building for the fire safety during experiments.

Eighteen experiments have been carried out in this experimental building. The data base of thermal, toxic and smoke hazards has been created. The details of Experiment 1–8 for pool fires and Experiment 9-18 for wooden furniture are given in Table 1 and Table 2, respectively. Wooden furniture such as sofa, bed, dining tables etc are burned in the burn room as shown in Fig. 3-4. The data generated in the experiments are compared with the prediction of FDS model and found near to the experimental data.

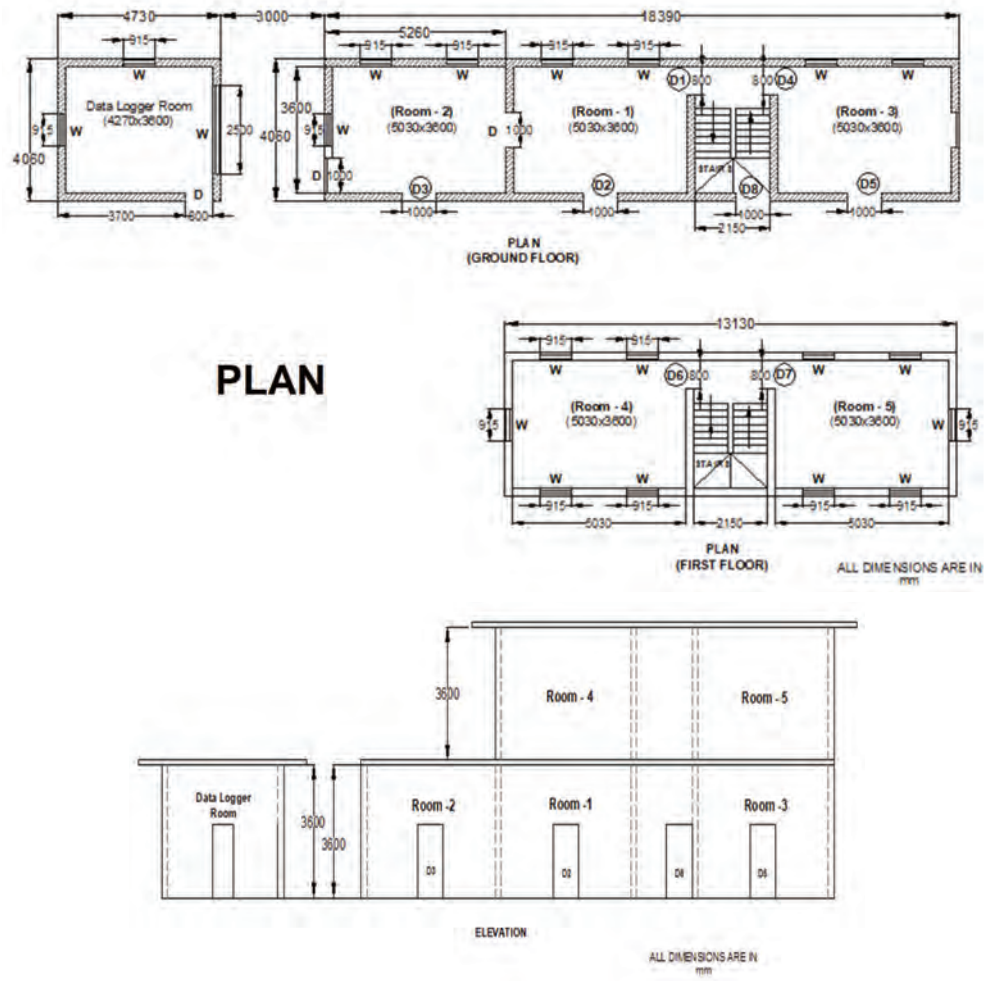


Fig. 1: Experimental 2-Storey Row Building with Data Logger Room

Fig. 2: (a) Experimental Two Storey Row Building with Instrumentation

Fig. 2: (b) Experimental Two Storey Row Building with Instrumentation

Fig. 3: Furniture Fire in Burn Room (Burning of Wooden Sofa)

Fig. 4: Furniture Fire in Burn Room (Burning of Wooden Bed on Platform 1)

Table 1: Details of Pool Fire's Experiments

Sl. No	Expt. No	Fuel	Rear wall Windows	Platform 1	Platform 2	Ignition on	Ignition Source	Fire location	Fire duration min
1.	Exp 1	Benzene	closed	4 kg	Nil	Platform1	Pilot Flame	Centre	5:40
2.	Exp 2	Benzene	open	4 kg	Nil	Platform1	Pilot Flame	Centre	5:13
3.	Exp 3	Heptane	closed	4 kg	Nil	Platform1	Pilot Flame	Centre	6:59
4.	Exp 4	Heptane	open	4 kg	Nil	Platform1	Pilot Flame	Centre	6:54
5.	Exp 5	Benzene	closed	4 kg	4kg	Platform2	Pilot Flame	Centre	5:31
6.	Exp 6	Benzene	open	4 kg	4kg	Platform2	Pilot Flame	Centre	5:27
7.	Exp 7	Heptane	closed	4 kg	4kg	Platform2	Pilot Flame	Centre	7:29
8.	Exp 8	Heptane	open	4 kg	4kg	Platform2	Pilot Flame	Centre	7:04

Table 2: Experimental Details for Furniture Fires

Sl. No	Expt. No	Fuel on Platform 1	Fuel on Platform 2	Rear wall Windows	Mass of Fuel on Platform 1 (kg)	Mass of Fuel on Platform 2 (kg)	Source Fuel	Ignition Source	Fire location	Fire duration min
1.	Exp 9	Jamun wood Bed	-	Closed	50.9	0	Platfrom 1	LPG burner for 30 min	Centre	00:46:40
2.	Exp 10	Jamun Wood Bed	-	Open	50.7	0	Platform 1	LPG burner for 30 min	Centre	00:43:00
3.	Exp 11	-	Jamun Wood Bed	Closed	0	51.9	Platform 2	LPG burner for 30 min	Centre	01:01:00
4.	Exp 12	-	Jamun Wood Bed	Open	0	51.9	Platform 2	LPG burner for 30 min	Centre	00:43:20
5.	Exp 13	Jamun Wood Bed	Jamun wood sofa	Closed	49.9	40.2	Platform 1	LPG burner for 30 min	Centre	00:38:34
6.	Exp 14	Jamun Wood Bed	Jamun wood sofa	Open	50.8	40.4	Platform 1	LPG burner for 30 min	Centre	00:50:30
7.	Exp15	Jamun wood Sofa	Jamun wood bed	Closed	41.7	50.9	Platform 1	LPG burner for 30 min	Centre	00:58:10
8.	Exp 16	Jamun wood sofa	Jamun wood bed	Open	40.5	50.9	Platform 1	LPG burner for 30 min	Centre	01:14:00
9.	Exp 17	Dining Table with 4 chairs	Dressing Table	Closed	77.5	28.7	Platform 1	LPG burner for 30 min	Centre	00:52:15
10.	Exp 18	Dining Table with 4 chairs	Dressing Table	Open	80.4	27.7	Platform 1	LPG burner for 30 min	Centre	01:20:35

AcSIR

AcSIR

The Institute is conducting an integrated M. Tech. – Ph.D. (IMP) Programme under the aegis of Academy of Scientific & Innovative Research (AcSIR) since 2010 in the area of 'Building Engineering & Disaster Mitigation (BEDM)'. The Institute is also taking Ph.D. students in the area of Engineering Sciences, Chemical Sciences and Physical Sciences.

M. Tech.

- 6th batch (2015-17) – 5 students completed

Ph.D.

- One APJ Kalam Fellow worked for 2 months for summer training in the Institute.
- Presently total 14 Ph.D. students are enrolled in AcSIR at CSIR-CBRI.

Some of the highlights of the student activities in the current year are:

1. Project evaluation of the M. Tech Students (2015-17 batch) by the external experts in the presence of the Director, faculty members and students

2. Address of the Hon'ble Prime Minister at the Student Leaders Convention on September 11, 2017, on the theme "Young India, New India- A Resurgent Nation: From Sankalp to Sidhhi" was attended by the staff, AcSIR students and teachers

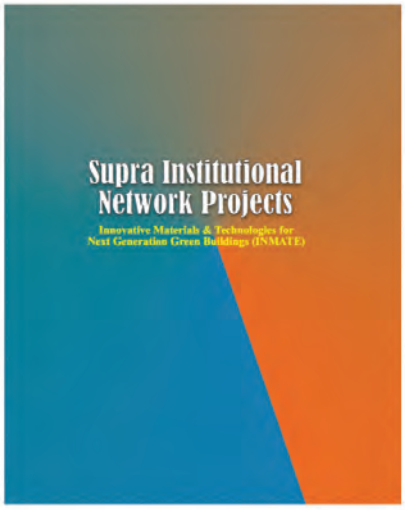
Information, Extension & Project Management

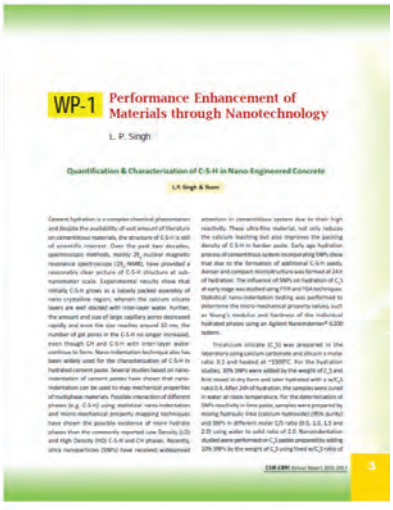
Publication Group

The Publication Group continued to serve as the nerve centre of the Institute conducting and coordinating multifarious activities, such as, collection, storage and dissemination of R&D information; handling scientific and technical enquiries; publicity and public relations, compilation, editing and publication of Annual Report to meet the inter and intra-institutional information needs, editing and publication of CSIR-CBRI Newsletter and भवनिका (Newsletter in Hindi) periodically; publication of Building Research Notes, Project Profile, Technical and Divisional Brochures etc., preparation of other scientific/technical reports and filling up of questionnaires/organizations; providing inputs for CSIR Annual Report as well as for CSIR News and CSIR Samachar; reporting of the scientific and technical work carried out at the Institute in Hindi and English and Publicity of the Institute's R&D capabilities through Print & Electronic Media.

1. CSIR-CBRI Annual Report

- R&D Highlights
- Research Output
- Glimpse of Activities
- R&D Projects
- Consultancy Projects
- Sponsored Projects
- Information, Extension and Project Management
- CBRI Family
- Visits, Lectures, Meetings etc.
- Faculty Training, Motivation and Adoption of Schools & Colleges by CSIR-Central Building Research Institute, Roorkee
- Training Programmes
- Date Line





Tasks Involved: Manuscript evaluation, editing, proof-reading, graphic design, layout, illustration, print production, binding, publishing, dissemination and feedback

2. CBRI in CSIR News and CSIR Samachar

S. No.	Article	Volume	Page	Month
1.	CSIR-CBRI Develops Indigenous Cathodic Protection System for Steel Reinforced Concrete Structures	Volume 67 No. 7 & 8	76-79	April 2017
2.	CSIR-CBRI Organizes Student Awareness Programme	Volume 67 No. 7 & 8	80-81	April 2017
3.	CSIR-CBRI Organizes Workshop Training-cum-Motivational Programme for Teachers	Volume 67 No. 7 & 8	81-83	April 2017
4.	CSIR-CBRI Organizes Science Exhibition	Volume 67 No. 7 & 8	91-94	April 2017
5.	National Technology Day at CSIR-Central Building Research Institute, Roorkee	Volume 67 No. 9 & 10	113-114	May 2017
6.	Road from Waste Built by CSIR-CBRI & NTPC	Volume 67 No. 11 & 12	123	June 2017
7.	CBRI Organizes Student Awareness Programme	Volume 67 No. 11 & 12	132-135	June 2017
8.	CSIR Techno Fest at CBRI, Roorkee	Volume 67 No. 15 & 16	184-187	August 2017
9.	CBRI Celebrates CSIR Platinum Jubilee Foundation Day	Volume 67 No. 17 & 18	213-215	September 2017
10.	IISF 2017: CBRI, Roorkee Organizes Science Fest, Press Meet and Public Outreach Programme	Volume 67 No. 19 & 20	234-236	October 2017
11.	CSIR-CBRI Organizes Teachers' Workshop	Volume 67 No. 23 & 24	267-270	December 2017
12.	CSIR-CBRI's 'Geo-polymer Concrete' Road gets Accreditation	Volume 68 No. 3 & 4	20	February 2018
13.	World Energy Conservation Day Observed at CSIR-CBRI	Volume 68 No. 3 & 4	27-29	February 2018
14.	Students Visit CSIR-CBRI	Volume 68 No. 3 & 4	30-31	February 2018
15.	Studies on Consolidation & Deformation Characteristics of Ordinary & Geo-synthetic Encased Stone Column Improved Soft Soil: CSIR-CBRI, Roorkee	Volume 68 No. 5 & 6	42-43	February 2018
16.	CSIR-CBRI Celebrates its Foundation Day	Volume 68 No. 5 & 6	54-56	March 2018

Tasks Involved: Plan, schedule and organize the publication of highlights of CBRI achievements/activities in CSIR News

CBRI in CSIR Samachar

क्रम सं.	लेख	अंक	पृष्ठ	माह
1.	सीएसआईआर महानिदेशक डॉ. गिरीश साहनी का सीबीआरआई दौरा	वर्ष 5 अंक 4	56-59	अप्रैल 2017
2.	सीएसआईआर-सीबीआरआई, रुड़की द्वारा कृषिजन्य अपशिष्टों के उपयोग से इंजीनियरीकृत हलके गारे-फूस समिश्रण का विकास	वर्ष 5 अंक 5	72-75	मई 2017
3.	सीएसआईआर-सीबीआरआई, रुड़की में स्थापना दिवस समारोह का आयोजन	वर्ष 5 अंक 5	78-80	मई 2017
4.	सीएसआईआर-सीबीआरआई, रुड़की द्वारा सीमेंट में सिलिका नैनो कणों के सम्मिश्रण पर अध्ययन	वर्ष 5 अंक 6	86-88	जून 2017
5.	सीएसआईआर-सीबीआरआई, रुड़की ने युवा मन में जगाई वैज्ञानिक चेतना	वर्ष 5 अंक 6	90-93	जून 2017
6.	विद्यार्थियों द्वारा विज्ञान प्रतिभा का प्रदर्शन: सीएसआईआर-सीबीआरआई, रुड़की द्वारा विज्ञान प्रदर्शनी का आयोजन	वर्ष 5 अंक 7	108-109	जुलाई 2017
7.	सीएसआईआर-सीबीआरआई, रुड़की में प्रौद्योगिकी दिवस का आयोजन : तकनीक ऐसी हो जो धरातल पर खरी उतरे - डॉ. राजेंद्र डोभाल	वर्ष 5 अंक 7	110-112	जुलाई 2017
8.	सीएसआईआर-सीबीआरआई, रुड़की द्वारा विद्यार्थियों को वैज्ञानिक बनने के लिए प्रेरणा कार्यक्रम	वर्ष 5 अंक 8	124-127	अगस्त 2017
9.	आईआईएसएफ 2017 : सीएसआईआर-सीबीआरआई, रुड़की में विज्ञान उत्सव, पत्रकार सम्मेलन और जनसम्पर्क कार्यक्रम का आयोजन	वर्ष 5 अंक 9	131-133	सितम्बर 2017
10.	सीबीआरआई में जिज्ञासा कार्यक्रम के तहत वैज्ञानिक गतिविधियों से रूबरू हुए विद्यार्थी	वर्ष 5 अंक 9	134-135	सितम्बर 2017
11.	सीएसआईआर-सीबीआरआई में जिज्ञासा कार्यक्रम के तहत शिक्षक कार्यशाला का आयोजन	वर्ष 5 अंक 12	206-210	दिसंबर 2017
12.	सीएसआईआर-सीबीआरआई, रुड़की में विश्व ऊर्जा संरक्षण दिवस मनाया गया	वर्ष 6 अंक 2	30-32	फरवरी 2018
13.	सीएसआईआर-सीबीआरआई में स्वच्छता पखवाड़े का आयोजन	वर्ष 6 अंक 3	34-36	मार्च 2018
14.	सीएसआईआर-सीबीआरआई, रुड़की द्वारा अर्धस्थैतिक अवस्था में परिरुद्ध चिनाई भवन का निष्पादन	वर्ष 6 अंक 3	37-38	मार्च 2018
15.	सीएसआईआर-सीबीआरआई, रुड़की द्वारा उन्नत नरम मृदा में सामान्य एवं जियोसिंथेटिक एन्कैसेड स्टोन कॉलम की संघनन एवं निरूपण विशेषताओं पर अध्ययन	वर्ष 6 अंक 3	39-40	मार्च 2018
16.	सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की में राष्ट्रीय विज्ञान दिवस समारोह	वर्ष 6 अंक 3	41	मार्च 2018
17.	सीएसआईआर-सीबीआरआई की जियोपोलीमेर कंक्रीट रोड को आधिकारिक मान्यता प्राप्त	वर्ष 6 अंक 3	47	मार्च 2018

3. Bilingual CSIR-CBRI Newsletters/भवनिका- Newsletters in Hindi

भवनिका / CBRI Newsletter January –March 2018

भवनिका / CBRI Newsletter October-December 2017

भवनिका / CBRI Newsletter July-September 2017

भवनिका / CBRI Newsletter April-June 2017

Four Issues

Quarterly newsletter carrying information on activities and accomplishments of the Institute covering R&D Programmes; development of new products and technologies, their demonstration, transfer and commercialization; seminars, workshops, training programmes, exhibitions, etc; major events such as foundation day celebrations; publications, staff news, honours & awards etc.

4. CBRI in "CSIR in Media"

5. News-items/R&D Stories in Media covering Functions, Events, Conferences, Workshops etc.

6. Publicity through Advertisement in Conference/ Souvenir/Symposium Proceedings etc.

7. Outreach through Articles in Magazines, Periodicals etc. including

- निर्माणिका 2017-2018
- भारतीय वैज्ञानिक एवं औद्योगिक अनुसंधान पत्रिका, वर्ष 25, अंक 1 एवं 2
- वैज्ञानिक, अक्टूबर-दिसम्बर 2017
- वैज्ञानिक, अप्रैल-जून 2017
- नव संचेतना, वर्ष 2017, अंक 1

8. ENVIS Newsletter

CSIR-CBRI ENVIS Newsletter

9. Press Meet

A press meet was organized on September 14, 2017 to apprise the public at large about the 3rd India International Science Festival (IISF-2017) to be held October 13-16, 2017 at Chennai. Press Representatives from print and electronic media including Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Uttarancal Deep, Awam-e-Hind, Dainik Aaj, Punjab Kesari etc. attended the meet.

10. Faculty Training, Motivation, and Adoption of Schools and Colleges by CSIR-Central Building Research Institute, Roorkee

During this period, motivational and educational programmes were organized under the CSIR Scheme, "Faculty Training, Motivation and Adoption of Schools and Colleges by CSIR Labs" to motivate the teachers, inspire students, rekindle their interest towards science, provide them with appropriate resources and raise the standards of science education in schools and colleges.

- May 26, 2017: CSIR-CBRI Organized Student Awareness Programme
- December 14, 2017: Energy Conservation Day Awareness Programme

11. Jigyasa- Quest for Curiosity: Student-Scientist Connect Programme

1. February 10, 2018: Science Exhibition by Students
2. February 07, 2018: Teacher as Scientist
3. January 30, 2018: Motivational Lecture
4. January 18, 2018: Teacher as Scientist
5. December 14, 2017: World Energy Conservation Day
6. December 14, 2017: Quiz Competition
7. November 29-30, 2017: State-level Science Exhibition, Quiz and Seminar by Students
8. November 15, 2017: Quiz Competition
9. November 14, 2017: Motivational Lecture
10. November 13, 2017: Cleanliness Drive
11. November 02-03, 2017: State-level Teachers' Workshop
12. November 02, 2017: Science Exhibition by Students
13. October 12, 2017: Motivational Lecture
14. September 25, 2017: Brainstorming Session
15. September 25, 2017- October 25, 2017: Student Apprenticeship Programme
16. September 15, 2017: Brainstorming Session
17. September 12, 2017: Scientist as Teacher

12. India International Science Festival (IISF 2017) Precursor Events

- Press Meet
- Open Day & Science Festival

13. CSIR Platinum Jubilee Capsule Exhibition

14. Technology and Divisional Brochures

15. R&D Highlights/Research Output of CSIR-CBRI in CSIR Annual Report

Development, Construction and Extension Group

The Development, Construction and Extension Group at the Institute is involved in various activities with the objective to disseminate R&D outcomes of the Institute among the user agencies for field implementation. The Group organizes or participates in training programmes related to disaster resistant cost-effective housing, rural housing and creating awareness through exhibitions, professionals and related authorities. The Group also takes up developmental activities to develop user-friendly systems and their dissemination under the Documentation and S&T Intervention in the Traditional Architecture of Rural Areas of the Western Himalayan Region. Some of the activities have been highlighted below:

Exhibitions

The Group has participated in exhibitions, and interacted with the masses and created the general awareness about the various technical advancements of CSIR-CBRI. Details of various exhibitions are as follows:

1. Participated in 1 day Exhibition at award ceremony of MoRD at Vigyan Bhavan.
2. Participated in 1 day Exhibition at award ceremony of Uttarakhand declared as Open Defecation Free State.
3. Participated in 11 days exhibition at Parliament House for MP's, MLA's and other public representatives.
4. Participated in 1 day exhibition at Babaji Deshmukh Janshatabdi Samaroh at IARI, New Delhi.
5. Participated in 1 day exhibition-cum-road show organized at Andhra University, Visakhapatnam.

Parliament Exhibition Delhi

Babaji Deshmukh Janshatabdi Samaroh

Trainings

DC&E group has organized 4 training programme in the financial year 2017-18. A total number of 142 persons have been trained during the training programmes. Among 4 programmes (Skill/Training Programme on Innovative Technologies for Rural Housing at CSIR-CBRI (2 programmes), Convergence on Rural Housing at Odisha and Multi Hazard Resistant Housing and Habitat), 3 programmes were sponsored by Odisha Panchayati Raj Department

Training Programme for Officials of Odisha Govt.

and generated an ECF of Rs. 9 Lakh; and the other one was sponsored by Uttarakhand Govt. with an ECF of Rs. 6 lakh.

Students Visit

S. No.	Name of Institute/Organisation	Date of Visit	Number of Visitors
1.	IIMT Meerut	03.04.2017	46
2.	MIT Moradabad	07.04. 2017	100
3.	MPI Moradabad	03.05. 2017	45
4.	NITTTR Chandigarh	05.07. 2017	91
5.	Quantum School of Technology	23.08. 2017	42
6.	RCE Roorkee	28.08. 2017	42
7.	RIT Rorkee	06.09. 2017	30
8.	RCE Roorkee	07.09. 2017	155
9.	CCA Chandigarh	07.09. 2017	21
10.	KL Polytechnic	14.09. 2017	26
11.	North India Institute of Technology	21.09. 2017	43
12.	UPES Dehradun	22.09. 2017	52
13.	ITBP Academy Mussoorie	06.12. 2017	07
14.	Roorkee College of Engineering	20.03. 2018	84
15.	North India Institute of Technology, Najeebabad	23.03. 2018	17
16.	MIT Rishikesh	23.03. 2018	49
17.	Girls Polytechnic Dehradun	23.03. 2018	38
18.	Devbhoomi Institute of Technology	28.03. 2018	44

MPI Moradabad

NITTTR Chandigarh

RCE Roorkee

Quantum School of Technology

Commandants of ITBP

RIT, Roorkee

Production of Technical Videos

CSIR-CBRI has prepared short technical films on the different building technologies for its wider publicity among the community through web.

- Stone Block masonry
- Brick Panel
- C-Brick Making Machine
- Two-Pit Latrine System

Non-Working Models

The Institute has made 5 non working models on the housing designs developed under PMAY-G housing of Govt. of India for its wider publicity through exhibitions organized in different location of the country and the exhibition hall of the Institute.

Knowledge Resource Centre

'Knowledge Resource Centre' (KRC) of the Institute is actively engaged in acquisition, technical processing, updating the collection and providing the platform for e-access of information sources to expand the horizon of information base to the scientific community. It is fully automated having RFID enabled systems and services.

Acquisition

- **Books**: KRC purchased 170 numbers of books and received 19 numbers of books on gratis basis.
- **Journals**: The library has subscribed 53 (33 foreign +20 Indian) journals.

Library Statistics

The present position of library collection:

- Books including reports; standards; conference proceedings; theses & maps: 44901;
- Bound periodicals: 20680

Institutional Membership

CSIR-CBRI is a member of four national and three international professional/learned societies. KRC receive their publications against the annual membership fees.

- **National (India)**: Indian Geotechnical Society (IGS), Delhi; Institute for Steel Development and Growth (INSDAG), Kolkata; Indian Science Congress Association (ISCA), Kolkata; and Indian Green Building Council (IGBC), Hyderabad.
- **International / Foreign** : International Union of Laboratories & Experts in Construction Materials, Systems and Structures (RILEM), Bagneux, France, International Federation for Structural Concrete (fib), Lausanne, Switzerland and American Concrete Institute (ACI), USA

Exchange of Publications

Besides membership, the library received Annual Reports; News Letters; Technical Reports; Reprints and other materials in exchange from National and International Organizations.

Resource Sharing and Local Networking

KRC is maintaining relationship with the libraries located in Roorkee viz. Indian Institute of Technology; National Institute of Hydrology and providing resource sharing through inter library loan. Besides the local network, KRC is maintaining the liaison and relationship with the KRC's of CSIR Laboratories/DST Labs and other academic/research institutions.

Services

KRC is playing a coordinating role between users and the literature, providing personal Information service through Current Awareness (CAS) and Selective Dissemination of Information (SDI) using modern information technology. Besides the day to day circulation, KRC is also rendering the following specific services:-

• Documentation

a) **Paper Clipping Service (PCS)**: PCS is continued through scanning nine no. of newspapers in English and Hindi. The topics of the interest of the Institute under eleven major heads like- Building Materials; Structure & Foundation; Disaster Management: Earthquake & Landslides; Shelter Planning & Policy; Environment Science & Technology; Fire Research; CSIR/ CBRI etc. The paper clipping are kept in classified order for providing current awareness service to users.

b) **List of Latest Addition**: KRC is bringing out a quarterly list of latest arrivals of books for the general awareness of library users.

c) **Bibliographic Service**: KRC is providing bibliographic service to users on demand on the subject of interest from in house data base as well as international databases.

d) **Current Contents Page** (CCP): CCP of print journals is providing through attachment of mass e-mail to S&T members for current awareness.

- **Web-OPAC Search**: KRC has created a bibliographic database of documents and providing search facility through computer. Users can search any document through any access point like author, class no., subject, title, keyword and combination of search (Boolean search).
- **CD-ROM**: CD-ROMs are available in KRC viz. CIB Conference Proceedings, ACI Manual, Pate state: a database of CSIR patents; heritage buildings and sites.
- **In-house Database**: KRC is maintaining in-house bibliographic database of books and bound volumes of journals.
- **Internet Facility**: KRC has internet connectivity node with PC's as well as wi-fi connectivity for users to access of e-resources.
- **Access of E-Journals**: Now, access to over 2000 full text of e-journals of leading S&T publisher's viz., ASCE, full text of ASTM Standards, Elsevier (selected), Emerald, ICE (UK), IEEE, Nature, OUP, RSC, , T&F, Wiley, science databases like Web of Science (WoS) and patent databse viz. QPAT/ORBIT are available online under National Knowledge Resource Consortium (CSIR-DST E-journals Consortium) as well as direct subscription.
- **Knowledge Repository**: KRC has created Institutional Repository (IR) through dspace software. Large number of records has already uploaded contains full text database along with metadata of published research papers of S&T staff members of the institute as well as all Building Research Notes (BRN), Project Profiles, Annual Reports of CSIR-CBRI since 1953 and conference proceedings volumes, organized by CBRI. This database can be accessed at http://krc.cbri.res.in/dspace
- **Book Exhibition**: KRC has organized a book exhibition and displayed the latest Hindi books from own collection during the celebration of 'Hindi Pakhwara'.

Planning & Business Development

PBD Group acts as the main facilitator of the Institute for effective planning, monitoring, evaluation and project budgeting of all R&D and Externally Funded Projects such as Consultancy Sponsored Projects, Grant–In-Aid and technical services, etc. Important documents like annual plan of the Institute, manpower deployment, externally funded projects for MC agenda and R&D agenda for the Research Council are also dealt with by the Group. Besides this, the Group manages technology transfer to the industries, IPR management activities and execution of agreements & MoUs with various industries/ institutes/organisations.

PBD Group monitors and compiles the Monthly Progress Report (MPR) and Quarterly Progress Report (QPR) of the research activities of the Institute as well as the Research Utilization Data (RUD) for onward transmission to CSIR, New Delhi. The Group regularly maintains and monitors the project records in terms of physical and financial recommendations of internal monitoring committees, Research Council (RC) and Management Council (MC).

R&D Projects

During the year 2017-18, the Institute was intensely involved in formulating the deliberations of 31 in-house R&D & 03 Fast Track Translation (FTT) projects.

Project Evaluations & Peer Reviews

Internal review meetings and meetings with external experts are organized for review of new R&D and FTT projects. The ongoing projects are monitored for progress and/or mid-course corrections. Comments of experts are conveyed to concerned PIs and it is ensured that the same are incorporated before the projects are placed before the RC. R&D projects were processed under the R&D areas of the Institute, namely, Housing-Structure & Foundation, Conservation of Heritage Structures, Innovative Building Materials, Disaster Mitigation, and Energy Efficient System & Building Process & Automation.

The Group coordinated the scheduling of presentations & interacted with the project leaders for putting up the relevant documents. The inputs as an outcome of the meetings were incorporated in the projects prior to placing the same before the Research Council.

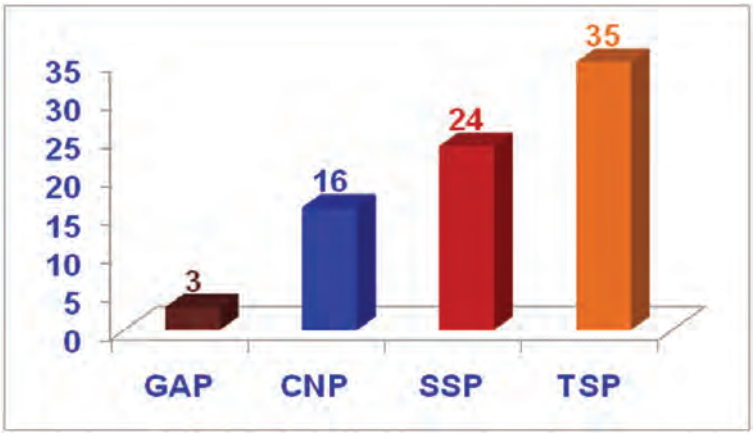
Research Council Agenda

Research Council Meetings are held to monitor the progress of R&D projects of the Institute. The R&D agenda of 54th & 55th RC meetings were prepared. The agenda covered the progress of ongoing projects as well as completed projects during the period and new projects taken by S&T staff. The outcome in terms of suggestion/direction/guidance was communicated to the concerned project leaders.

Externally Funded Projects

The Institute has undertaken various externally funded projects on the basis of the expertise in different areas in the form of Consultancy, Sponsored, Grant-in Aid and Testing.

A database of all the externally funded projects is maintained which helps in effective monitoring of these projects. Necessary record and receipts of GST/ Service Tax & TDS collection are maintained. GST/ Service tax is deposited with the authorities and Form-16 sent to CSIR for recoupment of tax deducted at source by the sponsors of various projects.



Manpower Planning & Deployment

Human Resource Management lays special emphasis on planning for optimal deployment of the scientific, technical, non-technical and administrative staff of the Institute. The Group gathers information regarding deployment from various groups for the preparation of manpower planning and deployment.

Management Council Agenda & Other Documents

Prepared agenda items related to externally funded projects and action taken for MC meeting. The Group also coordinated replies to various audits (CAG, CSIR and Service Tax), replies to RTI and Parliament questions.

Budget and ECF

CSIR Resource Input

Revenue	2754.574 Lakh
Capital	792.397 Lakh
Special Projects	28.195 Lakh
Total	**3575.166 Lakh**

External Cash Flow

Private	228.199 Lakh
Government + PSU	713.878 Lakh
Total	**942.077 Lakh**

Special Events

National Technology Day

CSIR-Central Building Research Institute, Roorkee observed the National Technology Day on May 11, 2017 to celebrate technological breakthroughs of Indian technology and inspire young minds in the areas of science and technology. Dr. Rajendra Dobhal, Director General, Uttarakhand State Council of Science and Technology, Dehradun graced the occasion as the Chief Guest and Dr. Bikas Mohanty, Professor, Indian Institute of Technology, Roorkee and Member, Research Council, CSIR-CBRI as the Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.

Addressing the gathering, Dr. Rajendra Dobhal stressed on the necessity of "Technology Management" to help in better commercialisation of the new built techniques, so that the technology reaches the target population including the poorest of the poor. He compared the R&D budget of various countries and expressed his concern on the microbial cost that is burned in supply. He pointed out that the country still lacks a consolidated technology database of all the developed technologies. Thus, the information on the latest developments in not available to the investors or public at large. He said that a scientist cannot be asked to play the role of a businessman. The country needs to develop domain experts and technology management experts to help in the marketing of the new built technology. Also, the commercial viability of a patent application must be checked and maintained to develop the practice of output oriented research and development work. Any technology that does not provide any substantial use to the target market should be discarded. The technology developed must follow the market and have some use for the target population. He also stressed on the need of a healthier public-private bonding for the development of technologies and their commercialization. The research and development activities should not be limited to public organization funded by the government. Also, both private and government research and development facilities should work together and also partner with industries for development of sustainable and commercially acceptable technologies.

Reminiscing about the glorious technological advancement of the country, Dr. Bikas Mohanty motivated the scientist to further add to the technological prowess of the nation and presented an intriguing lecture on "Current Challenges and Future Directions in Technology". He said that philosophy drives science and technology. It finds a problem and we need to raise our knowledge level to achieve the solution. He cited various examples from chemical engineering and biology to explain the process of development of a technology. Observation, modelling, search and research play vital role in the development of an economical technology. There is a constant

search for the scope of improvement in a technology to consume lesser energy. Technology cannot be limited or bound. It exists in different scales from nano, pico, yocto to peta, giga, and yotta; and follows various streams from geology, polymer, food to astrophysics, and more. He said that the relationship between science and technology is interdependent. The development of a new technology follows an S-curve of development, improvement, maturity and aging. These different S-curves over a period form the straight line of progress and development. Any technology developed should have a large target population and should be easy to consume, economical, sophisticated and different. It should have modularity and flexibility in the design to adapt to the changing market scenarios. The cost and time of production of a technology should decrease, and it should see an increase in the production capacity. After the industrial and information revolution, the world is moving forward to achieve improved socio economic structures, with a new agro-based 'Carbon Neutral' revolution. We need to move forward by maintaining balance of ecology, with the perspective of economic advance. He also stressed on the importance of 'Process Intensification' and explained that the future holds a shift from large to small size industries that produce cheaper, smaller, safer products with less wastage and energy consumption. We need to adopt and work to improve the sustainable concepts of recycle society, green technology and biomimicry. He redefined profit stating that profit should equate to the combination of ecology, ethics, and sustainability along with monetary gains.

In his Presidential Address, Dr. N. Gopalakrishnan welcomed the guests and highlighted various scientific achievements of CSIR-CBRI, Roorkee. He motivated the S&T staff to take interest in understanding the principles and practical applications of science for a brighter future of our nation. He stressed that science should be explored for the benefit of the mankind so as to improve health, income and living standard of the common masses.

He said that research and development is the soul of a country and we now need to give emphasis on technological output along with other tangible outputs.

On this occasion, the second book in the CSIR Platinum Jubilee Series, edited by Shri Yadvendra Pandey, Chief Scientist and compiled by Shri Rajeev Kumar Sharma, Shri Pradeep Kumar Yadav and Shri Vineet Kumar Saini on 'CBRI Building Business Profile-Process Know-how and Technologies' was released. The latest edition of the quarterly bilingual publication of the Institute, 'CBRI Newsletter-Bhavinka', was also released.

Earlier, Dr. A.K. Minocha, Chief Scientist, welcomed the gathering, informed about the significance of the day and presented a formal introduction of Dr. Rajendra Dobhal. Shri S.K. Singh, Senior Principal Scientist, presented a formal introduction of Dr. Bikas Mohanty.

World Environment Day

CSIR-Central Building Research Institute, Roorkee along with The Institution of Engineers (India), Roorkee Local Chapter celebrated World Environment Day on June 5, 2017 to promote awareness on the importance of preserving our bio-diversity, the need to identify problems related to the environment and ways to take corrective action.

Dr. Kapil Kumar Joshi, Director and Chief Conservator, Uttarakhand Forestry Training Academy, Haldwani graced the occasion as the Chief Guest and Prof. Rajesh Chandra, Chairman, Town Planner Institute, Roorkee as the Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function. The celebrations began with the planting of trees by the guests in CSIR-CBRI, Roorkee Campus as a gesture of harmonious living with nature.

Dr. Kapil Kumar Joshi talked on the concept of environmentalism, carbon emission and rapid irregular climate change. He expressed his concern for the planet and quoted that the Earth is moving towards a 4 ℃ rise, way beyond the permissible 2 ℃ rise with respect to the pre-industrial era. He said that to revert the situation we need to shift from the concepts of sustainable development and production and adopt the concept of sustainable consumption so that there are resources left for the future generation. He also presented an intriguing lecture on "Energy Conservation through Biomass Briquetting". He suggested that the paper mill should use the bagasse generated from the sugar mill for the production of paper. Also, the sugar mill should use bio-briquettes made from excess pine needles in the forest as fuel. Thus, the use of the excess pine needles from the forest reduce the chance of forest fires and provide employment to local villagers, the bagasse from sugar mills are effectively used in paper mills and qualify as construction and demolition material and the use of bagasse instead of wood to produce paper effectively reduces deforestation.

Prof. Rajesh Chandra informed the gathering about the importance of space in a good construction practice. He expressed his concern on the scarcity of water and energy resources, increase in population and pollution and the rapid deforestation. He said that the land is limited and is becoming scarce with the increase in population. He compared the data of different countries to show that our nation

has a very low land to population ratio. This limited land is also shared for agriculture and forestry. Thus we need to adopt the concept of vertical construction for its optimum use.

Shri Malvinder Singh, Chairman, The Institution of Engineers (India), Roorkee Local Chapter addressed the gathering and asked everyone to revaluate their actions and reconnect to nature. He invited everyone to take the 'Green Pledge' to take care of land and environment, recycle and reuse, and conservation of land and water.

In his Presidential Address, Dr. N. Gopalakrishnan expressed his concerns on the present day environmental scenario and the impending doomsday conditions such

as global warming. He informed that CSIR-CBRI is working in the right direction to face these challenges by developing environment friendly building materials such as cement free concrete and other organic building materials.




On this occasion, the book 'CSIR-CBRI Tips for Good Construction Practices in Buildings', edited and compiled by Dr. Ajay Chaurasia, Shri Shubham Singhal, Shri Jalaj Parashar and Shri Shubham Kumar was released.

Earlier, Dr. A.K. Minocha, Chief Scientist, welcomed the gathering, informed about the theme 'Connect People to Nature' and presented a formal introduction of Dr. Kapil Kumar Joshi. Dr. Achal Mittal, Senior Principal Scientist, presented a formal introduction of Prof. Rajesh Chandra.

Independence Day

CSIR-Central Building Research Institute, Roorkee celebrated the Independence Day with a deep sense of patriotism and gaiety on August 15, 2017 at the Main Lawns of the Institute. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee hoisted the National Flag, addressed the gathering and took the salute at the March Past performed by the security guards. The school children from Bal Vidhya Mandir and CBRI Junior High School presented various cultural programmes on patriotic themes.






CSIR-CBRI, Roorkee Participated in the Rajasthan Start-up Fest

CSIR-Central Building Research Institute, Roorkee participated in the Rajasthan Start-up Fest during August 17-18, 2017 at UIT Auditorium, Kota. The Hon'ble Chief Minister of Rajasthan, Mrs. Vasundhara Raje inaugurated the Fest. More than 150 industrialists benefitted from the Fest.

The CSIR-CBRI Team of Dr. Rajni Lakhani, Shri Rajesh Kumar and Shri Shahnawaz Khan displayed the building products such as Flooring-cum-Wall Tiles, Paver blocks and Lightweight Blocks utilizing Kota Stone Waste. The Display got a positive response from the visitors. The industrialists visited the display and raised their queries along with valuable feedbacks. Important dignitaries including Mrs. Vasundhara Raje, Chief Minister of Rajasthan; Shri Surender Pal Singh, State Minister of Mines; Mrs. Aparna Arora, Chairperson, Rajasthan State Pollution Control Board (RSPCB); Shri Amit Sharma, RSPCB Regional Officer (Kota) visited and interacted with the CSIR-CBRI Team.

Sadbhavna Diwas

CSIR-Central Building Research Institute, Roorkee observed Sadbhavna Diwas on August 20, 2017 with a view to promote harmony amongst people of all religion, languages and states and goodwill towards everyone. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee administered 'Sadbhavna Pledge' to the staff members of the Institute.

Workshop on Optimization in Engineering

CSIR-Central Building Research Institute, Roorkee organized a workshop on "Optimization in Engineering" on August 25, 2017.

Inaugurating the workshop, Dr. A. K. Minocha, Chief Scientist said that optimization is required in every field of life, whether it is engineering or science. Dr. Abha Mittal, Senior Principal Scientist and Organizing Secretary gave detailed information about the workshop. Dr J.C. Bansal, Secretary, Soft Computing Research Society, Delhi informed the participants about the society. Dr. P.K.S. Chauhan, Principal Scientist conducted the function.

During the programme, Dr. Abha Mittal presented a lecture on "Introduction to Optimization and Analytical Techniques"; Dr. Kusum Deep, Professor, IIT, Roorkee, gave lectures on "Particle Swarm Optimization and its Applications" and "Genetic Algorithm"; Dr J.C. Bansal, South Asian University, New Delhi presented a lecture on "Swarm Intelligence: An Intelligent Way of Problem Solving"; and Dr. D.P Kanungo, Senior Principal Scientist presented a lecture on "ANN and Fuzzy Logic and its Applications".

Dr. Atul Kumar Agarwal, Senior Principal Scientist guided the participants through the labs of CSIR-CBRI, Roorkee and informed them of the various technologies developed by the Institute through vibrant models. The workshop concluded by the distribution of

certificates to the participants during the closing ceremony. About 25 participants from different institutions of Dehradun, Udham Singh Nagar, Moradabad, Gwalior, Rishikesh, Delhi, Haridwar, Roorkee and Modi Nagar participated in the workshop.

Hindi Week

Hindi Week was observed at CSIR-Central Building Research Institute, Roorkee during September 14-21, 2017 with great zeal and enthusiasm. Dr. Suvir Singh, Chief Scientist, coordinated the event.

On the occasion, a Hindi Books Exhibition was organized at the Knowledge Resource Centre (Library) of the Institute under the supervision of Dr. S.K. Senapati, Principal Technical Officer and In-charge, Library. A reading session was also organized for the children of CSIR-CBRI personnel, wherein Dr. S. K. Senapati, Dr. Pradeep Chauhan and Shri Mehar Singh read interesting abstracts from the children's literature section.

On September 21, 2017, Shri Vimalkant Sanwalji Dave, Retired Professor, Department of Geology, IIT Roorkee graced the valedictory function as Chief Guest and presented a lecture on "Seeds of Environment in the Ancient Sanskrit Literature". He said that in ancient Indian literature, there has been a lot of emphasis on the protection of the environment and it has been associated with the person's conduct and behaviour. He informed that even the Vedas highlight the importance of ideals and ethics in the society.

The Closing Ceremony was chaired by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee.

In his Presidential Address, Dr. N. Gopalakrishnan said that it is our constitutional duty to do our work in Hindi language and inspired the scientists to write scientific articles in Hindi language so that it is easily accessible to the general public. He called upon everyone for the combined responsibility to accept Hindi as official language of our country for comprehensive growth and development.

On this occasion an edition of 'CSIR-CBRI Tips for Good Construction Practices' and the latest edition of the Quarterly Bilingual 'CBRI Newsletter Bhavanika' were also released.

Shri Suba Singh, Hindi Officer welcomed the gathering and presented the performance and description of the organization's activities and achievements throughout the year. Dr. Pradeep Chauhan, Principal Scientist and In-charge Official Language Implementation, introduced the Chief Guest and presented details of the activities held throughout the week.

Winners of various competitions organized during the week including Hindi noting and drafting, scripting Competition, poetry recitation and extempore were felicitated. Shri Mehar Singh, Hindi Officer presented a vote of thanks.



CBRI Celebrates CSIR Platinum Jubilee Foundation Day

The CSIR Foundation Day was celebrated with great enthusiasm at CSIR-Central Building Research Institute, Roorkee on September 26, 2017. Established in 1942, CSIR completes the 75th year of its contributions in the scientific achievements of India. The yearlong Platinum Jubilee Celebrations at CSIR-CBRI, Roorkee ended with a grand CSIR Foundation Day Celebration on September 26, 2017.

Dr. Rajiv Kumar Tayal, Executive Director, Indo-US Science and Technology Form (IUSSTF), New Delhi graced the occasion as Chief Guest and Dr. Debanik Roy, Scientist (Robotics) and Chief Programme Coordinator, Board of Research in Nuclear Science (BRNS), Department of Atomic Energy (DAE), Government of India, Mumbai as Guest of Honor.

Presenting a talk on "Embracing the Change to Build a Strong Future", Dr. Rajiv Kumar Tayal explained that only the fittest i.e., the most adaptive, survives and so we need to reinvent and adapt new dynamics that lasts for the next 75 years. Addressing the gathering, Dr. Debanik Roy urged the Institute to work diligently,




doing goal-oriented and time-managed research to bring out pro-people technologies from lab to land. Dr. A. K. Minocha, Chief Scientist read the message of Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee and congratulated the CSIR family for glorious history and contributions in the service of the country.



On this occasion, the latest edition of 'Central Building Research Institute Annual Report' was released. Dr. Suvir Singh, Chief Scientist presented the formal introduction of the Chief Guest. Dr. Achal Mittal, Senior Principal Scientist presented the formal introduction of the Guest of Honor and proposed a vote of thanks.

As an important part of this day, the laboratories of CSIR-CBRI, Roorkee were open to the students and the general public from 9:00 AM, giving everyone the opportunity to become familiar with the R&D work of the Institute and get the opportunity to interact with the scientists.

CSIR-CBRI, Roorkee staff members who have completed twenty-five years' service in CSIR and the scientists and staff of CSIR-CBRI, Roorkee superannuated during the year, were felicitated on the occasion. The winners of painting competition and science quiz, organised for students of classes 6 to 12 in several categories on assorted topics, were also awarded on the occasion. Meritorious students getting more than 90% marks in three science subjects, in the Intermediate Examination, were awarded with a lump sum cash award of Rs. 3000/-. The superannuated staff of the Institute, over 200 students from Kendriya Vidyalaya No. 1, Kendriya Vidyalaya No. 2 and Doon Public School along with their faculty also graced the occasion besides other dignitaries.

Diwali Mela

The Diwali Mela was organized jointly by CSIR-CBRI Staff Club and Shanti Nagar Ladies Club Roorkee on October 13, 2017 at Shanti Nagar Colony ground. Dr. A.K. Minocha, Chief Scientist, inaugurated the Mela and visited all the stalls organized by members of CBRI Ladies Club. Stalls offering wide variety of delicious traditional food, handicraft items, fun games and swings for kids etc. were highly appreciated. This annual festival was fun for the CSIR-CBRI, Roorkee family and the visitors alike. Entertaining activities like dance competition, theme based fancy dress competition, tambola, and lucky dip etc. were organized and appreciated by audience, viewers, and judges. Prizes were distributed to the winners of all the competitions including Lucky Dip. Viewers appreciated the whole programme and perceived the importance of 'Festival of Light' in life.



Vigilance Awareness Week

Vigilance Awareness Week was celebrated at CSIR-Central Building Research Institute, Roorkee during October 30, 2017-November 4, 2017. The Vigilance Awareness Week was inaugurated by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee with the Oath of Integrity, wherein the Institute staff pledged to be sincere and honest in their daily workings.

Dr. Ashok Kumar, Senior Principal Scientist, presented a talk on "My Vision-Corruption Free India" and said that today corruption has spread like cancer in our country and to fight it we all need to self-mediate and bring positive changes in our behavior.

The Closing Ceremony of Vigilance Awareness Week was organized November 4, 2017. Ms. Nitika Khandelwal, Joint Magistrate (IAS) Roorkee, graced the occasion as the Chief Guest and Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.

In her address, Ms. Nitika Khandelwal said that it is necessary to change our thinking to fight corruption. She said that along with getting rid of institutional corruption, we have to stay away from corrupt thinking. Democracy is for the people and we can step in the direction of corruption-free India by bringing transparency in all our work and by providing the right information to the people.

In his Presidential Address, Dr. N. Gopalakrishnan said that we all need to work together to fight



corruption. He encouraged everyone to carry out all the work carefully and with transparency even at the institutional level so that better results will emerge.

Shri Ajay Dwivedi, Senior Technical Officer, welcomed the Chief Guest. Dr. P.K.S. Chauhan, Principal Scientist, presented the details of the activities of the week. Winners of various competitions organized during the week including speech competition and poster competition for children of CSIR-CBRI, Roorkee staff personnel were felicitated. Shri Vinod Kumar, Administrative Officer presented a vote of thanks.



Swachhta Pakhwada

CSIR-Central Building Research Institute, Roorkee observed Swachhta Pakhwada during November 1-15, 2017 under which awareness programmes were organized to educate on the importance of cleanliness.

The Pakhwada was inaugurated by Dr. N. Gopalakrishnan, Director CSIR-CBRI, Roorkee with the 'Swachhta Pledge' wherein all the officers and employees of the Institute pledged to donate their time and energy to keep their families, villages, societies and surroundings clean for an overall development of the country.

The employees followed their resolution of cleanliness through various cleanliness drives every day. Message of Cleanliness was spread through digital boards, posters, banners and cleanliness drives etc. under "Swachhta Jagrukta" drive. Pest control and fogging were carried out on all the floors of the Institute and residential areas under "Swachh Parisar" programme. Under the "Swachh Anubhag" drive, the old and unused furniture, files, papers, newspapers, magazines etc. were disposed from all the sections. Obsolete and useless items of the Institute were auctioned under the "Swachh Neelami"

programme. Under "Swachh Neer" programme an intensive inspection and cleaning of all the toilets, sewer lines, drainage systems, water installations, drinking water filters, faucet, tank etc. of the Institute

residential area and school were carried out. Under the "Swachh Ahaar" programme, clean and nutritious food, plastic restriction and use of dustbin were emphasized in the canteen of the office. All the doors, windows, curtains and equipment of the Institute were scrubbed and repaired under the "Swachh Karyalya" programme.

In this direction, under the "Swachh Paryavaran" programme, Dr. N. Gopalakrishnan and other officials planted trees around the Institute premises on November 14, 2017 to promote a clean and healthy environment.

At the same time, under "Swachh Samvad" drive, an essay competition was organized on the subject of 'Cleanliness and Hygiene' for the staff of the Institute under the supervision of Shri Vineet Saini, Senior Scientist wherein Shri Kaushik Pandit secured the first place, Shri Rajesh Tyagi got the second and Shri Aman Kumar received the third prize.

In order to provide awareness and information about cleanliness and hygiene in children under the "Swachh Pratispardha" drive, an Awareness Programme and Quiz Competition on 'Cleanliness & Hygiene' were organized under the guidance of Dr. Atul Kumar Agarwal, Senior Principal Scientist, for students of class 9-10.

The winners of all the competitions organized during the Swachhta Pakhwada were felicitated by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee.

Training Programme on Housing for All - Innovative Technologies for Rural Housing

CSIR-Central Building Research Institute, Roorkee has developed innovative technologies for architectural and structural design of multi-hazard resistant construction. These building technologies have been demonstrated in field, and hands-on training has been provided to grass root level functionaries in different parts of the country. The Institute has also completed the task of validation of the architectural and structural rural housing designs of 13 states of the country developed by the MoRD & UNDP under the PMAYG Scheme, recently. Also, the development of architectural and structural rural housing designs, technical support for construction of demonstration houses and training to the field level staff under Biju Pucca Housing Scheme are being provided on the request of Panchayati Raj Department of Odisha. It is essential to mass implement disaster-resistant/innovative rural technologies

developed by different institutions. This demands development of skills and capacity building among the administrative and technical functionaries at the state/district level for its systematic implementation. Recently, a team of field level officers had visited CSIR-CBRI, Roorkee and acquired the knowledge of rural technologies developed by the Institute. Further, Panchayati Raj Department, Government of Odisha has requested CSIR-CBRI, Roorkee to provide training/ demonstration to their Engineers and Assistant Project Directors etc. for the enforcement of systematic rural housing scheme for the construction of sustainable rural houses under different government schemes.

Accordingly, a four-day training programme on "Innovative Technologies for Rural Housing" was organized during December 28-31, 2017 at CSIR-Central Building Research Institute, Roorkee. The programme was attended by 28 Assistant Project Directors of Panchayati Raj Department of Odisha Government. The training programme was particularly aimed at enhancing knowledge and skills of the implementing archives to incorporate innovative and disaster resistant building techniques in rural house design through lectures, demonstrations and hands-on exercises and to build durable, disaster resilient and low cost houses which are acceptable to the local community.

The training programme was inaugurated by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee and emphasized the role of innovative technologies in construction of low cost housing scheme to build

disaster resilient houses across the country with the involvement of CSIR-CBRI, Roorkee for providing technical support for development of sustainable built environment. He also said that this can be achieved by enhancing the knowledge and skills of implementing authorities through providing training/demonstration/ skill developmental activities to the field level functionaries.

The programme incorporated technical sessions on mainstreaming of disaster risk reduction, innovative technologies for rural housing, foundation, building designs/components/services and new building materials; field demonstration of the products and

field visit for demonstration of building technologies implemented at different locations. Lectures were delivered by Scientists of CSIR-CBRI, Roorkee.

Later, the concluding session was chaired by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee. Dr. R. Dharmaraju, Senior Principal Scientist apprised about the four days activities of the training programme followed by the feedback from the participants. They expressed that the latest knowledge and innovations learnt during the programme would help them in construction of durable, low cost and disaster resistant houses under the housing scheme of Odisha.

The session concluded with the distribution of certificates to the participants and vote of thanks proposed by Shri S.K. Negi, Senior Principal Scientist and Training Coordinator.

Training Programme on Housing for All - Innovative Technologies for Rural Housing

A four-day training programme on "Housing for All - Innovative Technologies for Rural Housing" was organized during January 11-14, 2018 at CSIR-Central Building Research Institute, Roorkee for the engineers of Odisha Government. The programme was particularly aimed at enhancing knowledge and skills of the implementing archives to incorporate innovative and disaster resistant building techniques in rural house design for building durable, disaster resilient and low cost houses, which are acceptable to the local community, through lectures, demonstrations and hands-on exercises.

The training programme was inaugurated by Ms. Nikita Khandelwal, IAS, Joint Magistrate, Roorkee.

During her Inaugural Address, Ms. Nikita Khandelwal emphasized on the application of innovative technologies in construction of low cost housing and disaster resilient houses that are being provided to the society under the different government schemes. She appreciated the efforts of CSIR-CBRI, Roorkee in providing technical support for development of sustainable built environment across the country.

In his Presidential Address, Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee informed that the Institute is involved in providing better low cost housing technologies to the community and these technologies need to be implemented at the grass root levels properly. He said that this can be achieved by enhancing the knowledge and skills of implementing authorities through providing training/demonstration/skill developmental activities to the field level functionaries.

The training programme consisted of technical sessions, on various topics including mainstreaming of disaster risk reduction; innovative technologies for rural housing; foundation, building designs/components/services; new building materials and field demonstration of the products, followed by a field visit for demonstration of building technologies implemented at different locations.

The concluding session was graced by Shri Savin Bansal, IAS, Additional Secretary, Department of Disaster Management & Rehabilitation, Dehradun as Chief Guest.

In his address, Shri Savin Bansal expressed that interaction with technology inventor and field level implementer is very much demanded for the



construction of low cost housing that is durable and acceptable by the community. He appreciated the technical support of CSIR-CBRI, Roorkee on capacity building and implementation of innovative housing technologies for providing disaster resilient houses to the community.

Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee assured to provide all the technical support needed for the implementation of Biju Pucca/PMAY-G houses that are being constructed across the state of Odisha.

Dr. R. Dharmaraju, Senior Principal Scientist and Training Coordinator apprised about the various activities organized during the training programme.

During the session, the programme received feedback from the participants. The participants expressed that the latest knowledge and innovations learnt during the programme would help them in construction of durable, low cost and disaster resistant houses under the housing scheme of Odisha.

The session concluded with the distribution of certificates to the participants. Shri S.K. Negi, Senior Principal Scientist proposed a vote of thanks. The programme was attended by 35 engineers of Panchayati Raj Department of Odisha Government.

Republic Day

The Republic Day of the Nation was celebrated with a deep sense of patriotism combined with gaiety on January 26, 2018 at CSIR-Central Building Research Institute, Roorkee main lawns. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee hoisted the National Flag, addressed the gathering and took the salute of the March Past performed by the guards. The school children from Bal Vidya Mandir and CBRI Junior High School presented various cultural programmes on patriotic themes.






Training Programme on Engineering Simulations

A three-day training programme on "Engineering Simulations: CFD & FEM" was organized at CSIR-Central Building Research Institute, Roorkee during January 31, 2018 - February 2, 2018 to equip scientists and students of CSIR-CBRI, Roorkee with the knowledge of FEM/CFD.

Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee inaugurated the course and enriched participants on the importance of FEM and CFD and correct usage of such powerful codes. The programme was conducted by Dr. Shorab Jain, Principal Scientist of the Institute and Shri Aaron Ashwin Murugan and Shri Niraj Paliwal from Entuple Technologies, Partner of ANSYS India Ltd.

Current day Engineering problems require high-level computer simulation of fluid flows, structure-mechanical systems, thermal and chemical processes in complex systems. Using well-established engineering tools, such as the Finite-Element-Method (FEM / FEA) or Computational Fluid Dynamics (CFD), it is possible to have meaningful, descriptive insights into the problem e.g. into the flow field or temperature distributions within your equipment, the stress condition, vibration behaviour or life span of your component. This detailed three-dimensional, realistic information allows functional and efficient design and target-oriented dimensioning of components.

The course content include fundamental concepts and tools used in an integrated fashion for carrying out FEM and CFD simulations using a powerful tool from ANSYS, Inc. i.e. Fluid dynamics simulations using ANSYS Fluent and Structural mechanics simulations using ANSYS Mechanical. The course was problem-based wherein participants learnt through hands-on experience. The participants were enlightened on the concepts of finite-element analysis and computational fluid dynamics and made to practice using a common solution approach to problems involving different physics: structural mechanics, fluid dynamics and heat transfer.

The programme concluded with the distribution of certificates to the participants by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee. The training programme was attended by 35 participants that included scientists, technical officers, project assistants, students of AcSIR and trainee students.

CSIR-CBRI Foundation Day

CSIR-Central Building Research Institute, Roorkee celebrated its 72nd Foundation Day on February 10, 2018. Prof. N. Raghavan, Professor of Practice, IIT Chennai & Chairman, Research Council, CSIR-CBRI, Roorkee graced the occasion as Chief Guest and Shri Kamal Kishore, Member, National Disaster Management Authority, New Delhi as the Guest of Honor. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.

In his Presidential Address, Dr. N. Gopalakrishnan expressed his gratitude and best wishes to everyone who has directly or indirectly made a contribution in

this glorious journey of the Institute. He said that even though the Institute faced a great deal of difficulties but it has risen upto the challenge through its resilience and dedication. He assured that the Institute will continue to serve the nation by carrying out R&D in all aspects of housing and assisting the building industry.



Addressing the gathering, Prof. N. Raghavan, Chairman, RC said that CSIR-Central Building Research Institute, Roorkee is the crown jewel of civil engineering and has made unprecedented contributions for the growth and development of the nation. He encouraged the scientists and staff of the Institute to build sustainable, safe, cost-effective and durable cutting edge building techniques. He appealed to the scientists to be prepared for the upcoming challenges through discipline and self-inspection.

Shri Kamal Kishore, in his address, complimented CSIR-CBRI, Roorkee for making its mark on the whole world through its achievements. He said that the fingerprint of CSIR-CBRI, Roorkee can be found across the globe as they take inspiration from the R&D works of the Institute like reconstruction of villages after Uttarkashi earthquake by building Kedar Kutir, fire protection measures for Salar Jung museum etc. He encouraged the Institute to transit from pilot projects to large scale projects, engage with the industry and make them reach the general public.

The Institute was open for the students of the schools and colleges of Roorkee and the public at large. The students of Kendriya Vidyalya No. 1 and Kendriya Vidyalya No. 2 participated in the Science Exhibition under the "Jigyasa-Quest for Curiosity" student scientist connect programme organized under the supervision of Dr. Atul Kumar Agarwal, Senior Principal Scientist & Jigyasa Programme Coordinator. The Exhibition also displayed the technical achievements of the Institute









through the display of the Institute Publications including the Institute's Technical Brochures, Building Research Notes, Annual Reports, and Newsletters etc.

On this occasion the Diamond Jubilee Director's Award for Best Research Paper of Rs. 15,000/- and a citation was awarded jointly to Dr. Anindhya Pain, Shri V.S. Ramakrishna and Dr. S. Sarkar for the paper titled "Seismic Transition Failure Analysis of MSW Landfill using Pseudo-Dynamic Approach"; and Dr. L.P. Singh, Shri W. Zhu and Ms. Usha Sharma for the paper titled "Quantification and Characterization of C-S-H in Silica incorporated Cementitious System".










The Diamond Jubilee Director's Award for Development of Best Technology which has Maximum Impact on the Society of Rs. 10,000/- and a citation for each technology was awarded to four technologies- "Design of High Draught Brick Kiln" by Shri E.S. Heera Lal, Dr. A.K. Minocha, Shri S. Maiti, Dr. Neeraj Jain and Shri Vivek Sood; "Building Products using Kota Stone" by Dr. Rajni Lakhani and Shri Rajesh Kumar; "Boring Machine for making Horizontal Bores under the Ground" by Dr. S.K. Panigrahi, Shri Narendra Kumar, Shri R.S. Bisht and Shri Sameer; and "Technology for Coal Ash Utilization through Geopolymer Concrete for In-Situ Construction" by Ms. G. Ishwarya, Ms. Humaira Athar, Shri Rakesh Paswan, Md. Reyazur Rehman, Shri Jeeshan Khan, Shri S.K. Singh and Ms. Sandhya Deshwal.

Shri V.P.S. Rawat, Security Officer and Shri Sudhir Sharma, Ex- Technical Officer were awarded

a Samman Patra and a Trophy in recognition of Excellence in sports at State level in the age category of 50+ and at International level in the age category of 61-72 respectively. A Samman Patra and cash award of Rs. 3000/- was awarded to Shri Raj Singh, Security Guard in recognition of his sincere and extra vigilance in performing his duties during the year 2017-2018.

Empowerment: Key to National Development' was organized wherein Dr. Atul Kumar Agarwal stood first, Shri Ashish Kharkwal placed second and Dr. Rajni Lakhani received the third prize.

Dr. A.K. Minocha, Chief Scientist conducted the proceedings and presented the formal introduction of the Chief Guest. Dr. Suvir Singh, Chief Scientist

A Debate competition was organized under the supervision of Shri Aman Kumar on the topic 'Social Media-A Boon or a Curse' in which Shri Arpan Maheshwari stood first, Shri Sushil Kumar stood second and Shri Saksham Bhardwaj received the third prize. An Essay Writing Competition on the topic 'Women

presented the formal introduction of the Guest of Honor and proposed a vote of thanks.

The students of various schools, superannuated staff of CSIR-CBRI, Roorkee and all the staff members of the Institute also witnessed the occasion besides other dignitaries.

Training Programme on Multi Hazard Resistant Housing and Habitat

On the request of Department of Disaster Management & Rehabilitation, Dehradun, one-week training programme on "Multi Hazard Resistant Housing & Habitat" was organized during February 19-23, 2018 at CSIR-Central Building Research Institute, Roorkee for the engineers of Uttarakhand Government. The programme aimed to impart technical training under disaster resilient planning, design and construction and on the best practices in planning, design, construction and maintenance of multi-hazard resistant housing.

The training programme was inaugurated by Dr. A.K. Minocha, Chief Scientist, CSIR-CBRI, Roorkee. He emphasized on the incorporation of multi-hazard resistant construction technologies, in construction of low cost housing scheme for building disaster resilient houses across the country, with the involvement of CSIR-CBRI, Roorkee for providing technical support in the development of sustainable built environment. He also said that this can be achieved by enhancing the knowledge and skills of implementing authorities

through providing training/demonstration/skill developmental activities to the field level functionaries.

Different technical sessions, on various topics including mainstreaming of disaster risk reduction; innovative technologies for rural housing; foundation, building designs/components/services; new building materials and field demonstration of the products were covered during the programme.

The concluding session was chaired by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee. During this session, training coordinators, Shri S.K. Negi, Senior Principal Scientist and Dr. Ajay Chourasia, Principal Scientist apprised about the five days activities of the training programme, followed by the feedback from the participants. The participants expressed that the latest knowledge and innovations learnt during the programme would help them in their individual fields.

The session concluded with the distribution of certificates to the participants by Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee, followed by vote of thanks proposed by Dr. R. Dharmaraju, Senior Principal Scientist. The programme was attended by 38 engineers of various departments of Uttarakhand Government.

International Workshop on Innovations in Safe and Sustainable Infrastructure

A one-day International Workshop on "Innovations in Safe and Sustainable Infrastructure" was jointly organized by IC-IMPACTS HQP Network, Canada and CSIR-Central Building Research Institute, Roorkee, India on February 26, 2018. The primary aim of this workshop was to bring together scientific community and HQPs to exchange new advances and ideas to address safe and sustainable infrastructures.

Our evolving society is in dire need of emerging and futuristic technologies to overcome various challenges with respect to infrastructures. Real-world experiences have been consistently showing that emerging technologies can address our challenges. Providing such robust and sustainable technological developments can prevent hazards such as, but not limited to, infrastructure damages, monitoring of structures to prevent it from hazards, smart materials to achieve the desired properties which will be economic and reusable and so forth.

Distinguished speakers from related universities and research laboratories were invited to throw light on corresponding challenges. In addition, engineers and students can benefit from hands-on training and demonstration sessions on advanced smart technologies.

Dr. A.K. Minocha, Chief Scientist inaugurated the workshop and gave his lecture on "Demolition Wastes". Dr. Suvir Singh, Chief Scientist gave a presentation on "Fire Behavior on Concrete Structures". Professors from IIT Roorkee and Concordia University presented their research topics during the workshop. The workshop was successful in creating a unique opportunity through communicating and networking with entrepreneurial researchers, scientists and state-of-the-art industrial innovations.

The workshop was attended by Professors, Scientists and students from national and international level. There were total 40 participants in the workshop and 3 delegates from Canada through Skype.

National Science Day

CSIR-Central Building Research Institute, Roorkee celebrated the National Science Day on February 28, 2018. Prof. Raj Hirwani, Former Head and Technical Advisor, CSIR Unit for Research and Development of Information Products (CSIR-URDIP), Pune graced the occasion as the Chief Guest and Prof. Anjan Sil, Head, Department of Metallurgical and Materials Engineering, IIT, Roorkee was the Guest of Honor. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.

Prof. Raj Hirwani presented a lecture on "Patent Information for Research and Business Development", and apprised about patents, patent citing analysis, patent mapping etc. Explaining the importance of patents, he said that patinformatics opens new areas of research and plays a crucial role in determining

the Institute's core strength, structure, capacity, mergers and acquisitions, investment risk, human resources management etc. He also gave details on the services offered by URDIP to CSIR, nation's start-up companies, other institutions and companies in the domestic and foreign corporate world.

Prof. Anjan Sil presented a lecture on "Energy Storage Materials for Sustainable Future" and talked about green energy, lithium ion batteries and their miniaturization, electronic vehicles, polymer based materials, energy storage devices, nanotechnology, carbon nanotubes etc. He also discussed the research being carried on in the advanced areas of sustainable lithium alternates, new cost effective techniques, reuse of lithium extracts etc.

In his Presidential Address, Dr. N. Gopalakrishnan, Director, discussed the contributions and achievements of CSIR-CBRI, Roorkee.

Dr. S. Sarkar, Senior Principal Scientist conducted the programme and presented the formal introduction of the Chief Guest. Dr. S.R. Karade, Senior Principal Scientist presented the formal introduction of the Guest of Honor and Dr. B. S. Rawat, Principal Scientist presented a vote of thanks.

International Women's Day

International Women's Day was celebrated on March 9, 2018, at Ravindra Nath Tagore Auditorium, CSIR-Central Building Research Institute, Roorkee with the theme 'Time is now: Rural & Urban Activists transforming Women's Lives' to draw inspiration from the vibrant life of the women activists whose passion and commitment have won women's rights over the generations. Mrs. Hema Raghvan graced the occasion as the Chief Guest and Mrs. Charu Chaturvedi as the Guest of Honor. Mrs. Jaishree Gopalakrishnan, Patron, CSIR-CBRI Ladies Club presided over the function.

Expressing her views, Mrs. Hema Raghvan said that we need to take inspiration from the remarkable women activists all over the world, who have bravely spoken out to gain access to justice, advocated for legal reform, stood up for their custodial rights and taken to the streets to turn protests into broader-based movements for women's rights, to show everyone that when women support one another, they can overcome any stigma.

Mrs. Charu Chaturvedi said that it is our responsibility to speak with one voice for equal

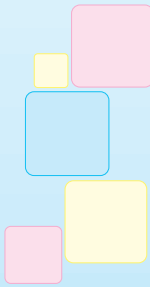
opportunity and accountability to all genders, from grass root networks to government leadership. We need to put an end to the impunity and the silent suffering of women in rural and urban areas, including women domestic workers, and empower the oppressed women of the society, by awakening them to their basic rights.

Mrs. Jaishree Gopalakrishnan said that a healthy society is one that provides equal power to a wide mix of voices, debates and learns from the varied threads of experience and perspectives, for every decision-making. If the voices of the women are missing, then there is an important gap in the fabric of society, as these quietened voices count in millions. We need to empower these voices to rise in strength and solidarity to set things right.

Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee graced the occasion also. While expressing his thoughts on women empowerment, he said that the culture of gender-based poverty, abuse and exploitation has to come to an end for a new generation of equality to be born. Dr. Purnima Parida, Senior Principal Scientist welcomed the dignitaries and the guests. Mrs. Rashmi Rathore, Section Officer expressed her views on the challenges faced by the women at work place.

Dr. Abha Mittal, Senior Principal Scientist said that we need to recognize the tireless work of activists who have been central to the global movements for gender equality by highlighting the complexities of the challenges facing women and influencing policies. We must continue to rally and inspire diverse groups of people to support and shape the agenda of gender equality, so that the young minds learn to value and respect women.

All the women staff of CSIR-CBRI, Roorkee, members of the CSIR-CBRI Ladies Club and others participated in the programme and voiced their opinions.



Student-Scientist Connect Programmes

Student Awarenness Programmes

CSIR-Central Building Research Institute, Roorkee organized a Student Awareness Programme under the CSIR Scheme, "Faculty Training, Motivation & Adoption of Schools & Colleges by CSIR Labs", for science students of classes 11 and 12, on May 26, 2017 to generate scientific thinking in the younger generation and create the foundation of a strong mind contributing to the development of the country.

In his Presidential Address, Dr. N. Gopalakrishnan, Director, CSIR-CBRI welcomed the students and helped them understand the difference between science and technology. He informed that civil engineering is the oldest science. It creates a habitat- something that is in peace with nature while resisting the forces of nature and maintaining synergy with the principles of science. It has evolved with adoption and incorporation of modern technologies. He shared an example and said that the brick making technique was present even in the time of Mohenjo-daro, but with latest developments such as nanotechnology, this technique has evolved to newer levels. Now we need to take science to the people with sustainability. He encouraged the students to question, imagine and build up curiosity. He motivated the students to become a scientist.

Dr. Suvir Singh, Chief Scientist, CSIR-CBRI presented an informative lecture on ''Fire Research''. With the help of two case studies, he explained how a fire spreads inside and outside a building, the time taken by the fire to spread and how to minimize loss. With the help of short video films, he depicted the initial, growth, and flashover, fully developed, decay and spread stages of a fire. He also showed the various clips depicting the fire resistance of new developed building structure elements such as fire resistant glasses and thermal shock protected column. He informed about the technologies developed for the prevention, protection and confinement of the fire. He emphasized on the presence of an efficient fire escape to minimize loss.

Dr. R.D. Dwivedi, Principal Scientist, CSIR-CIMFR Regional Centre, CBRI Campus, Roorkee presented an enlightening lecture on ''Exposure to Tunnel Engineering''. He informed about the importance of tunneling stating that a tunnel shortens the distance thus reduces fuel and carbon emission. It prevents weathering of path due to extreme conditions, avoids accidents and traffic jams dues to landslides and earthquakes and protects from extreme climatic conditions. He showed short videos

of the recently inaugurated Chenani-Nashri tunnel in Jammu & Kashmir. This 9 km long tunnel shortens the 42 km long distance between the Chenani and Nashri cities while protecting the travelers from the forces of nature. The main tunnel is provided with escape tunnel, with escape routes at regular intervals to provide a quick and safe exit in case of an emergency.

Earlier, Dr. Atul Kumar Agarwal, Senior Principal Scientist and Programme Coordinator, CSIR-CBRI welcomed the students and motivated the students with an intriguing lecture on ''Career Opportunities''. He said that education should be such which forms character, increases strength of mind, expands intellect, and enables one to stand on one's own feet. It should devoid us of any misconception, myths and superstitions and provide us with the strength to face the world. He motivated the students with the life and works of Dr. Lalji Singh, Former Director, CSIR-CCMB, who fought the superstitions surrounding the genetic disorders affecting his village and founded a non-profit research and service organization, the Genome Foundation, with the aim of diagnosing and treating genetic disorder affecting the Indian population, in particular the under-privileged people residing in rural India, with the participation and voluntary services of scientists and professionals. Dr. Lalji worked in the field of DNA fingerprinting technology and is known as the "Father of Indian DNA Fingerprinting".

Dr. Agarwal enlightened the students on the importance of educational training programmes and asked them to adopt a scientific approach of questioning and interactions through active participation. He emphasized that everyone has some innate quality that must be discovered and honed. We need to get self-motivated and understand the 'Value' of our thoughts and self, 'View' the output of our thoughts, 'Verify' the facts involved, and achieve them to attain 'Victory', otherwise everything will be in 'Vain'. He advised the students to not shy away from failure but to learn from them. He encouraged them to aspire for the top slot and prepare by refining strategies. He informed how Sir Thomas Elva Edison was considered simple minded and denied education at schools, but he did not lose hope and became genius of the century. Dr. Agarwal advised the students to combat stress by organizing time, setting goals, understanding work process, avoiding burnout, changing revision methods, taking care and not worrying. The present scenario carries many challenges, for which we must decide on our priorities. He stressed that the students must remember the subjects of their choice and their weak points while choosing a stream. He informed the students about numerous professional courses, open and distance learning system, and a vast sea of career opportunities in every lifestyle including advertising, bio-technology, computer training, distance learning, engineering, finance, hotel management, information technology, law, mass communication, service and tourism etc. He also informed that with an all-round approach towards R&D, CSIR also provides a wide window of opportunities in all the fields in all the areas of life. Entrepreneurship and self-employment are also a huge field of opportunity for which proper vocational education can develop the required attitude, knowledge and skills. He also gave a detailed overview of the CSIR scheme of Faculty Training, Motivation & Adoption of Schools & Colleges by CSIR Labs.



Dr. Abha Mittal, Senior Principal Scientist, CSIR-CBRI presented the formal introduction of all the speakers and also presented a vote of thanks.

The participants visited the enriched labs of CSIR-CBRI, Roorkee and learned about the latest developments and technologies by the Institute. A Science film featuring CBRI scientific innovations and success stories was also screened. They also had an interactive session with the Institute's scientist where they put their curiosity to rest and quenched their thirst for knowledge. The programmes got positive feedbacks from the participants and were defined as motivating, inspiring and interesting.

The programme was attended to by more than 100 science students along with their faculty members from Asha Modern International School and Sofia House of Children's Senior Academy, Roorkee along with their faculty members Dr. Anuj Kumar Sharma, Shri Manu Malhotra, Ms. Deepti Jain, Mrs. Nisha Vashishtha and Ms. Sadiya Hasan.

Dr. Atul Kumar Agarwal, Programme Coordinator also informed that the Institute would be starting a unique opportunity for students of classes 9 to 12, to discover the meeting point of science and creativity at CSIR-Central Building Research Institute, Roorkee. The programmes will arouse scientific curiosity and passion in children through interactions with scientists, experiments, laboratory visits, talks and display of technologies and research.



CSIR Platinum Jubilee Capsule Exhibition

To celebrate the 75 years of service of CSIR and its 38 laboratories, CSIR organized capsule exhibitions across the country. As a part of these celebrations, CSIR-Central Building Research Institute, Roorkee organized a three-day CSIR Platinum Jubilee Capsule Exhibition for students, teachers, public and user agencies at the Institute during August 10-12, 2017. The exhibition provided an opportunity for the young students, scientists and the public to come under one roof and witness the achievements and researches by CSIR.

The CSIR Platinum Jubilee Capsule Exhibition was inaugurated by Dr. S.K. Jain, Director, National Institute of Hydrology, Roorkee and Dr. N. Gopalakrishnan, Director, CSIR-Central Building Research Institute, Roorkee. The Chief

Guest witnessed a huge footfall and most significant and path breaking technologies developed by the 38 laboratories of CSIR.

In his presidential address, Dr. N. Gopalakrishnan said that the Institute is inaugurating these celebratory capsule exhibitions with a three-day CSIR Platinum Jubilee Capsule Exhibition. The aim of the technical festival is to inform the people especially students about the various innovations and technologies developed by CSIR, educate them on the new and emerging areas of science and provide an opportunity for interaction and exchange of ideas with the scientific community.

The exhibition displayed the research and development works of CSIR laboratories in every field of science including aerospace and strategic sector, agriculture and floriculture, chemicals, petrochemicals and water, ecology and environment, energy, engineering and infrastructure, food and nutrition, healthcare, IP and entrepreneurship, nurturing human resources, leather, materials, minerals and mining etc. and the technologies developed under CSIR 800.

Various technologies including early warning system for landslides, paving tiles from industrial wastes, indigenous civil avionics, critical technologies for LCA, acoustic tests facility for India's space programme, micro aerial vehicles, high tech indigenous system for measurement of visibility at airports to aid pilots, technology for nuclear waste immobilization, promising aromatic plants and medicinal herbs, affordable healthcare, eco-friendly pest management, indigenous autonomous underwater vehicle, zero discharge using HRTS, water desalination techniques, gemstone processing, Skill India initiatives, CSIR-Traditional Knowledge Digital

Library, patent informatics, DNA based Hepatitis B vaccine, protein rich supplementary food, solar PV-RO systems, 'Ayush' drugs, alternate raw materials for leather, wood substitute building materials, building products from Kota stone waste and preservation of heritage structures etc., were explained through technical charts.

Shri S.K. Negi, Dr. Atul Kumar Agarwal, Dr. R. Dharamraju and Shri S.K. Singh, Senior Principal Scientists of the Institute coordinated the event.

The visitors also get an opportunity to share their questions, inquisitions and thoughts through discussions with the scientific community. Science films featuring CSIR and CBRI scientific innovations and success stories were also screened.

The exhibition saw huge crowds of general public, researchers, user agencies and visit from about 6000 students from different schools and colleges of Roorkee and surrounding areas, including Methodist Girls Inter College, Swan Public School Bhagwanpur, Adarsh Bal Niketan, J.P. International School Laksar, Delhi Public School, Phonics Group of Institutes, K.L. Polytechnic, Children's Senior Academy Roorkee and Manglour, Shivalik Public School, Kendriya

Vidyalaya 1, Kendriya Vidyalaya 2, Shivalik Ganges Public School, Bal Vidhya Mandir, CBRI Junior High School, K.L.D.A.V. Inter College, College of Engineering Roorkee, Chandra Shekhar Public School, Arya Kanya Inter College, Scholar's Academy, New Era Public School Bhagwanpur, Skyward Public School etc.

The exhibition saw wide publicity with coverage in local dailies such as Amar Ujala, Hindustan, Uttaranchal Deep, Rashtriya Sahara, Dainik Jagran, Vaigyanik Drishtikon, Gramin Janta etc., and media coverage in electronic channels such as DD National, ETV, LIVE Today etc.

Scientist as Teacher

The scientists of CSIR-Central Building Research Institute, Roorkee presented a lecture at Kendriya Vidyalya No. 1 on September 12, 2017 under the "Scientist as Teacher" programme.

Addressing the gathering, Dr. Pradeep Kumar, Senior Scientist asked the students to analyse how science and mathematics have developed and are affected by many diverse individuals, cultures, societies and environment. This will provide them with a huge amount of data to understand the needs of the people and innovate accordingly. He encouraged the students to appreciate the role of science in meeting the challenges of life such as climate change and in opening new avenues in areas of agriculture, energy, information and sports etc.

All the students of Kendriya Vidyalaya No. 1, alongwith teachers, Vice Principal and Principal were present during the lecture.

Brainstorming Session

CSIR-Central Building Research Institute, Roorkee organized a Brainstorming Session for students of class 9-12 on September 15, 2017 to lay emphasis on the development of science as a major instrument for achieving goals of self-reliance, socio-economic and socio-ecological development of the nation.



The students interacted with Institute scientists and had intense discussions on various topics including health, industry, transport and communication, innovations in renewable resources for sustainable environment, innovations in food production and food security, mathematical solutions in everyday life etc. The scientists encouraged the students to feel the science all around them and gain knowledge by solving as many problems as they can by relating the learning process to the physical and social environment.

About 200 students from Kendriya Vidyalaya No.1 and Kendriya Vidyalaya No. 2 participated in the programme. The students also visited the enriched laboratories of the Institute.



IISF 2017: Science Fest and Public Outreach Programme

CSIR-Central Building Research Institute, Roorkee organized a Public Outreach Programme for school children, college students, teachers, industry personnel, media and public as a precursor event of 3rd India International Science Festival (IISF-2017) during September 14-15, 2017 at CSIR-CBRI, Roorkee.

Inaugurating the programme, Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee welcomed the school children and encouraged the students to take inspiration from eminent scientists such as Sir C.V. Raman, Dr. A.P.J. Abdul Kalam and Dr. Meghnad Saha to achieve science excellence.

Dr. R.K. Goel, Chief Scientist and Scientist-in-Charge, CSIR-CIMFR Regional Centre, CBRI Campus, Roorkee presented an interesting lecture on "Tunneling in Rocks"and informed about the diverse types of tunnels, their excavation process, equipment used, construction challenges and the key safety features during the process.

Dr. Suvir Singh, Chief Scientist, CSIR-CBRI presented an informative lecture on "Fire Engineering". He informed the student about the fire resistance of new developed building structure element technologies such as fire-resistant glasses and thermal

shock protected column developed for prevention, protection, and confinement of the fire, through short video films.





Dr. Atul Kumar Agarwal, Senior Principal Scientist, presented a lecture on "VIBHA & IISF-2017" and informed that the Ministry of Science and Technology and Ministry of Earth Sciences in association with VIBHA (Vijnana Bharti) and National Institute of Ocean Technology (NIOT) are organizing the 3rd India International Science Festival (IISF-2017) with its theme "Science for New India" during October 13-16, 2017 at Chennai to showcase Indian science achievements and innovation for the students, young researchers, and the general public. He informed that the festival has planned various activities including Special session on 'Deep Ocean Research', Science & Technology Ministers Conclave, Sensitizing Youth to Flagship Programs of Government (SYPOG-Young Scientist's Conclave), Science Village: 'Parliament to Panchayat', National Meet on 'Social

Organizations and Institutions', Women Scientist & Entrepreneur's Conclave, National Science Teachers' Workshop with special focus on North East, Industry Academia Interaction, Mega Science, Technology & Industry Expo, India International Science Film Festival, Grassroots Innovators' Summit, National Start-up Summit 2017, Round Table Meet on 'Mass Communication', Attempt of Students in Guinness Book of World Records, National Level Competition - Ideas For 'Bharat Nirman', Outreach Programme (Open Days), Satellite Seminars and Cultural Events with the aim to provide focused information on a large bracket of areas.

The participants visited the labs of CSIR-CBRI, learned about the Institute technologies and had an interactive session with the Institute's scientists.

Dr. L.P. Singh, Principal Scientist, CSIR-CBRI, Roorkee presented introductions of the guests and proposed a vote of thanks.

The programme was attended by more than 500 students along with their faculty members from various schools and colleges including Kendriya Vidyalaya No. 1, Kendriya Vidyalaya No. 2, Swan Public School, KLDAV (PG) College, College of Advanced Technology, and Phonics Group of Institutes.

As a prelude to the event, a Press Meet was organized on September 14, 2017 to apprise the public about the forthcoming event. Dr. A.K. Minocha, Chief Scientist chaired the press meet and Dr. Atul Kumar Agarwal, Nodal Officer, briefed about the programme. Press Representatives from Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Uttaranchal Deep, Awam-e-Hind, Punjab Kesari, Hindi Khabar, Shah Times and Jan Bharat Mail etc. and electronic media personnel from D.D. News, India News, Live Today and ETV News etc. attended the meet.

Student Apprenticeship Programme

To extend student's classroom learning with that of a very well-planned research laboratory based learning through the prestigious labs of CSIR, Council of Scientific and Industrial Research (CSIR) and Kendriya Vidyalaya Sangathan (KVS) has launched the student-scientist connect programme, "Jigyasa-Quest for Curiosity", connecting 1,151 KVs with 38 CSIR laboratories and benefitting one lakh students and nearly 1,000 teachers annually.

In this direction, the "Student Apprenticeship Programme" was inaugurated by Dr. N. Gopalakrishnan, Director, CSIR-CBRI on September 25, 2017 under CSIR scheme "Jigyasa-Quest for Curiosity" at CSIR-Central Building Research Institute, Roorkee to inculcate a culture of inquisitiveness on the one hand and scientific temper on the other among school students.

Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee welcomed the children and said that a calm mind is like a sponge that absorbs knowledge easily. He encouraged the students to relax their mind and have an interactive and educational session with scientists and experts. He said that science is very curious. It is a concept and the physical manifestation of this concept,

that helps the society, is technology. He said that we need to find ways to explore science for the benefit of the mankind so as to improve health, income and living standard of the common masses. He encouraged the students to question, imagine and build up curiosity, as curiosity has its own reason for existing and imagination crosses the limits of knowledge to encircle the world. He motivated the students to become a scientist.

Under this programme, 72 students of Kendriya Vidyalaya No. 1 and Kendriya Vidyalaya No. 2 have been selected, to develop their scientific innovation as a vibrant model using the Institute's rich laboratories and resources for a month under the direction of the Institute scientists.

Under the guidance of Institute scientists, the students worked on the areas of "Health, Cleanliness and Nutrition", "Disaster Management", "Natural Resource Management", "Food and Agriculture", "Lifestyle and Livelihood", "Traditional Knowledge System", "Energy" and "Source of Energy" etc. and displayed their scientific knowledge through live models.

Dr. Atul Kumar Agarwal, Senior Principal Scientist and Jigyasa Programme Coordinator, presented a lecture on "Jigyasa: What, Why, How" and said that Jigyasa means curiosity, about knowing the what, why and how of any subject. This is the first step in inculcating a scientific temper. It is our curiosity which separates us from other animals. Referring to scientists like Einstein, Henry Ford, and A.P.J. Abdul Kalam, he said that the value of education is not to remember facts, but to train the intellect to be able to think. Whether a person is twenty or eighty, if we stop learning, the mind gets old and weak. It is through the scientific approach and passion of youth, that India will stand as a world class example of an intellectual capacity and will be respected around the world.

Dr. Agarwal said that with this concept, CSIR-Central Building Research Institute, Roorkee will be organizing various activities including Teachers as Scientists and Scientists as Teachers, Teacher's Workshops, Science and Math Club, Vacation Programmes, Lab Visits, Display of Institute R&D, Science Exhibition, and Lectures by Eminent Experts etc. throughout the year under "Jigyasa" Scheme.

Brainstorming Session

CSIR-Central Building Research Institute, Roorkee organized a Brainstorming Session for students of class

9-12 on September 25, 2017 to give shape to their innovative ideas and learn from each other's experiences.

The students interacted with Institute scientists and had intensive discussions on various topics

including natural resource management, food and agriculture, energy, health, hygiene and nutrition, life style and livelihood, disaster management, traditional knowledge systems etc. The scientists encouraged the

students to pursue their natural curiosity, creativity, innovation and inventiveness.

About 150 students from Kendriya Vidyalaya No.1 and Kendriya Vidyalaya No. 2 participated in

the programme. The students also visited the enriched laboratories of the Institute.

Motivational Lecture

The scientists of CSIR-Central Building Research Institute, Roorkee presented a motivational lecture at Kendriya Vidyalya No. 1 on October 12, 2017 during a two-day workshop for TGT Science.

Addressing the gathering, Dr. A.K. Minocha, Chief Scientist, CSIR-CBRI, Roorkee emphasised on the importance of discipline in the life of a teacher. He said that a teacher should be motivated to create a good learning experience for the students. For this, discipline in every aspect of life is very important. A teacher cannot truly teach a child values until he practices them in his own life. A student looks upon his teacher for important values of life. They are the students' role models. He said that time management, creative thinking and optimism are some of the key principles that a teacher should adopt for a better learning experience.

All the participants and Science and Mathematics teachers of Kendriya Vidyalaya were motivated for systematic teaching-learning, creative thinking and scientific attitude.

Science Exhibition by Students

CSIR-Central Building Research Institute, Roorkee organized a Science Exhibition by the Students on November 2, 2017 to display the scientific temper and inquisitiveness of the youth. Shri Somit Shrivastav, Deputy Commissioner, Kendriya Vidyalaya Sangathan, Dehradun, Uttarakhand; Dr. Kulwant Singh,

Scientist H, Department of Materials Sciences, Bhabha Atomic Research Centre, Mumbai; and Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee, alongwith other scientists of the Institute

visited the exhibition, apprised the students' models and encouraged them.

The students of Kendriya Vidyalya No. 1 and Kendriya Vidyalya No. 2 participated in the Science Exhibition organized under the supervision of Dr. Atul Kumar Agarwal, Senior Principal Scientist & Coordinator Jigyasa Programme. Shri V.K. Tyagi, Principal, Kendriya No. 1, Roorkee coordinated the exhibition.

Students from Kendriya Vidyalya No. 1-Kartik presented a model on "Aquaponics & Terrace Farming: Future Urban Farming", Kamal Nath presented a model on "Infinity Wheel", Aman Kumar demonstrated "Sudoko", Ankush Kumar displayed the model of "Innovative Toilet with Sensors", Ravi

Kumar presented a model on "Network Simulator", Ansh Dhiman demostrated a model of "Ecosan Toilet & Bio-Toilet", Anurag Pant presented a model on "Easy Transportation in Hilly Region &

Electricity Generation", Abdulla displayed a model on "Hydraulic Bridge", Shikhar Shiv presented a model on "Magic of Trignometry", Gaurav Kumar presented a model on "Best out of Demolition Waste", Shivanshi Tyagi demonstrated a model on "Traffic Control without Traffic Lights & Traffic Police" and Gungun presented a model on"Innovative ways of Traffic Control in Cities".

Students from Kendriya Vidyalaya No. 2-Ismiti Bisht and Prachi Kashyap displayed their model

on "Resource Management"; Abhishek, Akash and Ankit demonstrated a model of "Air Filter"; Sachin Bisht and Ravish presented a model on "Fire Disaster Management"; Upwan Pundir and Vibha Chauhan demonstrated a model on "Water Body Conservation and Waste Management".

The students got an opportunity to interact with the scientists of the Institute and discuss their innovative ideas. The scientists and experts visited the exhibition, questioned the students, suggested improvements and encouraged them.

State-level Teachers' Workshop

CSIR-Central Building Research Institute, Roorkee organized two-day Teachers' Workshop during November 2-3, 2017 under the "JIGYASA-Quest for Curiosity" programme with the aim of inspiring teachers to aid in connecting science with the society. A total of 42 teachers from 40 different Kendriya Vidyalayas of Uttarakhand state participated in the workshop.

On November 2, 2017, the students of Kendriya Vidyalaya No. 1, Roorkee welcomed the teachers with a science exhibition displaying live models and a welcome song.

The two-day workshop commenced with Lightening of Lamp and Saraswati Vandana at the Rabindra Nath Tagore Auditorium on November 2, 2017. Shri Somit Shrivastav, Deputy Commissioner, Kendriya Vidyalaya Sangathan, Dehradun, Uttarakhand, graced the occasion as the Chief Guest and Dr. Kulwant Singh, Scientist H, Department of

Materials Sciences, Bhabha Atomic Research Centre, Mumbai graced the occasion as the Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function and Dr. Atul Kumar Agarwal, Senior Principal Scientist and Jigyasa Programme Coordinator, CSIR-CBRI, Roorkee conducted the function.

Addressing the gathering, Shri Somit Shrivastav, presented detailed information about the Kendriya Vidyalaya Sangathan, its values and principles. He requested the teachers to take inspiration from the life of the Aadikavi Valmiki and bring about a positive change in the lives of their students.

Dr. Kulwant Singh, inspired the teachers with various life incidents depicting simple life and high thinking of great teachers and educationalists including Dr. S. Radhakrishnan and Madan Mohan Malviya and discussed the importance of education and a motivated teacher in life.

In his Presidential Address, Dr. N. Gopalakrishnan said that in our country the teachers are not mere people they are Gurus and hold the honour of being higher than God. He therefore requested the teachers to respect the dignity of this honour through their conduct and always carry out their duties with dedication.

Dr. Atul Kumar Agarwal, apprised about the JIGYASA programme, its objectives and the various activities to be covered during the period. He presented the formal introduction of the Chief Guest.

The students of Kendriya Vidyalaya No. 1, Roorkee also presented a programme depicting the scientific achievements of scientists. Dr. L. P. Singh, Principal Scientist, CSIR-CBRI, Roorkee presented the formal introduction of the Guest of Honour and proposed the vote of thanks.

The workshop continued with notable presentations by various eminent scientists and experts. Dr. A.C. Dwivedi, CSIR, New Delhi presented a lecture on "Reinventing Yourself through Motivated Mindsets" and said that the quality of any nation depends on the quality of education of its citizens, which in turn depends on the quality of teacher and the quality of a teacher on his level of motivation. Thus, a motivated teacher is the pivot of building a strong and inspired the nation.

B.K. Bhagwan Bhai from Mount Abu Rajasthan presented a lecture on "Ethical Values from Positive Thoughts", said that the teacher shapes the character of a student and the nation. He said that an ideal teacher should improve his conduct through humility and endurance to create a strong and positive character for the students.

Dr. Atul Kumar Agarwal, presented a lecture on "CSIR & CBRI: An Overview" and informed how starting with the indelible ink, the hallmark of the nation's fabric, CSIR has left an indelible mark on every sphere of life. With an all-round approach towards R&D, CSIR reflects India in its diversity and heterogeneity. From agriculture to deep sea explorations, earth sciences to informatics, leather optical fibers, pigments to weather forecasting, CSIR has registered its presence. Swaraj, the first tractor, baby milk powder and first super computer are some of the most applauded accomplishments of CSIR. He also informed that as a pioneer in the building sector, CSIR-CBRI, Roorkee is dedicated to research, development, and innovation (RD&I) in finding timely, appropriate, and economical solutions to the problems of Building Materials, Health Monitoring and Rehabilitation of

Structures, Disaster Mitigation, Fire Safety, Energy Efficient Rural and Urban Housing.

Dr. Arvind C. Ranade, Senior Scientist, Vigyan Prasar, Delhi presented a lecture on "The Sun and India's Aditya Mission" and explained the various scientific phenomena formulating the Sun. He discussed the various stars in the universe and hidden secrets with in them.

Dr. Abha Mittal, Senior Principal Scientist, CSIR-CBRI, Roorkee conducted technical sessions.

In the evening, under the guidance of the Vigyan Prasar team, participants observed the planets like Mars, Saturn, under a "Night Sky Watch" programme and received astronomical information about them.

The participants also visited the enriched laboratories of the Institute and interacted with the Institute's scientists.

Inaugurating the second day of the two-day teachers' workshop on November 3, 2017, Dr. Atul Kumar Agrawal, presented a talk on "Art of Living" and encouraged the teachers to lead stress free life through a group activity related to life philosophy.

Dr. Kulwant Singh presented a lecture on "Material for Fusion Reactor Experimental Reactor" and said that there is a huge shortfall in the expected production of electricity in India. A clean, eco-friendly, renewable resource is needed and this can be achieved by nuclear fusion.

Dr. Suvir Singh, Chief Scientist, CSIR-CBRI, Roorkee presented a lecture on “Fire Safety and Challenges in Buildings”, and informed about the

Dr. L.P. Singh presented a lecture on “Applications of Nanotechnology in Buildings” and informed about the use of nanotechnology to modulate concrete and optimize loading capability in buildings.

building structure elements responsible for the spread of fire, how to minimize loss and the latest structure element technologies such as fire-resistant glasses and thermal shock protected column etc. developed for the prevention, protection and confinement of the fire.

Dr. R.K. Goel, Scientist In charge, CSIR-CIMFR Regional Centre, Roorkee presented a lecture on “Tunnel Engineering”, and explained about the diverse types of tunnels, their excavation process, equipment used, construction challenges and the key safety features during the process.

Dr. A.C. Dwivedi presented a lecture on "Teaching and Leadership through Time Management" and inspired the teachers to develop qualities of optimism, effective communication, time management, efficiency and effectiveness and suggested to teach the students how to think instead of what to think.

Dr. Atul Kumar Agarwal presented a lecture on "That's a Myth: Know the Science" and asked the teachers to teach their students the actual facts and science behind the common myths.

In the Panel Session, under the chairmanship of Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee, the panellists Dr. A.C. Dwivedi, Dr. Kulwant Singh, Dr. Arvind C. Ranade, Dr. L.P. Singh and Dr. Atul Kumar Agarwal interacted with the participants and answered their queries. The participants shared their thoughts and experiences with experts in a mutual panel discussion.

Shri V.K. Tyagi, Principal, Kendriya Vidyalaya No. 1, Roorkee coordinated with CSIR-CBRI, Roorkee for the successful implementation of the programme.

In the Concluding Session, the programme received a positive feedback from the participants wherein they described it as interesting, creative and informative. The programme concluded with the distribution of certificates and mementoes to the participants and a vote of thanks proposed by Dr. Atul Kumar Agarwal.

Cleanliness Drive

CSIR-Central Building Research Institute, Roorkee observed Swachhta Pakhwada during November 1-15, 2017 under which awareness programmes were organized regularly through overall cleanliness of all the sections of the Institute.

A Swachhta Awareness Programme was also organized on November 13, 2017 for the students to educate them on the importance of cleanliness in our day-to-day lives.

Welcoming the students, Dr. Atul Kumar Agarwal, Senior Principal Scientist, CSIR-CBRI & Coordinator Jigyasa Programme explained the importance of cleanliness and hygiene to the students, saying that clean and hygienic habits build a healthy body and in a healthy body resides a healthy mind.

Dr. Agarwal, while presenting a lecture on "Waste Management", urged the students to adopt the three R related to waste- Reduce, Recycle and Reuse.

Students also visited the enrich laboratories of CSIR-CBRI and received information about the research work done in the field of rural and urban sanitation and waste management etc.

The students from various schools including Kendriya Vidyalya No. 1, Roorkee participated in the programme.

Motivational Lecture

On the occasion of Children's Day, the scientists of CSIR-Central Building Research Institute, Roorkee presented a motivational lecture at Kendriya Vidyalya No. 1 and Kendriya Vidyala No. 2 on November 14, 2017.

Dr. D.P. Kanungo, Senior Principal Scientist, CSIR-CBRI, Roorkee presented a motivational talk to the students of Kendriya Vidyalaya No. 1, Roorkee. He encouraged the students to develop scientific thinking in their daily activities, to question and to solve the science behind everything. This would build a strong intellect and inquisitive mind that would be monumental in bringing about a new and innovative scientific breakthrough.

Addressing the students at Kendriya Vidyalaya No. 2, Dr. Atul Kumar Agarwal, Senior Principal Scientist and Jigyasa Coordinator, CSIR-CBRI, presented a lecture on "Curiosity: Key to Innovation" and emphasised on the importance of curiosity in life. He said that a child is always curious. Everything is new to a child and he is not afraid to venture and learn about the unknown. This curiosity helps him learn new things, grow and adopt to its surroundings. It is this curiosity that the child learns to walk, to grab and to hold; and it is this curiosity that helps him learn to talk and express his wonder. As we grow, we supress this curiosity which hinders our intellectual and overall growth. He said that on this occasion of Children's Day we should free our curious mind and let the child in us learn and grow. He encouraged the children to nurture this curiosity present in all of them and build on it to create a new and innovative future.

All the students of Kendriya Vidyalaya, along with their teachers, Vice Principal and Principal were present during the lecture.

Quiz Competition

CSIR-Central Building Research Institute, Roorkee observed Swachhta Pakhwada during November 1-15, 2017, a Quiz Competition on "Cleanliness & Hygiene" was organized under the guidance of Dr. Atul Kumar Agarwal, Senior Principal Scientist, on November 15, 2017 for students of class 9-10, in order to provide awareness and information about cleanliness and hygiene in children at CSIR-CBRI, Roorkee. Shri Alok Gupta, PGT, Kendriya Vidyalaya No. 1, acted as the quiz master for the programme.

Students benefited from the questions related to the subjects like cleanliness, health, science and technology. A special round of the Quiz Competition was focused on CSIR, in which questions based on CSIR and its laboratories and technologies were asked, that helped the students enrich their knowledge about new scientific innovations.

The winners of the Quiz Competition were felicitated by Dr. N. Gopalakrishnan, Director, CSIR-CBRI. The students of Kendriya Vidhyalaya No. 1 with the team of Anuj, Shalini and Riya placed first; the team of Pradip, Deepali and Paras placed second; and the team of Vishu, Piyush and Abhishek received the third prize. Gold, silver and bronze medals were awarded to the winners and certificates were provided to all the participants. The students also visited the enriched laboratories of the Institute and interacted with the Institute scientists.

State-level Science Exhibition, Quiz and Seminar by Students

The 45th Regional Science Exhibition was organized at Kendriya Vidyalya No. 1, Roorkee during November 29-30, 2017.

Shri Somit Shrivastav, Deputy Commissioner, Kendriya Vidyalaya Sangathan, Dehradun, Uttarakhand, graced the occasion as the Chief Guest and Dr. Atul Kumar Agarwal, Senior Principal Scientist, CSIR-CBRI, Roorkee as the Guest of Honour. Shri V.K. Tyagi, Principal, Kendriya Vidyalaya No. 1, Roorkee presided over the function.

Addressing the gathering, Shri Somit Shrivastav stated many quotes from various scriptures to explain the importance of our roots and traditions that teach us various lessons from every walk of life. He asked the students to take inspiration from the life of Sant Vivekanand, who said that life is the

greatest teacher and we can be an eternal student if we learn and grow from our experiences in it. He asked the students to think new, innovate and bring a new innovative revolution in the world through their works.

Dr. Atul Kumar Agarwal presented a talk on "Jigyasa-Quest for Curiosity" and encouraged the students to adopt a curious outlook towards life. He said that curiosity leads to creativity and innovation. One should be curious about its surroundings, to question and understand the why, how and what about everything. This would help us learn and build of a new and innovative world, free of superstitions.

Various moral, cultural and scientific programmes were presented by the students during the function.

The students from 34 Kendriya Vidyalayas of the Dehradun Region participated in the programme and presented their models on various sub-themes including natural resource management, food and agriculture, energy, health, hygiene and nutrition, life style and livelihood, disaster management, traditional knowledge systems etc.

The scientists from CSIR-CBRI, Roorkee- Dr. Abha Mittal, Mrs. Neeta Mittal, Dr. P.C. Thapliyal, Shri B. Srinivas and Shri Vineet Saini, acted as co-judges for the exhibition. The Principal of Kendrya Vidyalaya No. 2 Mrs. Anjali Thakkar and Kendriya Vidyalaya Augustymauni Shri Vijay Nathani, were also present during the programme.

The scientists and experts visited the exhibition, questioned the students, interacted with them, suggested improvements and encouraged them.

A Quiz competition was also organized during the programme. Two students from each participating Kendriya Vidyalayas participated in the quiz competition. Also, 13 students participated in a Seminar and gave presentation on "Digital Transaction Promises and Challenges".

Quiz Competition

A Quiz Competition on Energy Conservation was organized at The Institute of Engineers (India), Roorkee Local Chapter under the guidance of Dr. Atul Kumar Agarwal, Senior Principal Scientist, CSIR-CBRI & Coordinator Jigyasa Programme on December 14, 2017 to celebrate World Energy

Conservation Day with the aim of encouraging students to adopt practical measures of energy conservation in our daily life.

In the quiz competition, several questions related to energy conservation and alternative energy sources were asked in various rounds.

In addition, questions related to small but effective methods of energy conservation that can be followed by the students in their daily routine were also asked in a special round, so that the students were motivated to contribute towards this direction by conserving energy in their daily activities. Students benefitted greatly from the questions related to energy conservation.

Students from Kendriya Vidyalaya No. 1 secured the first, Cantonment Board Senior Secondary School secured second, Doon Public School students secured third place and students of New Era Public School got fourth position. All the winners were awarded with Gold, Silver and Bronze Medals.

Shri Malvinder Singh, Chairman of the Institute of Engineers (India), Roorkee Local Chapter, encouraged the students and Secretary Dr. Achal Mittal presented a vote of thanks.

World Energy Conservation Day

Students Awareness Programme was organized at CSIR-Central Building Research Institute, Roorkee on December 14, 2017 to celebrate World Energy Conservation Day with the aim of explaining the importance of energy, depletion of energy sources, its impact on sustainable environment system and practical measures of energy conservation in our daily life.

About 150 students of classes 9-11 from Kendriya Vidyalaya No. 1, New Era Public School, Doon Public School and Cantonment Board Senior Secondary School, along with their teachers participated in the programme.

Welcoming the students, Dr. Atul Kumar Agarwal, Senior Principal Scientist, CSIR-CBRI & Coordinator Jigyasa Programme explained the importance of energy conservation to the students, saying that the day is not far when our future generation would curse their ancestors for their greed and mismanagement, as there would be no petrol or electricity left for them.

Dr. Agarwal, while presenting a lecture on "Energy Conservation and Alternative Energy Sources", urged all to use solar energy, solar rickshaw, solar bikes, solar panels, solar lights, and solar chargers as means of alternative energy. There are many such areas in India where there are mountains and deserts and the flow of wind is also very fast. Harnessing energy through windmills in such areas would be a major game changer in the energy conservation sector. Biogas

can also be easily made from animal and agricultural wastes. This will contribute to the saving of money as well as environmental protection.

Students also visited the laboratories of CSIR-CBRI and received information about the research work done in the field of energy conservation, such as energy efficient buildings, solar power etc. Under the programme, children were educated on the importance of energy conservation, energy efficiency, energy utilization and important issues related to energy through lectures, video films and discussions with scientists. Shri D.K. Sehgal, Dr. Suvir Singh, Dr. A.K. Minocha and Dr. L.P. Singh were also present during the programme.

Teacher as Scientist

CSIR-Central Building Research Institute, Roorkee organized a "Teacher as Scientist" programme for students of Kendriya Vidyalaya No. 1, Roorkee on January 18, 2018 under the Jigyasa Programme.

The teachers of Kendriya Vidyalaya No. 1, played the role of scientists for the students and performed various experiments with them in the enriched laboratories of the Institute. They also gave lectures on various topics and explained various phenomena of science.

Mrs. Anita Bisht, PGT Chemistry, Kendriya Vidyalaya No. 1, Roorkee gave a lecture on corrosion and its possible impact on buildings. She explained how corrosion occurs, the risk of corrosion on buildings, and the resulting loss due to its negative impact. She explained the chemical reactions that take place in various metals due to corrosion and encouraged the students.

The students interacted with the teachers outside the school premises and in role though similar but different from the usual. The students also visited the enriched laboratories of the Institute and interacted with the Institute scientists. About 100 students from Kendriya Vidyalaya No. 1 participated in the programme.

Motivational Lecture

On the occasion of National Cleanliness Day, the scientists of CSIR-Central Building Research Institute, Roorkee presented a motivational lecture at Kendriya Vidyalaya No. 1 on January 30, 2018.

Addressing the gathering, Dr. Atul Kumar Agarwal, Senior Principal Scientist and Jigyasa Coordinator, CSIR-CBRI, presented a lecture on "Importance of Cleanliness and Hygiene" and emphasised on the importance of cleanliness and hygiene in our daily lives. He said that this date holds a very important significance in the Swachhta Abhiyan as it was the dream of Mahatma Gandhi that our nation be clean. He elaborated by saying that cleanliness should not only be in our surroundings, schools and homes, but it should start from within. We should make cleanliness a habit and also clean our hearts and souls from any negative emotion and follow the path of righteousness. He encouraged the children to adopt clean and healthy lifestyle for a healthier future.

All the students of Kendriya Vidyalaya No. 1, along with their teachers, Vice Principal and Principal attended the lecture.

Teacher as Scientist

CSIR-Central Building Research Institute, Roorkee organized a "Teacher as Scientist" programme for scientists on February 07, 2018 under the Jigyasa Programme.

The teachers of Kendriya Vidyalaya No. 1, played the role of scientists and had enriched discussions with the scientists and staff of the Institute.

Mr. Alok Gupta, PGT, Kendriya Vidyalaya No. 1, Roorkee gave a lecture on the advancements in social media and its negative impact on the society. He talked how social media has brought about new bouts in cyber-bullying, decreased productivity, attack on privacy etc. He said that the children today have forgotten how enjoy their childhood, their childhood revolves around social media and they forget to make memories.

Dr. Atul Kumar Agarwal, Senior Principal Scientist and Jigyasa Coordinator, CSIR-CBRI, presented a talk on "Judicious Use of Social Media". He explained that social media is a powerful tool that can be beneficial in many ways but can also be the tool of our doom. So it must be used with the caution, it demands. He said that we should not let social media guide our lives, replace

our family or friends and forget to live and enjoy our life. It should be used as a tool of empowerment, to enhance our knowledge and give boost to our creativity. He said that education is the key to control it. Chapters on judicious use of social media should be included in the school curriculum so that our future generation becomes aware of the challenges and learn to derive maximum benefits from social media without becoming a slave to it.

Science Exhibition by Students

On the occasion of its 72nd Foundation Day, CSIR-Central Building Research Institute, Roorkee organized a Science Exhibition by the Students on February 10, 2018 to display the scientific temper and inquisitiveness of the youth. Prof. N. Raghavan, Professor of Practice, IIT Madras & Chairman, Research Council, CSIR-CBRI Roorkee; Mr. Kamal Kishore, Member, National Disaster Management Authority, New Delhi; and Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee, along with other scientists of the Institute visited the exhibition, apprised the students' models and encouraged them.

The students of Kendriya Vidyalya No. 1 and Kendriya Vidyalya No. 2 participated in the Science Exhibition organized under the supervision of Dr. Atul Kumar Agarwal, Senior Principal Scientist & Coordinator Jigyasa Programme.

Dr. Atul Kumar Agarwal also presented a lecture on "Breaking Supertitions", asking the students to look for the facts & science behind things and to not fall for the myths prevailing in the society.

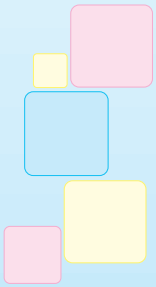
Students from Kendriya Vidyalya No. 1-Ravi and Kamal presented "Stress Monitoring in Students App" and "Survivors Wheels"; Amogh Chahal presented

a model on “Natural Resources”; Simran and Harsh demonstrated “Ecosan Toilets” and “Utilization of Biodegradable Waste from Train Toilets”.

Management”; Upwan Pundir and Vibha Chauhan demonstrated a model on “Water Body Conservation and Waste Management”.

Students from Kendriya Vidyalaya No. 2-Ismiti Bisht and Prachi Kashyap displayed their model on “Resource Management”; Abhishek, Akash and Ankit demonstrated a model of “Air Filter”; Sachin Bisht and Ravish presented a model on “Fire Disaster

The students got an opportunity to interact with the scientists of the Institute and discuss their innovative ideas. The scientists and experts visited the exhibition, questioned the students, suggested improvements and encouraged them.



Projects

In-house R&D Projects

S. No.	Project No.	Title of the Project	Principal Investigator Co-Investigator	Duration
HOUSING- STRUCTURE & FOUNDATION				
Development of Fast, Durable and Energy Efficient Mass Housing Scheme			**Dr. Ajay Chourasia** **Dr. Ashok Kumar**	
1.	OLP 0399	WP 1: Development of Materials For Mass Housing Structural Elements 1.1 Development of cold-formed steel (CFS) wall panels housing system with improved structural performance & fire resistance 1.2 Development of Bio-based construction material for sustainable mass housing.	Er. Chanchal Sonkar Dr. A.K. Mittal Dr. Leena Chaurasia	0917-0320
2.	OLP 0400	WP 2: Performance Evaluation of Precast Panels and Framed Structural System. 2.1 Standardization of designs & layouts of prefab housing units with improved thermal performance. 2.2 Development of prefab RC shear wall systems and evaluation of their lateral load resistance. 2.3 Development of efficient mechanical anchorage device for precast beam-column joint. 2.4 Performance evaluation and improvisation of pre-fabricated building systems. 2.5 Development of dry-construction technology in buildings.	Ms. Sayantani Lala Dr. Shailza Singh Dr. S.K. Panigrihi Ms. C. Shermi Dr. Kishore Kulkarni	0917-0320
3.	OLP 0401	WP 3: Reducing Resource Use in Housing Construction. 3.1 Recycling of agricultural/ industrial/solid wastes for building infrastructures. 3.2 Eco-friendly corrosion inhibition to improve concrete durability. 3.3 Protective coating for improved energy efficiency in buildings. 3.4 Development of anti-termite barrier for mass housing.	Er. Soumitra Maiti Dr. A.K. Minocha Dr. S.R. Karade Dr. P.C. Thapliyal Dr. B.S. Rawat	0917-0320

4.	OLP 0402	WP 4: Mechanization in the Housing Construction Sector. 4.1 Mechanization in construction process of mass housing. 4.2 Mechanization in production of prefabricated building components of mass housing.	Dr. S.K. Panigrahi Er. Ravindra S. Bisht Er. Soju J. Alexander	0917-0320
5.	OLP 0403	WP 5: Disaster Resiliency in Housing Project. 5.1 Design interventions for enhancement of robustness in traditional construction, numerical and experimental investigation. 5.2 Design of confined masonry construction using different types units (concrete masonry block, AAC block). 5.3 Improvement in CSIR-CBRI developed pre-fab technologies. 5.4 Design of fire safety and evacuation strategy for buildings.	Ms. Swati Kulashri Ar. S.K Negi, Dr. Ajay Chourasia Er. Ashish Pippal Dr. Shorab Jain	0917-0320
6.	OLP 0404	WP 6: Geotechnical Solutions for Mass Housing Schemes. 6.1 Ground improvement technique to mitigate liquefaction hazards for safe building construction. 6.2 Ground improvement using granular pile anchor foundation (GPAF) system. 6.3 Modified static and seismic design methodology of piled-raft foundation. 6.4 Design and strengthening measures for building foundation systems in hilly regions.	Dr. S. Ganesh Kumar Dr. Pradeep Kumar, Er. M Samanta Er. Koushik Pandit	0917-0320
Science & Technology Intervention for Development of Safe and Sustainable Building Infrastructure in NE Region			**Er. M. Samanta** **Er. Soumitra Maiti**	
7.	OLP 0412	WP 1 : Sustainable Materials and Technologies 1.1 Architectural and Structural Engineering Interventions in Housing Stock of NE Regions 1.2.1 Development of wood plastic composite Bamboo Fiber and locally available material. 1.2.2 Development of Building Components Using Locally Available Agro-Materials 1.3 Development of portable energy efficient domestic waste water management system 1.4 Foundation technology for NE 1.5 Performance Enhancement of Integral Collector-Storage (ICS) Passive Systems	Er. Soumitra Maiti Ms. Sayantani Dr. Hemlata, Er. Santha Kumar G. Dr. S. Ganesh Kumar, Dr. Chandan S. Meena,	0118-1220

8.	OLP 0413	WP 2 : Disaster Assessment and Mitigation in NE Himalayas	Dr. DP Kanungo Dr. S. Sarkar Er. M. Samanta	0118-1220
9.	OLP 0414	WP 3 : Societal Dissemination – Demonstration, Training & Skill Development for the NE Region	Dr. R. Dharmaraju Ar. S.K. Negi	0118-1220
10.	OLP 0415	Development of Innovative Hybrid Connections for Pre-Cast Concrete Construction	Dr. S.R. Karade Dr. R. Siva Chidambaram	1117-1020
11.	OLP 0416	Prefabricated Ferro cement Sandwich Panel based Housing System	Er. S.K. Singh Er. Subash C.B. Gurram Er. Surya M.	1017-0320
12.	OLP 0395	Studies on consolidation and deformation characteristics of stone columns with and without geo-synthetic encasement in soft clay	Dr Ganesh Kumar Er. M. Samanta	0716-0618
CONSERVATION OF HERITAGE STRUCTURES				
Conservation and Restoration of Heritage Structure			**Dr. A.K. Mittal**	
13.	OLP 0396	WP 1: Classification, Analysis and Restoration Technologies. 1.1 Classification of important heritage structures and extracting superior features of Indian traditional knowledge of building science. 1.2 Development of novel and simplified analysis procedure for the structural systems. 1.3 Effect of Construction Activities adjacent to Heritage Structures and Remedial Measures for Strengthening of Foundations for Heritage Structures 1.4 Development of innovative structural restoration and retrofitting strategies for the heritage structures. 1.5 Structural analysis of heritage buildings pre and post retrofitting	Ms. Hina Gupta Er. Debdutta Ghosh, Ms. Aswathy M.S., Er. Siddharth Behera	0917-0320
14.	OLP 0397	WP 2: Non-Destructive Evaluation. 2.1 Development of hybrid non-destructive techniques and signal processing algorithms for multi-wave imaging. 2.2. In-accessible foundation studies of Cultural Heritage sites using non-invasive techniques	Er. Debdutta Ghosh Dr. P.K.S. Chauhan Ms. Hina Gupta	0917-0320

15.	OLP 0398	WP 3: Material Development. 3.1 Conservation and restoration of lime mortars and brickworks. 3.2 Development of compatible repair materials for stone masonry in heritage structures 3.3 Identification of fungi on select heritage structure and development of suitable anti-fungal chemical from medicinal plants.	Dr. L.P. Singh Dr. Rajni Lakhani Dr. Rajesh K. Verma	0917-0320
INNOVATIVE BUILDING MATERIALS				
16.	OLP 0417	Pilot scale preparation of silica nanoparticles and their applications in cement based materials	Dr. L.P. Singh Er. Srinivasarao Naik B	1017-0919
17.	OLP 0418	Process technology development of geopolymer concrete with varying classes of fly ash for use in precast building components	Er. Md. Reyazur Rahman Er. Rakesh Paswan	1017-0920
18.	OLP 0419	Recyclability of marble waste in concrete production and other building products.	Dr. Rajni Lakhani Er. Rajesh Kumar	0917-0820
19.	OLP 0420	Development of self-compacting recycled aggregate concrete for precast building components.	Er. Monalisa Behra Er. Santha Kumar G. Md. Reyazur Rahman	1017-0919
20.	OLP 0421	Development of cost effective material for sound absorption with partial air purification properties.	Er. Siddharth Er. S. Maiti	1017-0919
ENERGY EFFICIENT SYSTEM & BUILDING AUTOMATION				
21.	OLP 0392	Dissemination, Training, Demonstration of Improvement of Appropriate Rural Housing Technologies.	Ar. S.K. Negi Dr. R. Dharmaraju	1016-0917
22.	OLP 0422	Efficient Solar thermal collector	Er. Nagesh B. Balam Dr. Tabish Alam	1017-0919
DISASTER MITIGATION				
Safety of vital installations against natural and manmade Disasters			**Dr. Suvir Singh** **Dr. S. Sarkar**	
23.	OLP 0405	WP 1: Design and Development of fire safety measures for vital installation. 1.1 Experimental and Numerical simulation studies for hazard assessment in real fire scenario	Dr. A. Aravind Kumar Dr. Rajiv Kumar	0917-0320

24.	OLP 0406	WP 1: Design and Development of fire safety measures for vital installation. 1.2 Development of fire retardant/resistant materials for fire safety enhancement.	Dr. Harpal Singh	0917-0320
25.	OLP 0407	WP 1: Design and Development of fire safety measures for vital installation. 1.3 Development of fire retardant coating for interior materials	Er. A.A. Ansari	0917-0320
26.	OLP 0408	WP 1: Design and Development of fire safety measures for vital installation. 1.4 Analysis of reinforced concrete members exposed to fire and development of retrofit techniques.	Dr. Banti Gedam Dr. H.C. Arora Dr. Suvir Singh	0917-0320
27.	OLP 0409	WP 2: Design and development of structural systems and buildings for protection against progressive collapse: Manmade & Natural Hazards. 2.1 Design against progressive collapse failure of structures - Impact and Blast loads.	Er. M.M. Dalbehera Dr. A.K. Mittal Er. S. Behera	0917-0320
28.	OLP 0410	WP 2: Design and development of structural systems and buildings for protection against progressive collapse: Manmade & Natural Hazards. 2.2 Design against progressive collapse failure of structures - Earthquake and fire loads.	Er. S. Behera Dr. A.K. Mittal Er. M.M. Dalbehera	0917-0320
29.	OLP 0411	WP 3: Safety of vital infrastructures against landslides (SOVIAL).	Dr. Shantanu Sarkar Dr. D.P. Kanungo	0917-0320
BUILDING PROCESS & AUTOMATION				
30.	OLP 0423	Development of Mobile Sensing Device for Complex Working Environment of Civil Structures	Er. Ravindra S. Bisht Dr. S.K. Panigrahi	1017-0919
31.	OLP 0425	Seismic Performance enhancement of buildings using smart base isolation.	Er. Soju J. Alexander Dr. S.K. Panigrahi	0118-1220

CSIR Fast Track Translation (FTT) Projects

S. No.	Project No.	Title of the Project	Principal Investigator Co-Investigator	Duration
1.	MLP 0512	Foundation System for Light Structures	Er. Manojit Samanta Sh. Ajay Dwivedi	1 year 06 months
2.	MLP 0511	Building Products using Kota Stone Cutting and Slurry Waste	Dr. Rajni Lakhani Er. Rajesh Kumar	2 years
3.	MLP 0513	Development of a Boring Machine Based on Trenchless Technology	Dr. S K Panigrahi Sh. Narendra Kumar	1 year 06 months

Externally Funded Projects

S.N.	Project No	PI	Party Name	Title
1.	CNP0017	S. K. Singh	Executive Engineer, Construction Division-6, CPWD, C-418, I.P. Bhawan, New Delhi	Condition Assessment & Suggesting Appropriate Repair & Rehabilitation of EPFO Residential Colony at Bhavishya Nidhi Enclave, Malviya Nagar, New Delhi
2.	CNP0037	S. K. Singh	Superintending Engineer, Central Public Works Department (CPWD), Shimla Central Circle, Kennedy Cottage, Shimla	Performance Evaluation / Testing of Materials including Existing Stones and New Stones etc. for Restoration of Gorton Castle Building (AG Office) at Shimla -Package I
3.	CNP0077	S. K. Singh	Executive Engineer, Central Public Works Department (CPWD), New Delhi Project Division, 3, B.D. Marg, New Delhi	Concrete Permeability Tests on Concrete Samples from Western Court, New Delhi
4.	CNP0087	Suvir Singh	The Hospital Engineer, PGIMER, Chandigarh	Fire Safety Audit of APC, AEC & ACC Buildings of Hospital
5.	CNP0097	Shorabh Jain	The Hospital Engineer, PGIMER, Chandigarh	Evaluation and Design of Fire Fighting Pumping System for the Complete Institute Campus
6.	CNP0197	B. Singh	Dome International (I) Ltd., 66, G.I.D.C. Odhav, Opp. Water Tank, Odhav, Ahmedabad	Evaluation of Glass-Fiber Reinforced Polyester Panel for Use as a Dome Material
7.	CNP0307	D.P. Kanungo	Commissioner & Secretary, Govt. of Nagaland, Nagaland State Disaster Management Authority, Home Department, Kohima, Nagaland	Stability Analysis and Remedial Measure Design for Landslide Mitigation below Nagaland Legislative Assembly, Kohima-Thizama Road
8.	CNP0337	S. K. Singh	Executive Engr., Supreme Court Project Zone, Gate No. 9, Pragati Maidan, New Delhi	Permeability, Compressive Other Test on Concrete Samples
9.	CNP0347	S. K. Singh	Executive Engineer, Flyover Project Division, F-23, PWD, Govt. of Delhi, Ramesh Park, Near Shakarpur Police Station, New Delhi	Rehabilitation & Strengthening of Janak Setu Flyover in New Delhi

Externally Funded Projects

10.	CNP0407	S. K. Singh	GM (Tech & ML), IOCL Pipeline Division, NRPL, Panipat	Condition Assessment and Suggestion for Rehabilitation & Strengthening Measures of MLPU Shed at Ambala
11.	CNP0487	Ajay Chaurasia	Chief Project Officer, Rail Vikas Nigam Ltd., Rishikesh	Expert Advice on Structural Design for Proposed Office Building of RVNL at Rishikesh
12.	CNP0607	S. K. Singh	Executive Engineer, IIT Project Division-I, CPWD, Near Vikramshilla Apartment, IIT Delhi Campus, New Delhi	Performance of Water Permeability of Concrete Specimens of Engineering Block - 99B & 99C at IIT Delhi Campus, New Delhi
13.	CNP0667	Jeeshan Khan	Sr. Manager Technology, Research and Technology Centre, Asian Paints Limited, Plot No. C-3B/1, TTC Industrial Area, MIDC Pawane, Thane-Belapur Road, Navi Mumbai	Evaluation of Smart care Quartz Crystalline Admix & Smart care Quartz Crystalline Coating for Concrete
14.	CNP0677	S. K. Singh	Ex. Engineer, Public Works Department (PWD), Delhi High Court Civil Division (M-4310), PWD Near Gate No. 6, JLN Stadium, New Delhi	Concrete Permeability Tests on Concrete Samples C/o New Building (S-Block) for Delhi High Court, New Delhi
15.	CNP0707	S. K. Negi	Director (A&P), Ministry of Development of North Eastern Region, Vigyan Bhawan Annexe, New Delhi	Comparative Study of Bamboo Versus Conventional Houses Construction System with special focus on NE Region
16.	CNP0767	H. C. Arora	District Development Commissioner, Govt. of J & K, Udhampur	Structural Proof Consultancy of Sports Stadium, Udhampur
17.	GAP0127	R. Dharmaraju	Director, Defence Terrain Research Laboratory (DTRL), DRDO, Metcafe House, New Delhi	Deformation and Slip Surface Studies of Narendra Nagar Landslide Area Based on Geotechnical Investigations and Instrumentation Monitoring

Externally Funded Projects

18.	GAP0547	L. P. Singh	Department of Science & Technology, Technology Bhawan, New Mehrauli Road, New Delhi	Nano-Engineered Concrete for Sustainable Infrastructure
19.	GAP0657	Ashok Kumar	Sh. J.B. Reddy, Principal Scientific Officer/Scientist D, Govt. of India, Dept. of Science & Technology, Ministry of Science & Technology, Technology Bhawan, New Mehrauli Road, New Delhi	Zero Peak Energy Building Design for India (ZED-i)
20.	SSP0047	A. K. Minocha	Director (Environment), Dept. of Environment, Govt. of NCT, 6th Level, C-Wing, Delhi Secretariat, New Delhi	Recycling of Silt from Storm Water Drains, Sludges from Water Treatment Plant/Sewage Treatment Plant and Ash From Waste to Energy Plant into Useful Products
21.	SSP0107	A. K. Mittal	Director Technical for DG MAP, Integrated HQ of MoD (Army), Kashmir House, Rajaji Marg, DHQ PO, New Delhi	Structural Stability, Health Assessment and Suggesting Seismic Strengthening Measures for Buildings No. P-117 & P-118 at OD Line, Allipore, Kolkata
22.	SSP0237	A. K. Mittal	Executive Engineer, Agra Central Division, CPWD, Agra	Structural Health Assessment and Suggesting Strengthening Measures for Income Tax Building at Sanjay Place, Agra
23.	SSP0247	S. Sarkar	Mr. P. K. Padhi, STC Pvt. Ltd., Dehradun	Geotechnical Investigation and Slope Stability Assessment and Remedial Measure for Tungnath Temple, Rudraprayag
24.	SSP0277	Suvir Singh	Head-R&D Cell, EDRC-RBU, TC-2, 4th Floor, L&T Construction, Manapakkam, Chennai	Studies on Fire Behaviour of Load Bearing RC Walls

Externally Funded Projects

25.	SSP0287	S. K. Singh	Executive Engineer (CD-II), Delhi State Industrial & Infrastructure Development Corp. Ltd. (DSIIDC), Tech Centre Building, Wazirpur Industrial Area, New Delhi	Condition Assessment & Retrofitting Strategies for Newly Constructed Buildings under Urban-Poor/Slum Rehabilitation Scheme at Tikri Kalan, Punjabi Bagh, West Delhi
26.	SSP0297	S. R. Karade	GreenJams Infrastructures LLP, 401, 10-5-14/C. Mantis Apts, Facor Layout, Ramnagar, Vishakhapatnam, Andhra Pradesh	Development and Characterization of Lime Based Hemp Concrete
27.	SSP0327	B.Singh / G. Ishwarya	NTPC Energy Technology Research Alliance (NETRA) NTPS Limited, E-3, Ecotech-II, Udhyog Vihar, Greater Noida, UP	Demonstration Research Project on Laying of Geoploymer Concrete Road Stretch at NTPC Dadri Site
28.	SSP0357	Ajay Chourasia	UP Rajkiya Nirman Nigam Ltd., Srinagar Unit-Z, Srinagar (Garhwal)	Quality Control and Checking of Architectural / Structural Drawings / Details
29.	SSP0377	A. K. Mittal	Project Manager-1A, Delhi Metro Rail Corporation (DMRC), Metro Bhawan, Fire Brigade Lane, Barakhamba Road, New Delhi	Structural Assessment of Buildings Damaged by DMRC Tunnelling Work at Rameshwar Nagar, New Delhi
30.	SSP0437	Suvir Singh	Ram Manohar Lohia Hospital, New Delhi	Fire Safety Audit of Ram Manohar Lohia Hospital: OPD, Emergency, Blood Bank, OPT, CSR
31.	SSP0447	Shorab Jain	Ram Manohar Lohia Hospital, New Delhi	Fire Safety Audit of Ram Manohar Lohia Hospital: Doctors Hostel, Nurses Hostel, Ward Bldg, Laundry anf Fire Fighting Pumping Station
32.	SSP0497	Suvir Singh	Mahatma Gandhi Institute of Medical Sciences, Wardha	Fire Safety Audit of MGIMS

Externally Funded Projects

33.	SSP0517	S. K. Singh	Dy. Program Director, Uttrakhand Urban Sector Development Investment Program (UUSDIP), 777, Saatvik Tower, Rajendra Nagar, Kaulagarh Road, Dehradun	Post Construction Quality Check Through Non-Destructive Testing of 16 Overhead Tanks and 01 Ground Level Service Reservoir in Haldwani
34.	SSP0537	S. K. Singh	Superintending Engineer, CPWD, Shimla Central Circle, Kennedy Cottage, Shimla	Technical Advice and TPQA & QC of Repair, Retrofitting and Restoration of Gorton Castle Building (AG Office) at Shimla
35.	SSP0557	A. K. Mittal	Senior Divisional Engineer III, DRM Office, Delhi Division, Northern Railway, State Entry Road, Connaught Place, New Delhi	Technical Examination for Restoration of Main Station Building at Delhi Junction Railway Station
36.	SSP0587	A. K. Mittal	Asstt. Director of Archives, National Archives of India, Janpath, New Delhi	Scientific Material Investigations for the Heritage Building of National Archives of India, New Delhi
37.	SSP0597	Suvir Singh	Executive Engineer, IISER Mohali Project Division (E), CPWD, Sector 7B, Chandigarh	Fire Safety Audit of Expansion of Nehru Hospital at PGIMER
38.	SSP0617	Rakesh Paswan	Head, Project Development, Arvind Composites, PO Khatraj, Tal: Kalol, Dist. Ghandhinagar	Evaluation of Arvind Brand FRP Pultruded Composite Section/ Panels and Their Use in Warehouse Construction
39.	SSP0627	A. K. Mittal	Superintending Archaeologist, Archaeological Survey of India, Bhubaneshwar Circle, Bhubaneshwar	Monitoring of Steel Portal Frame installed in Jagmohana of Shree Jagannath Temple Puri by CSIR-CBRI
40.	SSP0637	A. K. Mittal	Executive Engineer, Dehradun Central mandal-1, CPWD, 20-Subhash Marg, Dehradun	Repair and Retrofitting of Forest Research Institute (FRI) Building, Dehradun
41.	SSP0647	Soumitra Maiti	Team Energy Systems, SCO 87, 2nd Floor, Sector 4, Panchkula, Haryana	Adequacy cum Completion Report for Design of High Draught Brick Kiln provided by CSIR-CBRI Roorkee

Externally Funded Projects

42.	SSP0717	Suvir Singh	Director, Lady Hardinge Medical College, New Delhi	Fire Safety Audit of JICA Building, Smt. Suchetra Kriplani and Kalawati Saran Hospital
43.	SSP0727	Shorab Jain	Director, Lady Hardinge Medical College, New Delhi	Fire Safety Audit of New Multistory Building, Electrical Substation near JICA block, DG Set Complex and Electrical Substation
44.	TSP0027	Suvir Singh	Horizon Chutes Pvt. Ltd., S.No. 11/16/2 Village Nanded, Pune-Sinhagad Road, Pune	Fire Performance Assessment of Fire Doors
45.	TSP0057	A. A. Ansari	Raj Builtcon, A-205, Nishat Complex, Opp. Theosophical Society, Salatwada Road, Baroda	Fire Performance Characteristic Studies on FRP Pultruded Section
46.	TSP0067	Suvir Singh	Sadbhav Engineering Ltd., C/o Delhi Metro Rail Corporation Ltd., Office of Chief Project Manager-9, Near Mundka Metro Station, Mundka, Delhi	Fire Performance Assessment of Fire Doors
47.	TSP0117	B. Singh	Er. Surinder Singh Chhokar, Sr. Sectional Engineer / Northern Railway / Jind Junction	Testing of PPR Pipes and Fittings (Microbial Efficacy of the Pipes)
48.	TSP0137	Suvir Singh	Navair International Ltd., Plot No. 468, HSIDC Industrial Area, Phase-I, Barhi, Sonipat, Haryana	Fire Performance Assessment of Wooden Fire Door
49.	TSP0147	Suvir Singh	Trio Elevators Co. (I) Ltd., 404 Shivam Complex, Near Buyangdev Cross Road, Sola Road, Santej Dist. Gandhinagar, Ahmedabad	Fire Performance Assessment of Landing Door
50.	TSP0157	Suvir Singh	J.C. Fire Door Corporation, A-64, Shivshakti Estate, Near Bhavana Road Line Phase-I, GIDC Vatva, Ahmedabad	Fire Performance Assessment of Fire Door

Externally Funded Projects

51.	TSP0167	Suvir Singh	Bhawani Steel Fabricators, 63, Rural Industrial Estate, Arya Nagar, Loni, Ghaziabad	Fire Performance Assessment of Glazed Fire Door
52.	TSP0177	A. A. Ansari	Hira Technologies Pvt. Ltd., Plot No. I-01, (Part-II), Khed Industrial Park DTA, Village Kanhersar, Tal Khed, Dist Pune, Maharashtra	Reaction to Fire Characteristic Studies on Cross Linked Polyolefin's (XLPE Foam) Thermal Insulation
53.	TSP0187	Suvir Singh	Gandhi Automations PVt. Ltd., 2nd Floor, Chawda Commercial Centre, Link Road, Malad (W), Mumbai	Fire Performance Assessment of Fire Shutter
54.	TSP0207	Suvir Singh	Kone Elevator (I) Pvt. Ltd., India Land Tech Park Tower-B, 3rd Floor No. 14, 3rd Main Road Ambattur Industrial Estate, Chennai	Fire Performance Assessment of Elevator Landing Door
55.	TSP0217	A. A. Ansari	NTPC Ltd., North Karanpura Super Thermal Power Project, Near Block Office Padwa, Dist. Chatra, Jharkhand	Fire Performance Characteristic Studies of PUF Panels
56.	TSP0227	Suvir Singh	CS Components Pvt. Ltd., 205, Vastu Prestige, 2nd Floor, New Link Road, Andheri (W), Mumbai	Fire Performance Assessment of Fire Door
57.	TSP0257	Suvir Singh	GWS Engineers & Fabricators Pvt. Ltd., A-512, TTC Industrial Area, Mahape, Navi Mumbai	Fire Performance Assessment of Fire Door
58.	TSP0267	P. C. thapliyal	Asstt. Exec. Engineer (Construction), Office of the Dy. Chief Engineer, Southern Railway, Madurai, Tamil Nadu	Evaluation of IPNet paints to be used in guage conversion work between Sengottai and Edaman railway Stations

Externally Funded Projects

59.	TSP0317	L. P. Singh	Patanjali Research Foundation, Patanjali Yogpeeth-I, Delhi-Hardwar Haridwar	Characterization of Samples by Instrumental Techniques
60.	TSP0367	Suvir Singh	Johnson Lifts Pvt. Ltd., #17, Poonamallee Bye Pass Road, Poonamallee, Chennai	Fire Performance Assessment of Glazed Lift Landing Door
61.	TSP0387	Suvir Singh	KPC Project Ltd., #1-2-339/1, Street No. 6, Gagan Mahal, Domalguda, Hyderabad	Fire Performance Assessment of Fire Doors
62.	TSP0397	Suvir Singh	Office of the Executive Engr, Health Project Division (North), Public Works Department (GNCTD), Dr. BSA Hospital Complex, Sector-6, Rohini, Delhi; Globe Civil Projects Pvt. Ltd., Delhi	Fire Performance Assessment of Fire Door
63.	TSP0417	Suvir Singh	Mukund Overseas, Plot No. 73-45, 19-A, Carnac Siding Road, 104/114, P.D.Mello Road, Mumbai	Fire Performance Assessment of Fire Door
64.	TSP0427	P. C. Thapliyal	Senior Section Engineer (Bridges), Chennai Egmore, Chennai Division, Southern Railway, Chennai; Bismi Engg. Works, Madurai; Client: BISMI Engg. Works, Madurai	Evaluation of IPNet paints to be used under Southern Railway
65.	TSP0457	A. A. Ansari	Hira Technologies Pvt. Ltd., Plot No. I-01, (Part II), Khed Industrial Park DTA, Village Kanhersar, Tal-Khed, Dist Pune, Maharashtra	Fire Performance Characteristic Studies on XLPE Foam Thermal Insulation Without Foil (Plain Foam)

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66.	TSP0467	Suvir Singh	Tripti Engg. Services Pvt. Ltd., A/124, Baghajatin Pally, P.O. Regent Estate P.S. Patuli, Kolkata	Fire Performance Assessment of Fire Door (One Number for 120 min. Standard Fire Exposure)
67.	TSP0477	Suvir Singh	Selens Lift Components Pvt. Ltd., 14/144A, Sitra Road, Kalapatti, Coimbatore	Fire Performance Assessment of Fire Door
68.	TSP0487	Suvir Singh	Amul Boards Pvt. Ltd., Goyal Avenue Plot No. 318, Ward 12/B, Opp. Reliance Mart, Gandhidham (Kutch), Gujarat	Fire Performance Assessment of F ire Doors
69.	TSP0497	Suvir Singh	Berger Paints India Ltd., A-99/3 Okhla Industrial Area, Phase-II, New Delhi	Fire Performance Assessment of Fire Doors
70.	TSP0507	Suvir Singh	GWS Engineers & Fabricators Pvt. Ltd., A-512, TTC Industrial Area Mahape, Navi Mumbai	Fire Performance Assessment of Fire Rated Metal Door
71.	TSP0527	Suvir Singh	Paulson Industries, Kokkapilly, P.O. Thiruvamkulam, Ernakulam, Kerala	Fire Performance Assessment of Fire Door
72.	TSP0567	P. C. Thapliyal	Shree Maharaj Chemitech, Mohbewala Industrial Area, Dehradun	Testing of Superplasticiser
73.	TSP0577	A. A. Ansari	R S Plasfab Pvt. Ltd., Plot No. 41 & 42, Phase III, Kasba Industrial Estate, Kolkata	Reaction to Fire Characteristic Studies on uPVC Profiles for Doors & Windows
74.	TSP0687	Suvir Singh	Airpro Engineering Pvt. Ltd., 301, Mohan Ashish, Dr. Almeda Road, Panchpakhadi, Thane	Fire Performance Assessment of Fire Dampers
75.	TSP0697	Suvir Singh	Alfa Peb Ltd., 43/41, Nanjappa Layout, 3rd Floor, Stone Artz Bldg, Adugodi, Bangalore	Fire Performance Assessment of Fire Door

CBRI Family

CBRI Family

Group-IV-Scientific Staff

S. No.	Name	Designation
1.	Dr. N. Gopalakrishnan	Director
2.	Dr. A.K. Minocha	Chief Scientist
3.	Mr. R.S. Chimote	Chief Scientist
4.	Dr. Suvir Singh	Chief Scientist
5.	Dr. (Mrs.) Abha Mittal	Sr. Principal Scientist
6.	Dr. Ashok Kumar	Sr. Principal Scientist
7.	Mr. S.K. Negi	Sr. Principal Scientist
8.	Dr. Shantanu Sarkar	Sr. Principal Scientist
9.	Dr. R. Dharma Raju	Sr. Principal Scientist
10.	Dr. Harpal Singh	Sr. Principal Scientist
11.	Dr. Pardeep Kumar-I	Sr. Principal Scientist
12.	Dr. Atul Kumar Agarwal	Sr. Principal Scientist
13.	Mr. A. A. Ansari	Sr. Principal Scientist
14.	Dr. Purnima Parida	Sr. Principal Scientist
15.	Dr. D.P. Kanungo	Sr. Principal Scientist
16.	Dr. Achal Kumar Mittal	Sr. Principal Scientist
17.	Dr. Rajni Lakhani	Sr. Principal Scientist
18.	Mr. S.K. Singh	Sr. Principal Scientist
19.	Dr. S.R. Karade	Sr. Principal Scientist
20.	Mr. Nadeem Ahmed	Principal Scientist
21.	Dr. Rajesh Deoliya	Principal Scientist
22.	Dr. A.P. Chaurasia	Principal Scientist
23.	Dr. Sujit Kumar Saran	Principal Scientist
24.	Dr. Navjeev Saxena	Principal Scientist
25.	Dr. P.C. Thapliyal	Principal Scientist
26.	Dr. B.S. Rawat	Principal Scientist
27.	Dr. L.P. Singh	Principal Scientist
28.	Dr. Shorab Jain	Principal Scientist
29.	Dr. S.K. Panigrahi	Principal Scientist
30.	Dr. Rajesh K. Verma	Principal Scientist
31.	Dr. P.K.S. Chauhan	Principal Scientist
32.	Mr. H.C. Arora	Sr. Scientist

33.	Dr. Leena Chaurasia	Sr. Scientist
34.	Dr. Neeraj Jain	Sr. Scientist
35.	Mr. Vineet Kumar Saini	Sr. Scientist
36.	Mr. Ravindra Singh Bisht	Scientist
37.	Mr. Nagesh Babu Balam	Scientist
38.	Mr. Manojit Samanta	Scientist
39.	Mr. Soju Joseph Alexander	Scientist
40.	Mr. Soumitra Maiti	Scientist
41.	Mr. Srinivasrao Naik B.	Scientist
42.	Mr. Subash Chandra Bose Gurram	Scientist
43.	Dr. A. Aravind Kumar	Scientist
44.	Dr. Anindya Pain	Scientist
45.	Mr. Mickey Mecon Dalbehera	Scientist
46.	Mr. Piyush Mohanty	Scientist
47.	Mr. Siddharth Behera	Scientist
48.	Ms. Ishwarya G.	Scientist
49.	Ms. Monalisa Behera	Scientist
50.	Mr. Rajesh Kumar	Scientist
51.	Mr. Rakesh Paswan	Scientist
52.	Mr. Chanchal Sonkar	Scientist
53.	Mohd. Reyazur Rahman	Scientist
54.	Mr. Santha Kumar G.	Scientist
55.	Mr. Koushik Pandit	Scientist
56.	Ms. Sayantani Lala	Scientist
57.	Ms. Hina Gupta	Scientist
58.	Mr. Debdutta Ghosh	Scientist
59.	Ms. Surya M.	Scientist
60.	Ms. Swati Kulashri	Scientist
61.	Ms. Shailza Singh	Scientist
62.	Mr. Ashish Pippal	Scientist
63.	Ms. Shermi C.	Scientist
64.	Mr. S. Ganesh Kumar	Scientist
65.	Mr. Chandan Swaroop Meena	Scientist
66.	Mr. Banti A Gedam	Scientist
67.	Dr. Kishore S. Kulkarni	Scientist
68.	Mr. Mohammad Jeeshan Khan	Scientist

69.	Mrs. Aswathy M.S.	Scientist
70.	Dr. Tabish Alam	Scientist
71.	Mr. R. Siva Chidambaram	Scientist
72.	Dr. Hemlata	Scientist
73.	Mr. Sidhharth	Scientist

Group III Technical Staff

74.	Dr. Rajiv Kumar	Principal T.O.
75.	Mr. D.K. Sehgal	Principal T.O.
76.	Dr. S.K. Senapati	Principal T.O.
77.	Mr. Narendra Kumar	Principal T.O.
78.	Mr. Rajesh Kumar	Principal T.O.
79.	Dr. P.K. Yadav	Principal T.O.
80.	Mr. Dalip Kumar	Principal T.O.
81.	Mr. Rajeev Kumar Sharma	Sr. T.O. (3)
82.	Mr. Sushil Kumar	Sr. T.O. (3)
83.	Dr. M.K. Sinha	Sr. T.O. (3)
84.	Mr. Zamir Ahmad	Sr. T.O. (3)
85.	Mr. Rakesh Kumar –II	Sr. T.O. (3)
86.	Mr. Vivek Sood	Sr. T.O. (3)
87.	Mr. Jalaj Parashar	Sr. T.O. (3)
88.	Mr. Ram Ashray Rai	Sr. T.O. (2)
89.	Mr. Bharat Bhushan	Sr. T.O. (2)
90.	Mr. Naresh Kumar	Sr. T.O. (2)
91.	Mr. Rajesh R. Ghadse	Sr. T.O. (2)
92.	Mr. B.K. Kalra	Sr. T.O. (1)
93.	Mr. Itrat Amin Siddiqui	Sr. T.O. (1)
94.	Mrs. Deepti Karmakar	Sr. T.O. (1)
95.	Mrs. Gayatri Devi	Sr. T.O. (1)
96.	Mr. Amit Kush	Sr. T.O. (1)
97.	Mr. Ajay Dwivedi	Sr. T.O. (1)
98.	Mr. Sameer	T.O.
99.	Mr. D.S. Dharamshaktu	T.O.

Group II

100.	Mr. Rishi Pal Singh	Sr. Tech. (2)
101.	Mr. Sushil Kumar	Sr. Tech. (2)

102.	Mr. Himanshu Sharma	Sr. Tech. (2)
103.	Mr. Rajinder Kumar	Sr. Tech. (2)
104.	Mrs. Neelam Gupta	Sr. Tech. (2)
105.	Mrs. Sangeeta Sharma	Sr. Tech. (2)
106.	Mr. Sheeraj Ahmad	Sr. Tech. (2)
107.	Mrs. Saroj Rani	Sr. Tech. (2)
108.	Mr. Anil Kumar Sharma	Sr. Tech. (2)
109.	Mr. Jameel Hasan	Sr. Tech. (1)
110.	Mr. U.C. Bhatnagar	Sr. Tech. (1)
111.	Mr. Manmeet Singh	Sr. Tech. (2)
112.	Mrs. Urmila Kotnala	Sr. Tech. (2)
113.	Mr. B.S. Bisht	Sr. Tech. (1)
114.	Mr. Rajeev Bansal	Sr. Tech. (1)
115.	Mr. Pradeep Kr. Kapooria	Sr. Tech. (1)
116.	Mr. Arvind Saini	Sr. Tech. (1)
117.	Mr. Harish Kumar	Sr. Tech. (1)
118.	Mr. Sukhbir Sharma	Sr. Tech. (1)
119.	Mr. Arvind Kumar	Sr. Tech. (1)
120.	Mr. Sharad Kumar	Sr. Tech. (1)
121.	Mr. Mam Chand Agarwal	Sr. Tech. (1)
122.	Mr. Arvind Kumar Sharma	Sr. Tech. (1)
123.	Mr. Tahir Husain	Sr. Tech. (1)
124.	Mr. Francis Charles	Sr. Tech. (1)
125.	Mr. Ghanshyam Mittal	Sr. Tech. (1)
126.	Mr. Kedar Nath	Sr. Tech. (1)
127.	Mr. Iqbal Ahmed	Sr. Tech. (1)
128.	Mr. Manoj Kumar Tyagi	Sr. Tech. (1)
129.	Mr. Jai Pal	Sr. Tech. (1)
130.	Mr. Shorab Khan	Sr. Tech. (1)

Group I Supporting Staff

131.	Mr. D.P. Yadav	Lab. Asstt.
132.	Mr. Amar Singh (SE)	Lab. Asstt.
133.	Mr. Gurucharan Singh	Lab. Asstt.
134.	Mr. Rajeshwar	Lab. Asstt.
135.	Mr. Rishi Pal (SE)	Lab. Asstt.

136.	Mr. Vijay Kumar	Lab. Asstt.
137.	Mr. Vishwas Kumar	Lab. Asstt.
138.	Mr. Jagdish Pal	Lab. Asstt.
139.	Mr. Deepak Kumar	Lab. Asstt.
140.	Mr. Subhash Chand	Lab. Asstt.
141.	Mr. Rajesh Kumar	Lab. Asstt.

Administrative Staff /House-Keeping

142.	Mr. Vinod Kumar	A.O.
143.	Mr. Ajay Kumar Sharma	S&PO
144.	Mr. J.K. Chaurasia	F&AO
145.	Mr. Sukhvir Singh	S.O. (S&P)
146.	Mr. Lekh Raj Kaushik	S.O. (S&P)
147.	Mr. S.K. Jakhwal	S.O. (G)
148.	Mrs. Rashmi Rathore	S.O. (G)
149.	Mr. V.K. Sharma	S.O. (G)
150.	Mr. Constan Kujur	S.O. (G)
151.	Mr. K. Arora	P.S.
152.	Mr. Satya Pal	P.S.
153.	Mr. V.P.S. Rawat	Security Officer
154.	Mr. Naresh Yadav	Sr. Steno
155.	Mrs. Archana	Sr. Steno
156.	Mr. Arvind Kumar	Sr. Steno
157.	Mr. Dalpat Singh	Sr. Steno
158.	Mr. Dharam Singh Negi	Sr. Steno
159.	Mr. Mehar Singh	Hindi Officer
160.	Mr. Suba Singh	Hindi Officer
161.	Mrs. Nisha Tyagi	Asstt. (G) Gr. I
162.	Mrs. Sarita Khanna	Asstt. (G) Gr. I
163.	Mrs. Sheema Farhat	Asstt. (G) Gr. I
164.	Mr. Sudhir Kumar	Asstt. (G) Gr. I
165.	Mr. Shiv Kumar	Asstt. (G) Gr. I
166.	Mr. Pawan Kumar	Asstt. (G) Gr. I
167.	Mrs. Mamta Sharma	Asstt. (G) Gr. I
168.	Mr. Virendra Singh	Asstt. (F&A) Gr. I
169.	Mr. Aman Kumar	Asstt. (F&A) Gr. I

170.	Mr. Vipin Kumar Sharma	Asstt. (F&A) Gr. I
171.	Mr. Suraj Pal Singh	Asstt. (F&A) Gr. I
172.	Mr. Satyarth Prakash	Asstt. (F&A) Gr. I
173.	Mrs. Rubina Zaidi	Asstt. (F&A) Gr. I
174.	Mr. Sanjeev Bansal	Asstt. (S&P) Gr. I
175.	Mrs. Anju Rani Simon	Asstt. (S&P) Gr. I
176.	Mr. Arpan Maheshwari	Asstt. (S&P) Gr. I
177.	Mr. Kalam Singh Chauhan	Asstt. (S&P) Gr. I
178.	Mr. Vishwash Tyagi	Asstt. (S&P) Gr. I

Group C

179.	Mrs. Arun Lata	Asstt. (G) Gr. II
180.	Mr. Sushil Kumar	Asstt. (G) Gr. II
181.	Mr. Sanjay Kr. Tyagi	Asstt. (G) Gr. II
182.	Mrs. Seema Ahuja	Asstt. (G) Gr. II
183.	Mr. Ravinder Kumar	Asstt. (G) Gr. II
184.	Mr. Mukesh Kumar	Asst. (S&P) Gr. III
185.	Mr. Radhey Shyam	Driver (NT)
186.	Mr. Satya Pal	MTS
187.	Mr. Raj Kumar	MTS
188.	Mrs. Usha	MTS
189.	Mrs. Bala	MTS
190.	Mr. Subhash Chand	MTS
191.	Mr. Inder Pal (ACP)	MTS
192.	Mr. Desh Raj	MTS
193.	Mr. Rakesh Kumar	MTS
194.	Mr. Ramesh Kumar	MTS
195.	Mr. Santosh Kumar	MTS
196.	Mr. Rakesh Kumar	MTS
197.	Mr. Krishna Gopal Thakur	MTS
198.	Mr. Rohitash Kumar	MTS
199.	Mr. Radhey Shyam	MTS
200.	Mr. Ranbeer Singh	MTS
201.	Mr. Devendra Kumar	MTS
202.	Mrs. Prakash Kaur	MTS
203.	Mrs. Anju	MTS

204.	Mr. Khalil Ahmad	MTS
205.	Mr. Subhan Singh	MTS
206.	Mr. Anit Kumar Pal	MTS
207.	Mr. Pritam Giri	MTS
208.	Mr. Pooran Vassi	MTS
209.	Mr. Kirat Pal	MTS
210.	Mr. Kiran Pal	MTS
211.	Mr. Rajesh Kr. Yadav	MTS
212.	Mr. Jai Prakash	MTS
213.	Mr. Ranjeet Singh	MTS
214.	Mr. Satya Pal	MTS
215.	Mr. Satya Pal Singh	MTS
216.	Mr. Mehraj Deen Khan	MTS
217.	Mr. Dharam Singh	MTS
218.	Mr. Sunil Kumar	MTS
219.	Mr. Rakesh	MTS
220.	Mr. Arun Kumar	MTS
221.	Mr. Ravinder Kumar	MTS
222.	Mr. Dil Bahadur	MTS
223.	Mr. Rajinder Pal	MTS
224.	Mr. Malkhan Singh	MTS
225.	Mr. Dheer Singh	MTS

Transfer & Posting

1. Mr. Siddharth	Scientist From CSIR-CGCRI, Kolkata to CSIR-CBRI, Roorkee	14/08/2017
2. Dr. Purnima Parida	Senior Principal Scientist From CSIR-CRRI, New Delhi to CSIR-CBRI, Roorkee	28/09/2017
3. Mrs. Savita Vishwakarma	Asst. (G) Gr. I From CSIR-IITR, Lucknow to CSIR-CBRI, Roorkee	20/11/2017

Transfer on Promotion

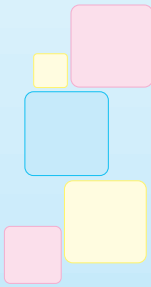
Mr. Lekh Raj Kaushik	Assistant Gr. I (S&P) to Section Officer (S&P) From CSIR-IIP, Dehradun to CSIR-CBRI, Roorkee	29/09/2017

Promotion

1.	Mr. Vineet Kumar Saini	Scientist to Senior Scientist	19/07/2013
2.	Mr. Dalip Kumar	Sr. T.O. (3) to Principal T.O.	07/05/2014
3.	Mr. Zamir Ahmad	Sr. T.O. (2) to Sr. T.O. (3)	12/05/2014
4.	Dr. M.K. Sinha	Sr. T.O. (2) to Sr. T.O. (3)	28/05/2014
5.	Mr. Naresh Kumar	Sr. T.O. (1) to Sr. T.O. (2)	14/06/2014
6.	Mr. Manmeet Singh	Sr. Technician (1) to Sr. Technician (2)	26/06/2014
7.	Mrs. Deepti Karmakar	T.O. to Sr. T.O. (1)	20/07/2014
8.	Mr. Rajesh Kumar	Lab Attd. (2) to Lab Assistant	11/03/2015
9.	Mr. Ajay Dwivedi	T.O. to Sr. T.O. (1)	21/07/2015
10.	Mr. Rakesh Kumar	Sr. T.O. (2) to Sr. T.O. (3)	01/11/2015
11.	Mr. Vivek Sood	Sr. T.O. (2) to Sr. T.O. (3)	25/01/2016
12.	Mr. Rajesh R. Ghadse	Sr. T.O. (1) to Sr. T.O. (2)	31/01/2016
13.	Mr. Jalaj Parashar	Sr. T.O. (2) to Sr. T.O. (3)	08/02/2016
14.	Mrs. Urmila Kotnala	Sr. Technician (1) to Sr. Technician (2)	14/03/2016
15.	Mr. Mukesh Kumar	M.T.S. to Asst. (S&P) Gr. III	12/03/2018

Superannuation

1.	Mr. Dharampal	MTS	30/04/2017
2.	Mr. Yadvendra Pandey	Chief Scientist	30/06/2017
3.	Dr. B. Singh	Chief Scientist	31/07/2017
4.	Mr. Jaswinder Singh	Principal Technical Officer	31/07/2017
5.	Dr. Manju Mittal	Senior Principal Scientist	31/08/2017
6.	Mr. Inderpal	MTS	31/08/2017
7.	Mr. Mani Ram	MTS	31/08/2017
8.	Mrs. Kusum Lata	MTS	31/08/2017
9.	Mr. P.K. Yadav	Senior Technician	30/10/2017
10.	Mr. Shubhash Chand	Technician	30/11/2017
11.	Mr. Santosh Kumar Mishra	Technician	30/11/2017
12.	Mr. Rizwanul Hasan	Senior Technician	30/11/2017
13.	Mrs. Neeta Mittal	Senior Principal Scientist	31/12/2017
14.	Mr. Dhan Prakash Yadav	Lab Asstt.	31/12/2017
15.	Mr. Dharam Pal Singh	Asstt. (G)	31/12/2017
16.	Mr. Ramesh Kumar Johar	Asstt. (G)	31/12/2017
17.	Mr. Amar Singh	Senior Technician (1)	31/01/2018
18.	Mrs. Sunita	Asstt. (G) Gr. I	31/01/2018
19.	Dr. B.M. Suman	Principal Technical Officer	28/02/2018
20.	Mr. R.C. Saxena	Senior Hindi Officer	31/03/2018



Research Papers

RESEARCH PAPERS

Foreign Journal

1. A. Singh, Y. Pandey, Ashok Kumar, M.K. Singh, Anuj Kumar and S.C. Mukhopadhyay, "Ventilation Monitoring and Control System for High Rise Historical Buildings", IEEE Sensors Journal, Vol. 17, No. 22, November 15, 2017, pp. 7533-7541.

2. B.M. Suman and P.K. Yadav, "Empirical Approach for Prediction of Indoor Air Temperature of a Building", IOSR Journal of Mechanical and Civil Engineering, Vol. 14, No. 5, Ver. 1, 2017, pp. 44-49.

3. Balvir Singh, R.S. Chidambaram, S. Sharma and N. Kwatra, "Behavior of FRP Strengthened RC Brick In-filled Frames subjected to Cyclic Loading", Structural Engineering and Mechanics, Vol. 16, No. 5, 2017, pp. 557-566.

4. Bivina G.R., Purnima Parida, Mukti Advani and Manoranjan Parida, "Pedestrian Level of Service Model for Evaluating and Improving Sidewalks from various Land uses", European Transport\Trasporti Europei, International Journal of Transport Economics, Engineering and Law, No. 67, January 2018, ISSN 1825-3997.

5. Chandan Swaroop Meena, Akash Deep and Arup Kumar Das, "Understanding of Interactions for Bubbles Generated at Neighbouring Nucleation Sites", Heat Transfer Engineering, Vol. 39, No. 10, pp. 885-900, DOI: 10.1080/01457632.2017.1338866.

6. C. Shermi and R.N. Dubey, "Study on Out-Of-Plane Behaviour of Unreinforced Masonry Strengthened with Welded Wire Mesh & Mortar", Construction and Building Materials, Vol 143, July 15, 2017, pp. 104-20.

7. C. Shermi and R.N. Dubey, "Performance Evaluation of a Reinforced Masonry Model and an Unreinforced Masonry Model using a Shake Table Testing Facility", Journal of Performance of Constructed Facilities (ASCE), Vol. 32, No. 1, November 22, 2017, 04017121.

8. E. Rajasekar, Ashok Kumar and Ramachandriah Alur, "Thermal Performance of Building Envelopes", Encyclopedia of Sustainable Technologies, 1st Edition, Elsevier, Vol. 2, July 2017, pp. 169-188.

9. K.K. Pradhan, S. Chakraverty and S.K. Panigrahi, "Implementation of Numerical Approximations in Studying Vibration of Functionally Graded Beams", International Journal of Dynamics and Control, Springer, November 29, 2017 (online), pp. 1-24.

10. Kishor S. Kulkarni, Ashok Kumar and Navjeev Saxena, "An Integrated Approach towards a Model Village: Case Study from Belagavi District", Journal of Environmental Nanotechnology, Vol. 6, No. 2, June 2017, pp. 48-54.

11. L.P. Singh, W. Zhu, T. Howind and U. Sharma, "Quantification and Characterization of CSH in Silica Nanoparticles Incorporated Cementitious System", Cement and Concrete Composites, Vol. 79, May 2017, pp. 106-116.

12. Mukti Advani, Purnima Parida and Shobhna Pattnaik, "Pedestrian Serviceability Index Including Pedestrians on Vehicle-Path", Journal of Traffic and Transportation Engineering, Vol. 5, No. 6, November-December 2017, S. No. 20.

13. M.A. Iqbal, V. Kumar and A.K. Mittal, "Behaviour of Pre-stressed and Reinforced Concrete Plates Subjected to Impact Loads Induced by Free Falling Indenter", Procedia Engineering, Vol. 173, 2017, pp. 397-402.

14. M.K. Singh, S. Kumar, R. Ooka, H. B. Rijal, G. Gupta and Anuj Kumar, "Status of Thermal Comfort in Naturally Ventilated Classrooms during the Summer Season in Composite Climate of India", Building and Environment, Vol. 128, January 15, 2018, pp. 287-304.

15. M. Sharma, M. Samanta and S. Sarkar, "A Laboratory Study on Pullout Capacity of Helical Soil Nail in Cohesionless Soil", Canadian Geotechnical Journal, Vol. 54, No. 10, pp. 1482-1495, DOI: org/10.1139/cgj-2016-0243.

16. Neeraj Jain and A.K. Minocha, "Pollution Monitoring, Dispersion Modelling and proposed Siting Criteria for New Brick Kilns", Journal of Environmental Science, Toxicology and Food Technology (IOSR), Vol. 11, No. 12, December 2017, pp. 53-59.

17. Neeraj Jain and R. K. Verma, "Characterization and Utilization of ETP Sludge of an Automobile Industry for Development of Construction Products", Journal of Mechanical and Civil Engineering (IOSR), Vol. 15, No. 2, March 2018, pp. 65-71.

18. Priyanka Tomar, Rajni Lakhani, V.K. Chhibber and Rajesh Kumar, "Macro-Defect Free Cements: A Future Oriented Polymer Composite Materials for Construction Industries", Composite Interfaces, Taylor & Francis Ltd., Vol. 25, No. 5-7, February 2018, pp. 607-627, DOI: 10.1080/09276440.2018.1439637.

19. R. Bharti, R.S. Chidambaram, and N. Kwatra, "Influence of Fiber Reinforced Concrete on Plastic Behavior on Exterior Beam Column Joint under Cyclic Loading", Procedia Engineering, Vol. 173, 2017, pp. 1122-1129.

20. Rajesh Kumar, Rajni Lakhani and Priyanka Tomar, "A Simple Novel Mix Design Method and Properties Assessment of Foamed Concretes with Limestone Slurry Waste", Journal of Cleaner Production, Elsevier, Vol. 171, January 2018, pp. 1650-1663, DOI:10.1016/j.jclepro.2017.10.073.

21. R. Kumar, S. Singh and L.P. Singh, "Studies on Enhanced Thermally Stable High Strength Concrete Incorporating Silica Nanoparticles", Construction and Building Materials, Vol. 153, October 30, 2017, pp. 506-513.

22. R. Palla, S.R. Karade, G. Mishra, U. Sharma and L.P. Singh, "High Strength Sustainable Concrete using Silica Nanoparticles", Construction and Building Materials, Vol. 138, May 01, 2017, pp. 285-295.

23. R.S. Chidambaram, and P. Agarwal, "Performance Evaluation of Innovative Hybrid Rebar Coupler in Reinforced Concrete Beams Subjected to Monotonic Loading", Structural Concrete, DOI: 10.1002/suco.201700083.

24. Sayantani Lala, N. Gopalakrishnan and Ashok Kumar, "A Comparative Study on the Seismic Performance of the Different Types of Bamboo Stilt Houses of North-East India", Journal of Environmental Nanotechnology, Vol. 6, No. 2, June 2017, pp. 59-73.

25. S. Rajput, L.P. Singh, C.U. Pittman and D. Mohan, "Lead (Pb^{2+}) and Copper (Cu^{2+}) Remediation from Water using Superparamagnetic Maghemite (γ-Fe_2O_3) Nanoparticles Synthesized by Flame Spray Pyrolysis (FSP)", Journal of Colloid and Interface Science, Vol. 492, April 15, 2017, pp. 176-190.

26. Shailza Singh and Prabhjot Singh Chani, "Thermal Comfort Analysis of Indian Subjects in Multi-Storeyed Apartments: An Adaptive Approach in Composite Climate", Indoor and Built Environment, DOI: 10.1177/1420326X17712797.

27. T. Alam and Man Hoe Kim, "Heat Transfer Enhancement in Solar Air Heater Duct with Conical Protrusion Roughness Ribs", Applied Thermal Engineering, Vol. 126, pp. 485-469.

28. V. Kumar, M.A. Iqbal and A.K. Mittal, "Energy Absorption Capacity of Pre-stressed and Reinforced Concrete Slabs Subjected to Multiple Impacts", Procedia Structural Integrity, Vol. 6, 2017, pp. 11-18.

29. V. Kumar, M.A. Iqbal and A.K. Mittal, "Behaviour of Pre-stressed Concrete under Drop Impact Loading", Procedia Engineering, Vol. 173, 2017, pp. 403-408.

30. V. Kumar, M.A. Iqbal and A.K. Mittal, "Impact Resistance of Pre-stressed and Reinforced Concrete Slabs under Falling Weight Indenter", Procedia Structural Integrity, Vol. 6, 2017, pp. 95-100.

31. V.S.R. Annapareddy, A. Pain, and S. Sarkar, "Seismic Translational Failure Analysis of MSW Landfills using Modified Pseudo-Dynamic Approach", International Journal of Geomechanics, Vol. 17, No. 10, October 2017, DOI: 10.1061/(ASCE)GM.1943-5622.0000990.

32. V.V. Nelubova, P. Hou, V.V. Strokova, L.P. Singh, D.D. Netsvet and D.O. Bandarenko, "Complex Study of Modified Binder Properties", Advances in Engineering Research, Vol. 133, 2017, pp. 543-548.

National Journal

1. Ashok Kumar, Sayantani Lala and Kishor S. Kulkarni, "Impact of Increased Heights and Floor Area Ratio (FAR) on Housing Environments", Nirman Sarika, World Habitat Day Special Issue, Vol. 6, No. 3, July-September 2017, pp. 58-63, BMTPC, New Delhi.

2. Ashok Kumar, Sayantani Lala, Kishor Kulkarni and Vijay Raj Deopa, "Housing at the Centre for Sustainable Future of Cities", Journal of Indian Buildings Congress, Volume 25, No. 2, December 2017, pp. 153-160, ISSN 2349-7475.

3. अतुल कुमार अग्रवाल, "सस्ती भवन तकनीक-सीबीआरआई का राष्ट्र निर्माण में योगदान", भारतीय वैज्ञानिक एवं औद्योगिक अनुसंधान पत्रिका, वर्ष 25, अंक 1 एवं 2, 2017, पृ. 63-74, , सीएसआईआर- राष्ट्रीय विज्ञान संचार एवं सूचना स्रोत संस्थान, नई दिल्ली।

4. अतुल कुमार अग्रवाल, "आधुनिक युग की विकसित भवन सामग्रियां", वैज्ञानिक, वर्ष 49, अंक 4, अक्टूबर-दिसंबर 2017, पृ. 23-27, हिन्दी विज्ञान साहित्य परिषद, भाभा परमाणु अनुसन्धान केंद्र, मुंबई।

5. अतुल कुमार अग्रवाल, "भवन निर्माण सामग्रियों में लकड़ी का विकल्प", वैज्ञानिक, वर्ष 49, अंक 2, अप्रैल-जून 2017, पृ. 27-31, हिंदी विज्ञान साहित्य परिषद, भाभा परमाणु अनुसन्धान केंद्र, मुंबई।

6. बाल मुकुंद सुमन, "भवनों में पर्यावरण अनुकूलित उष्मारोधी सामग्री के उपयोग से भूमंडलीय ताप का नियंत्रण", वैज्ञानिक, वर्ष 49, अंक 2, अप्रैल-जून 2017, पृ. 21-26, हिंदी विज्ञान परिषद।

7. Jiten Shah, Gaurang Joshi, Shriniwas Arkatkar and Purnima Parida, "Estimation of Free Speed of Pedestrian Flow on Stairways at Busy Suburb Rail Transit Station in India", Current Science, Vol. 113, No. 5, September 2017, pp. 10.

8. N. Gopalakrishnan, Ashok Kumar, Kishor S. Kulkarni and Sayantani Lala, "Green Buildings: An Imperative Development", RITES Journal, Vol. 20, No. 1, January 2018, pp. 14.1-14.16.

9. R.S. Chidambaram, V.V.S.S.K. Dadi, and P. Agarwal, "Seismic Retrofitting of Damaged Column of Buildings by using External Bolted Mechanical Couplers with and without FRP Confinement", The Master Builder, Vol.19, No.11, 2017, pp. 32-36.

10. S.K. Singh and S.K. Kirthika, "Manufactured Sand: A Foreseeable Alternative to River Sand", Nirman Sarika, World Habitat Day Special Issue, Vol. 6, No. 3, July-September 2017, pp. 39-46, BMTPC, New Delhi.

11. S. Sarkar and M. Samanta, "Stability Analysis and Remedial Measures of a Landslip at Keifang, Mizoram – A Case Study", Journal of Geological Society of India, Vol. 89, No. 6, 2017, pp. 617-740.

12. T.B. Roy, S. Banerji, S.K. Panigrahi, A. Chourasia, Tirca Lucia and Ashutosh Bagchi, "Modal Identification and Damage Detection in Structures Using Non-Linear and Non-Stationary Vibration Response", Journal of Structural Engineering, Vol. 44, No. 3, August-September 2017, pp. 220-227.

Papers in Conference/Workshop/Seminar etc.

1. A. Bhawani, S.C.B. Gurum, S. Maiti and A.K. Minocha, "Bagasse Ash- A Resource Material for Durable and Sustainable Concrete", National Seminar on Emerging Materials and Construction Technologies- Building Materials and Housing Technologies for Sustainable Development, February 22-23, 2018, pp. 156-163, BMTPC, New Delhi.

2. A. Chourasia, "Reinforced Concrete Prefab Technologies for Mass Housing Seismic Safety & Sustainability Issues", Conference on PEPSCON, January 19-21, 2018, Hyderabad.

3. A. Chourasia, Ankush B. and S. Singhal, "Confined Masonry Construction for Mass Housing", Conference on Infrastructure Sustainability in Hilly Regions CISHR, December 21-23, 2017, pp. 214, NIT Srinagar, Uttarakhand.

4. A. Chourasia and S. Singhal, "Innovative Connection Systems between Prefab RC Shear Walls and Column/ Beam", Conference on PEPSCON, January 19-21, 2018, Hyderabad.

5. A. Chourasia, Y. Kajale, S. Singhal and J. Parashar, "Promising Prefab Technology for Mass Housing in Indian Scenario", Conference on Infrastructure Sustainability in Hilly Regions CISHR, December 21-23, 2017, pp. 192, NIT Srinagar, Uttarakhand.

6. A. Chourasia, S. Gupta and S. Singhal, "Investigation on Headed Bars as Anchorage Device in Beam-Column Joint: A Literature Review", Conference on Infrastructure Sustainability in Hilly Regions CISHR, December 21-23, 2017, pp. 222, NIT Srinagar, Uttarakhand.

7. A. Chourasia, S. Singhal and J. Parashar, "Seismic Performance of Prefab RC Shear Walls: A Review", Conference on Infrastructure Sustainability in Hilly Regions CISHR, December 21-23, 2017, pp. 202, NIT Srinagar Uttarakhand.

8. Ashok Kumar, Kshitij Jain, Baldev Kishan and Neha Goel, "Development of Wayside Amenities in Hilly Regions", All India Workshop on All Weather Roads in Hilly Regions, April 29-30, 2017, The Institution of Engineers (India) Uttarakhand State Centre, Dehradun.

9. Ashok Kumar, Sayantani Lala, Kishor Kulkarni and Vijay Raj Deopa "Housing at the Centre for Sustainable future of Cities", 22nd Annual Convention and National Seminar on Housing for All in Urban and Rural Areas, December 22-23, 2017, New Delhi.

10. Atul Kumar Agarwal, "Youth-Focused Citizen Science: Importance of Developing Scientific Temper for Sustainable Development", Reaching the Unreached through Science & Technology, 105th Indian Science Congress, March 16-20, 2018, Manipur University, Imphal.

11. Atul Kumar Agarwal, "Communicating Science: Awakening Scientific Fervor in Youth", Scientific Session on Communication Implications & Opportunities, CSIR-NISCAIR-DST National Workshop on Science, Technology and Innovation Policy: Optimizing Communication & Information Research, January 23-25, 2018, NASC Complex, New Delhi.

12. Atul Kumar Agarwal, "Communicating India's Scientific Wisdom: Building Scientific Temper in Young Minds", Scientific Session on Science Communication, 17th Indian Science Communication Congress (ISCC 2017) on Communicating India's Scientific Wisdom: Changing Paradigms, December 21-22, 2017, Indian Institute of Mass Communication (IIMC), New Delhi.

13. अतुल कुमार अग्रवाल, "अभिनव भारत हेतु वैज्ञानिक दृष्टिकोण और चेतना जगाने में सीबीआरआई का योगदान", राष्ट्रीय संगोष्ठी : साहित्य, संस्कृति एवं विज्ञान, नवम्बर 17-18, 2017, वार्ता न. 25, शांति निकेतन।

14. अतुल कुमार अग्रवाल, "औद्योगिक विष से वरदान: सीबीआरआई का पर्यावरण संरक्षण में योगदान", पर्यावरण प्रदूषण : चुनौतियाँ एवम् रणनीतियां विषय पर अंतरराष्ट्रीय वैज्ञानिक संगोष्ठी, अक्तूबर 11-13, 2017, पृ. 21, सीएसआईआर-आईआईटीआर, लखनऊ।

15. Boski Chauhan, G.J. Joshi and Purnima Parida, "Candidate Driving Cycle Construction for Emission Estimation", 4th Conference of Transportation Research Group of India (CTRG), December 17-20, 2017, Mumbai.

16. Banti A. Gedam, N. M. Bhandari and Akhil Upadhyay, "Time-Dependent Behavior Prediction, Serviceability and Sustainability Problems for High-Performance Concrete Bridges", Facing the Challenges in Structural Engineering, GeoMEast 2017, July 15-19, 2017, pp 254-264, Sustainable Civil Infrastructures, Springer, DOI: https://doi.org/10.1007/978-3-319-61914-9_20.

17. C. M. Fourie, D. V. Bhatt, B. J. Silva, Anuj Kumar and G. P. Hancke, "A Solar-Powered Fish Pond Management System for Fish Farming Conservation", IEEE 26th International Symposium on Industrial Electronics (ISIE), June 19-21, 2017, Added to IEEE Xplore on August 08, 2017, pp. 2021-2026, DOI: 10.1109/ISIE.2017.8001565, Electronic ISBN: 978-1-5090-1412-5, Edinburgh, United Kingdom.

18. Chandan Swaroop Meena, Abhinav Jain and Arup Kumar Das, "Experimental Study of Boiling Heat Transfer on Horizontal and Inclined Cylinder", 44th National Conference of Fluid Mechanics and Fluid Power, December 14-16, 2017, Paper No. 75, Amrita Vishwa Vidyapeetham, Amritapuri Campus, Kollam, Kerala.

19. Debdutta Ghosh, Hina Gupta, A.K. Mittal and Raj Shekhar, "Advanced Non-Destructive Techniques for Mass Housing", All India Workshop on Mass Housing and Rapid Construction, November 13-15, 2017, pp. 83-90, The Institute of Engineers (India), Roorkee Local Centre, Roorkee, India.

20. Ganesh Kumar, "Treatment of Soft Clays by Combined Encased Stone Columns and Vacuum Consolidation", DFI-India 2017: 7th Conference on Deep Foundation Technologies for Infra-structure Development in India, October 05-07, 2017, pp. 112-116, IIT Madras, Chennai.

21. J. Mokani and S.R. Karade, "Green Corrosion Inhibitors for RC Structures", International Conference on Advances in Construction Materials and Structures (ACMS 2018), March 07-08, 2018, Paper ID A-234, Abstract Proceedings pp. 107, Indian Society for Construction Materials & Structures (ISCMS) and Dept. of Civil Engineering, IIT Roorkee, India.

22. L.P. Singh, D. Ali and U. Sharma, Invited Talk on "Early Stage Hydration Studies of Tricalcium Silicate using Silica Nanoparticles", International Conference on Advances in Construction Materials and System (ICACMS), September, 08-10, 2017, pp. 113-123, Chennai, India,.

23. L.P. Singh, "Nano-engineered Concrete for Sustainable Infrastructure", All India Workshop on Mass Housing and Rapid Construction, November 13-15, 2017, The Institute of Engineers (India), Roorkee Local Centre, Roorkee, India.

24. L.P. Singh and D. Ali, "Early Stage Hydration Studies of Cementitious Materials Incorporating Silica Nanoparticles", International Workshop on Nano-engineered Meta-Materials for Civil Infrastructure, May, 20-21, 2017, University of Jinan, Jinan, China.

25. M. Sharma, M. Samanta and S. Sarkar, "An Innovative Pullout System for Soil Nails and Anchors", Indian Geotechnical Conference 2017 GeoNEst, December 14-16, 2017, Th03_711, pp. 1-4, IIT Guwahati, India.

26. M. Surya, S.K. Singh and Nirmala Kharola, "Shape Memory Alloy – A Next Generation Construction Material", National Seminar on Emerging Building Materials and Construction Technologies, February 22-23, 2018, pp. 279-288, BMTPC, New Delhi, India.

27. Monalisa Behera and A.K. Minocha, "Microstructure, Mechanical and Shrinkage Characteristics of Recycled Fine Aggregate", National Seminar on Emerging Building Materials and Construction Technologies, February 22-23, 2018, pp. 14-21, BMTPC, New Delhi, India.

28. Monalisa Behera and A.K. Minocha, "Recycling and Management of C&D Waste as Construction Materials in Building Sector", National Conference on Waste to Wealth in Mineral and Metallurgical Industries", March 09-10, 2018, pp. 49-50, Bhubaneswar, India.

29. Nagesh Babu Balam, Akhilesh Gupta, Ashok Kumar and B.M. Suman, "Numerical Solution to Natural Convection in Rectangular Enclosures", International Conference ICET: EITM, December 16–18, 2017, NIT Hamirpur.

30. Nagesh Babu Balam, Akhilesh Gupta, Tabish Alam and Ashok Kumar, "Numerical Solution to Natural Convection in Triangular Enclosures and its application for Double Dome Solar Water Distillation Systems", International Conference APGRES, December 22 – 23, 2017, Banswara, Rajasthan.

31. Neeraj Jain, Soumitra Maiti and A.K. Minocha, "Bacterial Treatment of Pulp and Paper Mill Wastewater in Batch and Continuous Reactors", International Conference on Water Resource Management, January 11-12, 2018, pp. Tech 1/1-1/7, Academy of Water Technology and Environmental Management and CSIR-CGCRI, Kolkata.

32. Neeraj Jain, Soumitra Maiti and A.K. Minocha, "Fabrication of Road Paving Blocks Using Recycled Aggregates", National Seminar on Emerging Building Materials and Construction Technologies-Building Materials and Housing Technologies for Sustainable Development, February 22-23, 2018, pp. 61-71, BMTPC, New Delhi.

33. Neeraj Jain, and A.K. Minocha, "Management of Municipal Solid Waste in Integrated Processing Plant-A Case", National Seminar on Emerging Materials and Construction Technologies- Building Materials and Housing Technologies for Sustainable Development, February 22-23, 2018, pp. 156-163, BMTPC, New Delhi.

34. N. Tamilselvan, R.S. Chidambaram and S.R. Karade, "Research on Failures of Precast Structures and Some Innovative Solutions", National Seminar on Emerging Building Materials and Construction Technologies, February 22-23, 2018, pp.230-240, BMTPC, New Delhi.

35. Palak Goel, Anusha Agarwal and Atul Kumar Agarwal, "Information and Communication Technology: Empowering the Rural India", Reaching the Unreached through Science & Technology, 105th Indian Science Congress, March 16-20, 2018, Manipur University, Imphal.

36. P.C. Thapliyal, "Polymers having Renewable Content for Surface Coating Applications", International Conference on Advances in Construction Materials and Structures (ACMS 2018), March 07-08, 2018, Paper No. A-158, Abstract Proceedings pp. 69-70, Indian Society for Construction Materials & Structures (ISCMS) and Dept. of Civil Engineering, IIT Roorkee, India.

37. P.C. Thapliyal and Vibhrant, "Nanotechnology for Building and Construction Materials", International Conference on Nanotechnology for Human Welfare (ICNHW-2018), February 01-03, 2018, PP 60, pp. 238, H.V. Desai College, Pune, India.

38. Prashant Nisarta, Gaurang Joshi and Purnima Parida, "Qualitative Assessment of Sidewalk Facilities from Users' Perception", 4th Conference of Transportation Research Group of India (CTRG), December 17-20, 2017, Mumbai.

39. Priyanka Tomar, Rajni Lakhani, Rajesh Kumar and Shahnawaz Khan, "Influence of the Self Cross-linkable Polymers on the Properties of the Fly Ash Blended Composite Cements", International Conference on Mechanical, Manufacturing, Industrial and Civil Engineering, December 17, 2017, pp. 85-89, Jaipur, Rajasthan.

40. Priyanka Tomar, Rajni Lakhani and Rajesh Kumar, "Micro-structure and Thermal Properties of Polymer Modified Fly Ash Blended Cement Pastes for Repair Applications", National Seminar on Emerging Building Materials and Construction Technologies, February 22-23, 2018, pp. 49-54, India Habitat Centre, Delhi.

41. Priyanka Tomar, Rajni Lakhani and Rajesh Kumar, "Effect of Hydroxy Propyl Methyl Cellulose and Fly Ash on the Fresh and Hardened Properties of Cement Paste", International Conference on Advances in Construction Materials and Structures, March 07-08, 2018, Abstract Proceedings pp. 115, Indian Society for Construction Materials & Structures (ISCMS) and Dept. of Civil Engineering, IIT Roorkee, India.

42. Riya E Robin, Padma S, Purnima Parida, Jomy Thomas and Kannan S, "Optimal Strategy Based Transit Assignment including Travel Time Variance", 4th Conference of Transportation Research Group of India (CTRG), December 17-20, 2017, Mumbai.

43. Rajni Lakhani and Rajesh Kumar, "Sustainable Use of Kota Stone Waste", Workshop on Gainful Utilization of Marble Slurry and Other Stone Wastes, July 13, 2017, pp.191-192, Centre for Development of Stones (CDOS) and Malaviya National Institute of Technology Jaipur, India.

44. Ravi Kumar, S.C.B. Gurum, S. Maiti and A. K. Minocha, "Structural Performance of Concrete Produced with Recycled Fine Aggregates from Construction and Demolition Waste", National Seminar on Emerging Materials and Construction Technologies- Building Materials and Housing Technologies for Sustainable Development, February 22-23, 2018, pp. 156-163, BMTPC, New Delhi, .

45. R.S. Bisht, D.S. Rawat, S.K. Panigrahi and S.J. Alexander, "Locomotion Control of Omnidirectional Quad-Wheeled Electromagnetic Climbing Robot", 12th Uttarakhand State Science and Technology Congress, March 07-09, 2018, pp. 26, Dehradun.

46. R.S. Chidambaram and S.R. Karade, "Precast Concrete Element Connections, Issues and Innovative Solutions", International Conference on Advances in Construction Materials and Structures, (ACMS 2018), March 07-08, 2018, Paper No. A-156, Abstract Proceedings pp. 69, Indian Society for Construction Materials & Structures (ISCMS) and Dept. of Civil Engineering, IIT Roorkee, India.

47. S. Ganesh Kumar, Manojit Samanta and Pankaj, "Numerical Study of Pile Group with Different Spacing in Layered Soil under Dynamic Conditions", IGC-2017: Geotechnics for Natural and Engineered Sustainable Technologies, December14-16, 2017, pp. 1-4, Guwahati.

48. Shailza Singh, "Vernacular Architecture: A Sustainable Solution to Future Buildings in Himachal Pradesh (India)", International Journal of Arts and Sciences (IJAS) International Conference for Engineering and Technology, May 22-26, 2017, J.B. Martin Conference Center, Boston, MA.

49. S.K. Singh and S.K. Kirthika, "Positive Synergistic Effect of PP & Nylon Fibers in Concrete", National Seminar on Emerging Building Materials and Construction Technologies, February 22-23, 2018, pp. 22-32, BMTPC, New Delhi.

50. S.K. Singh, M. Surya and Pooja Gadekar, "Prefabrication – Emerging Technologies", National Seminar on Emerging Building Materials and Construction Technologies, February 22-23, 2018, pp. 241-253, BMTPC, New Delhi.

51. S. K Singh, M. Surya and Pooja Gadekar, "Prefabricated Construction- Issues, Quality Control and Quality Assurance", All India Workshop on Mass Housing and Rapid Construction, November 13-15, 2017, pp. 27-36, The Institute of Engineers (India), Roorkee Local Centre, Roorkee, India.

52. S.K. Singh, Mayank Rai, S.K. Kirthika and Shilpa Pal, "Performance of Hybrid Fiber Reinforced Concrete in Fire", 15th NCB International Seminar on Cement, Concrete and Building Materials, December 05-08, 2017, TS: VIII B, pp. (A172)1-11, New Delhi, India.

53. Soumitra Maiti, Neeraj Jain and A.K. Minocha, "Response Surface Methodology for Optimization of Copper Removal from Waste-Water by Fly Ash", International Conference on Water Resource Management, January 11-12, 2018, pp. Tech 4/1-4/11, Academy of Water Technology and Environmental Management and CSIR-CGCRI, Kolkata.

54. Tabish Alam, Ashok Kumar and Nagesh B. Balam, "Thermo-Hydraulic Performance of Solar Air Heater Duct Provided with Conical Protrusion Rib Roughnesses", 6th International Conference on Advances in Energy Research, December 12-14, 2017, pp.103, IIT Bombay.

55. T. Jami and S. Kumar, "Assessment of Carbon Sequestration of Hemp Concrete", International Conference on Advances in Construction Materials and Systems (ICACMS 2017), Vol. 4, September 03-08, 2017, pp. 665-673, RILEM Publications S.A.R.L and IIT Madras, Chennai, India.

56. T Jami, S.R. Karade and L P Singh, "Hemp Concrete – A Traditional and Novel Green Building Material", International Conference on Advances in Construction Materials and Structures (ACMS 2018), March 07-08, 2018, Paper No. A-233, Abstract Proceedings pp. 106-107, Indian Society for Construction Materials & Structures (ISCMS) and Dept. of Civil Engineering, IIT Roorkee, India.

In Magazines

1. अचल कुमार मित्तल, इतरत अमीन सिद्दीकी आदि, "रुर्बन मिशन एक सामाजिक पहल", निर्माणिका, 2017-2018, पृ. 39-48, सीएसआईआर- केन्द्रीय भवन अनुसन्धान संस्थान, रुड़की।

2. आभा मित्तल एवं नरेश कुमार, "बहुउपयोगी एवं पर्यावरण अनुकूल बैम्बू (बांस) के लाभ", निर्माणिका 2017-2018, पृ. 33-34, सीएसआईआर- केन्द्रीय भवन अनुसन्धान संस्थान, रुड़की।

3. अतुल कुमार अग्रवाल, "प्रकाशन समूह : संक्षिप्त परिचय", निर्माणिका, 2017-2018, पृ. 35-38, सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की।

4. अतुल कुमार अग्रवाल, "महिला सशक्तिकरण - राष्ट्र विकास की कुंजी है", नवसंचेतना, वर्ष 20, अंक 01, जनवरी-जून 2018, पृ. 09-15, सीएसआईआर- राष्ट्रीय विज्ञान संचार एवं सूचना स्रोत संस्थान, नई दिल्ली।

5. अतुल कुमार अग्रवाल, "पर्यावरण संरक्षण हेतु लकड़ी का विकल्प", नवसंचेतना, वर्ष 2017, अंक 1, पृ. 14-16, सीएसआईआर- राष्ट्रीय विज्ञान संचार एवं सूचना स्रोत संस्थान, नई दिल्ली।

6. B.M. Suman, "Study on Temperature and Heat Flow Reduction through Insulated Industrial Roof Buildings", National Building Materials & Construction World, Vol. 22, No. 8, 2017, pp. 180-186.

7. B. M. Suman, "Minimization of Heat Ingress using Insulated Hollow Concrete Block Wall in Buildings", New Building Materials & Construction World, Vol. 23, No. 7, January 2018, pp. 68- 76.

8. प्रकाश चन्द्र थपिलयाल, "इंटर पेनेटरेटिंग पोलीमर नेटवर्क (आईपीएन) आधारित एपॉक्सी लेप", निर्माणिका, 2017-2018, पृ. 21-23, सीएसआईआर- केन्द्रीय भवन अनुसन्धान संस्थान, रुड़की।

9. आर.के. वर्मा, एन. जैन, एल.पी. सिंह और ए.के. मित्तल, "भारतीय विरासत भवनों की सतह का कवकरोधी उपचार करने हेतु अनुसंधान", निर्माणिका 2017-2018, पृ. 17-20, सीएसआईआर- केन्द्रीय भवन अनुसन्धान संस्थान, रुड़की।

10. सुशांत कुमार सेनापति एवं शरद कुमार, "शोध कार्य के लिए बिब्लिओग्रफिक साइंस डेटाबेस एवं साइटेशन इंडेक्सिंग का महत्व", निर्माणिका 2017-2018, पृ. 30-32, सीएसआईआर- केन्द्रीय भवन अनुसन्धान संस्थान, रुड़की।

Technology Transferred & MoU Signed

The Following Technologies have been transferred by CSIR-CBRI:

S.N.	Name of Technology	Name of Licensee	Date
1.	Epoxy-Phenolic IPN Coating based on CNSL for the protection of Concrete and Steel Reinforcement in Concrete	M/s Berger Paints India Limited, Kolkata	July 17, 2017
2.	High Draught Brick Kiln	M/s Team Energy Systems, Panchkula, Haryana	August 08, 2017
3.	Building Products from Kota Stone Waste	M/s Rajasthan State Pollution Control Board, Jaipur	August 08, 2017
4.	High Draught Brick Kiln	M/s Pollution Consultants & Engineers, Faridabad	December 15, 2017
5.	IPN Coating for the protection of Reinforced Concrete Structures	M/s Elegant Superpolyplast Pvt. Ltd., Mumbai	December 27, 2017
6.	Horizontal Boring Machine for making Under Ground Bores	M/s Techno Industrial Marketing, Kashipur	January 12, 2018
7.	High Draught Brick Kiln	M/s Amit J Kumar & Associates, Ghaziabad	January 29, 2018
8.	IPN Coating for the protection of Reinforced Concrete Structures	M/s Kansai Nerolac Paints Pvt. Ltd., Mumbai	February 05, 2018
9.	C-Brick Machine – Capacity 5000 bricks per 8 hrs. shift (upgraded version)	M/s Diamond Engineering Corporation,Roorkee	March 07, 2018

Epoxy Phenolic IPN coating based on CNSL for the protection of concrete and steel reinforcement in concrete

IPN coating for the protection of reinforced concrete structures

High Draught Brick Kiln

Building Products using Kota Stone Waste

High Draught Brick Kiln

CSIR-CBRI, Roorkee signed MoUs with following Institutes:

- Vellore Institute of Technology University, Vellore
- Jaypee University of Engineering & Technology, Guna
- Madhav Institute of Technology & Science, Gwalior
- GreenJams Infrastructures LLP

Honours & Awards

Award on Development of Housing Design Typologies under Pradhan Mantri Awas Yojana - Gramin

The Institute has studied the geo-climatic conditions, prevalent natural hazards, building materials and living styles of the people of the villages of various districts of the state and technically reviewed the house typologies developed by MoRD and suggested S&T interventions to ensure construction of durable, safe, comfortable and economical house in 13 states under the Pradhan Mantri Gramin Awas Yojna. MoRD has subsequently published CSIR-CBRI recommendations in the form of a comprehensive compendium of PAHAL-I and PAHAL-II for implementation in 13 states across the country.

Annual award distribution function of Ministry of Rural Development was held at Vigyan Bhavan, New Delhi on June 19, 2017. The annual awards of the Ministry were distributed to the different individuals and organizations recognizing their contributions made for the upliftment of the rural masses under the different programmes across the country. CSIR-CBRI, Roorkee was awarded, recognizing its technical support as an Institution, for its valuable assistance in technical vetting of house design typologies developed for PMAY-G. Director of CSIR-CBRI, Roorkee Dr. N. Gopalakrishnan, along with Shri Y. Pandey, Chief Scientist and Shri S.K. Negi, Senior Principal Scientist received the award. The function was inaugurated by Chief Guest Shri Narendra Singh Tomar, Hon'ble Minister of Rural Development, Panchayati Raj and Drinking Water & Sanitation. During the award ceremony "Handbook on Solar Cooker" and "Ready Reckoner on Quality Construction of Rural Houses" prepared by CSIR-CBRI, Roorkee for the Ministry of Rural Development were also released.

As part of the function of the programme, an exhibition was also organized in which CSIR-CBRI displayed a solar cooker-working model which can be integrated with the kitchen during the construction itself, providing comfort to the home maker women. Dr. R. Dharmaraju, Dr. Ajay Chourasia, Shri H.K. Jain, Ms. Swati Kulashri, and Shri Ashish Pippal of CSIR-CBRI were also present on this occasion.

Dr. N. Gopalakrishnan Director, Shri Y. Pandey, Chief Scientist and Shri S.K. Negi Senior Principal Scientist receiving the award from Honorable Shri Narendra Singh Tomar, Minister of Rural Development, Panchayati Raj and Drinking Water & Sanitation and Shri Ram Kripal Yadav, Minister of State (Rural Development)

Dr. Anindiya Pain, Scientist:

- Awarded INAE Innovative Student Projects Award 2017 for his PhD thesis.
- Awarded IACMAG Excellent Paper Award 2017 by the International Association for Computer Methods and Advances in Geomechanics for his paper published in the International Journal of Geomechanics published by ASCE.

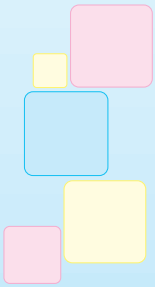
Dr. Anuj Kumar, Ramanujam Fellow was nominated as the Associate Editor, IEEE Access Journal, w.e.f. April 2017.

Dr. Ashok Kumar, Senior Principal Scientist

- Nominated for Pt. Jawaharlal Nehru Award in the field of Engineering & Technological Sciences, Department of Science & Technology, Government of Madhya Pradesh.
- Awarded the Certificate of Outstanding Contributions in Reviewing in recognition of the contributions made to the quality of the journal by The Editors of Energy & Buildings, Elsvier, Amsterdam, The Netherlands, during November 2017.

Shri S.K. Singh, Senior Principal Scientist, was nominated for Committee/Editor or Reviewer for:

- Journal of Construction Engineering, Technology and Management (JoCETM), STM Journals, INDIA
- International Journal of Advanced Research in Civil & Structural Engineering, ADR Publications, INDIA



Lectures Delivered

Lectures Delivered

1. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee and Shri Rajesh Kumar delivered a lecture on "Low Cost Building Products using Kota Stone Waste as an Aggregate Replacement" on January 06, 2018 at JECC, Sitapura, Jaipur.

2. Dr. Ashok Kumar, Senior Principal Scientist, delivered lectures on
   - "Thermally Efficient Building Envelopes", GIAN Workshop titled Low Carbon Built Environment, IIT Roorkee, April 11, 2017.
   - "CSIR-CBRI: Prospects, Association and Opportunities in Gujarat", CSIR–Gujarat Technological University (GTU) Interactive Session –Workshop, April 27, 2017.
   - "Approach to Green Buildings - Need of Sustainable Design", 1st BUILDINGS India 2017 Expo, New Delhi, May 11, 2017.
   - "Quantification of Different Parameters for Energy Efficiency in Buildings -Experimental and Simulation Studies", Engineers of Corps of Engineers, Western Command, Jaipur, August 04, 2017.
   - "Thermal Performance of Building Envelopes", Corps of Engineers, and MES, HQ, Chandigarh Zone, March 13, 2018.
   - "Energy Efficient Building Systems", HAL, Management Academy, Bangalore, March 27, 2018.

3. Dr. Atul Kumar Agarwal, Senior Principal Scientist delivered lectures on
   - "Patience & Perseverance: Key to Success", March 29, 2018, Children's Senior Academy, Roorkee.
   - "Breaking Superstitions", CSIR-Central Building Research Institute, Roorkee, February 07, 2018.
   - "Judicious Use of Social Media", CSIR-Central Building Research Institute, Roorkee, February 07, 2018.
   - "Importance of Cleanliness and Hygiene", Kendriya Vidyalaya, Roorkee, January 30, 2018.
   - "Learn to Read: Read to Learn", December 19, 2018, New Era Public School, Roorkee.
   - "Energy Conservation and Alternative Energy Sources", CSIR-Central Building Research Institute, Roorkee, December 14, 2017.
   - "Jigyasa-Quest for Curiosity", Kendriya Vidyalaya, Roorkee, November 29, 2017.
   - "Curiosity: Key to Innovation", Kendriya Vidyalaya, Roorkee, November 14, 2017.
   - "Waste Management", CSIR-Central Building Research Institute, Roorkee, November 13, 2017.
   - "CSIR & CBRI: An Overview", CSIR-Central Building Research Institute, Roorkee, November 02, 2017.
   - "Art of Living", CSIR-Central Building Research Institute, Roorkee, November 03, 2017.
   - "That's a Myth: Know the Science", CSIR-Central Building Research Institute, Roorkee, November 03, 2017.
   - "Overcoming Adversities", October 06, 2017, Shivalik Ganges Public School, Bhagwanpur.
   - "Jigyasa: What, Why, How", CSIR-Central Building Research Institute, Roorkee, September 25, 2017.
   - "VIBHA & IISF-2017", CSIR-Central Building Research Institute, Roorkee, September 15, 2017.
   - "Scientists Who Changed the World", August 05, 2017, Doon Public School, Roorkee.
   - "Career Opportunities", CSIR-Central Building Research Institute, Roorkee, May 26, 2017.
   - "Be Optimistic in Life", April 08, 2017, Shivalik Senior Secondary School, Roorkee.

4. Dr. Kishor K. Kulkarni, Scientist, delivered a lecture on "A Green Building Material for Sustainable Habitat", Seminar on Manufacturing Fly ash Bricks with New Technology, Bellary, Karnataka, July 27, 2017.

5. Dr. Abha Mittal, Senior Principal Scientist,
   - Delivered a key-note lecture on "Soft Computing Techniques and their Application in Building Research", 20th Annual Conference of Vijnana Parishad of India (VPI-2017) on Mathematical Sciences and Scientific Computing for Industrial Development (MSSCID-2017), November 24-26, 2017.
   - Chaired the Session on "Computational Techniques", 20th Annual Conference of Vijnana Parishad of India (VPI-2017) on Mathematical Sciences and Scientific Computing for Industrial Development (MSSCID-2017), November 24-26, 2017.

6. Dr. R.S. Chidambaram, Scientist, delivered
   - Keynote lecture on "Beam Column Joint and Its Behavior", Seminar, Mahindra Engineering College, Namakkal, Tamil Nadu, September 11, 2017.
   - Keynote lecture on "Role of High Performance Materials and Its Applications in Civil Engineering", National Level Seminar Programme on Role of High Performance Materials and Its Applications in Civil Engineering, Kongu Engineering College, Erode, Tamil Nadu, September 12, 2017.
   - Lecture on "Advanced Retrofitting Materials", Short Term Course on Seismic Vulnerability Study and Retrofitting , Dept. of Earthquake Engg., IIT Roorkee, January 08-23, 2018
   - Invited Talk on "Pre-Cast Concrete Connections, Issues and Innovative Solutions", PEPSCON 2018 Conference, Vijayawada, Pre Engineered Structures Society of India, January 19-21, 2018.
   - Lecture on "Pre-Cast Concrete Connections, Issues and Innovative Solutions", International Workshop on Innovations in Safe and Sustainable Infrastructure, IC-IMPACTS HQP Network, Canada and CSIR-CBRI Roorkee, February 26, 2018.
   - Invited Talk on "Seismic Effects on Precast Structure", Seminar on Pre-Fabricated Structures Including Multi Storeyed Buildings with Seismic Zone Modification, Military Engineering Services, Chandigarh, March 13, 2018.

7. Shri S.K. Singh, Senior Principal Scientist,
   - Delivered the Keynote Address, "Earthquake Resistant Design and Construction", National Conclave on Youth in Disaster Management, Vishwa Yuva Kendra, New Delhi & Rescue Foundation, August 25, 2017.
   - Co-chaired Technical Session- IV on "Use of Alternate Aggregates", 15th NCB International Seminar on Cement Concrete and Building Materials, NCCBM, New Delhi, December 07, 2017.
   - Co-chaired the Technical Sessions-III on "Gainful Utilization of Industrial Waste & Construction Debris", National Seminar on Emerging Building Materials and Construction Technologies, BMTPC, New Delhi, February 22, 2018.

8. Dr. S.R. Karade, Senior Principal Scientist, delivered lectures on
   - "Green Building Materials & Technologies", National Workshop on Low Cost Sustainable Building Materials & Construction Technologies, PSG College of Technology, Coimbatore, September 22-23, 2017.
   - "Corrosion of Steel in Concrete Structures - Current & Future Remedial Measures", Seminar on Galvanized Rebars in RCC Structures - Life Cycle Advantages, India Lead Zinc Development Association at Goa, November 15, 2017.
   - "Evaluation of Corrosion Induced Deterioration in Reinforced Concrete Structures", Course on Comprehensive module on Civil Engineering Concepts for the Engineers of Indian Oil Corporation, IIT, Roorkee, March 15, 2018.

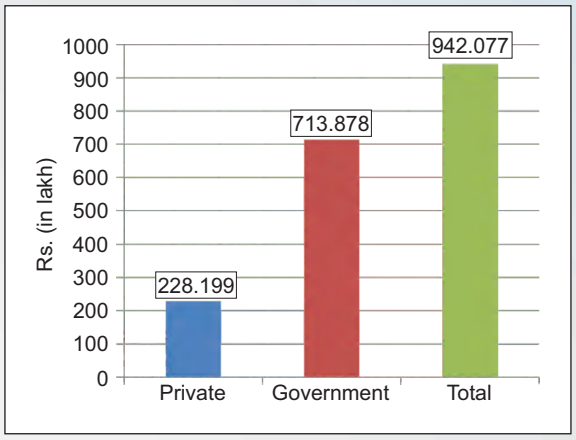
Date Line

Date Line

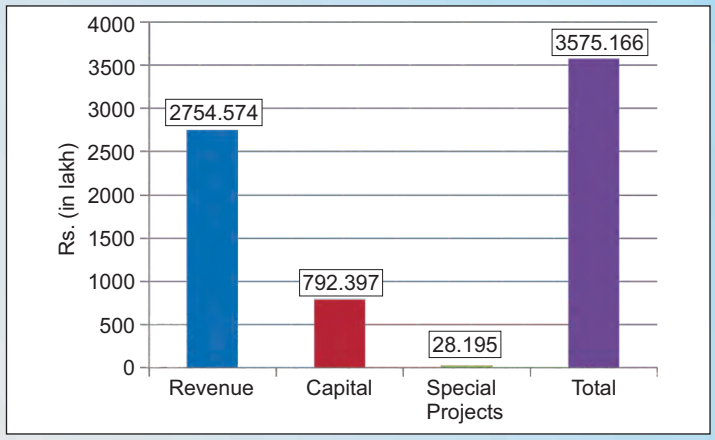
S. No.	Date	Event
1.	April 25, 2017	Review Meeting of Indo-US Project with the Consortium Partners CSIR-CGCRI & IIT, Roorkee
2.	May 11, 2017	National Technology Day
3.	May 26, 2017	Student Awareness Programme
4.	June 05, 2017	World Environment Day
5.	July 14, 2017	Review Meeting of Indo-US Project
6.	August 10-12, 2017	CSIR Platinum Jubilee Capsule Exhibition
7.	August 15, 2017	Independence Day
8.	August 17-18, 2017	CSIR-CBRI, Roorkee Participated in the Rajasthan Start-up Fest
9.	August 20, 2017	Sadbhavna Diwas
10.	August 25, 2017	Workshop on Optimization in Engineering
11.	September 12, 2017	Scientist as Teacher
12.	September 14-21, 2017	Hindi Week
13.	September 14-15, 2017	3rd India International Science Festival (IISF-2017) Precursor Events
14.	September 15, 2017	Brainstorming Session
15.	September 25, 2017	Student Apprenticeship Programme
16.	September 25, 2017	Brainstorming Session
17.	September 26, 2017	CBRI Celebrates CSIR Platinum Jubilee Foundation Day
18.	October 12, 2017	Motivational Lecture
19.	October 13, 2017	Diwali Mela
20.	October 30, 2017-November 04, 2017	Vigilance Awareness Week
21.	November 01-15, 2017	Swachhta Pakhwada
22.	November 02, 2017	Science Exhibition by Students
23.	November 02-03, 2017	State-level Teachers' Workshop
24.	November 13, 2017	Cleanliness Drive
25.	November 14, 2017	Motivational Lecture
26.	November 15, 2017	Quiz Competition
27.	November 29-30, 2017	State-level Science Exhibition, Quiz and Seminar by Students
28.	December 14, 2017	Quiz Competition
29.	December 14, 2017	World Energy Conservation Day

30.	December 28-31, 2017	Training Programme on Housing for All - Innovative Technologies for Rural Housing
31.	January 11-14, 2018	Training Programme on Housing for All - Innovative Technologies for Rural Housing
32.	January 18, 2018	Teacher as Scientist
33.	January 26, 2018	Republic Day
34.	January 30, 2018	Motivational Lecture
35.	January 31, 2018 - February 02, 2018	Training Programme on Engineering Simulations
36.	February 07, 2018	Teacher as Scientist
37.	February 10, 2018	CSIR-CBRI Foundation Day
38.	February 10, 2018	Science Exhibition by Students
39.	February 19-23, 2018	Training Programme on Multi Hazard Resistant Housing and Habitat
40.	February 26, 2018	International Workshop on Innovations in Safe and Sustainable Infrastructure
41.	February 28, 2018	National Science Day
42.	March 09, 2018	International Women's Day

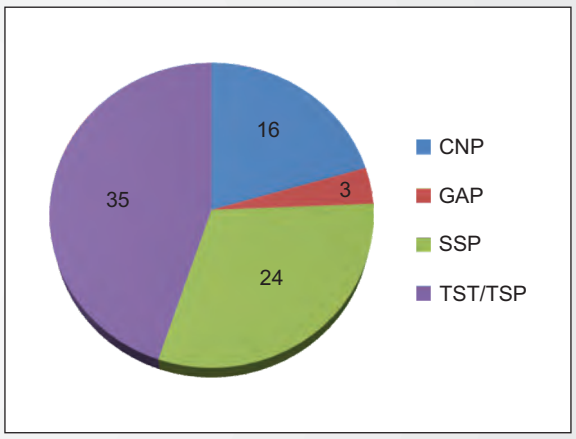
Performance/Projects/Human Resource



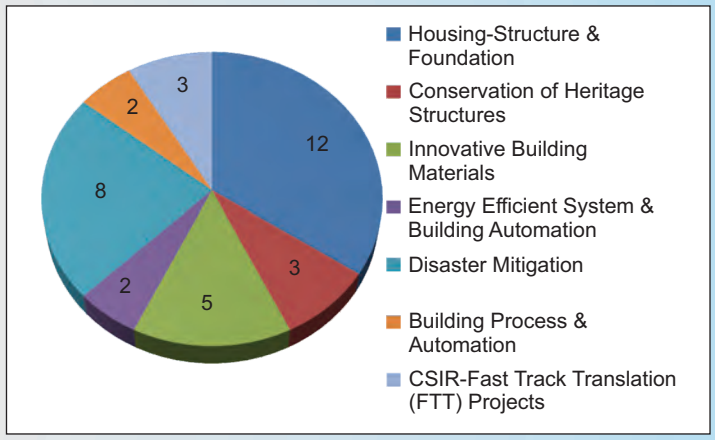
ECF



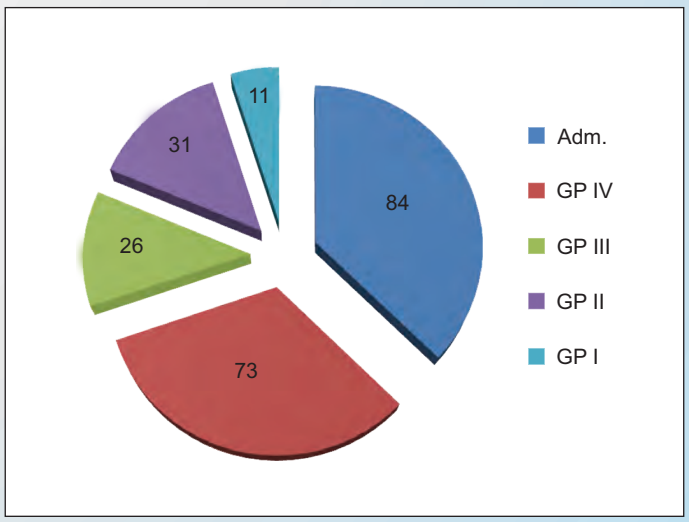
CSIR Resource Input



Externally Funded Projects



In-house R&D Projects



Human Resource

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