वार्षिक प्रतिवेदन

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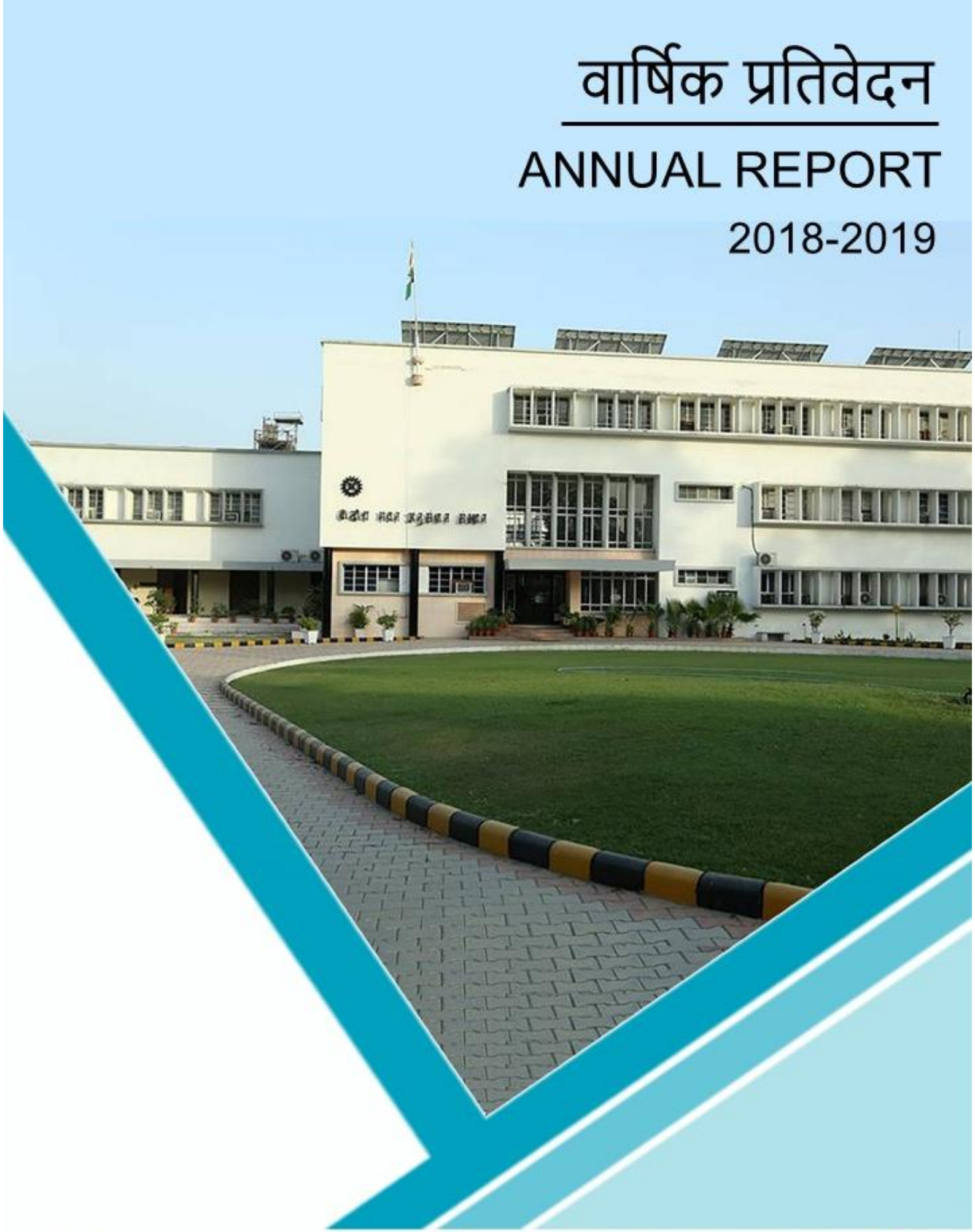
2018-2019



सीएसआईआर- केंद्रीय भवन अनुसंधान संस्थान, रुड़की, भारत

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Annual Report

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निदेशक की कलम से

सी एस आई आर– कद्रीय भवन अनुसंधान संस्थान, रुड़की का वर्ष 2018–19 का वार्षिक प्रतिवेदन प्रस्तुत करना मेरे लिए गर्व एवं हर्ष का विषय है। इस प्रतिवेदन में संस्थान की वर्ष भर की अनेक महत्वपूर्ण उपलब्धियों का उल्लेख किया गया है। भारत की संवृद्वि एवं विकास के लिए अनुसंधान, विकास एवं नवोन्मेष की खोज में की गयी प्रगति से मुझे अत्यंत हर्ष हो रहा है।

एक अग्रणी अनुसंधान एवं विकास संस्थान होने के नाते सीएसआईआर– सीबीआरआई, जो कि भवन विज्ञान एवं प्रौद्योगिकी के समस्त पहलुओं पर कार्य करता है, का उद्देश्य राष्ट्रीय चुनौतियों का समाधान खोजने हेतु अपने अनुसंधान, विकास एवं नवोन्मेश प्रदान करने वाला विश्वस्तरीय अनुसंधान एवं ज्ञान केंद्र बनना है, जोकि केवल नियोजन एवं अभिकल्पन तक सीमित ना रहते हुए भवनों में स्थिरता, प्रकार्य दक्षता, ताप सुखदता, लचीलापन (रेजिलिएंस), स्मार्टनेस, सुरक्षा, गति, निर्माण में उत्पादकता, वेस्ट–टू–वैल्थ, आपदा न्यूनीकरण आदि के लिए अभिनव समाधान प्रदान करता है।

संस्थान के मूल क्षमता ज्ञानमार्ग (कोर कांपिटेंसी डोमेन) के रूप में, वर्ष 2018–19 के दौरान सी एस आई आर– सी बी आर आई, ने छः प्रमुख लक्ष्य क्षेत्रों मुख्यतः (1) आवासन– संरचना एवं नींव, (2) दाय संरचनाओं की संरक्षण, (3) अभिनव भवन सामग्रियॉ, (4) ऊर्जा दक्ष प्रणाली (5) आपदा न्यूनीकरण एवं (6) भवन प्रक्रम एवं स्वचालन आदि के साथ अपने पथ पर आगे बढ़ना जारी रखा।

आवासन–संरचना एवं नींव वास्तुकला, इंजीनियरी एवं विज्ञान आदि की विधाओं को समन्वित करके, मास–हाउसिंग की चुनौतियों को समयबद्व रूप में पूरा करने के लिए तीव्र, टिकाऊ एवं ऊर्जा दक्ष मास–हाउसिंग योजना के विकास पर केंद्रित है। अभिनव आपना–प्रतिरोधी, पर्यावरण हितैशी, कम लागत एवं तीव्र निर्माण प्रौद्योगिकियों को विकसित करने हेतु संस्थान एक सुविचारित समग्र अनुसंधान कार्यक्रम के साथ आगे बढ़ा। इनमें से कुछ प्रौद्योगिकियॉ सीबीआरआई परिसर स्थित निर्माण प्रौद्योगिकी पार्क में प्रदर्षित की गयी हैं। इनमें से कुछ हैंः (1) प्रीकास्ट पैनल एवं फ्रेम सिस्टम के निष्पादन मूल्यांकन हेतु 3–एस सिस्टम (2) भवनों के लिए शुष्क निर्माण प्रौद्योगिकी एवं लाइट गेज स्टील सिस्टम (3) टिकाऊ सामूहिक आवासन (मास–हाउसिंग) हेतु जैव आधारित निर्माण सामग्री युक्त आवास इकाई, (4) सीबीआरआई द्वारा विकसित उन्नत प्री–फैब प्रौद्योगिकियों से आवास इकाई (5) पूर्वनिर्मित

(प्रीकास्ट) निर्माण हेतु अभिनव हाइब्रिड जोड (कनेक्शन), (6) सी एवं डी अपशिष्ट के उपयोग से पेवर ब्लॉक आदि। प्रदर्शित प्रौद्योगिकियों का मूल्यांकन विभिन्न कार्यात्मक निष्पादनों जैसे– जल तनावों (टाइटनेस), ध्वानिकी, ताप सुखदता, अक्षीय / पार्श्व भार आदि के लिए किया जाएगा।

दाय संरचनाओं का संरक्षण परियोजना के अंतर्गत, संस्थान ने अन्य प्रयोगशालाओं के साथ मिलकर, जिसमें सी एस आई आर–सी बी आर आई नोडल एजेंसी व मुख्य अभिदाता रहा, तथा अनेक लक्ष्यों की प्राप्ति की। दाय संरचनाओं के संरक्षण एवं मरम्मत को ध्यान में रखते हुए संकटमय अवसंरचनाअें की मजबूत संरचनात्मक स्वास्थ्य प्रबोधन हेतु कई प्रौद्योगिकियॉ विकसित की गयी ह। महत्वपूर्ण दाय संरचनाओं के वर्गीकरण हेतु एवं भारतीय भवन विज्ञान के परम्परागत ज्ञान की महत्वपूर्ण विशेषताओं का पता लगाने के लिए वर्गीकरण, विश्लेषण तथा मरम्मत की प्रौद्योगिकियौं विकसित की गयी और अध्ययन किये गये। जटिल दाय संरचना प्रणाली के लिए सरलीकृत विश्लेषण प्रकिया, नींव प्रणाली की भूतकनीकी जॉच, प्री एवं पोस्ट रेट्रोफिटिंग के लिए संरचनात्मक मरम्मत एवं रेट्रोफिटिंग तकनीकी का पता लगाया गया। दाय संरचनाओं का अविनाशी मूल्यांकन किया गया तथा नॉन इनवेसिव (बिना तोड़ फोड़ किये) तकनीकों का उपयोग करते हुए सांस्कृतिक दाय स्थलों की मल्टीवेव इमेजिन एवं ना दिखने वाली नीवों के अध्ययन के लिए हाइब्रिड अविनाशी मूल्यांकन तकनीकों एवं सिग्नल प्रोसेसिंग एलगोरिद्म के लिए अनुसंधान कार्य को आगे बढ़ाया गया। कुछ चयनित दाय संरचनाओं पर कवक की पहचान एव औषधीय पौधों से कवक रोधी रसायनों के विकास संबंधी शोध, चूना मसाला एवं ईंट चिनाई का संरक्षण व मरम्मत एवं दाय संरचनाओं में पत्थर चिनाई हेतु सुसंगत मरम्मत सामग्रियों का विकास जैस कुछ महत्वपूर्ण कार्य किये गये। फील्ड इंजीनियरां, तकनीकी एवं गैर तकनीकी जन शक्ति (कार्मिकों) एवं छात्रों के कौशल में वृद्वि हेतु अनेक प्रशिक्षण कार्यक्रम भी आयोजित किये गये।

अभिनव भवन सामग्रियों के अंतर्गत, संस्थान ने जियोपॉलिमर कंक्रीट के प्रक्रम प्रौद्योगिकी विकास के साथ–साथ पूर्व निर्मित भवन घटकों में उपयोग हेतु उड़राख की विभिन्न श्रेणियों, उत्पादन एवं अन्य भवन उत्पादों में मार्बल अपशिष्ट का पुनःउपयोग, पूर्व निर्मित भवन घटकों के लिए सेल्फ–कॉम्पैक्टिंग रीसाइकल्ड एग्रीगेट कंक्रीट का विकास, आंशिक वायु–शुद्धीकरण गुणधर्मो के साथ ध्वनि अवरोषण हेतु कम लागत सामग्रियॉ तथा निम्न तापमान कंक्रीटिंग हेतु सीमेंट–एडमिक्सचर सिस्टम पर अपना अनुसंधान कार्य जारी रखा।

ऊर्जा दक्ष प्रणाली के अंतर्गत उद्योग मानकों के अनुरूप निष्पादन का उच्च बारद्योतक (को–एफिशिएंट) प्राप्त करने के लिए, उच्च दक्षतायुक्त डबल ग्लेज्ड कलेक्टर का डिजाइन एवं विकास करने के उद्देश्य से एफि"ाएंट सोलर थर्मल कलेक्शन पर अनुसंधान कार्य जारी रहा। **आपदा न्यूनीकरण** के अंतर्गत, संस्थान ने महत्वपूर्ण अधिष्ठापनों की भूस्खलन से सुरक्षा तथा

वास्तविक अग्नि अवस्था में जोखिम निर्धारण हेतु प्रायोगिक एवं संख्यात्मक अनुकरण अध्ययनों पर ध्यान केंद्रित किया। **भवन प्रकम एवं स्वचालन** के अंतर्गत संस्थान में सिविल संरचनाओं के जटिल कार्य परिवेश हेतु मोबाइल सेंसिंग डिवाइस का विकास तथा स्मार्ट बेस आइसोलेशन का उपयोग करके भवनों की भूकम्पीय निष्पादन वृद्धि पर अनुसंधान कार्य जारी रहा।

वर्ष के दौरान, संस्थान ने दो नयी परियोजनाओं पर कार्य आरम्भ कियाः (1) सिलिका नैनों पार्टिकल्स का पायलट स्केल पर निर्माण व सीमेंट आधारित सामग्रियों में उनका उपयोग तथा (2) **सीएसआईआर फास्ट ट्रैक ट्रांसलेशनल (एफ टी टी)** परियोजना के अंतर्गत भवन अनुप्रयोग हेतु बांस कम्पोजिट स्ट्रक्चर/सेमी स्ट्रक्चरल घटकों का विकास । इसका उद्देश्य उत्पाद को शीघ्रतिशीघ्र अंतिम रूप देकर तुरंत प्रयोगशाला से बाजार तक लाना तथा समाज को तत्काल लाभ पहुंचाना है।

पिछले वषा की भांति, संस्थान के स्थायित्व एवं स्थायी विकास के लक्ष्य को महत्व देते हुए कई इन–हाउस अनुसंधान एवं विकास परियोजनाएं तथा बहुतेरी प्रायोजित अनुसंधान परियोजनाए संभाली। वर्ष के दौरान, संस्थान ने 15 इन–हाउस अनुसंधान व विकास परियोजनाए, 03 सीएसआईआर समन्वित मिशन मोड परियोजनाए, 03 एफ टी टी, 06 सहायता अनुदान, 29 प्रायोजित अनुसंधान, 17 परामर्शी एवं 46 परीक्षण परियोजनाएं संभाली। वर्ष के दौरान संस्थान ने रसायन सकियकृत एल डी स्लैग का उपयोग करके नवीन सीमेंटी सामग्रियॉ, कृत्रिम बालू का लक्षण वर्गीकरण तथा निर्माण में इसका प्रभावी उपयोग : एफ आर पी कम्पोजिट सैक्शन/ प्रोफाइल का मूल्यांकन व इनका वेयरहाउस निर्माण में उपयोग पर अनुसंधान कार्य आरम्भ किया। संस्थान ने इम्प्रूविंग बिल्डिंग एनर्जी एफिशिएंसी (आई बी ई ई ई) पर इण्डो–यूएस साइंस एण्ड टैक्नोलोजी फोरम (आई यू एस एस टी एफ) तथा डी एस टी द्वारा प्रायोजित इण्डो यूएस परियोजना में, संशोधित जलवायु वर्गीकरण, सोलर थर्मल कूलिंग सिस्टम, आर्टिफिशियल सिस्टम के साथ दिवा प्रकाश का समन्वयन, फेज चेंज सामग्रियों सहित कम ऊर्जा सामग्रियॉ एवं उन्नत प्रकाश प्रणाली पर कार्य करते हुए महत्वपूर्ण प्रगति की। इसी प्रकार, जीरो पीक एनर्जी बिल्डिंग डिजाइन फॉर इंडिया (जैड ई डी आई) पर इण्डो–यूके परियोजना के अंतर्गत विभिन्न जलवायु क्षेत्रों के लिए डायनमिक इन्सुलेशन सामग्रियों को अपनाने तथा भवनों में चरम ऊर्जा मांग को कम करने हेतु कार्य प्रगति पर है। इण्डोर एनवायरनमेंटल क्वालिटी मॉनीटरिंग एण्ड कण्ट्रोल सिस्टम बेस्ड ऑन वायरलेस सेंसर–एक्चुएटर नेटवर्क फॉर स्मार्ट इण्डोर एनवायरमेंट्स पर डीएसटी द्वारा प्रायोजित परियोजना में वायरलेस सेंसर एक्चुएटर नेटवर्क एवं मल्टी एजेंट सिस्टम स्ट्रेटजी के साथ इण्डोर पर्यावरण गुणवत्ता प्रबोधन प्रणाली विकसित करके महत्वपूर्ण प्रगति की गयी।

वर्ष 2018–2019 के दौरान संस्थान में लगभग 15.77 करोड़ रुपए बाह्य नकदी प्रवाह दर्ज किया गया जो कि सरकारी एवं निजी क्षेत्र की एजेंसियों तथा संगठनों के लिए किये गये संविदा अनुसंधान एवं विकास, सहायता अनुदान, परामर्शी परियोजनाओं तथा तकनीकी सेवाओं द्वारा अर्जित किया गया। इस अवधि के दौरान 113 शोध लेख विभिन्न जर्नल्स पत्रिकाओं, पुस्तक अध्यायों म प्रकाशित हुए तथा सम्मेलनों की कार्यवाहियों में प्रस्तुत किये गये।

यह संस्थान वैज्ञानिक एवं नवोन्मष्श अनुसंधान अकादमी (एसीएसआईआर) के तत्वावधान में **''भवन इंजीनियरी एवं निर्माण प्रौद्योगिकी**'' के क्षेत्र में समन्वित एम.टैक– पी.एच.डी. (आई एम पी) कार्यक्रम चला रहा है जो कि पहले एम.टैक **भवन इंजीनियरी एवं आपदा न्यूनीकरण** (बीईडीएम) के नाम से था। इस कार्यक्रम के सातवें बैच ने इस वर्ष के दौरान अपना शोध प्रबंध पूरा किया। संस्थान इंजीनियरी विज्ञान एवं रसायन विज्ञान में पीएच.डी. भी प्रदान करता है। वर्तमान में सीएसआईआर–सीबीआरआई में, एसीएसआईआर में कुल 17 पीएच.डी. छात्रों ने नामांकन करा रखा है।

रिपोर्ट में उल्लिखित कई शोध उपलब्धियों के अतिरिक्त, मैं वर्ष के दौरान संस्थान की अन्य विशिष्ट गतिविधियों पर प्रकाश डालना चाहूँगा। डॉ. शेखर सी. मांडे, महानिदेशक, सीएसआईआर और सचिव, डीएसआईआर ने 24 दिसम्बर, 2018 को अपनो यात्रा के दौरान सीएसआईआर–केंद्रीय भवन अनुसंधान संस्थान, रुड़की की अनुसंधान एवं विकास गतिविधियों की समीक्षा की तथा वैज्ञानिकों और कर्मचारियों और छात्रों का उत्साह वर्धन किया। उन्होंने किफायती आवास आपदा न्यूनीकरण और अपशिष्ट से धन अर्जन के लिए संस्थान के कार्यो की सराहना की तथा क्षेत्रीय अपशिष्ट, ग्रीन डवलपमेंट और ग्रीन प्रौद्योगिकियों से मूल्यवर्धित उत्पादों पर ध्यान केंद्रित करते हुए इस पर आगे बढ़ने का आग्रह किया। संस्थान ने अरूकस (Arrucus) प्राइवेट लिमिटेड, नई दिल्ली के साथ नॉलेज पार्टनर के रूप में पीएमवाइ–अफोर्डेबल हाउसिंग अवार्डस में योगदान देकर मूल्यांकन प्रक्रिया में शामिल होने के साथ–साथ नश्षनल अवाडस हेतु जूरी के तौर पर योगदान दिया है। संस्थान ने महानिदेशक, सीएसआईआर के नेतृत्व में सीएसआईआर प्रतिनिधि मंडल का भी प्रतिनिधित्व किया है, जो फ्रॉन्हूफर इंस्टीट्यूट्स, जर्मनी के नेतृत्व में सीएसआईआर और फ्रॉन्हूफर इंस्टीट्यूट्स, के साथ आपसी हितों के मुद्दों पर अनुसंधान और विकास सहयोग के संबंध में परस्पर साझेदारी के अवसरों की पहचान करने के लिए किया गया था। संस्थान के वैज्ञानिकों ने अंतर्राष्ट्रीय सम्मेलनों में शोध पत्र प्रस्तुत करने के लिए चीन, ब्रिटेन, जर्मनी और नेपाल का भी दौरा किया।

संस्थान ने राष्ट्रीय प्रौद्योगिकी दिवस, सीएसआईआर स्थापना दिवस और 73वें सीएसआईआर–सीबीआरआई स्थापना दिवस को ओपन–डे के रूप में मनाया। इसके अलावा राष्ट्रीय महत्व के दिनों जैसे विश्व पर्यावरण दिवस, अंतर्राष्ट्रीय योग दिवस और अंतर्राष्ट्रीय महिला दिवस आदि पर विभिन्न कार्यक्रमों, प्रतियोगिताओं और व्याख्यानों का आयोजन किया गया। विभिन्न प्रशासनिक कार्यशालाओं और कार्यक्रमों, सर्तकता और निविदा प्रक्रिया, आईपीआर जागरूकता इंटरैक्टिव सत्रों आदि का आयोजन किया गया। हिन्दी सप्ताह, सतर्कता जागरूकता सप्ताह तथा स्वच्छता पखवाडा इत्यादि का आयोजन किया गया। महत्वपूर्ण जागरूकता कार्यक्रमों जैसे हिन्दी भाषा को प्रोत्साहन, भ्रष्टाचार रोधी, साफ–सफाई एवं स्वच्छता इत्यादि का आयोजन किया गया।

एक बहुत अच्छी तरह से नियोजित अनुसंधान प्रयोगशाला आधारित शिक्षण के साथ छात्रों के लिए क्लासरूम लर्निंग का विस्तार करने के लिए, संस्थान ने सीएसआईआर योजना **जिज्ञासा–क्वैस्ट फॉर क्यूरियोसिटी : स्टुडेंट्स–साईंटिस्ट कनेक्ट प्रोग्राम** के अंतर्गत शिक्षको और छात्रों के लिए विभिन्न इंटरेक्टिव, प्रेरक और शैक्षिक कार्यक्रम, तकनीकी व्याख्यान, प्रदर्शनी और सेमिनार, कार्यशाला और प्रशिक्षण आदि का आयोजन किया। वर्ष के दौरान, विभिन्न स्कूलों और कॉलेजों के लगभग 5000 छात्रों एवं शिक्षका ने सीएसआईआर–सीबीआरआई, रुड़की द्वारा आयोजित 20 से अधिक कार्यक्रमों और गतिविधियों में भाग लिया। इसके अतिरिक्त, वर्ष के दौरान छह केवीएस क्षेत्रीय केन्द्रों के पीजीटी के लिए तीन दिवसीय राज्य स्तरीय पीजीटी की आवासीय कार्यशाला का आयोजन किया गया। आईआईएसएफ इवेंट के लिए एक प्रस्तावना के रूप में, 27–28 सितम्बर, 2018 के दौरान एक साईंस फेस्टिवल और प्रेस मीट भी आयोजित की गई।

संस्थान ने मास्टर ट्रेनरों, परियोजना निदेशकों, ठेकेदारों, इंजीनियरों, अधिकारियों, प्रोफेसरों और छात्रों के लिए विभिन्न कार्यशालाओं और प्रशिक्षण कार्यक्रमों का आयोजन किया, जिनमें दाय संरचनाओं के संरक्षण पर प्रशिक्षण कार्यक्रम, आपदा प्रभावित क्षेत्रों में किफायती आवास, उत्तराखंड में भवनों का आपदा रोधक अभिकल्प और निर्माण, भूस्खलन न्यूनीकरण तथा विस्तृत परियोजना रिपोर्ट की तैयारी, उत्तर–पूर्वी क्षेत्र में निर्माण सामग्री के रूप में बॉस का उपयोग, हिमाचल प्रदेश इत्यादि में भूकम्परोधी निर्माण आदि विभिन्न पहलुओं पर जानकारी दी गई।

भवनों में दीमक प्रबंधन, कन्फाइंड मेसनरी पर पुस्तक, वास्तुकला एवं नियोजन टीम द्वारा गरीबी रेखा से नीचे के आवासों के 15 प्रकारों के लिए कन्फाइंड मेसनरी हेतु संरचनात्मक अभिकल्प एवं विवरण, सुपीरियोरिटी फीचर्स ऑफ इंडियन हेरिटेज स्ट्रक्चर्स, कोर्स मैटीरियल्स/ प्रोसिडिंग्स ऑफ BHAGWAN- A search तथा सीएसआईआर–सीबीआरआई न्यूज लैटर–भवनिका सहित विभिन्न प्रकाशन प्रकाशित किए गए।

संस्थान एवं नई दिल्ली स्थित प्रसार केन्द्र ने पूरे देश में केंद्रीय, राज्य, सार्वजनिक एवं निजी क्षेत्रों के साथ सम्पर्क बनाए रखा। जैसे ही आप रिपोर्ट पढ़ेंगे तो मुझे आशा है कि आप संस्थान की गतिविधियों की गहरी जानकारी पाएंगे। निदेशक के रूप में, मैं यह भरोसा दिलाता हूँ कि संस्थान अधिक से अधिक ज्ञान, बेहतर कार्यक्रमों और उन्नत अनुसंधान और विकास आउटपुट के लिए अपनी खोज जारी रखेगा। हॉलाकि, यह वर्ष चुनौतियों और उपलब्धियों का वर्ष रहा है। हम अपनी उपलब्धियों के साथ ज्यादा खुश नहीं है, लेकिन हमेशा ही आगामी चुनौतियों और जिम्मेदारियों को पूरा करने के लिए उत्सुक हैं। पिछले एक वर्ष की उपलब्धियां, समर्पित कार्मिकों के समर्थन और योगदान का परिणाम है। मैं सभी समूह प्रमुखों, साथी वैज्ञानिकों, तकनीकी अधिकारियों और प्रशासन, वित्त एवं लेखा तथा भंडार एव क्रय अनुभाग का बहुत आभारी हूँ।

मैं अनुसंधान परिषद् के अध्यक्ष और सदस्यों के प्रति उनके परामर्श, मार्गदर्शन और सहायता के लिए कृतज्ञता व्यक्त करता हूँ। मैं महानिदेशक, सीएसआईआर और सीएसआईआर मुख्यालय के अन्य सहयोगियों के निरंतर सहयोग और मार्गदर्शन के लिए अपने हृदय से आभार प्रकट करता हूँ।

मैं अपने सहकर्मियों के पर्याप्त सहयोग की प्रशंसा करता हूँ जिन्होनें मुझे अपनी क्षमताओं के अनुसार अपने कर्तव्यो का पालन करने में मदद की है। वर्ष क दौरान सेवानिवृत्त हुए अपने साथियों का भी उनके योगदान के लिए आभार व्यक्त करता हूँ और उनके भविष्य के प्रयासों के लिए शुभकामनाएं देता हूँ। मैं इस वार्षिक रिपोर्ट की सामग्री के सम्पादन में उनके श्रमसाध्य प्रयासों के लिए मुख्य वैज्ञानिक, डॉ. अशोक कुमार को धन्यवाद देता हूँ। मैं इस रिपोर्ट को प्रकाशित करने हेतु प्रयासों के लिए वरिष्ठ प्रधान वैज्ञानिक, डॉ. अतुल अग्रवाल को भी धन्यवाद देता हूँ। अंत में, मैं हमारे प्रायोजकों, मूल्यवान ग्राहको, सीएसआईआर–सीबीआरआई के पूर्व सहयोगियों और सभी शुभ चितकों द्वारा प्रदान किए गए समर्थन और सहयोग को याद करना मेरे लिए खुशी का क्षण है।

भवन निर्माण क्षेत्र और बुनियादी ढॉचा उद्योग में अद्वितीय वृद्वि के साथ, हम एक रोमांचक भविष्य की आशा कर रहे हैं।

(डॉ. एन. गोपालकृष्णन)

From the Director's Desk

It is with great pride and pleasure that I present the Annual Report of CSIR-Central Building Research Institute, Roorkee for the year 2018-2019. The report highlights several prominent achievements of the Institute during the year. I am delighted to rejoice the progress in the quest of enhanced research, development and innovation for the growth and development of India.

CSIR-CBRI being a leading R&D Institute that covers all facets of building science & technology aims to be a word class research & knowledge center to offer its research, development and innovation in solving National challenges but not limited to planning & design, providing innovative solutions to achieve sustainability, function efficiency, thermal comfort, resilience, smartness, safety, speed, productivity in construction, waste - to- wealth, disaster mitigation in buildings etc.

During the year 2018-2019, CSIR-CBRI continued on its roadmap with six major thrust areas namely (i) Housing - Structure & Foundation, (ii) Conservation of Heritage Structures, (iii) Innovative Building Materials, (iv) Energy Efficient System, (v) Disaster Mitigation, and (vi) Building Process & Automation etc. as the core competency domains of the Institute.

The **'Housing-Structure & Foundation'** focused on *Development of Fast, Durable and Energy Efficient Mass Housing Scheme* to accomplish the challenges of mass housing in a time –bound manner by integrating disciplines of architecture, engineering & sciences etc. The Institute moved forward with a well conceived holistic research programme to develop innovative disaster-resilient, environment friendly, cost-effective and speedy construction technologies. A few of these are being showcased in the **'Construction Technology Park'** in the CBRI campus. Some of these are: (i) 3S system for performance evaluation of Precast Panels & Frame Systems (ii) Dry-construction technology and Light Gauge Steel System for Buildings, (iii) Dwelling unit with bio – based construction material for sustainable mass housing, (iv) Dwelling unit with improved CBRI developed prefab technologies, (v) Innovative hybrid connection for precast construction, (vi) Bamboo construction system, (vii) Paver Blocks using C&D waste, etc. The technologies demonstrated shall be evaluated for different functional performance viz. water tightness, acoustics, thermal comfort, axial/ lateral loads etc.

Under the project **'Conservation of Heritage Structures'**, the Institute carried forward various objectives working in collaboration with its sister laboratories with CSIR-CBRI as the Nodal agency and major contributor. Several technologies have been developed for robust structural health monitoring of critical infrastructure, with focus on conversation and restoration of heritage structures. Classification, analysis and restoration technologies were developed, and studies were carried out for classification of important heritage structures, and extracting superior features of Indian traditional knowledge of building science. The simplified analysis procedure for the

complex heritage structural systems, geotechnical investigation of foundation system, structural restoration and retrofitting techniques for pre and post retrofitting were evolved. Non-destructive evaluation of heritage structure was done, and research was taken forward for hybrid non-destructive evaluation techniques and signal processing algorithms for multi-wave imagine and in-accessible foundation studies of cultural heritage sites using non-invasive techniques. Research on identification of fungi on select heritage structure and development of suitable anti-fungal chemical from medicinal plants, conservation and restoration of lime mortars and brickworks and development of compatible repair materials for stone masonry in heritage structures, are some of the important activities carried out. Various training programmes were also organized for skill up gradation of field engineers, technical and non-technical manpower and students.

Under the **'I**nnovative Building Materials**'**, the Institute carried forward its research on 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 and other building products, development of self- compacting recycled aggregate concrete for precast building components, cost - effective material for sound absorption with partial air purification properties and cement-admixture system for low temperature concreting.

Studies under **'Energy Efficient System'** continued with research on efficient solar thermal collection with the aim to design and develop highly efficient double glazed collector to achieve higher coefficient of performance above industry standards. Under **'Disaster Mitigation'**, the Institute focused on safety of vital installation against landslides and experimental and numerical simulation studies for hazard assessment in real fire scenario. Under '**Building Process & Automation'**, the Institute continued with research on development of mobile sensing device for complex working environment of civil structures and seismic performance enhancement of building using smart base isolation.

During the year, the Institute initiated its research on two new projects-pilot scale preparation of silica nano-particles and their application in cement based materials and development of bamboo composites structure/semi-structural elements for building application under **CSIR Fast-Track Translational (FTT)** project with the aim to deliver products in short period by completing the last mile from lab to market and providing immediate benefits to the society.

As in the previous years, the Institute has handled several in –house R&D programmes and many sponsored research projects on giving importance to sustainability as well as sustainable development goals etc. During the year, the Institute handled 15 **in-house R&D projects, 03 CSIR Coordinated Mission Mode Projects, 03 FTTs, 06 Grant-in Aid, 29 Sponsored Research, 17 Consultancy, and 46 Testing projects.** During the year, the Institute initiated research on newer cementitious materials using chemically activated LD slag, characterization of manufactured sand, and its effective utilization in construction and evaluation of FRP composite section/profiles and their use in warehouse construction. The Institute made a significant

progress in **Indo-US project** sponsored by Indo-US Science & Technology Forum (IUSSTF) and DST on **'Improving Building Energy Efficiency (IBEEE)'** by working on revised climate classification, solar thermal cooling systems, integrating daylight with artificial system, low energy materials including phase change materials, and advanced lighting systems. Similarly, under **Indo-UK project on Zero Peak Energy Building Design for India (ZEDi),** the research is under progress to tune the dynamic insulation materials for different climatic regions and also working for lowering the peak energy demand in buildings. Under DST sponsored project on '**Indoor Environmental Quality Monitoring and Control System based on Wireless Sensor-Actuator Network for Smart Indoor Environments'**, significant progress has been made by developing an indoor environmental quality monitoring system with wireless sensor actuator network and Multi-agent System Strategy.

During the year 2018-2019, the Institute registered an external cash flow of nearly **15.77 Crore,** 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, **113 papers** were published in various journals, magazine, book chapters as well as presented in conferences proceedings.

The Institute offers an integrated M. Tech. – Ph.D. (IMP) Programme under the aegis of Academy of Scientific & Innovation Research (AcSIR) in the area of '**Building Engineering & Construction Technology',** from this year which was earlier offered as M.Tech. 'Building Engineering & Disaster Mitigation (BEDM)'. The seventh Batch of the programme completed their dissertation during the year. The Institute also offers Ph.D. in Engineering Sciences and Chemical Sciences. Presently there are total 17 Ph. D. students 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. **Dr. Shekhar C. Mande Director General, CSIR and Secretary DSIR,** reviewed the R&D activities of CSIR-Central Building Research Institute, Roorkee during his visit on December 24, 2018 and encouraged the scientists, staff and students. He appreciated the Institute's work in the direction of affordable housing, disaster mitigation, and waste to wealth generation and urged to take it forward with focus on value-added products from regional waste, green development and green technologies. The Institute also made contributions on PMAY- Affordable Housing Awards as a Knowledge Partner with Arrucus Pvt. Ltd., New Delhi for being in the evaluation process as well as Jury for the National Awards. The Institute also represented in CSIR delegation led by Director General, CSIR to Fraunhofer Institutes, Germany to identify synergistic partnership opportunities in terms of R&D cooperation on topics of mutual interest to both CSIR & Fraunhofer Institutes. The scientists also visited China, UK, Germany and Nepal for presenting papers in International Conferences.

The Institute observed Open Days on the occasion of National Technology Day, CSIR Foundation Day and 73rd CSIR-CBRI Foundation Day. Apart from this, various programmes,

competition and lectures from eminent personalities were arranged on days of National importance such as Word Environment Day , International Day of Yoga, and International Women's Day etc. Various workshops and programmes were carried out for staff including administrative workshop on vigilance and tender process, IPR awareness interactive session etc. Important awareness programmes such as encouragement of Hindi language, Fight Against Corruption, Cleanliness and Hygiene etc. were organized through Hindi Week, Vigilance Awareness Week and Swachhta Pakhwada etc.

To extend student's classroom learning with that of a very well-planned research laboratory based learning, the Institute organized various interactive, motivational and educational programmes, technical lectures, exhibitions and seminars, workshop and training, etc. for teachers and students under the CSIR scheme '**Jigyasa –Quest for Curiosity: Student-Scientist Connect Programme'**. During the year, about 5000 students and teachers from different schools and colleges participated in more than 20 programmes and activities including motivational and organized by CSIR-CBRI, Roorkee. In addition to this, a three day state level residency students' workshop and workshop for PGTs of six KVS regional centers was organized during the year. As a prelude to the IISF event, a science fest and press meet was also organized during September 27-28, 2018.

The Institute also organized various **workshops and training programmes** for master trainers, project directors, contractors, architects, engineers, officers, professors, scientists, and students covering various aspects of building science including training programmes on conservation of heritage structures, affordable housing in disaster prone areas, disaster resilient design and construction of buildings in Uttarakhand, landslide mitigation and Detailed Project Reports preparation, Utilization of Bamboo as building material in NE region, earthquake resistant construction in Himachal Pradesh etc. The institute also participated in various programmes for optimal dissemination of knowledge to maintain regular interaction and communication with the people of India and abroad. The Institute attended various enquiries pertaining to various problems of building and construction sector.

Several publications including a field guide on 'Termite Management in Building', Books on 'Confined Masonry', Structural Designs and Detailing for Confined Masonry for 15 types of EWS houses designed by Architecture & Planning team; Book and Website on 'Superiority features of Indian Heritage Structures', Course Material/Proceedings of BHAGVAN – A Search and a Booklet on 'CSIR-CBRI Newsletter – Bhavanika'.

The Institute along with its Extension Center at New Delhi continued to maintain liaison with Central, State, Public/Private sectors throughout the country. 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. 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. The accomplishments over the past year, and the work ahead are the result of the unfailing support and contribution of dedicated staff. I am immensely grateful to all the Group Leaders, fellow scientists, individuals, technical officers, and administrative, accounts and purchase staff, whose energy and support sustains us.

I express my deepest gratitude to the Chairman and the Members of our Research Council 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 contribution, and wish the best for their future endeavors. I thank Dr. Ashok Kumar, Chief Scientist for his painstaking efforts in editing the contents of this Annual Report. I also thank Dr. Atul Kumar Agarwal, Senior Principal Scientist for the efforts in bringing out this report. Last but not the least; it is a happy moment for me to remember the support and co-operation provided by our sponsors, valued customers, ex-colleagues of CSIR-CBRI and all well-wishers.

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

(Dr. N. Gopalakrishnan)

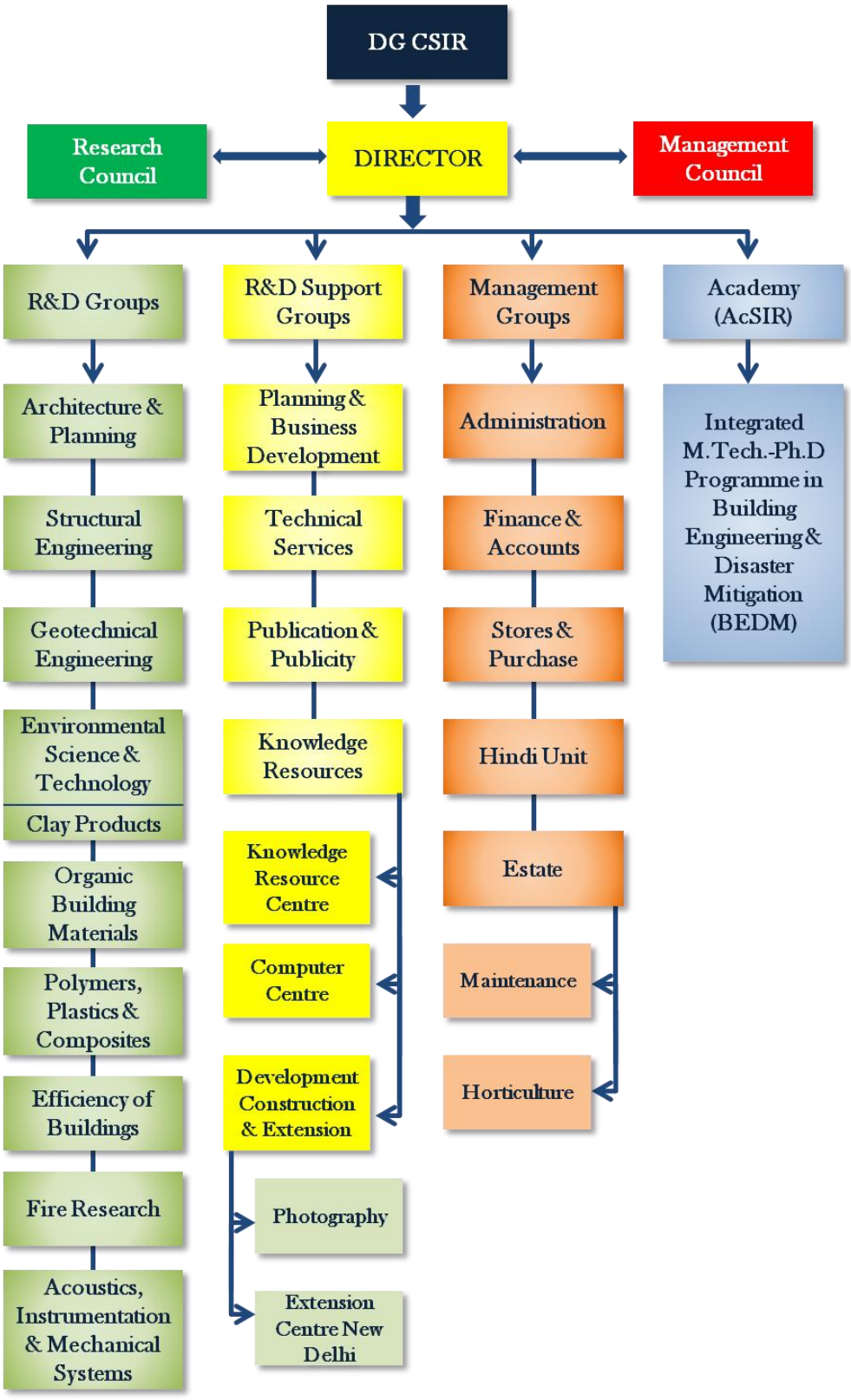
Our Vision

To be a world class research and knowledge centre of national importance for providing innovative solutions to all aspects of building science and 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.

CSIR-CBRI Organogram



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Member Secretary
CoA/AO
CSIR-Central Building Research Institute, Roorkee

HOUSING - STRUCTURE & FOUNDATION

Development of Fast, Durable & Energy Efficient Mass Housing Scheme

Ajay Chourasia & Ashok Kumar

In order to address housing shortage in a time-bound manner, the conventional system of housing construction is not adequate to achieve the target by 2022. Hence, there is a need to look for new emerging, disaster-resilient, environment friendly, cost-effective and speedy construction technologies which would form the basis of housing construction in India.

To meet the challenges being faced in mass housing, a considerable leap in knowledge in many disciplines of engineering, architecture, urban, rural and 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 attributes of *Safety, Functionality, Sustainability, Aesthetics, Speed* and *Economy*, well conceived holistic R&D programs have been taken-up at CSIR-CBRI to reinforce the National Mission-*Housing for All*. The Institute aspires to develop an eco-system to deliver on the technological challenges of the housing construction sector in a holistic manner.

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 & Layouts of Prefab Housing Units with Improved Thermal Performance' at the Institute.

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 CSIR-CBRI developed prefab component housing systems.

To provide long-lasting solutions that can address the delivery, quality and accessibility of affordable housing, R&D program 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 CSIR-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 major achievements during the period are bulleted here under:

- Developed "Construction Technology Demonstration Park" at CSIR-CBRI, Roorkee. The Park is a construction technology fusion ranging from vernacular to blue-sky (3D printing, emerging precast/prefab...). The technologies are not only demonstrated but also shall be evaluated for different functional tests viz. water tightness, acoustics, thermal comfort, axial/lateral loads etc. The emerging technologies being evaluated are: precast hybrid buildings, confined masonry, cold form steel, dry construction, bamboo housing system, 3-S precast building system, insulated concrete formwork (ICF) system, prefab steel housing building, and stay-in-place formwork system. Fig. 1 shows some glimpses of Construction Technology Demonstration Park at CSIR-CBRI, Roorkee.

Fig. 1: View of the Construction Technology Demonstration Park at CSIR-CBRI, Roorkee

- Lateral displacement control load tests under varying axial loads have been conducted on Cold Form Steel Panels with alternative schemes.
- Lateral load test on different precast RC shear walls viz. (i) precast hollow core RC wall (ii) precast wall-column connected through loop bar have been conducted. Also numerical analysis of (i) precast hollow core RC wall (ii) precast wall-column connected through loop bar (iii) in-situ RC column-wall have been carried out showing good agreement between experimental and numerical results.
- Pull-out test on cubes and beam-column joint using plain, grooved and ribbed headed bars have been carried out, demonstrating excellent performance of the developed headed bars.
- Developed typified layouts for mass housing schemes for EWS/LIG houses in different geo-climatic regions of India. Thermal performance of such buildings using different material and parametric study is in progress.
- Developed bricks made from recycled masonry aggregates/recycled concrete dust and RC planks using C&D wastes
- Design of affordable mobile crane, plastering machine, and modified C-Brick making machine completed. Fabrication in progress.
- Developed architectural and structural designs of EWS houses in different seismic zones for one to four storey buildings.
- Developed hollow core light weight concrete blocks for construction of confined masonry buildings.
- Completed construction of 3 lakh houses using S&T intervention and CBRI technologies in Odisha state.
- Conducted training of 500 engineers of different states of the country on multi-hazard resistant housing construction.
- Conducted shaking table tests on liquefiable ground subjected to sequential acceleration levels i.e. 0.1 g, 0.2 g, 0.3 g and 0.4 g and installation of sand compaction piles, PVDs, stone columns and encased stone columns for ground improvement.

Comparative Evaluation of Performance of Various Precast Panel & Frame Systems Developed by Various Research Groups & Selection of the Best Performing One for Specified Functionality

Ajay Chourasia, Sorab Jain, Siddharth Singh & Jalaj Parashar

Objective:

To evaluate the functional performance of selected commercially available precast building systems and suggest possible improvement

Progress Highlights:

A new stakeholder, Everest Industries Ltd. has shown interest in participating in the mission mode project mass housing to evaluate their housing technology for various functional aspects under this task.

Design of the water tightness test is done and fabrication of the test setup is in progress. The test setup is designed to simulate artificial rainfall at a rate of 138 mm/hr. The rainfall will be for a period of 5 hrs, quantifying a total rainfall of 690 mm/day. Fig. 1 and 2 show the test-setup for water tightness evaluation of housing system.

(a) **(b)**

Fig. 1: Proposed Test Setup for Water Tightness Evaluation of Housing System

The buildings tested for water tightness be accessed through a detailed visual inspection of both the exterior and interior wall surfaces. Locations that be checked for indications of leakage include but are not limited to: intersection of walls with floors and ceilings, window, door, vent, and louver openings; particularly at corners and mulled joints between units, handrail connections and intersection of walls with exterior balconies. Balcony features that can contribute to leakage problems are little or no slope away from the wall; absence of a curb under the wall and door; little or no slope to drain grates or scuppers; or handrail base which obstructs drainage; utility and building services penetrations, below setbacks, where an exterior wall on one floor is above an interior space of the floor below; intersection of an exterior wall and a roof plane.

All indications of past and existing water damage including, but not limited to, the following will also be assed: wet, damp, or water-saturated surfaces, colour differences caused by organic growth, staining, or corrosion, surface deposits associated with recrystallization of dissolved materials from within the walls. In masonry construction, this is commonly called efflorescence, but it can also occur in other wall types, staining indicating the flow or accumulation of water, areas repaired or patched due to prior leakage, blistering surface finishes that can indicate subsurface wetting.

In case of water leakage through window, door, curtain wall, simple hose spray test may be conducted without a pressure chamber, with the help of a calibrated nozzle operated at the prescribed pressure, distance, and sweep rate. Calibrated nozzle test depends on the kinetic energy of the spray to simulate the effect of wind-driven rain and the accumulation of water on surface to simulate run-down.

The functionality evaluation (thermal comfort, acoustics, water tightness) of the housing technologies will start once it is ready for evaluation.

Regarding thermal comfort and acoustic testing of AAC building at CSIR-CBRI Demo Park, the above-mentioned tests have been performed on site and data were recorded analysed and shown in Fig. 3-7. Table 1 and 2 shows the physical properties of AAC blocks.

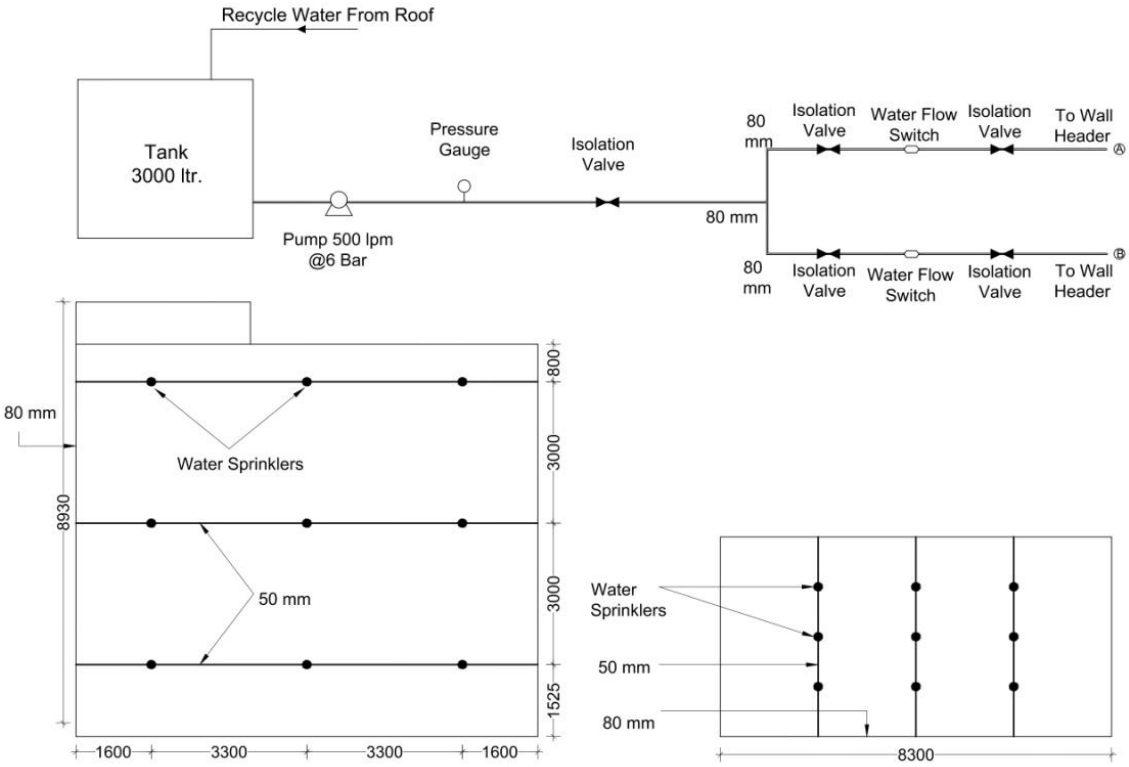


Fig. 2: Test Set Up For Water Tightness

Fig. 3: 3-S Demo Building

Fig. 4: Roof Before Being Ponded

Fig. 5: Water Ponding at Roof for 7 Days

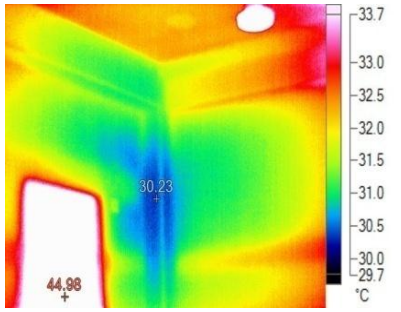
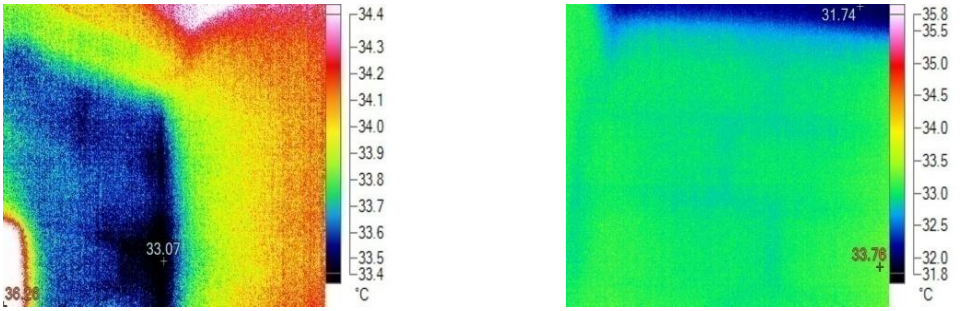


Fig. 6: Thermal Image of Inner Wall Before Ponding



(a) **(b)**

Fig. 7: Thermal Image of Outer Wall After Ponding

Table 1: Physical Properties of AAC Blocks & Related Thermal Conductivity Values

Physical parameters	Values
Temperature and humidity at the time of testing	41°C, 17 % R.H for the month of May
Wall construction	AAC blocks, 150 mm thick
Density	550-650 kg/m^3
Total wall thickness	180 mm (including plaster)
Glass window thickness	5 mm
Room size	3 m x 2.6 m
Window size	1.8 m x 1.4 m
Thermal conductivity of AAC block	0.11 W/ m. K
Test location	Roorkee, composite climate

Table 2: Acoustical Parameter Details of AAC & Other Building Blocks & Other Relevant Instrumental Details

Physical parameters	**Values**
Temperature and humidity at the time of testing	42 °C, 19 % R.H for the month of May
Sound transmission class (STC) rating of AAC block	44 dB
STC ratingConcrete block 100 mm thickness	52 dB
STC rating Brick wall with plaster	45 to 55 dB
Ambient noise at the time of testing	65 to 75 dB
Measuring range of sound level meter	30 dBA to 130dBA
Accuracy	± 1.1 dB at 1 kHz
Resolution	0.1 dB
Test location	Roorkee, composite climate

Fig. 8 shows the wall temperature of all the facades of AAC building namely east, west, north and south. From the figure, it can be clearly seen that outside wall temperature reaches to a maximum of 45 ºC for east and west facing walls at 1100 and 1500 hrs respectively for the month of April to June, 2019. Whereas, for north and south facing side, the maximum outside wall temperature has reached to 40 ºC. The inside wall temperature of all the directional faces does not exceed 32 ºC. Fig. 9(a) shows the rooftop/ceiling and outside/inside ambient room temperature. From Fig. 9(b) for outside wall/rooftop temperature follows a sinusoidal nature with maximum temperature at daytime and

minimum temperature at nighttime. The inside wall temperatures show an approximate straight plot varying from 28-32 ºC for 24 hours' measurement.

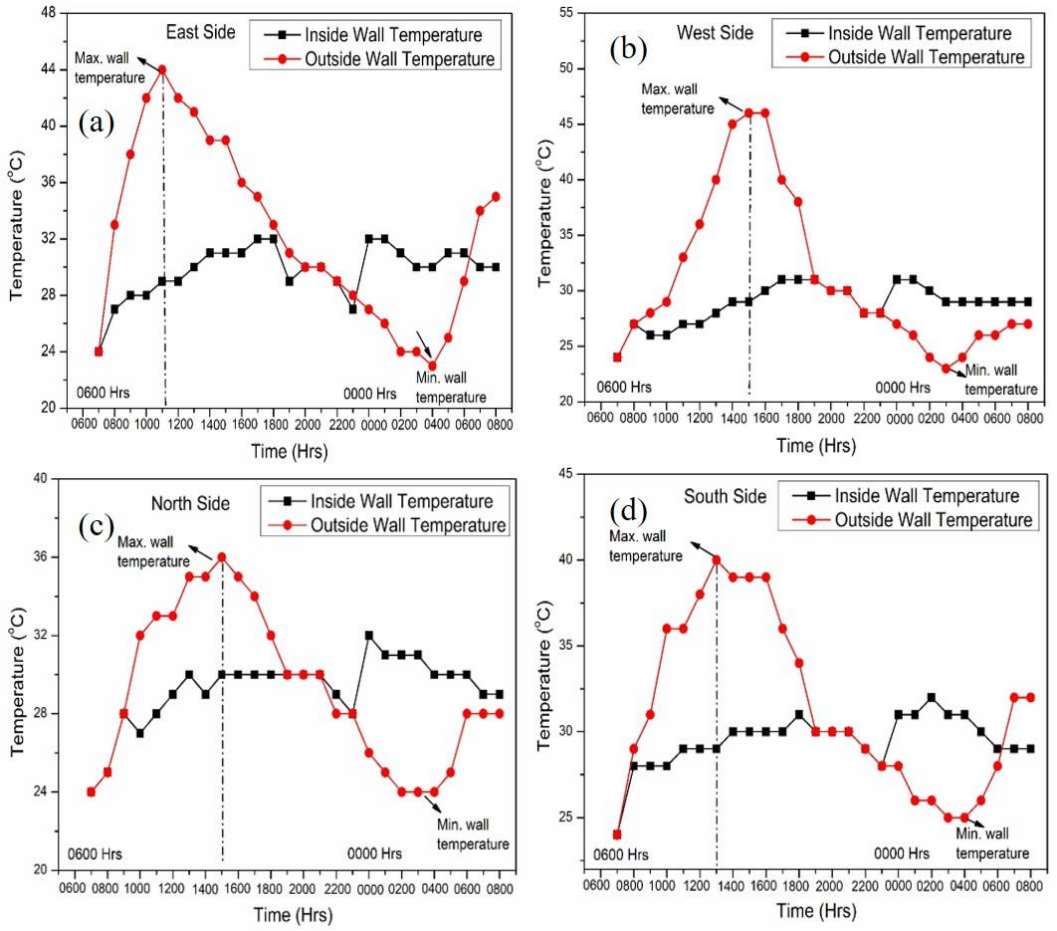


Fig. 8: Wall Temperature Variation for AAC Building facing towards East, West, North & South Side

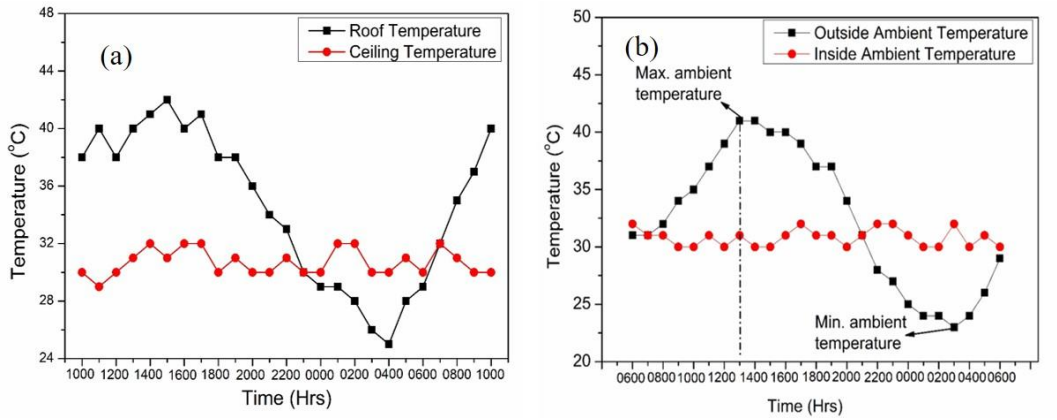


Fig. 9: Roof/Ceiling & Ambient Outside/Inside Temperature Variation for AAC Building

Fig. 10 shows the temperature difference of outside and inside wall temperature and it follows the sinusoidal plot. During the nighttime, the inside room temperature is higher than the outside temperatures because of heat entrapment through the glass windows in the room with no ventilated conditions.

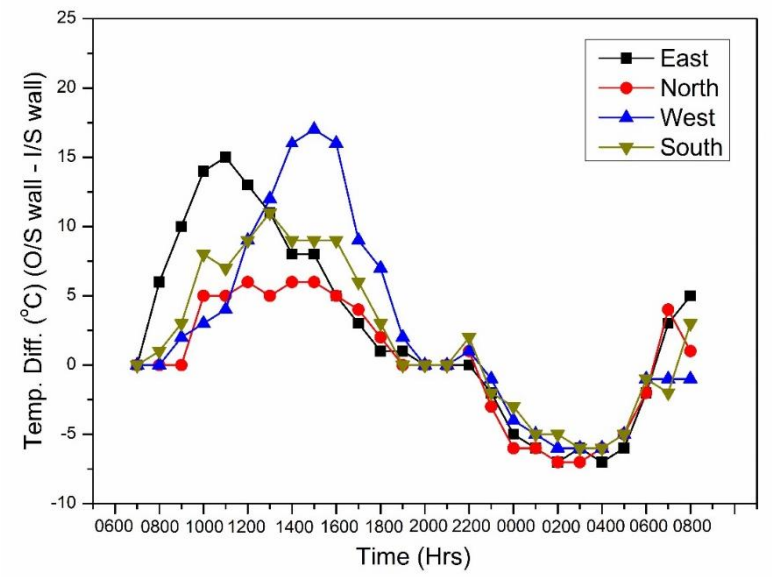


Fig. 10: Temperature Difference of Outside & Inside Wall Variation of All Directional Faces for AAC Building

The low value of inside wall and room temperature as compared to outside wall/ambient temperature is low value of thermal conductivity of AAC block. The outside and inside cement mortar and air voids in the AAC block make a composite panel. The thermal conductivity of air is around 0.024 W/m.K (at 0 °C), which enhances the thermal insulation. Therefore, the overall thermal comfort inside the building is good. The porous nature of AAC block along with plaster surface features can be confirmed form FE-SEM images in Fig 11.

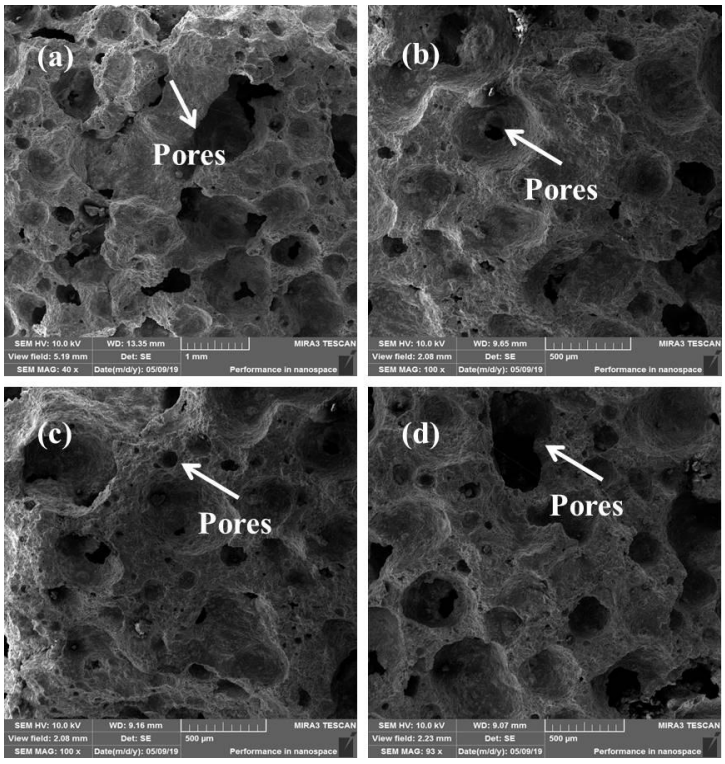


Fig. 11: FE-SEM Images of AAC Block

Fig. 12 shows the relative humidity of AAC building room with various ventilated and ambient conditions. It is evident from the Fig that in no ventilation and one sided ventilation condition the

R.H. level is about 60 percent. Whereas, for ambient and cross ventilation the relative humidity values falls under 50 percent. Therefore, cross ventilation is required for a low value of humidity for a comfort living. According to NBC 2015, the maximum humidity level for comfort living should not exceed 30-60 percent.

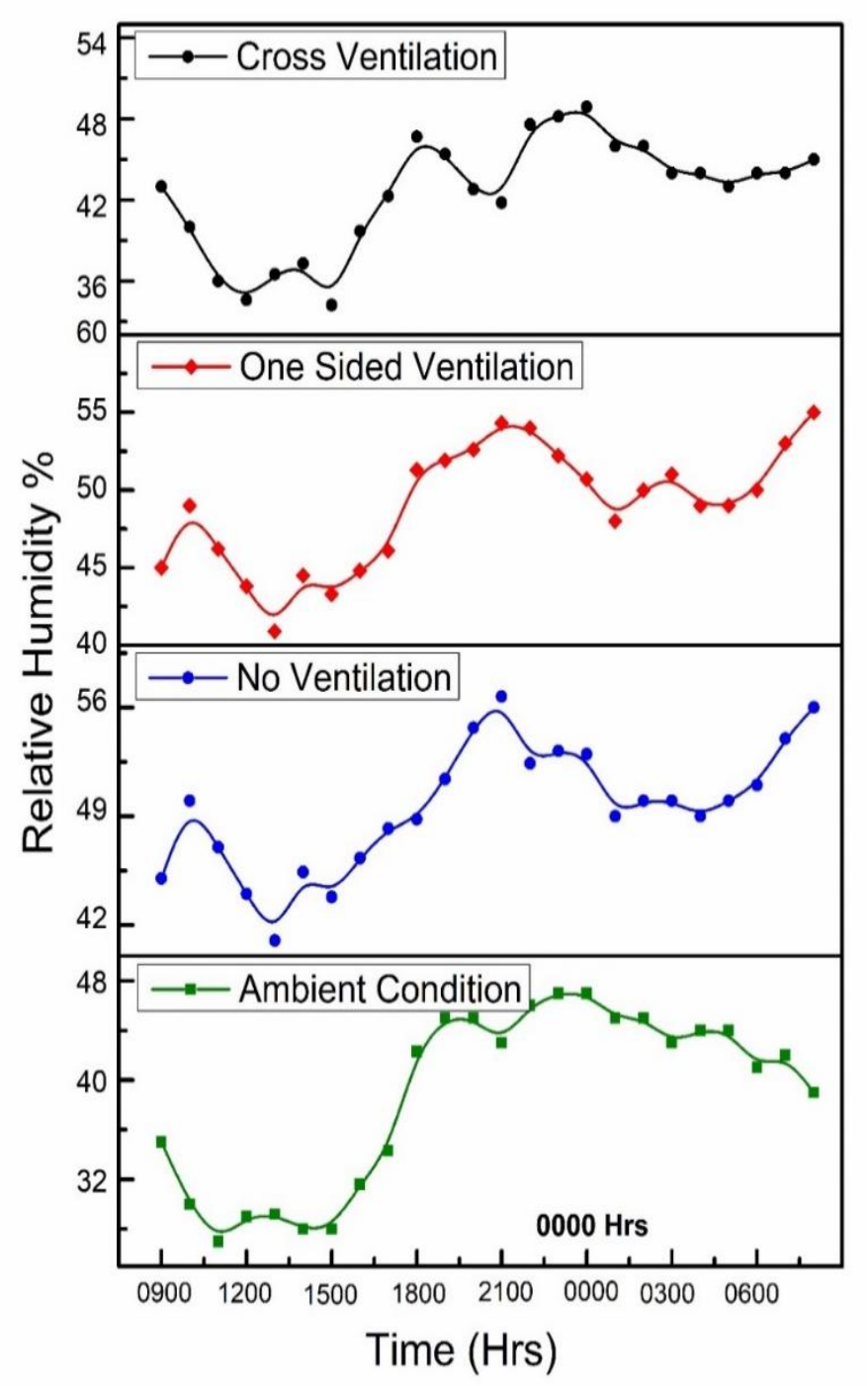


Fig. 12: Relative Humidity Variation in AAC Building

Regarding acoustic testing of AAC building, the noise source of 115 dB is created outside the building and indoor noise level is measured. Fig. 13 shows the sound isolation of outdoor to indoor noise level of wall, wall and window and ceiling structures. The noise reduction data is collected at 100 Hz interval from 100 – 3000 Hz.

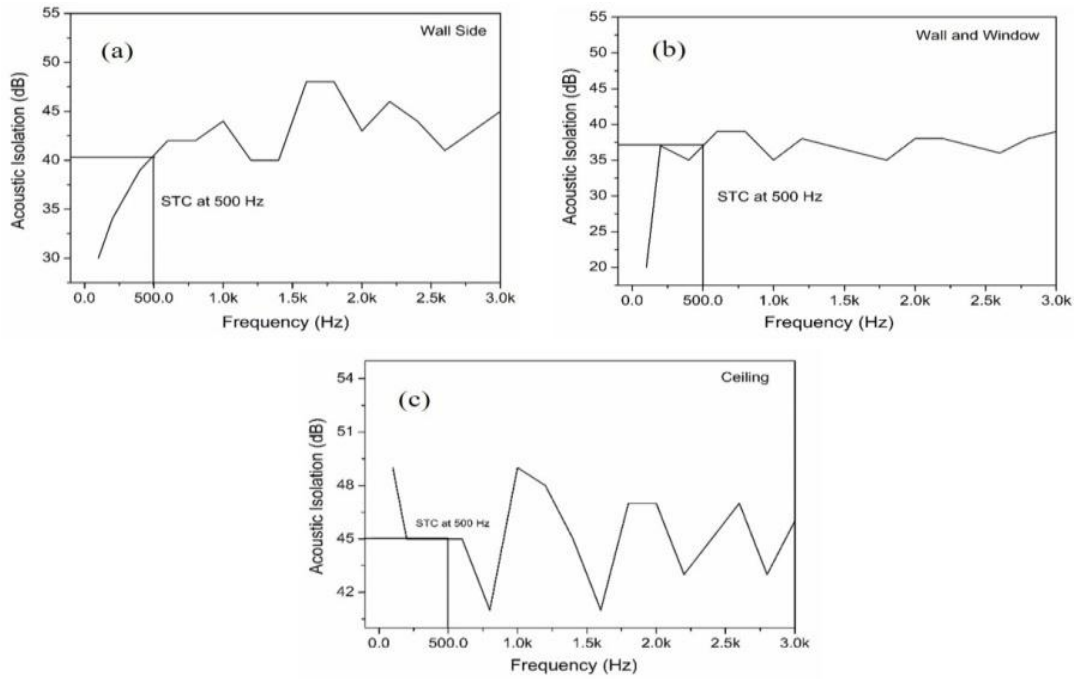


Fig. 13: Sound Isolation of AAC Wall, Wall/Window & Ceiling of AAC Building

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

Sayantani Lala, Ashok Kumar, Kishor Kulkarni, Seraj Alam, Navjeev Saxena & Chandan Swaroop Meena

Objective:

To develop standardized designs of houses using the concept of modular coordination complying performance parameters e.g. space efficiency, climate responsiveness, energy efficiency, disaster resilience, and cost effectiveness

Progress Highlights:

- Designs and layouts of twenty-five clusters for EWS category having carpet area of 30.0 sqm of each dwelling unit have been finalized using modular coordination system and standardization of each has been initiated. Typical plan of single unit and cluster of 4 units of EWS type are shown in Fig. 1(a) and Fig. 1(b) respectively.

- Designs and layouts of twenty clusters for LIG category having carpet area of 60.0 sqm of each dwelling unit have been finalized using modular coordination system and standardization of each has been initiated.

- Designs and layouts of ten clusters for MIG category having carpet area of 90-120 sqm of each dwelling unit have been finalized using modular coordination system and standardization of each has been initiated.

- 12 design options with flexible living space (to be converted into a habitable space using lightweight portioning panels) have been finalized.

- Thermal Performance and wind rose analysis of the fifteen clusters has been done considering seven building envelope materials (using Design Builder & Ecotect).
- Admittance method employed in order to estimate the indoor air temperature and thermal comfort condition.
- Annual analysis of daylight for various cluster are under progress.

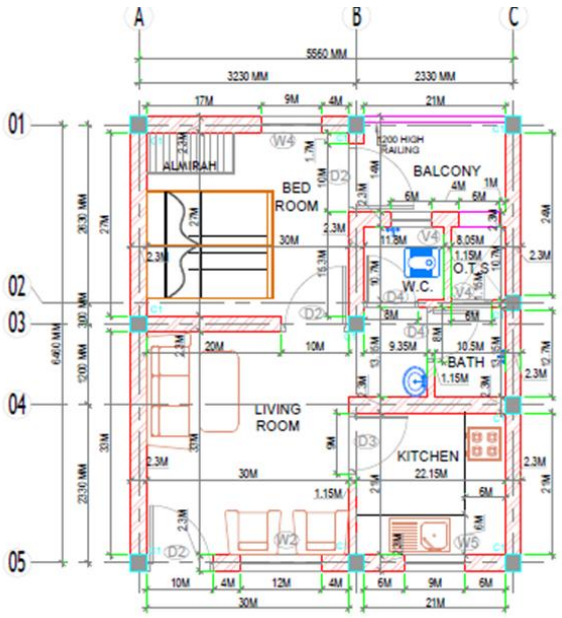


Fig. 1(a): Unit Plan of EWS

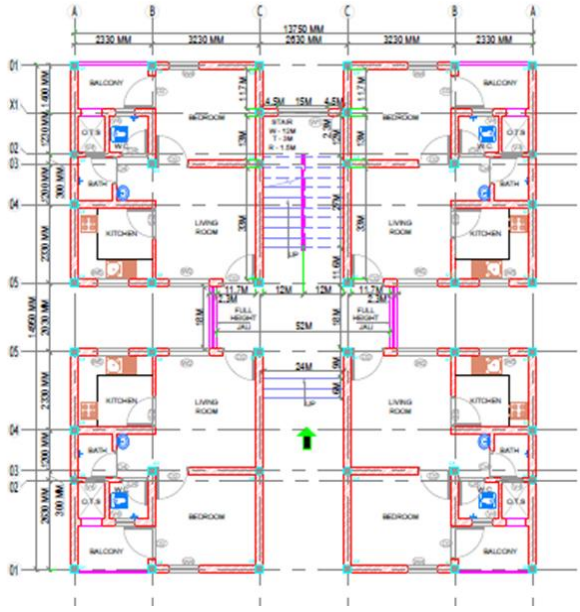


Fig. 1(a): Block/Cluster Plan of EWS with 4 Units of Each Floor

Development of Dry-Construction Technology in Buildings

Kishor Kulkarni, Sayantani Lala, Ashok Kumar, Ajay Chourasia, Navjeev Saxena, Abhinav Pratap Chauhan, Tabish Alam & Naresh Gupta

Objective:

To develop dry-construction technology for low-rise buildings

Progress Highlights:

Dry construction system is a primary steel structure which is made up of structural hollow sections, which having higher efficiency in resisting compression, bending and torsion in comparison with conventional sections. However, the application of hollow structural steel sections in building frameworks is limited, as suitable connection configurations have not been developed between such members. The current practices are to go for full penetration welds and for longer sections; diaphragms are inserted inside the column at beam flange levels. However, these practices involve considerable fabrication and cost and have disadvantages of the field welds introducing potential zones of fracture under seismic loads. The present research focuses on development of prequalified connections as per the AISC 358 seismic provision for G+3 storey steel framed building. The proposed connection is easy to fabricate and install and which enhance the construction speed.

- Structural design and shape optimization of three moment resisting beam column connector element has been completed and which are shown in Fig. 1(a-c).

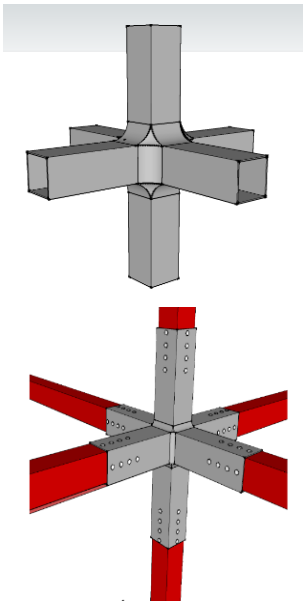


Fig. 1(a): Connector Element

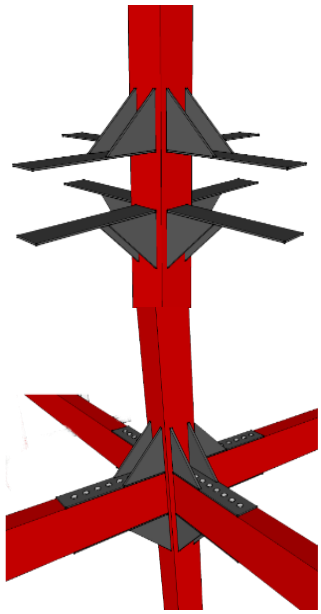


Fig. 1(b): Flange Plate Connection

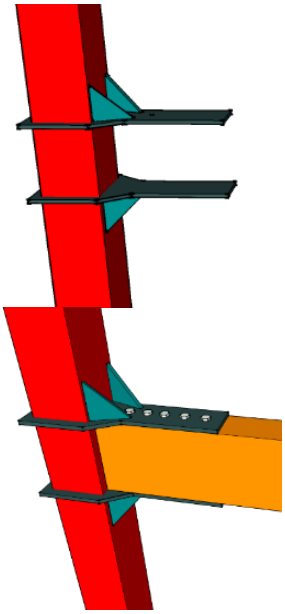


Fig. 1(c): External Diaphragm Connection

- The experimental and numerical study on three conceptualized moment resisting beam column connection has been done (Fig. 2(a-c)).

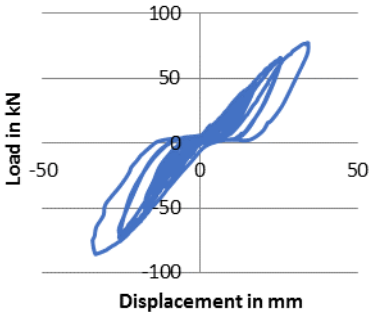


Fig. 2(a): Hysteresis Curve for Connector Element

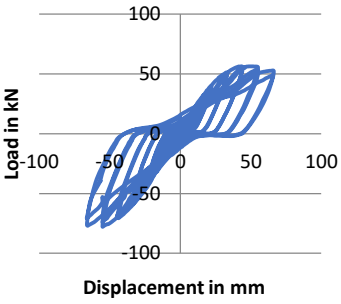


Fig. 2(b): Hysteresis Curve for Flange Plate Connection

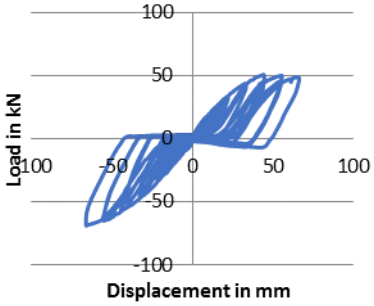


Fig. 2(c): Hysteresis Curve for External Diaphragm Connection

- The Industry interaction is established with Lindapter International, UK and with Visaka Industries, Hyderabad, India
- Dry Construction system demonstrated (Fig. 3) at Construction Technology Park of CSIR-CBRI, Roorkee

Fig. 3: Framed Structure of Dry Construction System for EWS Type House

Development of Bio-Based Construction Material for Sustainable Mass Housing

Leena Chaurasia

Objective:

To develop bio-based construction materials (bio-bricks and bio-concrete) for sustainable mass housing

Progress Highlights:

Keeping in view the higher composition of silica in desert sand sample, efforts have been made to isolate and identify bacteria species which are more active in silicon dioxide (SiO_2).

Studies on Bio-Based Calcareous & Siliceous Construction Materials

Evaluated strength characteristics and water absorption of bacteria treated/untreated desert sand-lime bricks and showed significant improvement in engineering properties. The determination of engineering properties was performed on bacteria treated / untreated bricks made from desert sand + lime and desert sand + lime + cement in varying proportions. The compressive strength and water absorption obtained was >7 MPa and 11 to 14 % respectively, for desert sand bricks comprising ureolytic and non-ureolytic bacteria. The tests were performed in accordance with IS 3495, Part 2: 1992.

New bacterial culture were made for preparation and identification of cost effective growth enhancing medium for bacteria. The study was performed on desert sand and Brahmaputra River sand. The tests were carried for in regards to sieve analysis, specific gravity, fineness modulus, and bulk density (as per IS 383.1970). To utilize the desert sand and Brahmaputra River sand for bricks production, mix proportioning have been performed comprising sand with/without bacteria and cement and water. The results showed an increasing trend of compressive strength and reduction in water absorption in dessert sand-bacterial bricks (Fig. 1 and 2).

Fig. 1: Bio-Bricks using Desert Sand & Bacteria

Fig. 2: Brahmaputra River Sand Bricks

Recycling of Agricultural/Industrial/Solid Wastes for Building Infrastructures

Soumitra Maiti, Santha Kumar G., Monalisa Behera & Neeraj Jain

Objective:

To develop prefabricated value added building products using recycled agricultural/industrial/solid waste construction and demolition (C&D) wastes/bagasse ash and evaluate their performance

Progress Highlights:

The novel methodology involves using high volume industrial by-products (fly ash, ggbs etc) with chemical activators (calcium/ sodium based solution) to enhance the performance of construction demolition wastes based bricks. The inferences from these results are as follows. The use of industrial by-products with chemical activator attained higher strength characteristics, lower permeable void content and lower water absorption by immersion. The photographs of the bricks are shown in Fig. 1. The bricks were designed based on the fluidity of 110 ± 2.5 mm. Such designed bricks achieved a strength more than 8 Mpa. The water absorption of the designed bricks is about 22%. This methodology is economical and environmentally feasible.

Fig. 1: Bricks made with C&D Waste

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 biomass silica as pozzolanic material in construction sector is very limited. The biomass silica (BS) 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. The major oxides such as SiO_2, Al_2O_3 and Fe_2O_3 present in BS is more than 90%, therefore, it act as the good pozzolanic material. The average size of BS used in this study was 24 µm.

Preliminary experimental studies were conducted to assess the effect of using BS as a pozzolanic material. Various properties on blended cement mortar containing various replacement level of BS were studied. Various blended mortar containing different percentages (0, 5, 10, 15, and 20) of BS, associated to fluidity of 135 ± 2.5 mm, were prepared to assess its behaviour.

The blended mortar corresponding to fluidity of 130 ± 2.5 mm, measured by flow table test, with respect to W/B ratio is presented in Fig. 2. From Fig. 2, it can be understood that the W/B ratio increases with incorporation of BS increases when blended mortar associated to 130 ± 2.5 mm. It is because the BS incorporated in cement mortar makes the mix to be somewhat stiff.

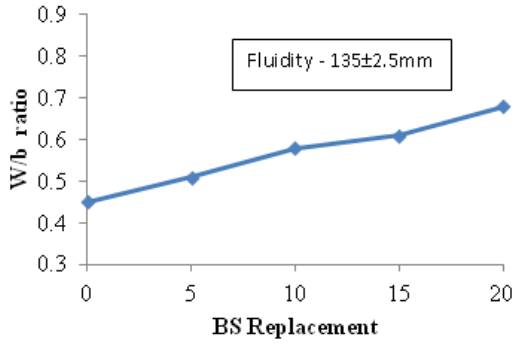


Fig. 2: Variation of W/B Ratio with respect to BS Replacement

The variation of compressive strength of blended mortar with respect to BS replacement is presented in Fig. 3. The compressive strength of blended mortar for 7 and 28 days were increased to considerable level as compared to control specimen. From Fig. 3, it can be understood that there is substantial increase in compressive strength when BS incorporation up to 15%. When mortar incorporated with 20% of BS, the strength was slightly decreased.

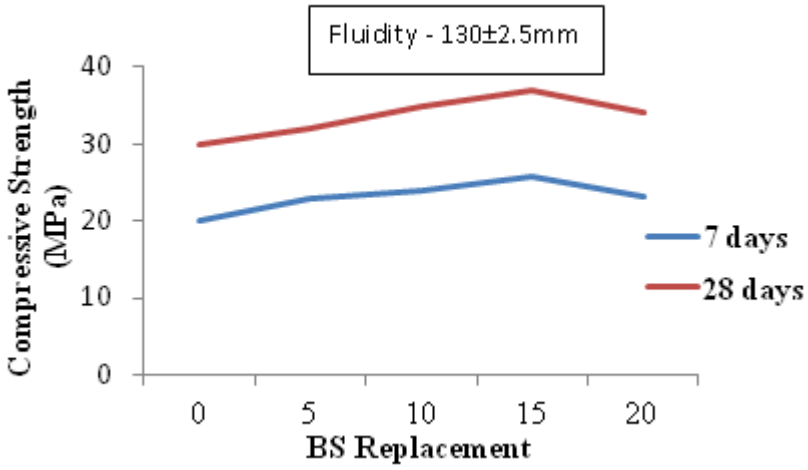


Fig. 3: Variation of Compressive Strength with respect to BS Replacement

Contribution to Demo Park:

Twenty thousand Paver blocks of size 200 mm x 160 mm x 80 mm have been casted by replacing 100% natural coarse aggregate with recycle coarse aggregate and used in pavement of Construction Technology Demonstration Park at CBRI. These paver blocks are developed by compaction technique and cured under water at 27 ± 2°C for a period of 28 days. The photographs of paver blocks are

shown in Fig. 4(a-b). Different tests of these paver blocks were carried out as per Indian standard. Compressive Strength, Flexural strength and water absorption of these paver blocks are: 41 MPa, 3.9 MPa and 3.8% respectively. And these paver blocks can be used for medium traffic purpose as these are satisfying the minimum strength requirements of M-40 grade as per IS: 15658:2006.

Fig. 4(a): C&D Waste based Paver Block

Fig. 4(b): Paver Block laying at Construction Technology Demonstration Park at CBRI

Protective Coating for Improved Energy Efficiency in Buildings

P.C. Thapliyal, S.R. Karade, Vibhrant & A. Dixit

Objective:

To prepare eco-friendly protective coating for RC prefab components with improved performance against corrosion, heat transfer and durability

Progress Highlights:

Work was started with the aim of developing multifunctional protective coating with improved energy efficiency for application on prefab RCC building components. Under this project, work is going on to prepare modified acrylic resin using renewable content from locally and easily available plant based materials. Selection of plants and design of experiments completed. Work on extraction for plant materials and characterization is in progress for developing the resin. Six papers were published in international and national conferences during the year 2018-19. One paper won best technical paper award in international conference CORCON 2018.

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

Ajay Chourasia, Shubham Singhal & Jalaj Parashar

Objective:

To investigate the seismic behaviour of precast reinforced concrete shear wall systems and their connections

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. The present research focuses on evaluation of loop bar connection between precast wall and columns, where the precast wall-column system was subjected to quasi-static lateral loading to determine lateral resistance and seismic parameters.

The system consists of solid precast wall connected to hollow precast columns at both the ends through loop bar connection. The wall is 1150 x 2260 mm, having 150 mm thickness. The column is 350 x 350 mm in cross-section, thus making total length of the system as 1850 mm. The system was designed as per IS 13920 : 2016. Concrete strength was M25 and reinforcement was Fe500. Loop bar consists of 6 mm high strength steel wire ropes embedded in wall and column. A transverse bar of 16 mm was inserted in the loop thus formed. Fig. 1 illustrates the installation of precast wall-column system in laboratory.

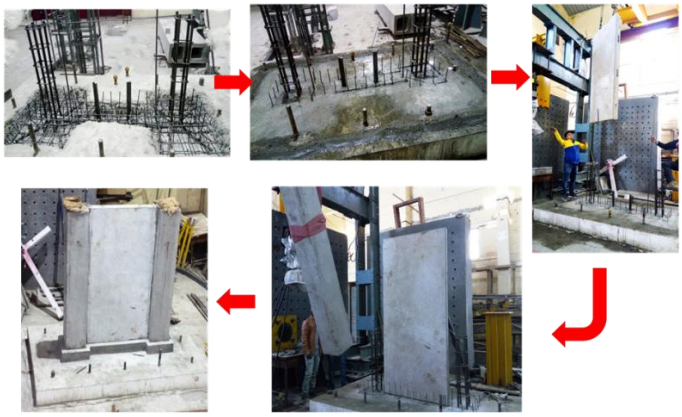


Fig. 1: Installation of Wall-Column in Lab

Fig. 2: Lateral Load Test of Precast Wall-Column

The system was subjected to displacement controlled quasi-static lateral loading (Fig. 2). Main aspects studied were damage pattern, lateral strength, stiffness, behaviour factor, drift, ductility and energy dissipation. The tested system demonstrated ductile behaviour, showing no shear cracks. There was no buckling in the vertical bars and connection between the precast wall and columns was effective in resisting lateral load. Table 1 shows the experimental results of the test. From the experimental investigation, it can be concluded that the developed system delivered enhanced seismic response.

Table 1: Experimental Results

Parameter	**Result**
Maximum lateral load	388 kN
Displacement at ultimate load	58 mm
Roof drift at ultimate load	2.57 %
Stiffness at yield point	24.28 kN/mm
Ductility	3.87

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

Ajay Chourasia, Jalaj Parashar, Shubham Singhal, R.S. Chidambaram & S.K. Panigrahi

Objective:

To develop efficient mechanical anchorage system for beam-column joints

Progress Highlights:

The beam-column joints of RC structure are more vulnerable when subjected to lateral forces, hence needs proper design and detailing of joints. Normally reinforcement bars are bent into other element at joints by development length, causing congestion of reinforcement and may lead to honey combing. Eventually, structural performance of beam-column joint is adversely affected, leading to insufficient strength of RC frame. Moreover, steel required in the provision of development length leads to cost overrun. Further, the bending of large diameter bar is a cumbersome and expensive process in terms of cost and labour and attracts possibility of corrosion. The headed bars can overcome the current issues associated with beam-column joints. The headed bars are proposed to be embedded into the beam-column joints instead of conventional development length. Beam-column specimens were provided with plain, grooved and ribbed headed bars. Beam measured 1 m in length, having cross-section of 225 x 170 mm. While column had 225 x 200 mm cross-section with 1.2 m length. Column was provided with Fe415 4-16 mm logitudinal reinforcement and beam with Fe415 6-12 mm longitudinal bars having 27 mm dia and 27 mm long Fe500 anchor welded to the end. Beam-column specimens were differentiated on the basis of type of headed bars (plain, grooved and ribbed) and joint detailing (confined, unconfined and optimized). Beam end was subjected to displacement controlled vertical cyclic loading, while column was subjected to a constant vertical loading of 25 kN with an actuator. The cyclic load at beam was applied at a rate of 0.1 mm/s at an interval of 10 mm. Column was fixed at both the ends with the help of steel plates and bolts to ensure fixed boundary condition. Fig. 1 shows the whole experimental set-up. The structural behavior was compared with conventional beam-column specimens with development length. Beam-column specimens with headed bars demonstrated better performance as compared to specimens with conventional development length. Table 1 shows a brief comparison of obtained results.

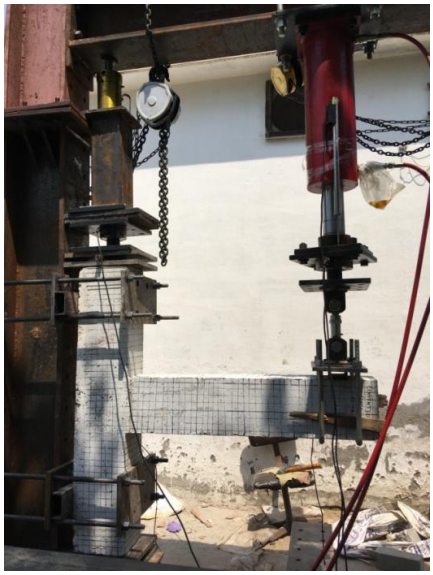


Fig. 1: Experimental Set-Up

Table 1: Comparison of Strength Parameters

Specimen	Lateral Load (kN)	Stiffness at Yield Point (kN/mm)	Ductility	Energy Ratio (%)
Conventional	33.10	2.26	4.72	62.30
Headed bar	47.80	2.43	4.96	64.79
% increase	44.41	7.52	5.08	4.00

Eco-friendly Corrosion Inhibitors to Improve Concrete Durability

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

Objective:

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

Progress Highlights:

On the basis of previous results i.e., yield, total phenolic content and number of anti-oxidants present in the extracts, it was established that the best-suited method for extraction was the refluxing of the shredded plant material for 24 hours. As the yield and obtained phytochemicals are very similar, the extracts obtained from soxhlet and reflux methods were being tested in the Simulated Pore Solution (SPS) using electrochemical techniques.

The electrochemical techniques which are being used for assessment of extracts to be used as corrosion inhibitors are Half-cell potential, Linear Polarization Resistance (LPR) tests and Potentio-dynamic tests in the laboratory. Also, the effect of the addition of extracts on the cement hydration was studied by use of semi-adiabatic calorimetry. The influence of extracts on setting time and compressive strength are studied and the results obtained so far are reported below. The effect on the surface morphology of the steel bar immersed in SPS with extracts for due time has been studied and reported. The chemical analysis of the extracts using FTIR, total phenolic content and GC-MS are in progress.

It was established that the presence of extracts (collected using maceration) in the SPS changes the electrochemical environment around the steel bar towards the reduction in corrosion rate. The electrochemical test results in terms of Half-cell potential, LPR and Potentio-dynamic Polarisation (PDP) tests for the collected extracts collected using reflux and soxhlet techniques are shown and discussed below.

The half-cell potential of the steel is the simplest way to measure the severity of corrosion on the steel reinforcement which qualitatively associates it with corrosion rate. The half-cell potential test results indicated that the potential of the steel reinforcement has a negative shift.

The following tasks were completed:

i) Pre-processing of raw materials

ii) Collection of extracts from different methods from raw materials

iii) Chemical analysis of various collected extracts

iv) Effect of extracts on hydration of cement and mechanical properties

v) Electrochemical investigations for extracts as corrosion inhibitors in simulated pore solution

The Potentio-dynamic Polarization (PDP) tests were conducted on the specimens to study the polarization behavior (anodic and cathodic) of the steel specimens immersed in the SPS with a various dosage of extracts. The observed change in the polarization characteristics signifies that the electrochemical and polarization behavior of the steel specimens has changed with the addition of various inhibitors. Also, the highest efficiency (92%) was exhibited by 2% dosage of Neem (soxhlet) so far and is proving to be highly effective as the efficiency keeps on increasing with time. The other extracts which offer similar efficiencies (~ 91%) are reflux extracts of gooseberry (dosage of 1%), eucalyptus (dosage of 2%) and neem; and, the soxhlet extracts of eucalyptus (dosage of 2%) and gooseberry (dosage of 2%).

LPR testing is the most important testing of all the electrochemical testing as it gives us information about the long term behavior of the corrosion inhibitors in simulated conditions. During the LPR testing, a polarization potential is applied to the steel reinforcement immersed in the solution and the current needed to maintain the polarization or the potential shift is measured. The current needed to maintain a specific voltage shift is directly related to the corrosion on the surface of the electrode in the solution, and the corrosion rate can also be calculated. The polarization resistance may be defined as the steady-state resistance that the steel – electrolyte interface presents to a change in potential brought by the application of small perturbation in the current. The results of LPR tests carried on various specimens having extracts collected from soxhlet process are shown in Fig. 1.

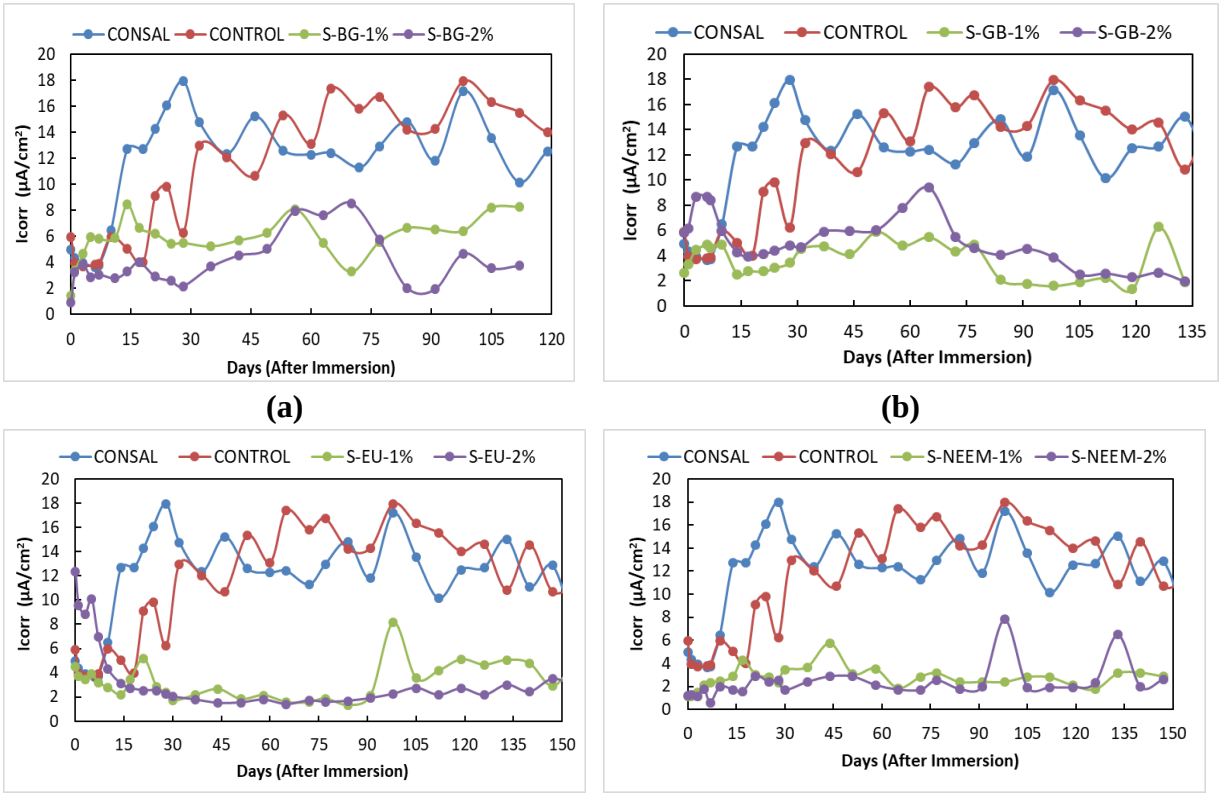


Fig. 1: Linear Polarisation Results for Various Soxhlet Extracts

It can be observed from the Fig. 1 that the corrosion rate in control (SPS) and control with NaCl (CONSAL) (3.5% w/v) specimens keeps on increasing with time at a higher rate while in all the other specimens containing the corrosion inhibitors the corrosion rate is much lower than the control and CONSAL specimens at any given point of time. It can also be observed that the corrosion rate in

specimens containing inhibitors are almost constant which indicates that the steel reinforcement is still in the initiation stage of corrosion and thus the onset of corrosion is delayed. The highest efficiency is exhibited by the Neem extract with a dosage of 2% (w/v) so far for which the corrosion rate is almost constant. Also, the efficiency of the inhibitors keeps on increasing with time as the corrosion rate in the control specimens keeps on increasing with time.

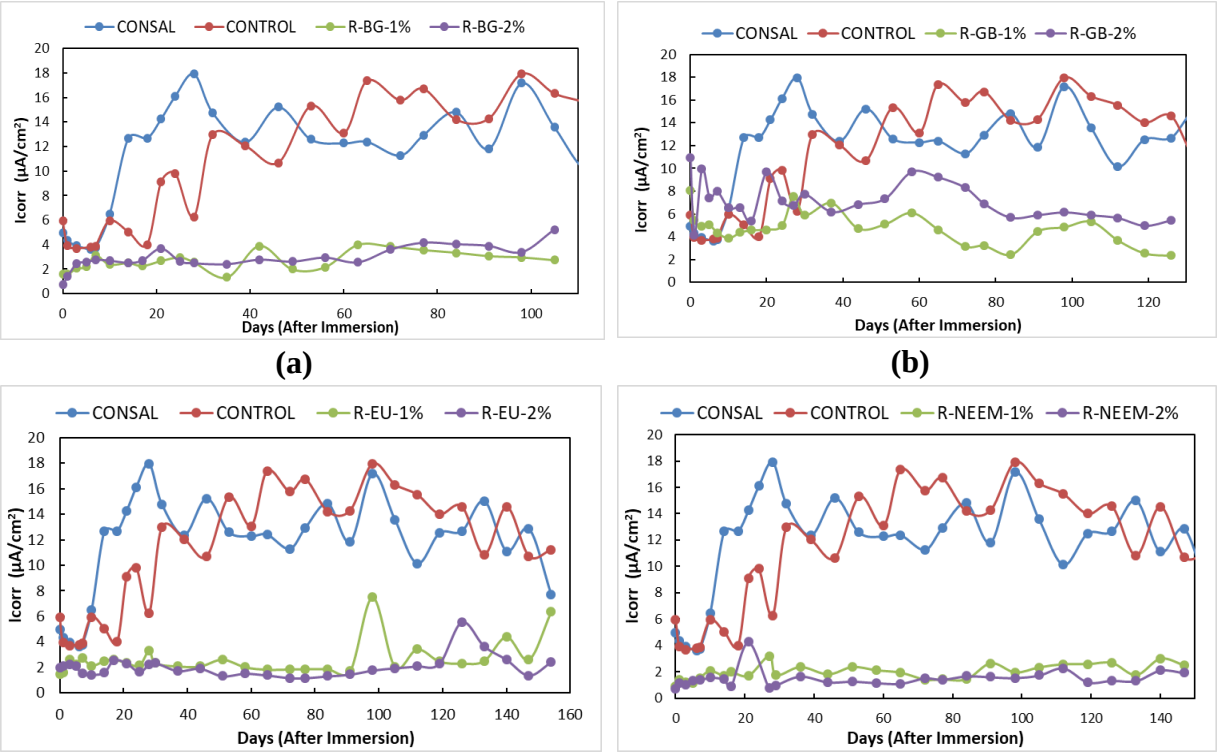


Fig. 2: Linear Polarisation Resistance Results of Various Reflux Extracts

The linear polarization results for reflux extracts are shown in Fig. 2 and it can be observed that the corrosion rate is substantially lower for the specimens containing corrosion inhibitors as compared to control and CONSAL specimens. It can also be observed that the corrosion rate in specimens containing the corrosion inhibitor obtained from Neem is fairly constant for both the dosages and is providing best corrosion inhibition efficiency of 93% (for a dosage of 2%). It should be noted that the specimens containing inhibitors (Neem and Eucalyptus) are almost constant which indicates that the steel reinforcement is still in the initiation stage of corrosion and thus, the onset of corrosion is delayed. Also, the efficiency of the inhibitors keeps on increasing with time as the corrosion rate in the control specimens keeps on increasing with time.

The effects of addition of extracts on the hydration of cement (w/c ratio of 0.3 and constant room temperature 23 °C) are being studied by using semi-adiabatic calorimetry and the results are as shown in Fig. 3.

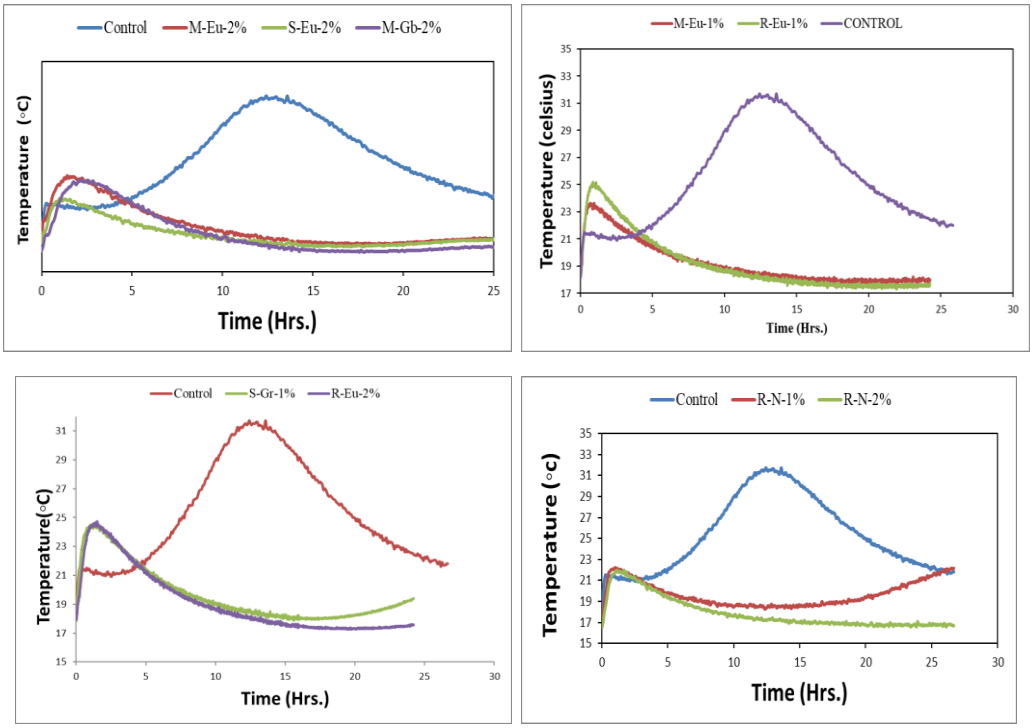


Fig. 3: Effect of the Addition of Corrosion Inhibitors on Cement Hydration

From the above 24 hours hydration temperature profiles of different mixes of maceration, reflux and soxhlet extracts at a dosage of 1% and 2%, it can be observed that the peak temperature of hydration for the specimens with the addition of extracts were very low as compared with the control specimens. This can be attributed to the presence of organic matter in the mix which coats and adsorb on the surface of cement particles blocking water to reach the cement particles during the mixing. The blockage of cement surface leads to a lower rate of hydration as only a small amount of water reaches the cement particles surface which was absorbed from the organic matter in turn adsorbed on the surface of cement particles. This can also be inferred from these temperature profiles that the compressive strength would be lower for the specimens with the addition of extracts as compared to control samples.

Also, the compressive strength of the mortar specimens containing extracts was carried out on the 50 mm cube samples which were cured underwater and surface dried before testing. Thus, the testing was carried out in saturated surface dried conditions and the rate of loading was kept at 0.23 MPa per second. For each specimen, triplicates were tested and the found average compressive strength is reported under (Fig. 4).

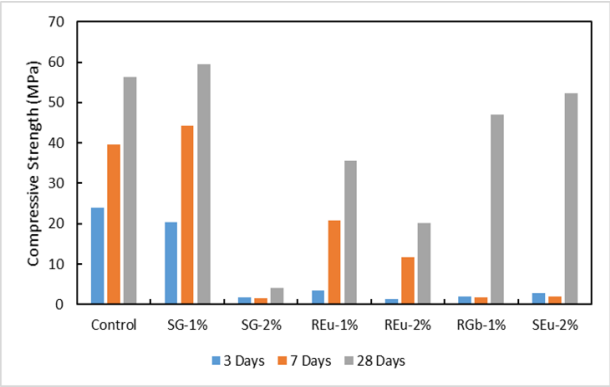
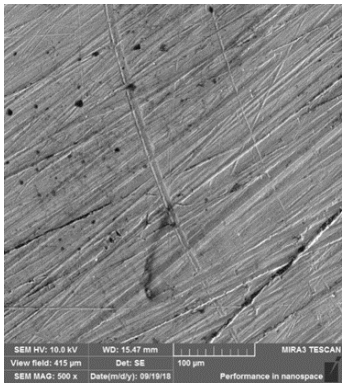


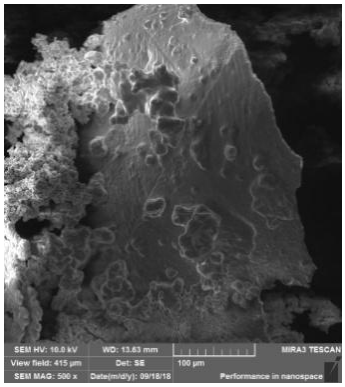
Fig. 4: Compressive Strength of Mortar Specimens

It can be observed that the compressive strength of the specimens prepared with the addition of extracts is very low at 3 and 7 days which is also supported by the initial hydration profiles of the specimens. Also, it is to be noted that the compressive strength of specimens with the addition of extracts at 28 days is very near to that of control specimens. There is an increase in the compressive strength of the specimens which suggests that delayed hydration is taking place for these samples.

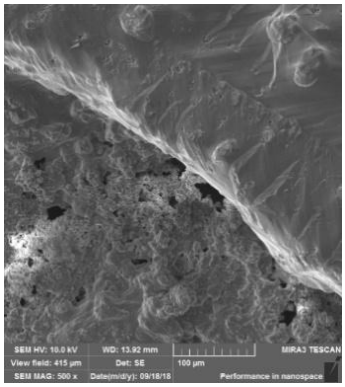
The surface morphology for the mild steel specimens was also studied to find out the adsorption of corrosion inhibitors (plant materials extracted using maceration) on the surface when immersed in SPS in the presence of inhibitors. The micrographs are shown in Fig. 5.



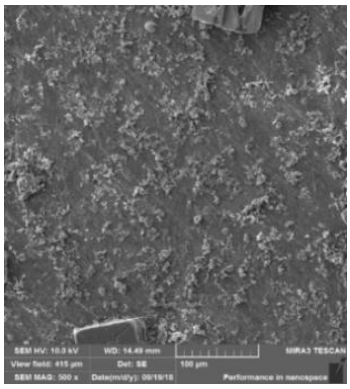
(a) Plain MS



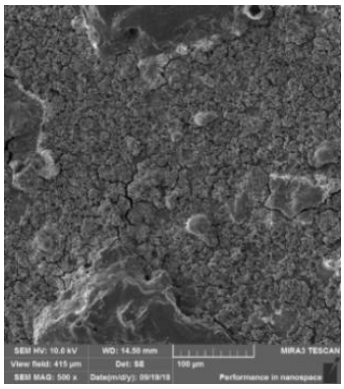
(b) Control



(c) Consal



(d) Gooseberry



(e) Eucalyptus

Fig. 5: Surface Micrographs of Mild Steel Immersed in SPS with Inhibitors for 30 Days

It can be observed that the control specimens and the specimens immersed in SPS with 3.5 % NaCl (CONSAL) dissolved in it have corroded and formation of rust have taken place on the surface deteriorating the specimens. It can also be noted that a uniform coating of organic material was formed on the surface of mild steel specimens (Fig. 5(d) and 5(e)) which were immersed in SPS with corrosion inhibitors as compared to plain mild steel specimen. Thus, it can be concluded that the extracts from chosen plant materials inhibit corrosion by forming a uniform coating on the metal surface by physisorption.

In addition, the chemical characterization and the anti-oxidant activity of the corrosion inhibitors and hydration studies are being carried out to assess and counter the influence of the corrosion inhibitors on cement hydration.

Mechanization in Construction Process of Prefabricated Building Components for Mass Housing

R.S. Bisht, S.K. Panigrahi, Ajay Chourasia, Narendra Kumar, Sameer, Dinesh Kumar & Soju J. Alexander

Objective:

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

Progress Highlights:

- Completed design and manufacturing drawings in Solidworks CAD software of the proposed affordable mobile crane (2 ton capacity).
- Fabrication of mast, boom, crane base, pole mechanism, counterweight cage and ring gear of the crane has been completed.
- Completed boom trip trajectory and workspace analysis using programming in MATLAB.
- Completed finite element simulation and design parametric analysis using FEA in ANSYS.
- Instrumentation and working trials of the mobile crane is currently under progress.

Mechanization in Production of Prefabricated Building Components & Wall Plastering for Mass Housing

S.K. Panigrahi, Narendra Kumar, R.S. Bisht, Ajay Chourasia, Dinesh Kumar, Sameer & Soju J. Alexander

Objective:

Modification of machine for prefabricated components in CSIR-CBRI for production of prefab components as per market requirement for mass housing and mechanization in wall plastering

Progress Highlights:

- Completion of complete mechanical design and manufacturing drawings of the wall-plastering machine.
- Successfully conducted working trials and demo of modified C-brick making machine.
- Completed the design and drawings of spraying unit, screeding unit and modification of a metal polisher for development of finishing unit.
- Completed fabrication of the mechanical part of the prototype wall-plastering machine.
- Instrumentation of the wall-plastering machine is currently ongoing.
- Prepared concept design of gypsum panel making machine.

Mechanization in the Housing Construction Sector

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 prefabricated 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.

The affordable modular mobile crane hoisting capacity vs. boom radius is compared with the existing crane and it is shown in Fig. 1(a). The programming in MATLAB platform is used to simulate the boom tip trajectory and workspace (Fig. 1(b-d)) analysis of the proposed mobile crane. The boom tip trajectory is performed using derived kinematic model for the four cases of boom luffing angles. The results shown in Fig. 1(b-c) show that the workspace of the proposed crane is in stationery vertical cylindrical cells for three different heights. This workspace is similar to a cylindrical configuration of a robot manipulator. The result shown in Fig. 1(c-d) indicates that the crane can lift the material to heights of 9.1 m, 11.6 m, 12.6 m, and 13.5 m from its base level at different boom luffing angles 0°, 30°, 45° and 60° respectively. This simulation also shows the variation of working radius (± 6.0 m, ± 5.15 m, ± 4.35 m and $\pm$ 3.30 m) for these four cases when slewing (φ) angle varies from 0° to 360°. Another simulation (Fig. 1(b)) carried out using MATLAB program shows the total workspace of the crane with the height of the mast varies from 0 to 8 m for different boom angles 0°, 30°, 45° and 60°.

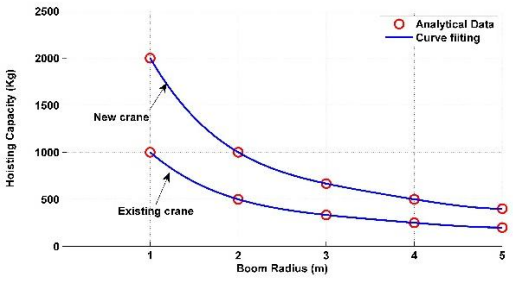


Fig. 1: (a) Crane Hoisting Capacity (kg) vs. Boom Radius (m)

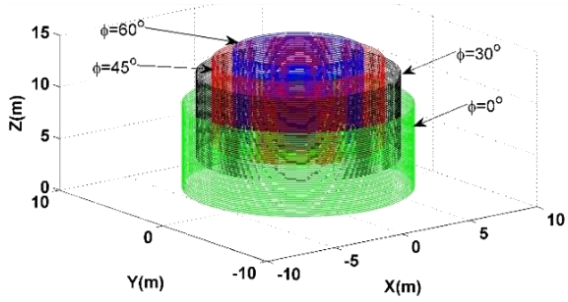


Fig. 1: (b) Workspace of the Proposed Crane for Four Cases of Luffing Angles

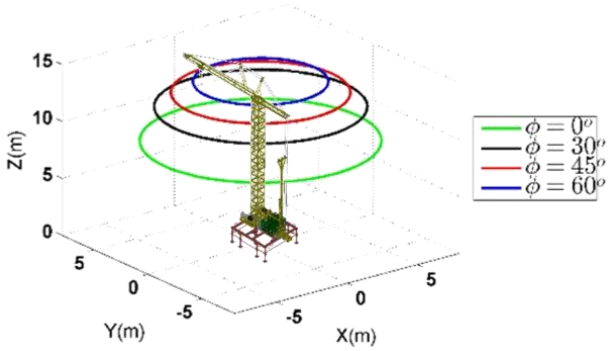


Fig. 1: (c) Boom Tip Trajectory of the Proposed Mobile Crane for Four Cases of Luffing Angles (Working Height 9.1 m, 11.6 m, 12.6 m & 13.5 m)

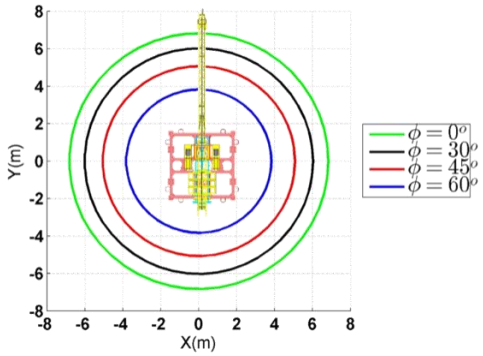


Fig. 1: (d) Workspace of the Proposed Crane for Four Cases of Luffing Angles (Working Radius: ± 6.0 m, ± 5.15 m, ± 4.35 m and ± 3.30 m)

Design analysis of the affordable modular mobile crane is performed using finite element analysis in ANSYS software. Detailed simulation results are shown in Fig. 2-5.

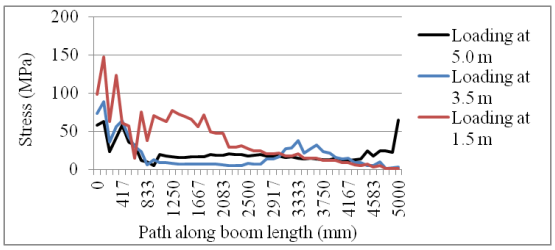


Fig. 2: Stress Variation Along the Mobile Crane Boom Length for Various Loading Radius Conditions

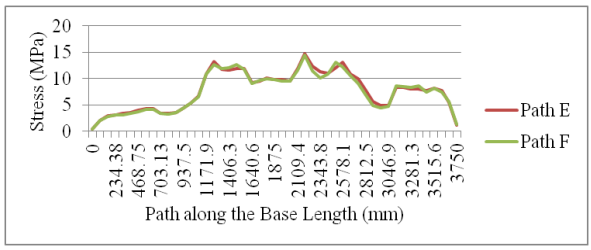


Fig. 3: Stress Variation along Crane Base Length for Two Parallel Outer-Section Path Denoted as (E & F)

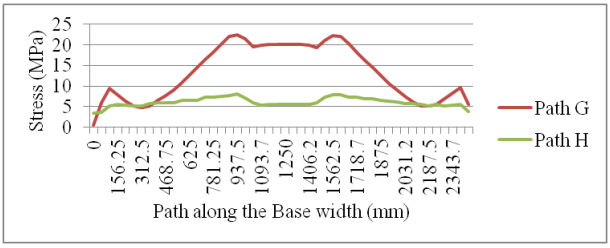


Fig. 4: Stress Variation along Crane Base Width for Two Parallel Outer-Section Path Denoted as (G & H)

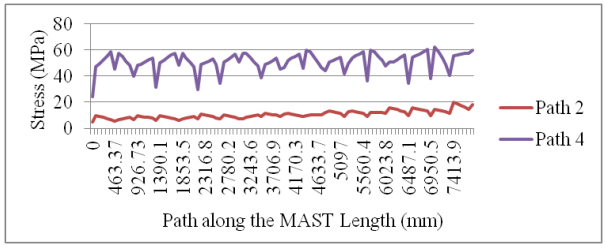


Fig. 5: Stress variation along Crane Mast Length, Where Path-2 is along the Counterweight Side & Path-4 is along the Hoisting Load Side

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

S.K. Negi, Ajay Chourasia & Ashish Pippal

Objective:

To develop robust technologies for traditional construction in hilly regions of India

Progress Highlights:

- CSIR-CBRI S&T interventions in traditional constructions for Government of Odisha in 2,00,000+ rural houses.
- Training imparted to 1200 persons.
- Drawings and specification development for bamboo trusses, frames and joint testing facility.
- S&T interventions to Panchayati Raj Department, Government of Odisha for development of Technology Park at Bhubaneswar displaying CSIR-CBRI technologies.
- Signed MoU with State Bamboo Mission, Madhya Pradesh to support them with S&T interventions for bamboo-based construction in the state.
- Organized two national workshops sponsored by Ministry of Development of North Eastern Region (MDoNER).
- Started construction of Bamboo based demo house at demo park site to assess the performance & life cycle of S&T Interventions suggested by CSIR-CBRI for Bamboo structures
- Prepared a model of bamboo-based demo building need to be constructed at Demo Park.
- Performed comparative study of bamboo versus conventional construction system.

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

Ajay Chourasia, Shubham Singhal & Jalaj Parashar

Objective:

Design of confined masonry buildings using different units

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. Further, the construction process is slow and tedious, which results in delay in construction activities. In order to overcome the limitations, alternate materials and construction process shall be adopted.

Confined Precast Building System comprises lightly reinforced foam concrete elements embracing lightweight precast wall panels at periphery and having thickness same as that of walls. Instead of laying brick-by-brick in wall construction; panels of size 900 mm x 450 mm having thickness 120 mm (up to two storey) and 200 mm thick (up to four storey) with 100 mm x 20 mm projection along-sides and 80 mm x 80 mm square groove at top edge of panel to accommodate horizontal rebar and in-situ concrete have been provided, as shown in Fig. 1. While converging to panel size, the concepts like “modularity, scalability, reconfigurability, flexibility, mobility” have been considered. To reduce handling weight, foam concrete wall panels with 2-6 mm dia bars having 40 mm x 25 mm loop at ends are provided which in-turn connected to adjoining panel by means of continuous vertical

reinforcement. In-situ concrete with 12 mm down aggregates is cast in lightly reinforced confining elements. The confinement of wall panel increases lateral/axial load resistance and localized failure of confined masonry wall. The RC floor could be precast RC planks or solid slab, adequately connected to bond beam and tie column.

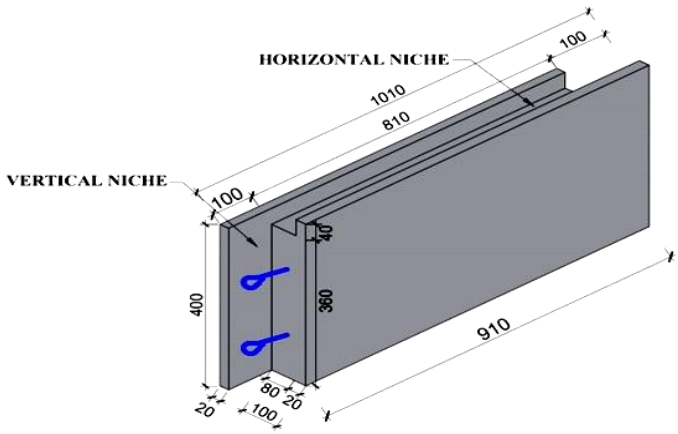


Fig. 1: Isometric View of Precast Foam Concrete Panel

Confined precast building using foamed concrete panels was modelled in Abaqus and analyzed under static lateral displacement-controlled loading for single-storey, two-storey and three-storey buildings. The topologies of the models were 3.06 m x 3.06 m in plan and height of one storey is 3.06 m having similar geometrical and material properties. The model consists of door and window openings of similar dimensions in all storeys. The data collected and observations made were for displacement capacity and damage grades. The failure modes observed were - propagation of tensile cracks near the window openings, cracks in panels extended diagonally, shear cracks in panels, crushing at toe and bending of vertical reinforcements. The damage observed at lower storey was more compared to upper storey as shown in Fig. 2. As the number of storey increases, the lateral load carrying capacity decreases (Fig. 3). Based on the maximum lateral load capacity of the systems horizontal acceleration was computed and compared with the zone factor as per IS 1893 : 2016 to verify the safety of the models. The foamed concrete panel shows better results in terms of lateral response. It was determined that foamed concrete buildings with single-storey can be constructed up to zone IV, foamed concrete buildings with two-storey can be constructed up to zone III and foamed concrete buildings with three-storey can be constructed up to zone II.

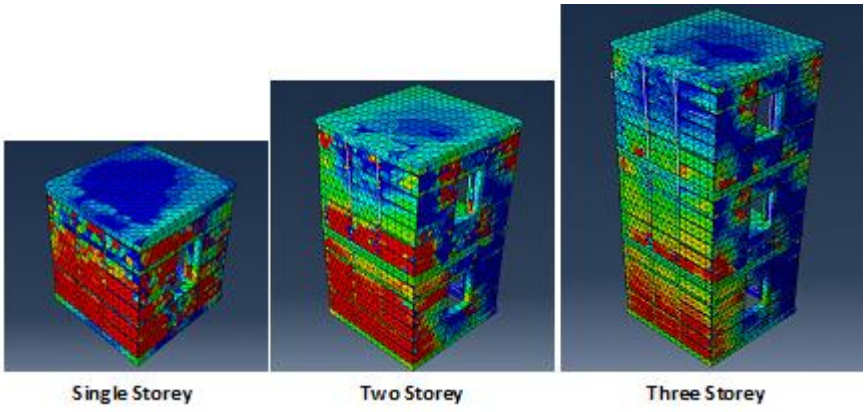


Fig. 2: Damage Pattern in Confined Precast Building

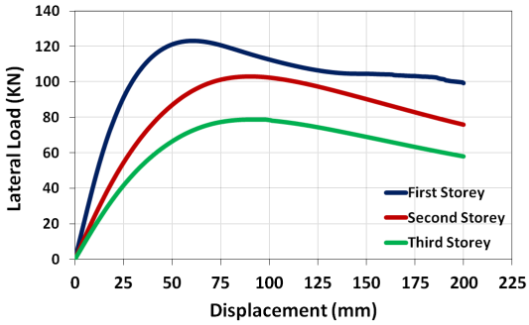


Fig. 3: Lateral Load-Displacement Curve for Confined Precast Building

Improvement in CSIR-CBRI Developed Prefab Technologies

S.K.Negi, Ajay Chourasia & Ashish Pippal

Objective:

Development and modification of CSIR-CBRI developed technologies (roofing/flooring) for utilization as prefab building components

Progress Highlights:

- Developed Modified Planks to reduce number of joints in the roofs.
- Developed Modified Joist to reduce the labour involved in lifting up the heavy joist earlier (now the weight of joist has reduced to one-third of previous one).
- Fabrication of Test Set-up for testing of permeability of RF signals across various construction materials is accomplished; purchase of required instruments to accomplish the set-up is under progress.
- Started construction of Demo House utilizing CSIR-CBRI old and updated prefab technologies and accomplished it up till roof level.

Ground Improvement Technique to Mitigate Liquefaction Hazard for Safe Building Construction

S. Ganesh Kumar & Anindya Pain

Objective:

- To identify and develop engineering solution for soils susceptible to liquefaction in seismic prone regions
- To improve the strength of liquefiable soils using ordinary and encased stone columns

Progress Highlights:

The work completed during the period involves: (i) shaking table tests on liquefiable ground subjected to sequential acceleration levels i.e. 0.1 g, 0.2 g, 0.3 g and 0.4 g; (ii) installation of 4 numbers of sand compaction piles having 0.111 m diameter and 0.6 m length in liquefiable ground and its performance evaluation under 0.1 g, 0.2 g, 0.3 g and 0.4 g sequential acceleration; and (iii) improvement in liquefiable ground with and without sand compaction piles under 40 % and 60 % relative density conditions.

The selection of sequential acceleration was simulated similar to recent Nepal earthquake conditions i.e. when the same liquefiable ground subjected to continuous shaking within a day with high or low acceleration intensity. In this study, incremental sequential acceleration conditions are adopted. For ground improvement, sand compaction piles (SCP) were installed in square pattern with a design spacing of 450 mm calculated according to its influence zone characteristics. From shaking table experiments, it was observed that acceleration plays a major role in initiating liquefaction. When un-reinforced ground at 40 % and 60 % relative density subjected sequential acceleration conditions, time required for causing liquefaction reduces with increase in acceleration intensity, which can be observed from Fig. 1 and 2 respectively.

Installation of sand compaction piles increases the liquefaction resistance. Soil prepared with 40 % relative density and with 0.1 g acceleration, no liquefaction was observed. However, the same ground when subjected to incremental sequential accelerations, liquefaction was observed. The time taken liquefaction initiation is comparatively more than untreated ground, which is seen clearly in Fig. 1 and 2. This time can be improved by installing more sand compaction piles with effective area improvement ratio. Similarly, no liquefaction was observed for the ground prepared with 60 % relative density when reinforced with sand compaction piles subjected to 0.1 g and 0.2 g acceleration conditions. It shows that, the installed four-column ground improvement system performs better under 0.1 g and 0.2 g acceleration levels. However, when the same ground subjected to high intensity i.e. 0.3 g and 0.4 g, liquefaction was observed. This suggests the importance of selecting area replacement ratio in ground treatment for liquefaction mitigation. Selection of adequate number of sand compaction piles with effective area replacement ratio improves the liquefaction resistance considerably. Comparative graph showing the performance of with and without sand compaction piles under 60 % relative density ground condition is shown in Fig. 1 and 2. From experimental test results, it can be observed that the performance of selected ground improvement technique should be checked under sequential acceleration conditions for improved performance and ensures safety of structures.

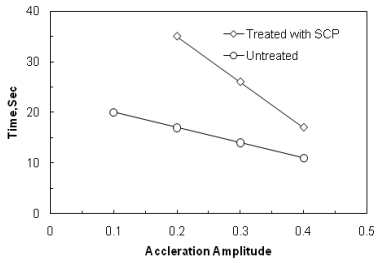


Fig. 1: Liquefaction Time (s) under Varying Acceleration Amplitude with & without Sand Compaction Piles (SCP), Relative Density-40 %

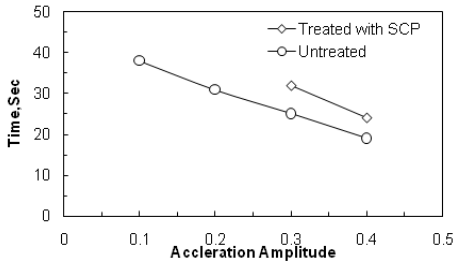


Fig. 2: Liquefaction Time (s) under Varying Acceleration Amplitude with & without Sand Compaction Piles (SCP), Relative Density-60 %

Ground Improvement using Granular Pile Anchor Foundation (GPAF) System

Pradeep Kumar & Koushik Pandit

Objective:

To develop a holistic scheme for design and construction of an improved granular pile anchor foundation system

Progress Highlights:

A comparative study on existing granular anchor pile systems has been carried out. Modifications over conventional GAP systems have been planned. Liquefaction potential case study of a clay soil stratum at Darbhanga, Bihar and application of GAP for ground improvement has been established through analytical study.

Numerical investigation of the parametric behaviour of jacketed granular piles is in progress. Modifications in the field test set-up are being carried out for experimentally finding out the probable failure pattern due to jacketing of the granular pile by geotextile membrane. Consultations are on-going with the fabricator for necessary modifications in the test set-up.

Fabrication drawings for the modified GPAF system have been prepared (Fig. 1 and 2). Communication with solar panel installation companies has been established regarding the use of GPAF system for solar panel foundation for which they have shown keen interest in the technology. In housing, a government agency has been identified to be a potential stakeholder in using the modified GPAF system for buildings. Numerical analysis and comparison between the proposed modified and conventional GPAF system has been completed. The modified system has been found to be more efficient in pullout behaviour than the conventional ones.

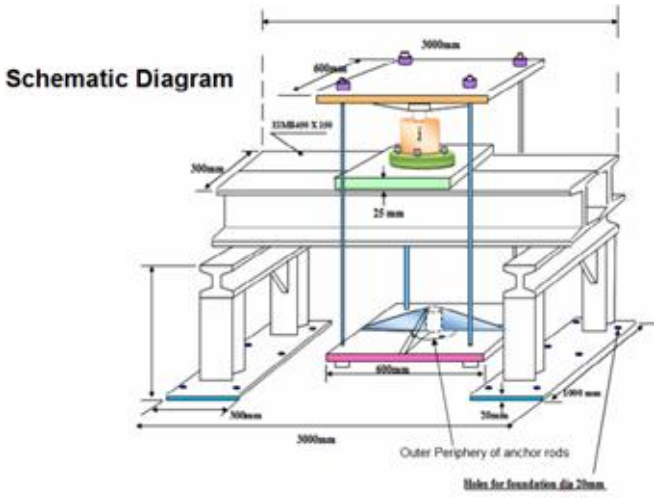


Fig. 1: Modified Field Test Set Up for the Granular Pile Anchor System

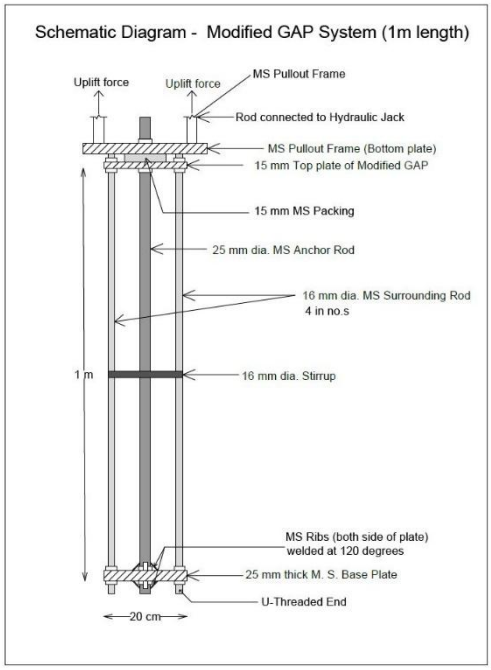


Fig. 2: Schematic View of the Modified System

After thorough literature survey and numerical analysis, the results obtained describe the optimum L/d ratio for 10 cm and 20 cm diameter modified Granular anchor piles (Table 1 and Fig. 3). This proposed system for the chosen L/d ratios will now be tested in a field-testing set-up at the CBRI site. In addition, the uplift capacity obtained through the analysis will be used to withstand the wind resistance offered to the solar panel in different regions of India according to IS 875 Part 3. Preparation of guidelines for GP/GAP is presently in progress. Wind load calculation for solar panel has been completed using ASCE STANDARD ASCE/SEI 7-05.

Comparative study of footing reaction on Solar Panel for Normal Granular Anchor Pile and Modified Granular Anchor Pile for the calculated wind load has been done. Prepared the fabrication drawings of the testing model based on the results of the numerical modelling.

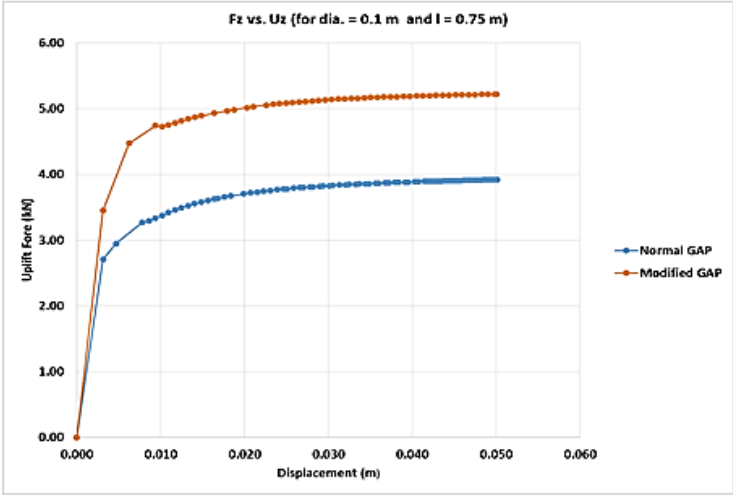


Fig. 3: Variation in Uplift Capacity for 10 cm dia. Pile and 0.75 m Length of both Conventional & Modified GAP

Table 1: Comparison of Uplift Capacity of Modified GPAF Systems for Two L/d Ratios

S. No.	L (m)	d (m)	L/d	Uplift Capacity Normal GAP at 0.05 m (kN)	Uplift Capacity Modified GAP at 0.05 m (kN)	Percentage Increase
1	0.25	0.1	2.5	2.47	3.54	31.74
2	0.5	0.1	5	3.02	4.00	32.45
3	**0.75**	**0.1**	**7.5**	**3.92**	**5.22**	**33.16**
4	1	0.1	10	5.43	7.15	31.81
5	1.25	0.1	12.5	6.67	8.45	26.64
6	1.5	0.1	15	7.80	9.99	27.97
7	0.5	0.2	2.5	7.69	8.50	10.53
8	1	0.2	5	12.02	15.48	28.78
9	1.5	0.2	7.5	17.66	23.64	33.86
10	**2**	**0.2**	**10**	**23.23**	**32.00**	**37.75**
11	2.5	0.2	12.5	26.52	31.14	17.42
12	3	0.2	15	26.03	30.29	16.36

Development of Modified Static & Seismic Design Methodology of Piled-Raft Foundation

Manojit Samanta, D.K. Malviya & Ajay Dwivedi

Objective:

Development of design methodology of pile-raft foundation for tall building under axial, lateral and combined loading considering the amplifications and nonlinear soil response in static and dynamic conditions for different soil conditions

Progress Highlights:

The present study deals with the nonlinear load sharing behaviour of pile and raft with settlement in clay through numerical analysis. Load sharing between pile and raft has been evaluated through three dimensional finite element based numerical analysis. 3D finite element based software has been utilized to analyze the problem and the conceptual diagram piled-raft is shown in Fig. 1. The piled-raft foundation system consisted of 15 m wide (B) and 2.5 m thick square raft with 16 numbers of rigidly connected floating piles of 0.5 m diameter (D_p). The distribution of piles beneath the raft was in square pattern. The raft-soil interface was considered as rigid while the pile-soil interface was considered as slip-type. The slip-type interface means that the soil was allowed to slip at the interface with the pile. This enables modelling of the real field behaviour of pile under vertical load. One quarter of the considered problem was modelled in numerical domain due to symmetry and shown in Fig. 2. The quarter geometry consisted of four numbers of rigid piles. Piles were placed at the centre-to-centre (c/c) distances of 2 Dp, 4 Dp, 6 Dp and 8 Dp. Details of the numerical domain were shown in Fig 4(a-b). The study focuses load-sharing contribution of pile and raft in a piled-raft system.

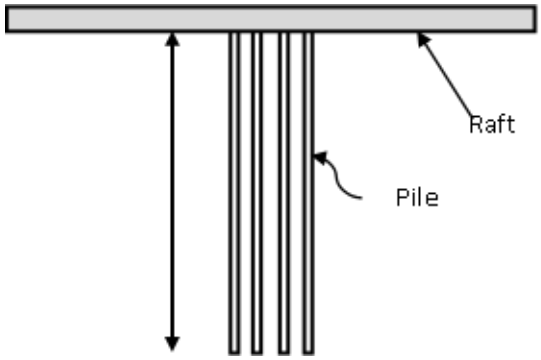
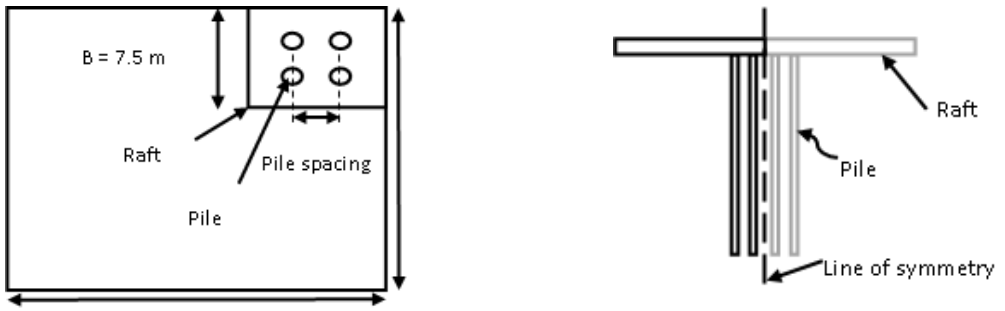


Fig. 1: Schematic Diagram of Piled-Raft

Finite element analyses were performed by creating three-dimensional models in PLAXIS 3D. Soil has been modelled as linear elastic perfectly plastic Mohr-Coulomb material with associated flow rule whereas pile and raft has been taken as linear elastic and modelled as beam and plate respectively. Un-drained behaviour of the soil was considered in the analysis. The soil continuum was discretized using 10-noded tetrahedral element, having three translational degrees of freedom in three perpendicular directions. Raft was discretized with six noded triangular elements, having six degrees of freedom at each node. Piles were created as solid circular pile with six degrees of freedom at each node. The soil-pile interface was modelled by 12-noded interface elements.



(a) **(b)**

Fig. 2: Schematic Diagram of One Quarter of the Problem Modelled in the Present Study

Each node has three translational degree of freedom, which allows the simulation of slipping and gapping between soil and pile. Fig. 3 shows the variation of raft-soil stiffness ratio with shear strength of soil calculated as per Horikoshi and Randolph (1997).

A mesh convergence study among coarse, medium, fine and very fine type of mesh revealed no significant change in magnitude of load sharing of pile and raft for fine and very fine mesh t, hence fine mesh has been selected for analysis. A relatively finer mesh around the pile and raft, and wider mesh around the remote boundary of the numerical domain was used.

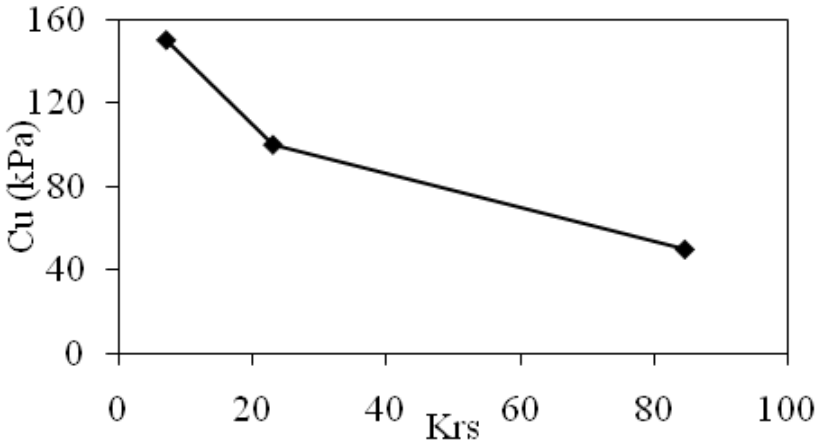


Fig. 3: Variation of K_{rs} with C_u

The horizontal boundary of the numerical domain in current analysis was extended to 10 B for eliminating the boundary effect on the response of piled-raft. Bottom boundary was set up at a depth of 2 L_p from the tip of pile to simulate the conditions of floating pile.

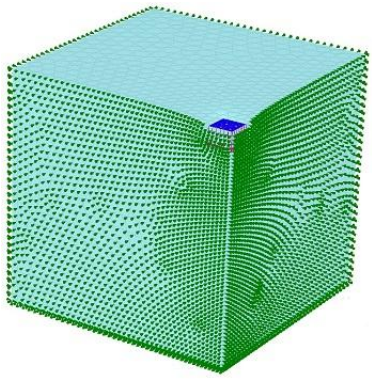


Fig. 4: (a) FEM Discretization with Boundary Conditions

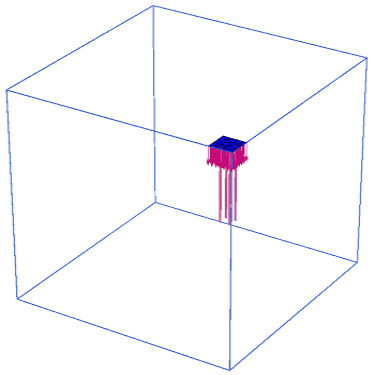


Fig. 4: (b) Model Boundary with Pile, Raft & Applied Vertical Settlement

Load sharing of pile and raft were studied considering the effect of soil type and pile spacing. Young's modulus of the soil with 50 kPa, 100 kPa and 150 kPa cohesion were calculated using correlation given by Poulos (1980).

Fig. 5(a) shows the percentage load shared by pile (α_p) and raft (α_r) respectively in a soil with 50 kPa cohesive strength. The load to piled-raft system were applied in the form of incremental uniform settlement with a value of 5 mm, 10 mm, 15 mm, 25 mm, 50 mm, 75 mm, 100 mm, 150 mm, 200 mm, 250 mm, 300 mm, 600 mm and 900 mm. The maximum load shared by the piles were at applied settlement of 50 mm for 2D and 4D spaced piles and at 25 mm for 6D and 8D spaced piles. Similarly the maximum load shared by the raft at applied settlement of 900 mm. Load sharing for piles

increases with the increasing spacing between the piles and value varies from 42.49 % to 76.08 % for 2D and 8D spacing respectively. However, the effect of pile spacing on load sharing of raft was not significant and varied from 72 % to 79 %.

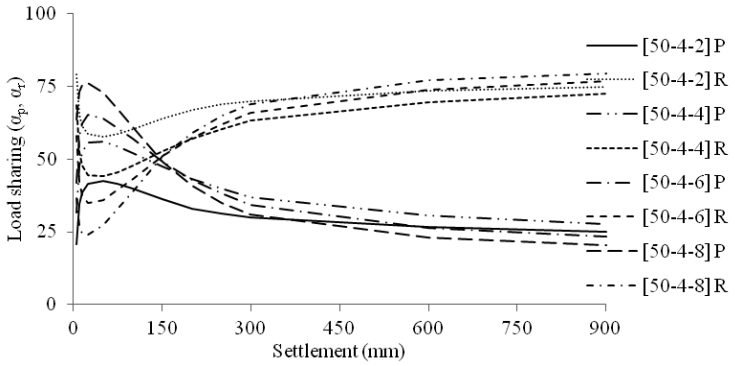


Fig. 5: (a) % Load Sharing of Pile [(P), α_p] & Raft [(R), α_r] in a Soil with 50 kPa Cohesion, with Varying Spacing (s) = 2D, 4D, 6D and 8D

Fig. 5(b) shows the percentage load shared by the piles increases gradually and maximum percentage of load shared by the piles were at applied settlement of 15 mm for 2D, 4D and 6D spaced piles and at 10 mm for 8D spaced piles for soil with 100 kPa cohesive strength. Load sharing for piles increases with the increasing spacing between the piles and value varies from 40.32 % to 73.12 % for 2D and 8D spacing respectively. However, the effect of pile spacing on load sharing of raft was not significant and varied from 84.83 % to 89.02 %.

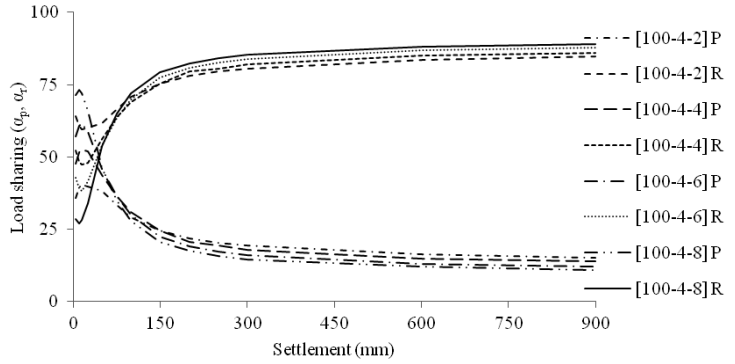


Fig. 5: (b) % Load Sharing of Pile [(P), α_p] & Raft [(R), α_r] in a Soil with 100 kPa Cohesion, with Varying Spacing (s) = 2D, 4D, 6D and 8D

Fig. 5(c) shows the percentage load shared by the piles increases gradually and maximum percentage of load shared by the piles were at applied settlement of 15 mm for 2D, 4D and 6D spaced piles and at 10 mm for 8D spaced piles for soil with 150 kPa cohesive strength. Load sharing for piles increases with the increasing spacing between the piles and value varies from 31.70 % to 57.78 % for 2D and 8D spacing respectively. However, the effect of pile spacing on load sharing of raft was not significant and varied from 89.14 % to 91.55 %.

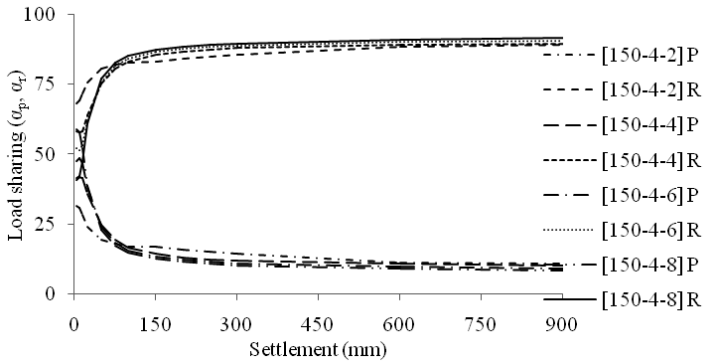


Fig. 5: (c) % Load Sharing of Pile [(P), α_p] and Raft [(R), α_r] in a Soil with 150 kPa Cohesion, with Varying Spacing (s) = 2D, 4D, 6D and 8D

Design & Strengthening Measures for Building Foundation Systems in Hilly Regions

Koushik Pandit & S. Sarkar

Objective:

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

Progress Highlights:

All 13 EWS (economically weaker section) building plans developed under standardization of design task at the institute for mass housing clusters have been analysed in Staad pro for earthquake zones IV and V (in which most of the hilly areas of India fall) for horizontal ground and sloping topography (Fig. 1). From these structural analyses, the maximum footing reactions have been computed for different load combinations as per the IS codes. These load values will be utilized to carry out foundation proximity interaction problems for hilly areas where clusters of houses come up. Further, the bearing capacity values based upon various RMR ranges were used for the computation of required footing sizes. The findings are as follows (Table 1) for EWS Plan 1:

Table 1: Bearing Capacity of Rock Mass based upon Various RMR Values

RMR of Rock Mass	Net Safe Bearing Capacity (kN/m^2) as per Table 3 of IS 12070: 2010	Earthquake Zone IV		Earthquake Zone V	
		Max. Design Load on Footing (kN)	Footing Size Required (m x m)	Max. Design Load on Footing (kN)	Footing Size Required (m x m)
100 to 81	4412	2720 for G + 3	0.78 x 0.78	1925 for G + 2	0.66 x 0.66
80 to 61	2843		0.97 x 0.97		0.82 x 0.82
60 to 41	1569		1.31 x 1.31		1.10 x 1.10
40 to 21	588		2.15 x 2.15		1.80 x 1.80
20 to 0	392		2.60 x 2.60		2.21 x 2.21

Similar Results for Other EWS Plans have been computed.

In continuation to the 2D finite element analysis of conventional strip footings on slopes, further numerical analysis of strip footing under pseudo-dynamic loading has been performed (Fig. 2).

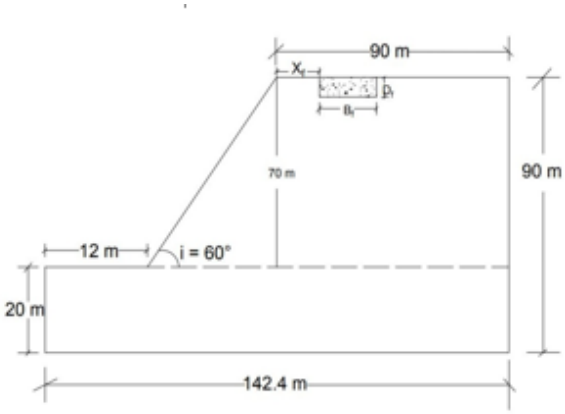


Fig. 1: Typical Geometry of the Slope Model

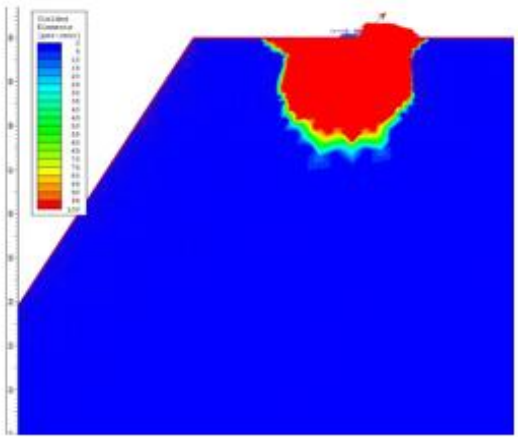


Fig. 2: Contour of Max. Shear Strain for a Typical Model

The obtained results have been compiled below in Table 2:

Table 2: Safety Factor of Slopes for Various Footing Sizes and their Locations w.r.t. Slope Crest

Foundation Depth (Df), m	Width of Footing (Bf), m	Footing Edge Distance (Xf)	Safety Factor of Slopes		
			Dry Static	Wet Static	Dry Pseudo-Static
0.2	0.2	5B = 1.0 m	1.00	1.00	1.00
		10B = 2.0 m	1.25	1.01	1.02
0.3	0.3	5B = 1.5 m	2.00	1.32	1.26
		10B = 3.0 m	2.08	1.37	1.29
0.4	0.4	5B = 2.0 m	1.30	1.14	1.13
		10B = 4.0 m	1.34	1.21	1.18

2D and 3D jointed discrete element modelling for rock mass has been initiated. For this purpose, universal distinct element code (UDEC) and three-dimensional distinct element code (3DEC) have been utilized. Once the expertise is developed, these codes will be used for carrying out the necessary parametric analysis for creating design charts and tabular values for foundation design on jointed rock mass.

Safety analysis of a slope (Fig. 3) with joints dipping at 145° (i.e., daylight out of the slope at 35°) and joint spacing of 20 cm was performed using discontinuum modelling in 3DEC. The failure mechanism that develops combines sliding along joints near the slope toe with tensile failure of the blocks near the top of the slope. The calculated factor of safety is 1.31 for this case (Fig. 4).

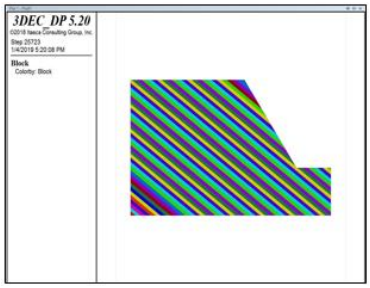


Fig. 3: Slope Model with Single Joints at 145^{o}

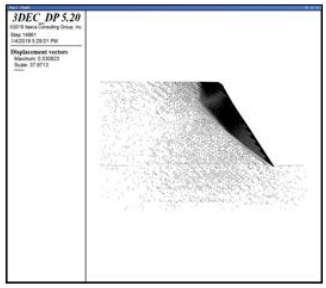


Fig. 4: Contour of Displacement Vectors

Numerical analysis for determining the maximum load bearing capacity has been done for footing size of 1m x 1m on a horizontal intact rocky ground. The safe load capacity was obtained was 138 kPa corresponding to a settlement of 11 mm (Fig. 5). Presently, analysis is under progress for single set of joints with varied spacing values.

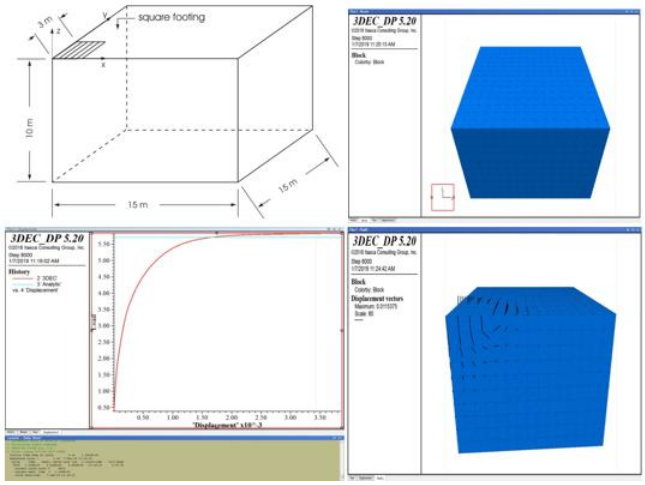


Fig. 5: Geometry, Model & Load-Displacement Curve for the Footing on Intact Rock

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

Manojit Samanta & Soumitra Maiti

Development of Innovative Hybrid Connections for Precast Concrete Construction

S.R. Karade & R.S. Chidambaram

Objectives:

- To develop an effective and economical hybrid connection technique using fiber reinforced composites and mechanical splices at the joints in precast framed structures
- To investigate the effectiveness of the hybrid connection in transmitting the forces at beam-beam, column to column and beam-column joints subjected to static as well as cyclic loading

Progress Highlights:

- Rebar Couplers have been developed and tested successfully to connect rebars of different sizes.
- The proposed precast connection techniques have been used and prepared a Column to Foundation Specimen and tested under cyclic loading.
- Precast beam to column connections with proposed methodology has been prepared and will be tested.
- Precast frame with CSIR-CBRI developed technique has been cast and will be tested.

Prefabricated Ferro Cement Sandwich Panel Based Housing System

S.K. Singh, Subash Chandra Bose Gurram & Surya M.

Objective:

To develop a housing system using ferrocement sandwich wall panels along with appropriate precast ferrocement roofing elements and foundation.

Progress Highlights:

Prefabrication is a process of fabricating some or all components of a unit or structure in a factory or on site under the open sky. Assembling and fitting prefabricated components together on site, where the structure is actually meant to be erected, is done later leading to readily usable unit or structure. With prefabrication, use of raw materials can also be optimized to make a good quality product. In most countries, prefabrication is adopted in building construction to increase productivity, improve quality, and cope with shortage of skilled labour. It is fast emerging as attractive alternative to on-site construction.

For casting ferrocement sheaths of the sandwich panel simultaneously, self-compacting mortar (SCM) shall be used. Self-compacting mortar was proportioned with cement, fly ash, super plasticizer and viscosity modifying agent (VMA) for a target compressive strength of 38.25 MPa. 24 trial mortar mix

proportions were tested and a mix proportion was finalized based on the slump flow and V-funnel test as specified by EFNARC guidelines. The mix proportions of the SCM is given in Table 1. Testing of self-compacting mortar is shown in Fig. 1 and 2**.**

Fig. 1: Mini Slump Flow Test

Fig. 2: V Funnel Test

Table 1: The Mix Proportions of Self-Compacting Mortar

Ingredients	**Cement**	**Fly-Ash**	**Fine Aggregate**	**Super Plasticizer (by Wt. of Cement + Fly-Ash)**	**VMA (by Wt. of Cement + Fly-Ash)**	**Water/ (Cement + Fly-Ash)**
Mortar Mix Proportion	0.73	0.27	2.0	4%	0.6%	0.43

The casting of sandwich panels (600 × 90/100 mm cross-section and 3000 mm height) with ferrocement skin layers on both the sides of 50 mm thick EPS core material has been attempted. Ferrocement layers were 20 and 25 mm thick for 90 and 100 mm thick panels, and reinforced with two and three layers of wire mesh of 20 gauge and 1/2" x 1/2" opening respectively. 3 mm steel was used as skeletal steel to hold the wire mesh of ferrocement layer in place and was also used to make Z-shape shear connectors to keep skeletal steel layers on both sides of EPS as shown in Fig. 3. Hardened ferrocement sandwich panels after curing are shown in Fig. 4.

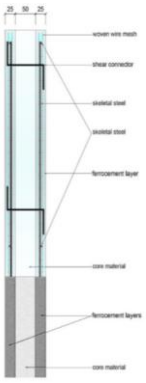


Fig. 3: Diagram of Panel

Fig. 4: Sandwich Panels Cast

Further work on casting of ferrocement sandwich panels with ribs is under progress. Self-compacting mortar shall be used to cast ferrocement sheaths and ribs of a panel in vertical position simultaneously.

Development of a New Constitutive Relationship for 1D Nonlinear Site Response Analysis

Anindya Pain

Objective:

To develop a new constitutive model whose model constants are calibrated using both curves (modular reduction and damping curves) at the same time.

Progress Highlights:

Seismic response of layered soil deposit subjected to earthquake excitation is still one of the most interesting topics in earthquake engineering. Seismic response of any site of interest is generally assessed by 1D equivalent linear or fully non-linear analysis.

In the present study, a Generalized Bouc-Wen class models is proposed to capture the asymmetric behaviour of soil at the high cyclic shear strain. The strength and stiffness degradation parameters are expressed as a function of dissipated hysteretic energy. The ordinary differential equation is solved using an explicit fourth order Runge-Kutta method. Particle Swarm Optimization (PSO) is used to identify the model parameters. The calibrated model could successfully capture the stiffness decay, loss of strength, pore water pressure and asymmetric behaviour of saturated sand for the high cyclic shear strain.

Pore water pressure (PWP) is an important parameter in a strain controlled cyclic triaxial test. Law et al. (1990) experimentally showed that there is a unique relationship between excess pore water pressure and cumulative dissipative energy over cyclic loading of sand. Hence, the pore water pressure may be obtained if the dissipated hysteretic energy is known. The pore water pressure may be determined utilizing the hysteresis energy dissipated in the GBW model along with the empirical relationship proposed by Law et al. (1990).

PWP response of Assam sand at different peak cyclic shear strain is reported in Dammala et al. (2019) for relative density (R_d) = 30 %, effective confining pressure (σ'_3) = 100 kPa and frequency (f) = 1 Hz. PWP response from the GBW model was compared with this experimental data to check the general prediction capability of the proposed model at other peak cyclic shear strain. The simulation results of PWP are quite comparable with the experimental results (Fig. 1). GBW model slightly under predicts the PWP response for lower peak cyclic shear strain but for higher peak cyclic shear strain the PWP response from GBW model matches exactly with the experimental results.

Till date the empirical PWP model of Vucetic and Dobry (1988) is used because of its simplicity. Recently, Mei et al. (2018) had improved the Vucetic and Dobry (1988) model based on the literature data on clean silica sand. Still the model is empirical in nature and solely depends on the curve fitting. GBW is a single model where the cyclic response and PWP model both are evaluated and they are interrelated. Fig. 2 shows comparison of PWP response for two peak cyclic shear strain γ = 0.075 % and 0.15 % from the model of Vucetic and Dobry (1988), Mei et al. (2018) and GBW with the experimental data of Dammala et al. (2019). Please note that, the response of earlier Vucetic and Dobry (1988) PWP model is very poor. It always overestimates the PWP irrespective of number of

loading cycles. PWP response obtained from Mei et al. (2018) and GBW are comparable and both are close to the experimental results. PWP model of Mei et al. (2018) is solely empirical in nature and it is limited to clean silica sand only. Whereas GBW model works, independent of soil type as it runs on the concept of energy dissipation, which is a physical quantity. Better approximation of the area under the hysteresis loop may be the key reason for better performance of GBW model.

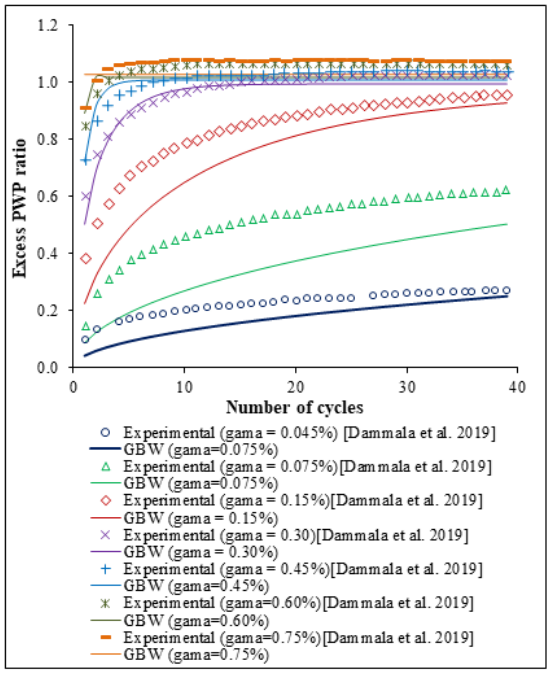


Fig. 1: Comparison of Excess Pore Water Pressure Ratio from GBW Model & Experimental Results from Dammala et al. (2019) of Assam Sand for Relative Density (R_d) = 30 %, Effective Confining Pressure (σ'_3) = 100 kPa & Frequency (f) = 1 Hz

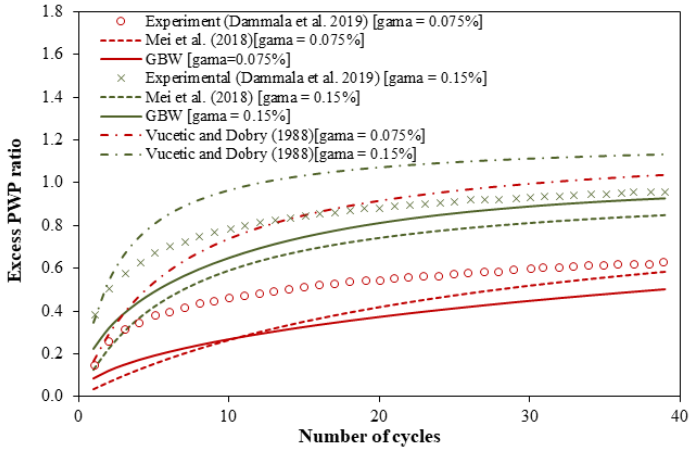


Fig. 2: Comparison of Excess Pore Water Pressure Ratio from GBW Model, Vucetic & Dobry (1988) Model, Mei et al. (2018) Model & Experimental Results from Dammala et al. (2019) of Assam Sand for Relative Density (Rd) = 30 %, Effective Confining Pressure (σ′3) = 100 kPa, Frequency (f) = 1 Hz & Peak Cyclic Shear Strain (γ) = 0.075 % & 0.15 %

CONSERVATION OF HERITAGE STRUCTURES

Technologies for Robust Structural Health Monitoring of Critical Infrastructure & Conservation & Restoration of Heritage Structures

A.K. Mittal

Objective:

To provide a holistic approach for conservation and restoration of Heritage Structures. The objective is classified in different domains as follows:

1. Classification & Categorization
   - Classification of Important Heritage Structures & Extracting Superior Features of Indian Traditional Knowledge of Building Science
     A.K. Mittal, Hina Gupta, Debdutta Ghosh &Amit Kush

2. Structural Analysis & Restoration Technologies
   - Simplified Analysis Procedure for the Complex Heritage Structural Systems
     Debdutta Ghosh, Hina Gupta & A.K. Mittal

   - Geotechnical Investigation of Foundation Systems
     Aswathy M.S., A.K. Mittal & Siddharth Behera

   - Structural Restoration & Retrofitting Techniques for Heritage Structures
     Hina Gupta, Debdutta Ghosh, A.K. Mittal & Siddharth Behera

   - Analysis of Heritage Structures: Pre & Post Retrofitting
     Siddharth Behera, A.K. Mittal, Debdutta Ghosh & Hina Gupta

3. Non-Destructive Evaluation
   - Hybrid Non-Destructive Evaluation Techniques & Signal Processing Algorithms for Multi-Wave Imaging
     Debdutta Ghosh, Hina Gupta & A.K. Mittal

   - In-Accessible Foundation Studies of Cultural Heritage Sites using Non-Invasive Techniques
     P.K.S. Chauhan, D.P. Kanungo, Zamir Ahmad, A. Dwivedi & B. Bisht

4. Environmental Aspects
   - Identification of Fungi on Select Heritage Structure & Development of Suitable Anti-Fungal Chemical from Medicinal Plants
     Rajesh K. Verma, Neeraj Jain, L.P. Singh & A.K. Mittal

5. Material Development
   - Conservation & Restoration of Lime Mortars & Brickworks
     L.P. Singh, Srinivasrao Naik B. & A.K. Mittal

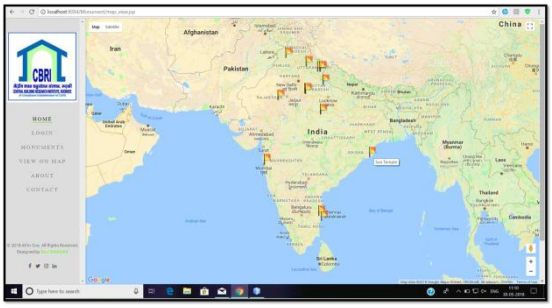
   - Development of Compatible Repair Materials for Stone Masonry in Heritage Structures

     Rajni Lakhani & Rajesh Kumar

6. Skill Development Program
   - Skill Development, Upgradation & Training Program for Field Engineers, Technical & Non-Technical Manpower
     A.K. Mittal, I.A. Siddiqui & Deepak Dharmshaktu

Progress Highlights:

- A website having unique data on Heritage Structures launched by DG, CSIR on December 24, 2018 (Fig. 1(a-c)).
- A book on collection of superiority features of Indian Heritage Structures also launched by DG, CSIR (Fig. 1(d)).



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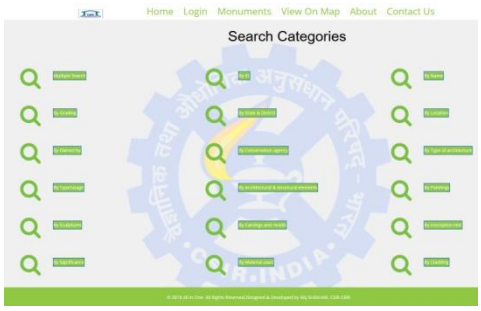


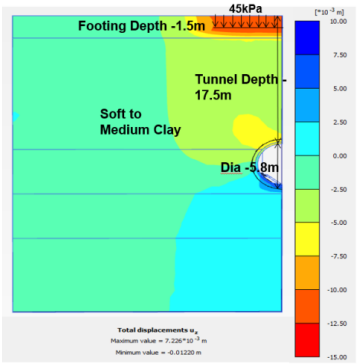
(b)

(c)

(d)

Fig. 1: Glimpses of Launch of Website & Superiority Feature Book on Heritage by DG, CSIR

- Settlement prediction due to tunnelling/excavation is undertaken through numerical analysis and analytical methods for nine case studies (Fig. 2). Study on ground improvement to mitigate settlement in progress.



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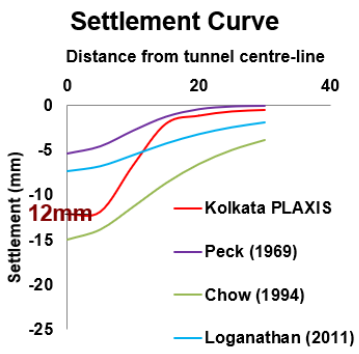
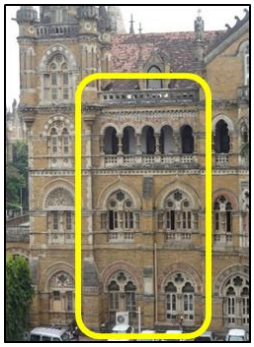


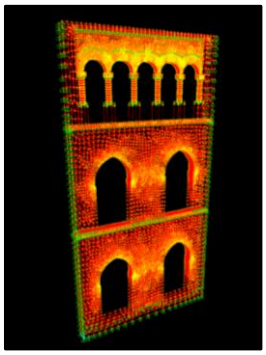
(b)

Fig. 2: Settlement Prediction due to Tunneling

- Study of various retrofitting schemes under practice for old buildings and heritage structures is carried out. Analysis with and without strengthening are applied for DRM Building, Mumbai (Fig. 4). Approximate analysis procedure is applied for Old Delhi Railway Station, CSMT Mumbai (Fig. 3). Different types of materials and techniques used in the heritage structures are being explored.



(a)



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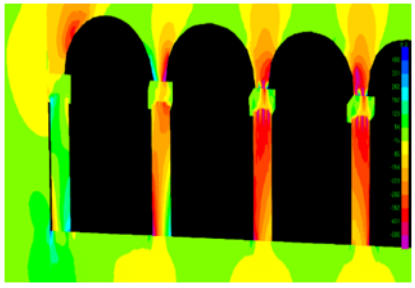
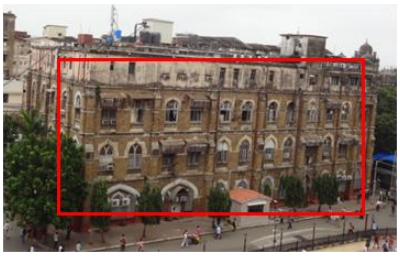
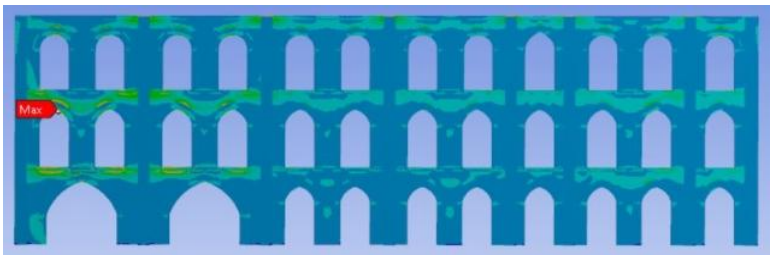


(d)

Fig. 3: The Front Façade of the Southern Wing of CSTM Building is Modeled for Structural Analysis



(a)



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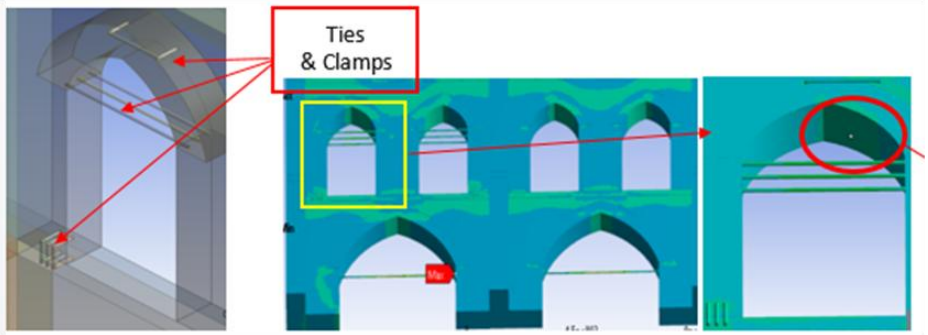


(c)

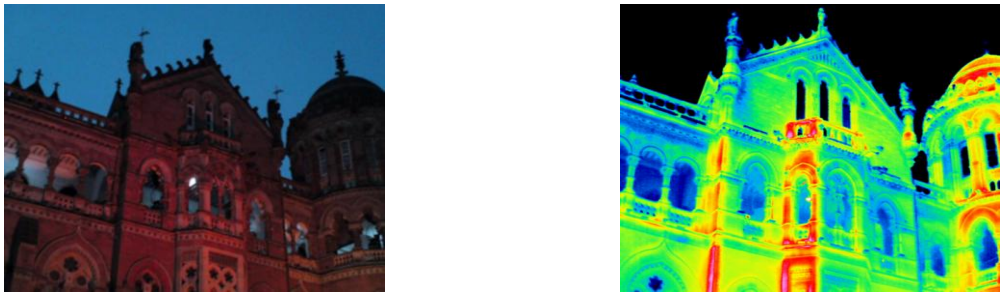
Fig. 4: FEM Analysis of DRM Building, Mumbai (without & with Strengthening)

- Experimentation is going on for the development of retrofitting strategy. Two innovative setups are developed for simulating diagonal tension testing (Fig. 5) and differential settlement of heritage structural component. After experimentation in the laboratory (Fig. 6), Vibrating Wire Strain Gauges (VWSG) were installed on the selected locations of steel box portal frame inside the Jagmohana of Shri Jagannath Temple, Puri. Data is continuously obtained from VWSG sensors, which were fixed to the portal frame by arc welding and covered with protection boxes.

Fig. 5: Test Setup for Diagonal Compression & Shear

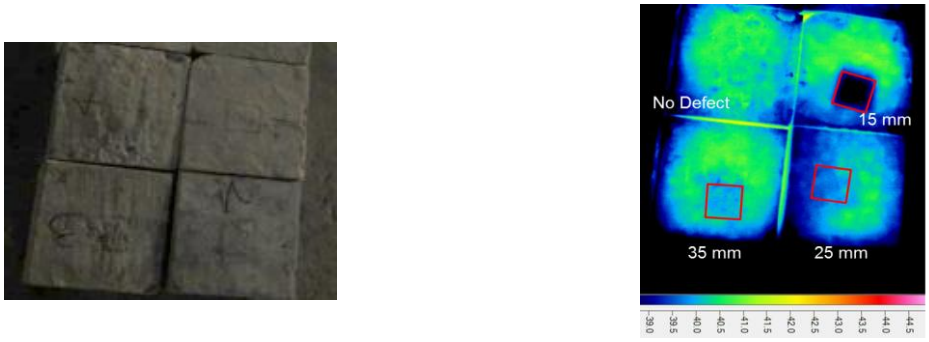
Fig. 6: Experimentation on Vibrating Wire Strain Gauge at Structural Engineering Laboratory of CSIR-CBRI

- Developed techniques for heritage structure inspection using active and passive thermography. Infrared thermography and ultrasonic technique is being used to detect defects in controlled concrete specimens. Phased and amplitude based thermal imaging algorithm is developed for delamination detection. The passive thermography technique is successfully applied to various heritage structures viz. NAI Delhi, CSTM Mumbai (Fig. 7), Old Delhi Railway Station, FRI Dehradun, Humayun's Tomb, Solani Aqueduct, UP Irrigation workshop etc. Algorithms are developed for active thermography (Fig. 8) and ultrasonic imaging technique.



(a) **(b)**

Fig. 7: CSMT Mumbai (Passive Thermography)

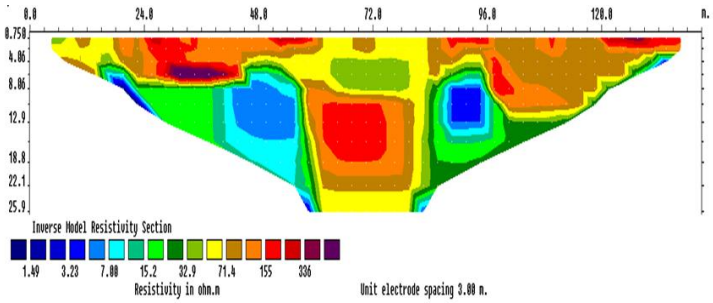


(a) **(b)**

Fig. 8: Defects Located at Several Depths are Detected (Active Thermography)

- The Resistivity Imaging Method (ERT) has been carried out at Solani Bridge new and old. The survey was conducted at two orthogonal directions at new Solani Bridge while along the river flow direction at old Solani Bridge. The data analysis shows the foundation signatures on the profiles and the results were in good agreement with the drawing available for old Solani Bridge (Fig. 9).

(a)



(b)

Fig. 9: Foundation Signatures Solani Bridge (Parallel to Bridge)

- Experimental work in progress to develop eco-friendly anti-fungal product (Fig. 10 and 11).

(a) **(b)** **(c)**

Fig. 10 : Microscopic Image of *Curvularia, Aspergillus* & *Fusarium*

(a) **(b)**

Fig. 11: Microscopic Image of *Talaromyces* & *Alternaria*

- Three sites of archaeological importance i.e. FRI (Forest Research Institute (Dehradun)), Solani Aqueduct (Roorkee) and NAI (Delhi) have been identified for the restoration of lime mortar and brickworks. Lime mortar and brick samples are collected from different locations of all three buildings for detail physio-chemical analysis (Fig. 12). Cost effective lab scale preparation of nano-lime and its characterization using various instrumental techniques (Fig. 13 and 14). Order placed for small pilot plant for nano-lime preparations. Efforts are being made to prepare nano-lime < 100 nm size.

Fig. 12: Mortar Sample of Solani Aqueduct, Roorkee

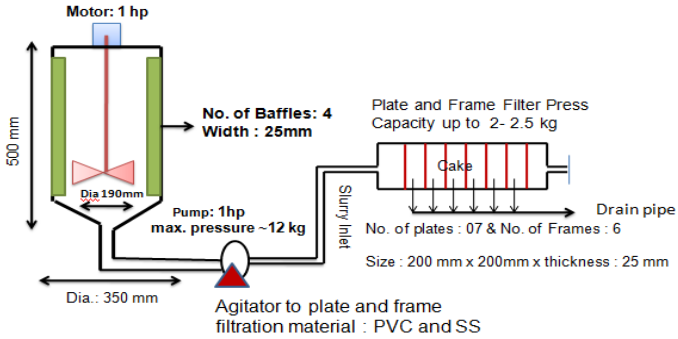
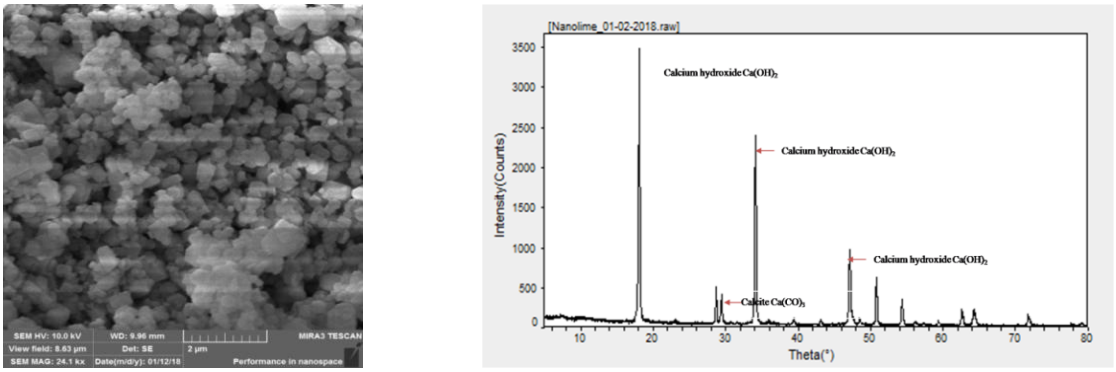


Fig. 13: Installed Integrated Agitator Vessel with Plate & Frame Filtration Unit



(a) **(b)**

Fig. 14: XRD & FE-SEM Analysis of Prepared Nanolime

- Characterization of raw materials viz., lime, fly ash and water-soluble polymers has been done for development of self-curing repair materials. Optimization of mix proportions for development of repair material is in progress. Characterization of various mixes through flow table, compressive strength testing, shrinkage tests and thermal analysis. (Fig. 15-17)

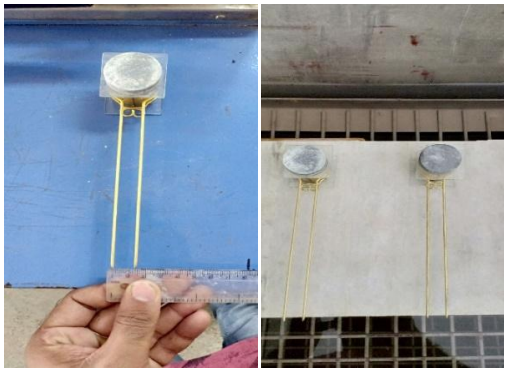


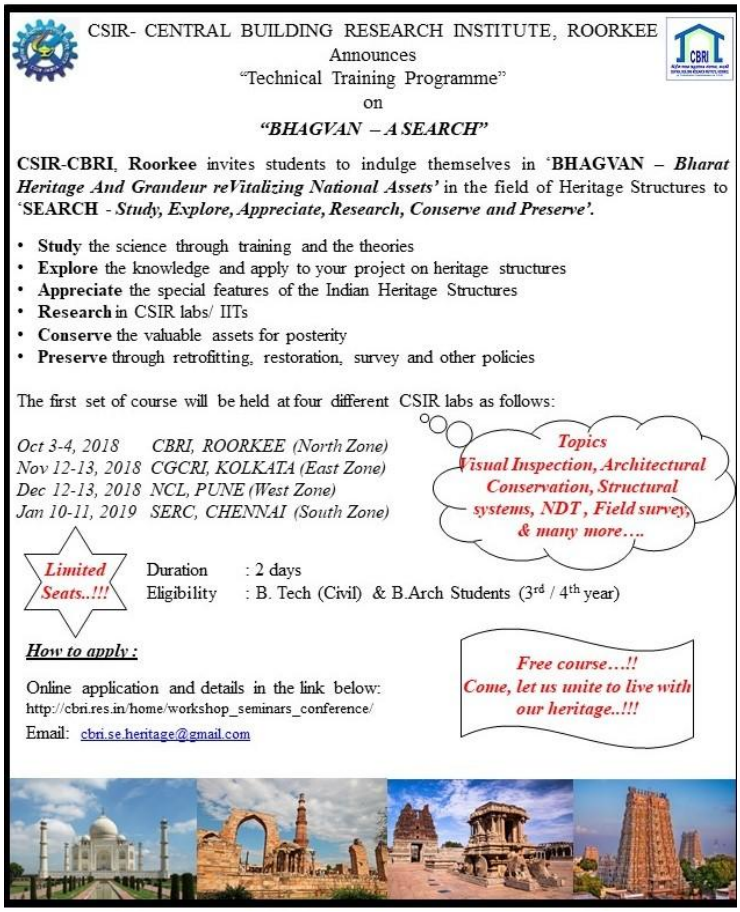
Fig. 15: Soundness Test

Fig. 16: Flow Table Setup

(a) **(b)**

Fig. 17: Compressive Strength Test on Lime Mortar Samples

- Technical training program development "BHAGVAN – A Search" (Bharat Heritage And Grandeur reVitalizing National Assets) has been conducted in 4 zones of the country: Roorkee (North), Pune (West), Kolkata (East), Chennai (South). Advertisement has been published in National Newspapers (Fig. 18). Students from India and abroad have attended the program (Fig. 19). PIs are guiding B. Tech and M. Tech students on different aspects of heritage structures.



CSIR- CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE
Announces
"Technical Training Programme"
on
"BHAGVAN – A SEARCH"

CSIR-CBRI, Roorkee invites students to indulge themselves in '**BHAGVAN** – ***Bharat Heritage And Grandeur reVitalizing National Assets'*** in the field of Heritage Structures to '**SEARCH** - ***Study, Explore, Appreciate, Research, Conserve and Preserve'.***

- **Study** the science through training and the theories
- **Explore** the knowledge and apply to your project on heritage structures
- **Appreciate** the special features of the Indian Heritage Structures
- **Research** in CSIR labs/ IITs
- **Conserve** the valuable assets for posterity
- **Preserve** through retrofitting, restoration, survey and other policies

The first set of course will be held at four different CSIR labs as follows:

Oct 3-4, 2018 CBRI, ROORKEE (North Zone)
Nov 12-13, 2018 CGCRI, KOLKATA (East Zone)
Dec 12-13, 2018 NCL, PUNE (West Zone)
Jan 10-11, 2019 SERC, CHENNAI (South Zone)

Topics
Visual Inspection, Architectural Conservation, Structural systems, NDT , Field survey, & many more….

Limited Seats..!!!

Duration : 2 days
Eligibility : B. Tech (Civil) & B.Arch Students (3rd / 4th year)

How to apply :

Online application and details in the link below:
http://cbri.res.in/home/workshop_seminars_conference/
Email: cbri.se.heritage@gmail.com

Free course…!!
Come, let us unite to live with our heritage..!!!

Fig. 18: Advertisement for the Training Program

(a)

(b)

(c)

(d)

(e)

(f)

Fig. 19: Glimpses of Training Program held in Different Zones of India

INNOVATIVE BUILDING MATERIALS

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. & S.K. Singh

Objective:

To develop precast building components from geopolymer concrete.

Progress Highlights:

The geopolymer concrete is an alternate to conventional cement concrete, which has several environmental benefits and advantages. The mix proportioning of geopolymer concrete with a compressive strength of 30 MPa was carried out using fly ash based composite binder. Two mixes were prepared. The mix consisted of 400 kg of binder and activator to binder ratio of 0.45. Fresh and hardened properties of the concrete were tested. The workability of geopolymer concrete was measured with slump cone test and was found to be 15 mm and 25 mm for the 2 mixes. The compressive strength of the mixes was 25.4 MPa and 28.6 MPa respectively at the age of 7 days. The 28 days compressive strength was 37.5 MPa and 38.4 MPa respectively. For comparison purpose, cement concrete samples were also prepared along with geopolymer concrete samples. Mix proportion of cement concrete for a compressive strength of 30 MPa was carried out. The compressive strength of the mix at an age of 7 days and 28 days was 34.9 MPa and 41.32 MPa respectively. Samples for testing of spitting tensile strength, flexure strength and elastic modulus for geopolymer and control cement concrete were also casted. These samples were tested at an age of 28 days. The splitting tensile strength of geopolymer concrete was 2.06 MPa and for cement concrete it was 2.82 MPa. The flexure strength of geopolymer concrete and cement concrete was 4.3 MPa and 4.9 MPa respectively. Elastic modulus and Poisson's ratio of geopolymer and cement concrete were evaluated by testing cylinder samples in a compression-testing machine as per IS 516. The elastic modulus of geopolymer concrete was found to be less than the cement concrete. The elastic modulus value for geopolymer concrete was 18.36 GPa while for cement concrete it was 35.92 GPa. The Poisson's ratio of both the concrete was found to be 0.17.

Prefabricated roofing elements of reinforced concrete plank and reinforced concrete joist were prepared from both geopolymer and cement concrete (Fig. 1). Precast reinforced panels of length 1.5 m, width 300 mm and 60 mm thickness were designed as per IS 13994. The reinforcement of 6 mm was used. Precast reinforced panels were cast using the two geopolymer concrete mixes. The dimensions of the casted precast samples were checked and were found to be within the tolerance limits prescribed by the code. The edges and corners of the panels were sharp and intact. RC joist of 2.5 m length, width 150 mm and depth 150 mm were prepared with geopolymer concrete and cement concrete. The samples were kept for 28 days and then the casting for the haunch feeling of plank and joist was carried out in accordance with IS 13990. The prepared samples are tested as per IS 13990. The RC planks have been tested for their deflection recovery under a load of 1.25 times the imposed design load (Fig. 2). The RC planks are loaded in a uniformly distributed form. Load-deflection curve of RC plank made of geopolymer concrete and cement concrete is shown in Fig. 3. It is found that the deflections under the maximum design imposed load (3 kN/m^2) are both well within that required for the serviceability condition. Failure load test is also done to access the load carrying capacity of the RC planks.

Fig. 1: Casting of RC Plank & Joist from Geopolymer Concrete

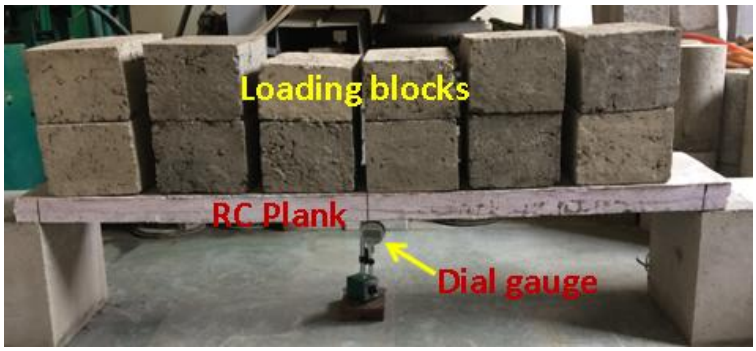


Fig. 2: Deflection Recovery Test of RC Plank

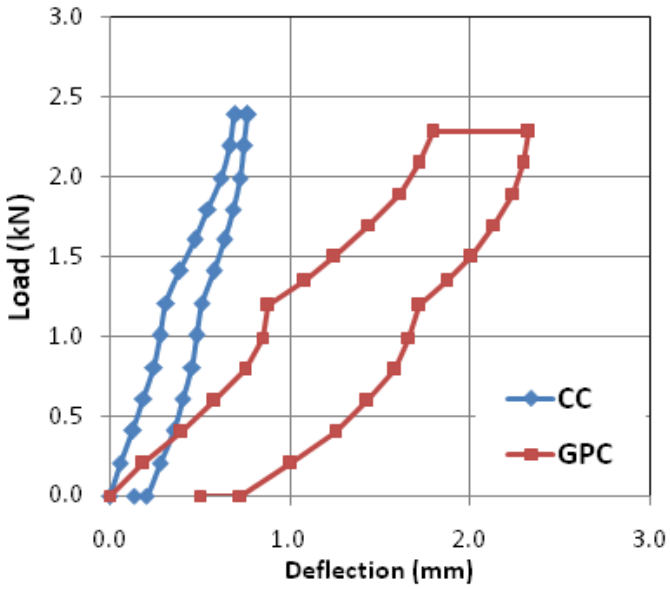


Fig. 3: Load-Deflection Curve for Deflection Recovery Test of RC Planks

Recyclability of Marble Waste in Concrete Production & Other Building Products

Rajni Lakhani, Rajesh Kumar & Koushik Pandit

Objectives:

- To develop the formulation for lightweight blocks i.e. autoclaved aerated concrete and cellular concrete blocks using marble cutting and 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:

As per the proposed objectives; after characterization of major raw materials (OPC, All-in-aggregates using marble waste, superplasticizer); mix-proportions (Table 1) were made to optimize the critical parameter for Mosaic flooring tiles. The preparation of mosaic flooring tiles of size 250 mm x 250 mm, 300 mm x 300 mm and 400 mm x 400 mm were done.

Basic raw materials used were cement (grey and white), marble waste chips, fine aggregates and coloring oxide. Three layers process were facing, intermediate and backing layers (Fig. 1). The facing mixture was first fed to a thickness of about 6.5 mm, then intermediate and then backing mixture to thickness of 9 mm each. The raw materials were mixed thoroughly and kept separately on platform of hydraulic press (pressure of 150 kg/cm^2). The tiles were kept for 24 hours for air setting and then immersed in water for 15 days. The cured tiles were kept in shed for a period of about 4-5 days for drying and polished.

Table 1: Mix-Proportions to Develop Mosaic Tiles using Marble Waste

Facing mixture					
White cement	**1**	**1**	**1**	**1**	**0.5**
OPC	**1.5**	**1.5**	**1**	**1**	**0.5**
Marble chips	**4**	**4**	**5**	**6**	**6.5**
Marble powder	**1**	**1**	**1.5**	**2**	**3**
Intermediate Mixture					
OPC	**1**	**0**	**0**	**0**	**0.5**
Fine agg. (MSW)	**1**	**0**	**0**	**0**	**1**
Backing Mixture					
OPC	**1**	**1**	**1**	**1**	**1**
Fine agg. (MSW)	**4**	**4**	**4**	**4**	**4**
WC: OPC: A	**1: 3.5: 10**	**1: 2: 8**	**1: 2: 10.5**	**1: 2: 12**	**0.5:2:14.5**
Waste content	**70.0 %**	**72.7 %**	**77.8 %**	**80 %**	**85.3 %**
MOR, MPa	**4.9**	**4.2**	**3.6**	**3.4**	**2.8**

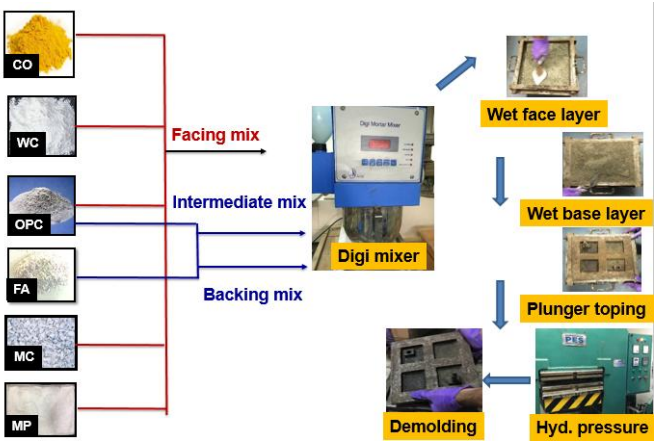


Fig. 1: Process of Manufacture
(*CO-Coloring Oxides; WC-White Cement; MC-Marble Chips; MP-Marble Powder)

The physico-mechanical properties of the tiles were determined as per IS: 1237 and 13801 (Fig. 2). The modulus of rupture (MOR) varied from 2.4 MPa to 4.9 MPa, water absorption (WA) ranged from 5% to 13.5% and wear resistance from 0.72 mm to 3.79 mm; for marble waste content of 60 % to 85%, respectively.

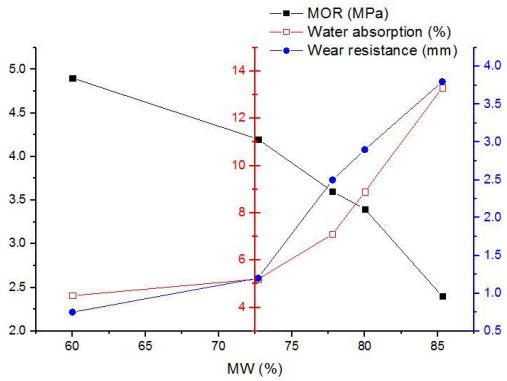


Fig. 2: MOR, WA & Wear Resistance of Mosaic Tiles

Mosaic tiles were developed using final optimized mix-proportion, as shown in Fig. 3.

Fig. 3: Developed Mosaic Flooring Tiles using 80-85% Marble Waste, by weight

Different physico-mechanical properties of above tiles were determined, as per IS: 1237 and 13801 (Table 2).

Table 2: Physico-Mechanical Properties of Developed Mosaic Tile (Heavy Duty & General Purpose)

Properties of Tiles	General Purpose	Heavy Duty	IS: 1237
Dimensions (mm)	As per Standard	As per Standard	200 X 200 } Thickness 22 mm 250 X 250 300 X 300 } Thickness 25 mm 400 x 400
Water Absorption (%)	5.0	8.5	10 Max.
Wet transfer strength (MPa)	3.0	4.9	3.0 Min.
Resistance to wear (mm)	2.5	0.72	2.0-3.5
Straightness (%)	0.44	0.35	1.0, Max.
Perpendicularity (%)	0.30	0.20	2.0 Max.
Flatness of tile surface (mm)	0.44	0.40	1.0 Max.

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

Monalisa Behera & Md. Reyazur Rahman

Objective:

To develop SCC made with recycled fine aggregate (RFA) at a partial or complete replacement for its application in the precast industry.

Progress Highlights:

Self-Compacting Concrete (SCC) is a new advancement in the concrete industry to satisfy the performance expectations in terms of faster construction time to fulfil the sustainable societal needs. It has established its importance in the construction industry, especially in the precast sector due to its high flowability, excellent passing ability and its better surface finishing characteristics. The increased inclination towards the natural resources due to huge demand in infrastructure has led to the severe environmental cost. SCC requires a higher amount of fine aggregate, which is more than 50 % of the total aggregate content which contributes towards the fluid carrying media along with the fine powder for coarse grain particles. Hence, producing self-compacting concrete (SCC) with recycled aggregate to replace natural aggregates will provide a sustainable solution in minimizing the environmental cost.

The target is aimed to achieve a target slump flow of more than 650 mm and target strength of 40 MPa. This study also evaluates the flow properties of the developed SCC made with RFA and its potential for the development of SCC for field implementation.

The prime concern in this study was to maintain the stability or the robustness of SCC made with RFA due to the high water absorption tendency of RFA, which may adversely affect the flow properties of the resulting concrete. The natural sand was replaced by RFA at 0 %, 50 % and 100 % by volumetric proportion. Several trail mixes are done to optimize the concrete mixes at various percentage replacement of the RFA. The self-compacting/ the flow criteria was achieved by adjusting only three parameters such as the water absorption kinetics, the super plasticizer and the VMA dosage

and keeping the other constituents of concrete such as the powder content, coarse and fine aggregate contents as constant. The target flow and the target strength were successfully achieved by all the mixes at various replacements of natural sand with RFA. This study demonstrated that the implication of RFA in developing SCC will give an insight of sustainability in construction sector with adequate mix design.

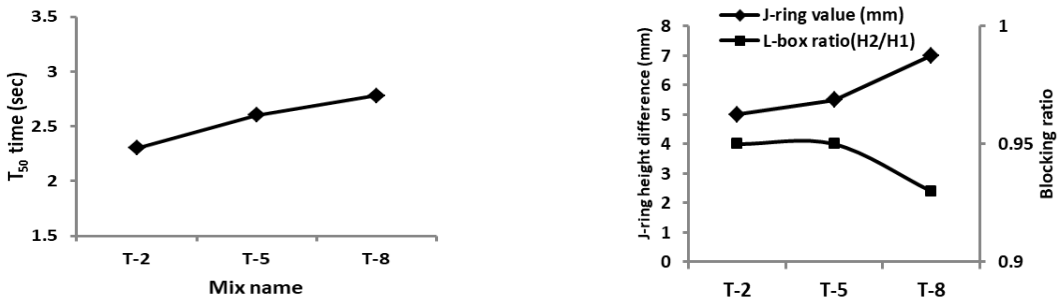
SCC has three functional requirements such as filling ability, passing ability and segregation resistance. These flow criteria of SCC have been successfully maintained and evaluated through slump flow, V-funnel, L-box, J-ring, U-box test and the static segregation test as shown in Fig. 1 and 2. The confirmatory test has also been evaluated through slump retention test. The slump flow values obtained by the three final mixes such as T-2, T-5 and T-8 are shown in Table 1 given below. The other flow criteria are evaluated and reported here in Table 2. The compressive strength of the SCC mixes is also shown in Fig. 3 with respect to various ages.

(a) **(b)** **(c)** **(d)** **(e)**

Fig. 1: Flow Criteria

Table 1: Slump Flow Value

Mix name	Slump flow (mm)	Visual observation
T-2	732	Viscous, No segregation
T-5	725	Viscous and No segregation
T-8	760	Viscous mix, no segregation



(a) **(b)**

Fig. 2: T_{50} Values, J-Ring & L-Box Results

Table 2: V-Funnel & U-Box Test Results

Mix name	V-funnel (sec)	V-funnel $T_{5\ min}$ (sec)	U-box ($H_2 - H_1$) (mm)	Visual observation
T-2	5.47	6.1	17	No blockage
T-5	8.37	9.25	10	No blockage
T-8	6.44	8.83	22	No blockage
Limit	7-12	+3	0-30	-

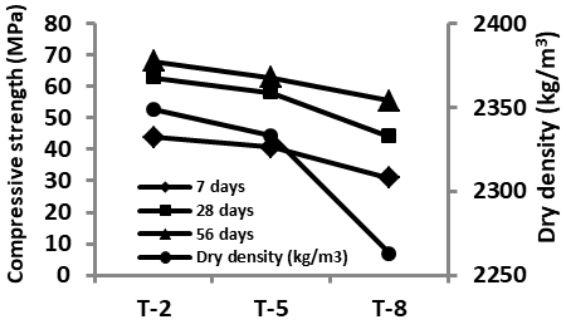


Fig 3. Compressive Strength & Dry Density

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

Siddharth Singh & Soumitra Maiti

Objectives:

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

Progress Highlights:

- Fluorogypsum (FG) panels were casted for acoustic, fire and thermal characterisation.
- Noise reduction coefficient (NRC) of perforated FG sample (100 mm diameter, 10 mm thickness) is around 50 percent with highest being 80 percent in 250-300 Hz.
- For non-perforated FG samples, the NRC value was found to be 22 percent.
- Weight issue of FG panels due to high density of FG (1.6-2.0 g/cc) has been resolved by addition of micro-silica.
- FG panels of 30 mm thickness (300 mm x 300 mm) without silica addition shows a thermal conductivity of 0.343 W/m.K and with silica addition: 0.242 W/m.K.
- Reduction of 30 percent in thermal conductivity is observed by silica addition.
- FG panels exposed to fire at 760 ºC shows no sign of flame spread or release of any toxic gases from the sample.

Acoustic testing of the FG samples was carried out for sound absorption, reflection and transmission loss measurements. Sound absorption coefficient of the perforated and non-perforated gypsum sample was done in accordance with ISO 10354-2 for diameter of 100 mm and 30 mm and 10 mm thick cylindrical sample. The frequency ranges for testing of the sample was in the range of 50 Hz to 2000 Hz. The obtained NRC data was analysed by AED 1401 software. Fig. 1 shows perforated, non-perforated FG samples of 100 mm diameter along with perforation design and shape in detail. Fig. 2 shows noise reduction coefficient (NRC), reflection coefficient plots of perforated and non-perforated FG sample. Fig 3 shows the unexposed surface temperature plots of 12 mm and 85 mm thick FG panels exposed to flame temperature of 760°C.

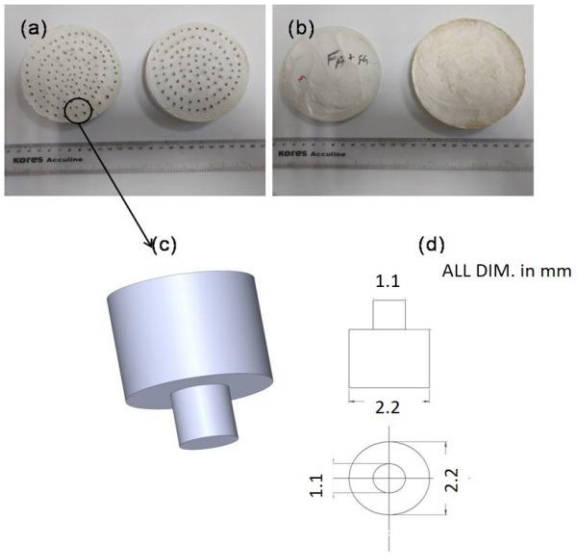
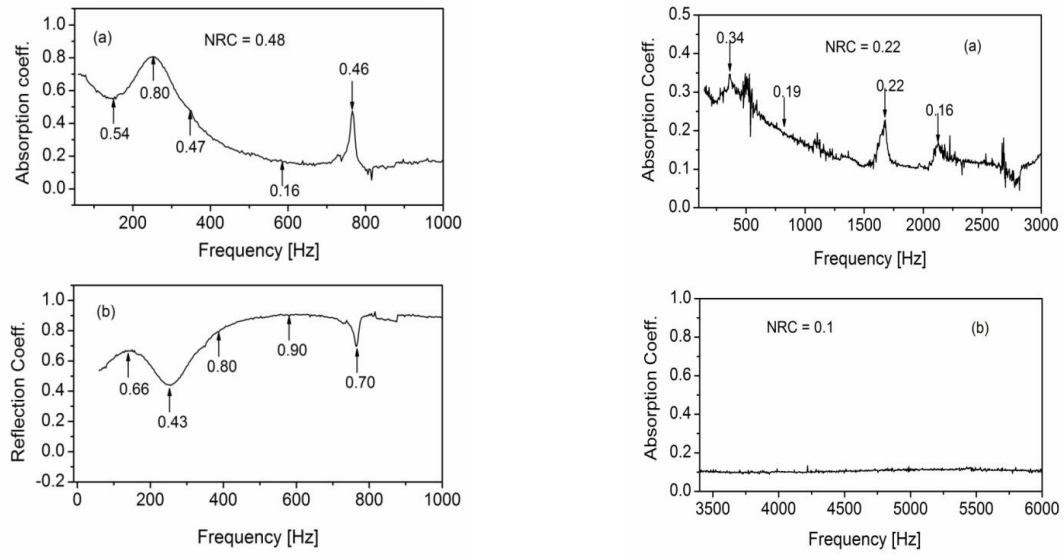
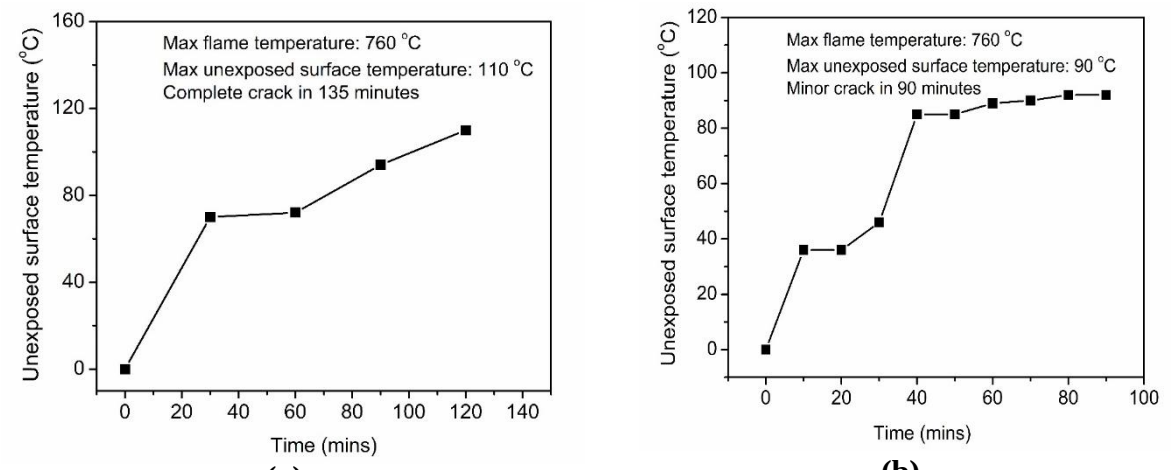


Fig. 1: (a) Perforated Fluorogypsum Test Specimens of 100 mm Diameter, (b) Non-Perforated Test Specimen of 100 mm Diameter (c) & (d) Designed Perforation Shape & Dimension for Sound Attenuation



(a) (b)

Fig. 2: (a) NRC & Reflection Plot of Perforated FG Sample & (b) NRC Plot for Non-Perforated (b) FG Sample



(a) **(b)**

Fig. 3: Unexposed Surface Temperature Plot for FG Panel (a) of 12 mm Thickness & (b) 85 mm Thick FG Block with Silica Addition

Development of Cement-Admixture System for Low Temperature Concreting

Jeeshan Khan, Ishwariya G., Md. Reyazur Rahman, Rakesh Paswan & S.K. Singh

Objectives:

- Effect of various admixtures on process of cement hydration at low temperature
- Improvement in cement paste microstructure under low temperature hydration process
- Performance evaluation of low temperature concrete

Progress Highlights:

- Cold weather is defined as a period when, for more than 3 consecutive days, the following conditions exist: (1) the average daily air temperature is less than 5 °C and (2) the air temperature is not greater than 10 °C for more than one-half of any 24-hr period (ACI Committee 306).
- Cold weather can leads to water freezing, slow hydration of cement and concrete freezes before acquiring adequate strength during curing that can have an adverse effect on properties of concrete and service life of structures. Conventional cold-weather concreting procedures employ artificial heating techniques to prevent freshly placed concrete from freezing. At low temperature, low hydration speed decelerates the formation of calcium-silicate-hydrate (C-S-H) and leads to a less dense C–S–H, which is the most important component of hydration, and bonding property, it results in a delayed resistance acquisition.
- Chemical admixtures are routinely used to improve and enhance the characteristics of concrete mixtures. A technologically simple and beneficial alternative is to use admixture. Calcium chloride has been widely used for many decades as an accelerator. However, due to its tendency to promote corrosion of steel, it is no longer recommended for use in steel reinforced concrete.
- Anti-freeze admixture with right combinations of chemicals are needed to achieve three primary objectives, depress the freezing point of the mix water available for the hydration process,

accelerate the strength gain at low temperature and reduces the overall quantity of water needed in the mixture with ensure a quick and sufficient hydration of a cementations composition.

- When the admixtures do not contain the same ions as in the cement phases (i.e., Ca, Si or Al ions), they accelerate the hydration process slowly. The admixtures calcium nitrate that contain the same cations as C_3S and C_2S, and accelerate hydration by nucleating action of such ions and these results in an intensification of the processes of crystallization of hydrate.
- In experimental investigations, OPC 43 cement (Ultratech ltd.) were used. Vicat apparatus determined initial and final setting time. Setting times of OPC 43 is shown in Fig. 1.

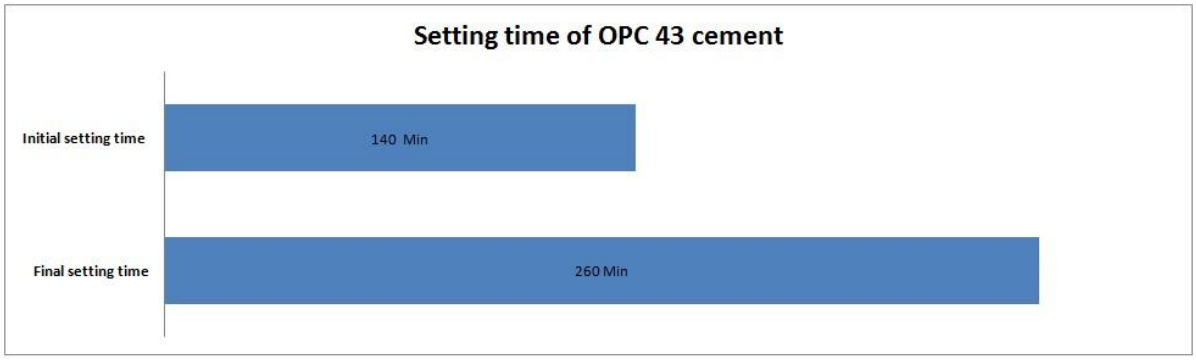


Fig. 1: Setting Times of OPC 43 at Room Temperature

Various formulations of anti-freezing admixtures based on different percentage of calcium nitrate with other admixture were made. Standard sand mortar cube samples were casted and cured at (3 °C) for 28 days without water curing. The result (Fig. 2) shows that admixture1 mortar given best results. Without admixture, OPC mortar compressive strength is only 11.4 MPa compared to 28 MPa of admixture1 at 28 days curing.

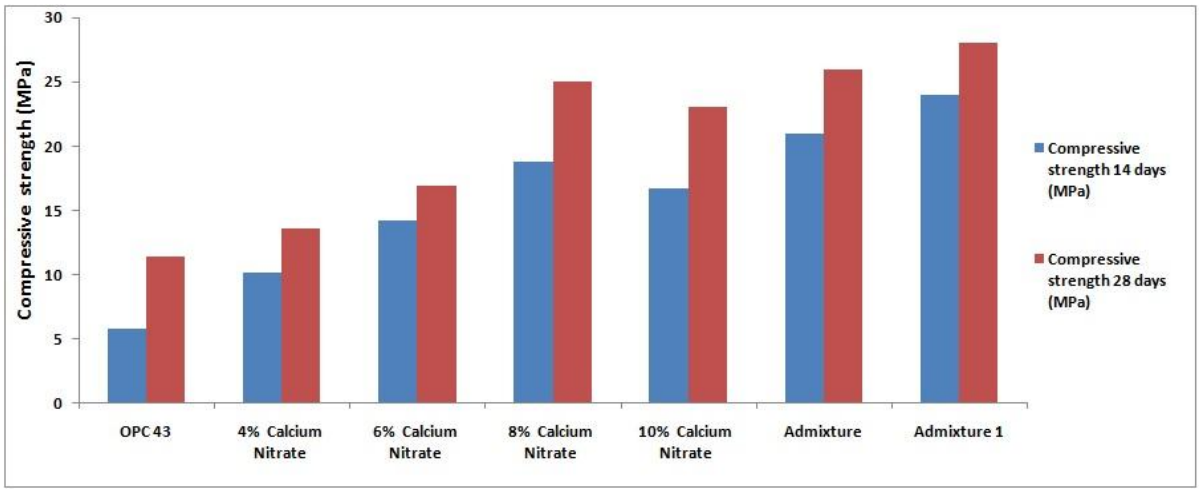
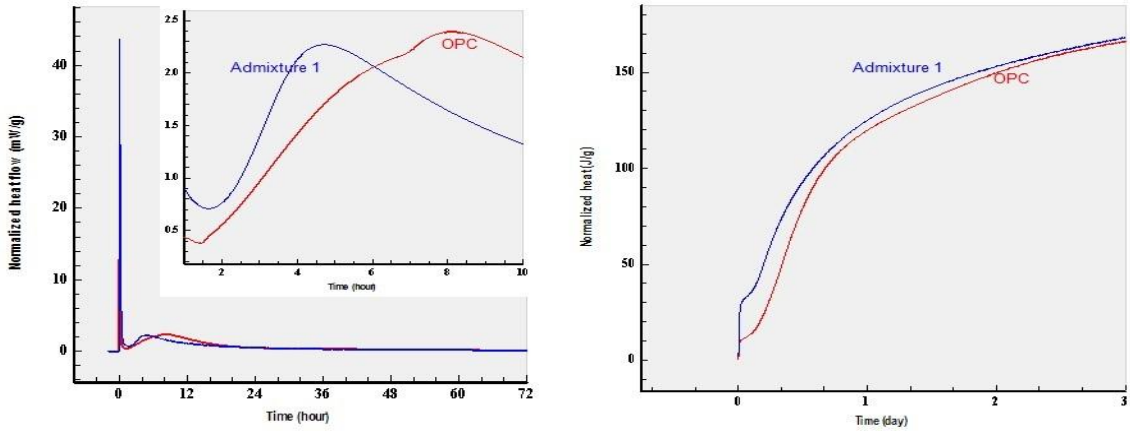


Fig. 2: Compressive Strength of Standard Sand Mortar Samples Cured at 3 °C for 28 Days

Isothermal conduction calorimeter used for comparison of heat flow rate and heat evolved with reaction time between OPC of with and without admixture1. Fig. 3 shows that OPC + admixture1 system is shown fast hydration acceleration peak at 4 hr 40 min compared to 8 hr OPC (Table 1).

Table 1: Calorimetric Response of OPC with & without Admixture

Mix	Temperature (°C)	Acceleration peak (mW/g)	Time to peak (Hr)	Cumulative heat at 72 h (J/g)
OPC	25	2.393	8 hr	166.131
OPC+ Admix1	25	2.271	4 hr 40 min	168.085



(a) **(b)**

Fig. 3: Normalized Heat Flow & Heat with & without Admixture1 OPC Paste at 25 ºC

In minus temperature curing study, with and without admixture standard sand mortar cube samples were casted and immediately transferred to the deepfreezer for curing at -5 ºC for 28 days (Fig. 4).

Fig 4: Curing of Samples in Deepfreezer

Compressive strength of these mortar samples is shown in Fig. 5. Admixture1 compressive strength was observed 19.3 MPa compared to 4 MPa of OPC at 28 days.

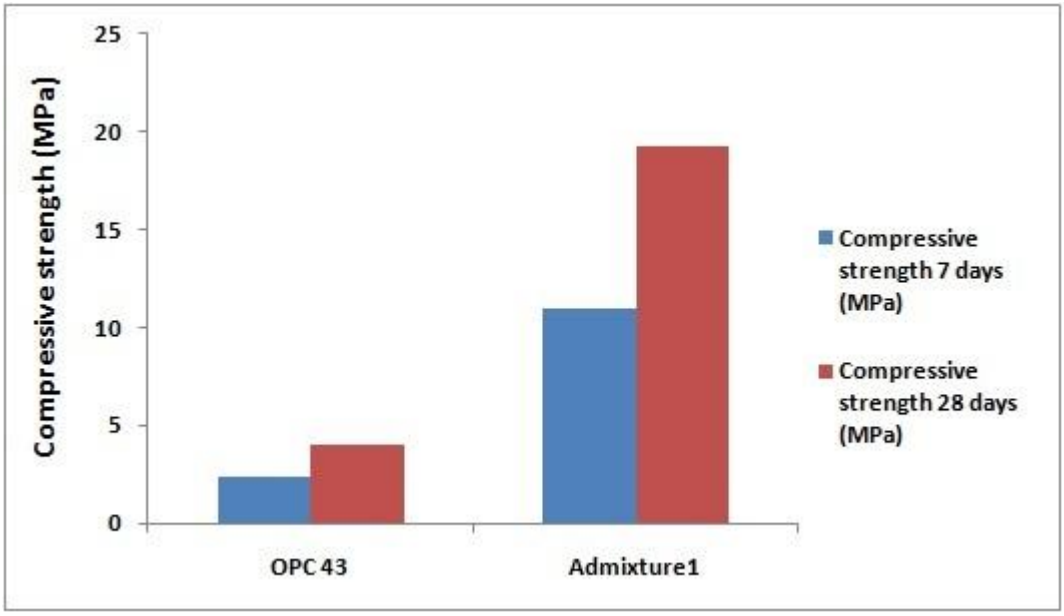


Fig. 5: Compressive Strength of Standard Sand Mortar Samples Cured in Deepfreezer at -5 °C for 28 days

ENERGY EFFICIENT SYSTEM

Efficient Solar Thermal Collector

Nagesh B. Balam, Tabish Alam & Chandan Swaroop Meena

Objectives:

- Design and development of high efficient double glazed solar collector
- Simulation of design parameters to achieve higher efficiency above industry standard

Progress Highlights:

Two prototypes of double glaze flat plate solar collectors, namely Collector I and Collector II are fabricated along with insulated water storage tanks as shown in Fig 1. Collector I comprises of two panes of low iron glass, separated by a spacer bar and seals to create a hermetically sealed environment. Argon gas is filled in between the two glass panes. The argon has been chosen because argon gas has 34 % lower thermal conductivity than air. Collector II has similar glasses and air is filled between the gaps of two glasses.

Fig. 1: Two Prototype of Double Glaze Flat Plate Collector

Testing of the both collectors started in the outdoor conditions of Roorkee at CSIR-CBRI, Roorkee. The temperature of absorber plate, inner glass, outer glass, water in tank and environment has been measured using T-type thermocouples. We report the comparison of double glazed collector filled with argon (collector I) and air (collector II). The absorber plate temperature of Collector I and II reaches above the 100 ºC as expected. The major difference of the temperature of outer glass can be seen in Fig. 2 and 3. The temperature of outer glass of collector I reaches around 40 ºC, whereas temperature of outer glass of collector II reaches around 65 ºC. This large temperature difference has been observed which implies that Collector I has lower heat loss in comparison to the heat loss in collector II.

The temperature of water in tank of Collector of I and II has also been presented in Fig. 2 and 3. Temperature of water in Tank of collector I has been observed around 80 ºC which is quite higher than the temperature of water in tank of collector II. This high temperature of water in collector I is only be possible to minimize the top heat loss through the double glazing filled with argon gas. Further, testing of collectors will be continued in the summer seasons for the solar thermal air conditioners.

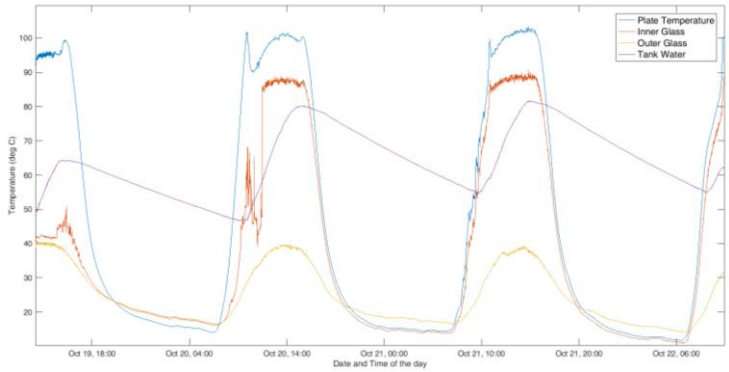


Fig. 2: Temperature of Absorber Plate Inner Glass, Outer Glass & Water in Tank with Time of the Days (Collector I: Argon Gas in Between Glasses)

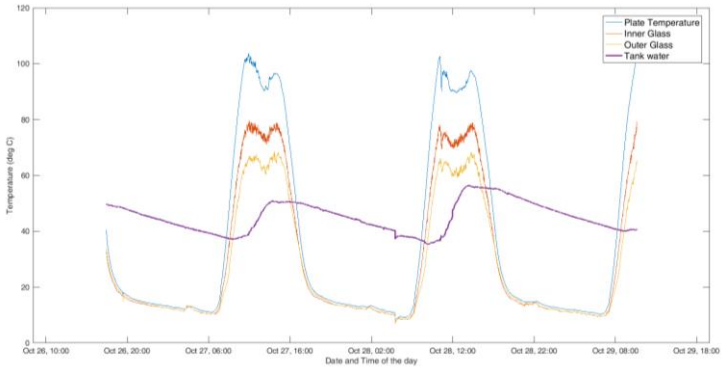


Fig. 3: Temperature of Absorber Plate Inner Glass, Outer Glass & Water in Tank with Time of the Days (Collector II: Air in Between Glasses)

The water tank temperature could be further increased by improving the heat transfer through fluid by modifying the design of collector. Due to less diameter of the flexible pipe, connecting solar collector to water tank the convection could not take place effectively. Pipe connecting collector to water tank at inlet and outlet diameter has been increased to improve the convection heat transfer. Riser tube diameters increased to improve the convective heat transfer. Again, the experiments were carried out after modifying the design of solar collector. The temperature and solar radiation profiles are shown in Fig. 4.

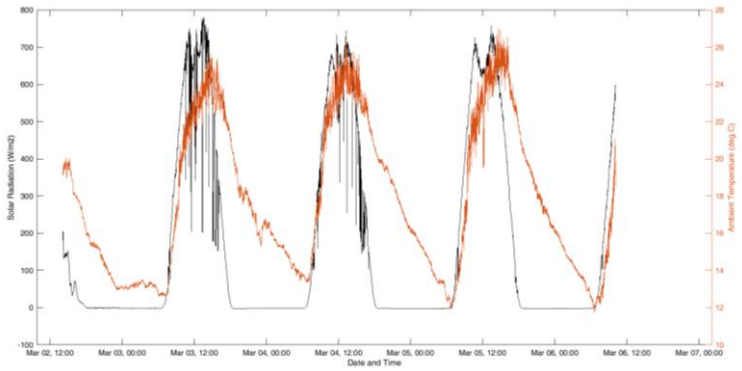


Fig. 4: Solar Radiation in W/m^2 & Ambient Temperature in ^{o}C for a Representative Days

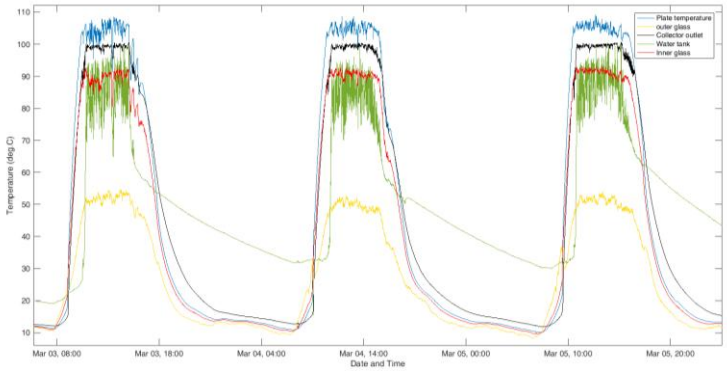


Fig. 5: Temperature of Absorber Plate Inner Glass, Outer Glass & Water in Tank with Time of the Days (Collector II: Air in Between Glasses)

It is observed in Fig. 5 that temperature of outer glass of double-glazing is approximately 50 ºC. Collector generates saturated steam at the outlet at 100 ºC which shows that the temperature can raise further for high temperature applications by using higher boiling point heat transfer fluids. Water tank temperature of double glazing collector reaches up to 90 ºC. Average collector efficiency calculated for a day is around 53 %.

DISASTER MITIGATION

Safety & Security of Vital Installations

Suvir Singh & S. Sarkar

Safety of Vital Installations against Landslides

S. Sarkar, D.P. Kanungo, Manojit Samanta, Anindya Pain, Koushik Pandit & S. Ganesh Kumar

Objective:

Design and development of efficient slope stabilization measures and instrumentation to mitigate landslide hazards in Uttarkashi region of Uttarakhand Himalaya for the safety of vital infrastructures

Progress Highlights:

The existing and potential landslide slopes along the Uttarkashi-Bhatwari road have been identified and mapped on the Google image with field checks. Based on the field observation, a few slopes have been identified which have potential for landslide occurrence (Fig. 1). Detailed field investigation was carried out to collect relevant engineering geological data of a few vulnerable slopes for stability assessment. Further field investigation is ongoing to identify and study more landslide potential areas for the complete stretch.

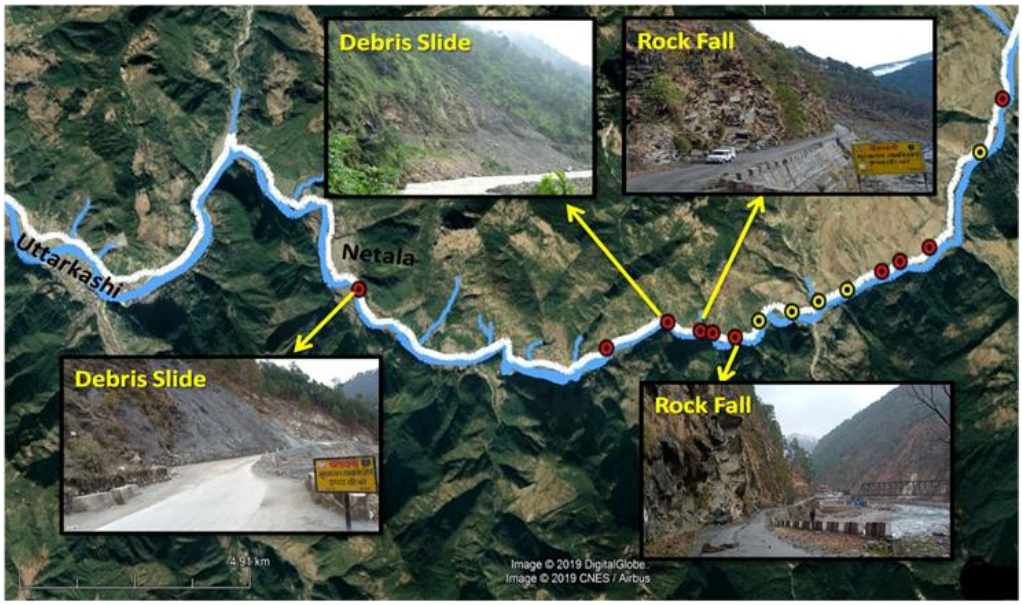


Fig. 1: Potential Landslides along Uttarkashi-Bhatwari Road

The kinematic analyses of the slopes were carried out to determine the possible mode of failures in identified potential rock slopes (Fig. 2). The slope stability analysis of a few vulnerable slopes having debris material was carried out using limit equilibrium and FEM (Fig. 3). The analysis was also carried out under dry and saturated conditions.

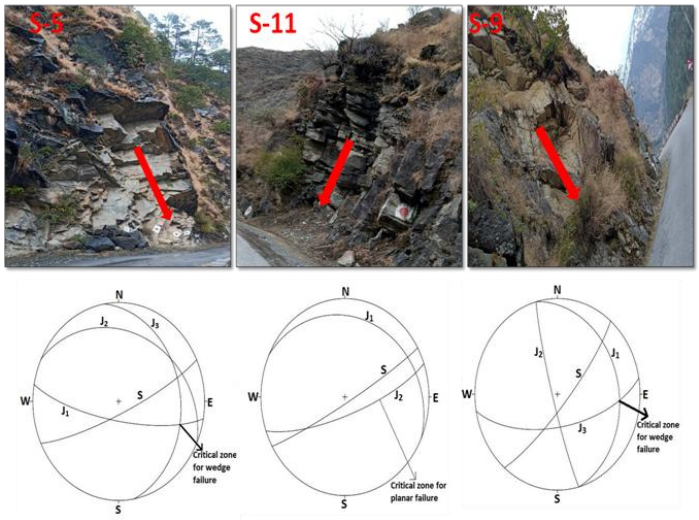


Fig. 2: Probable Failure Mechanism of Potential Rock Slides

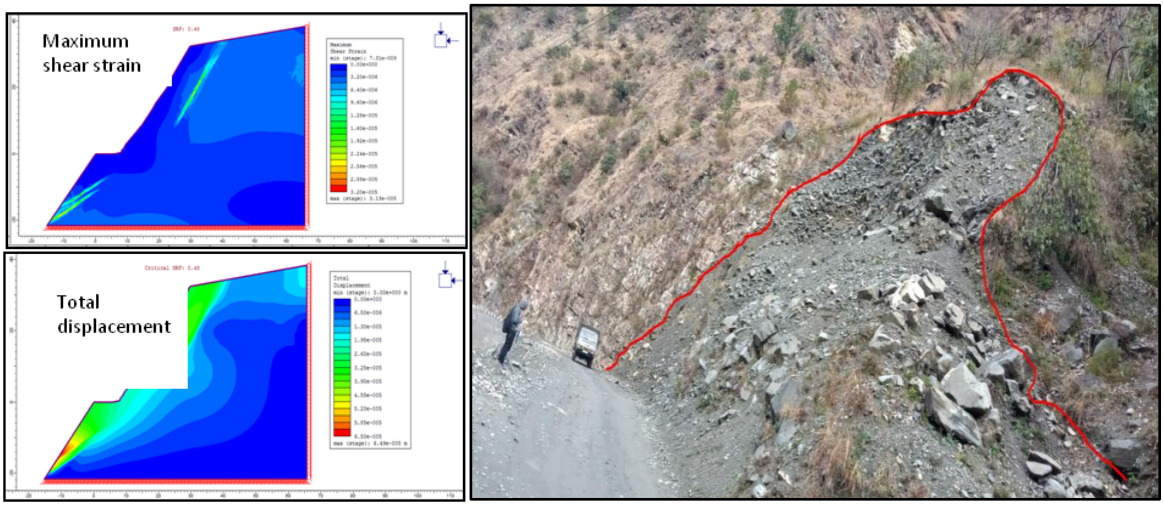


Fig. 3: Stability Analysis of a Debris Slope

Mitigation Measures

The studies are being carried out on few mitigation measures to control landslides. The idea is to develop some cost effective efficient measures and prepare design guidelines.

Design of Geo-Synthetic Reinforced Soil Retaining Structure with Concave Facing Profile

Engineered slopes are mostly built with a cross section of planar profile. But there are few theoretical studies which show that the concave profiles show better results in stability analysis and also helps in controlling erosion. Hence, optimal profile for the slopes having concave cross section under seismic and static conditions can be an attractive alternative. Horizontal Slice Method (HSM) has been used to find the most critical slip surface based on values of tensile strength for a reinforced slope with planar as well as concave facing.

A schematic diagram for a retaining wall with both planar and concave facing profile having inclination angle with horizontal = 60º, soil friction angle (φ) = 30^0, height= 7.5 m and unit weight (γ)= 16 kN/m^3 is shown in Fig. 4.

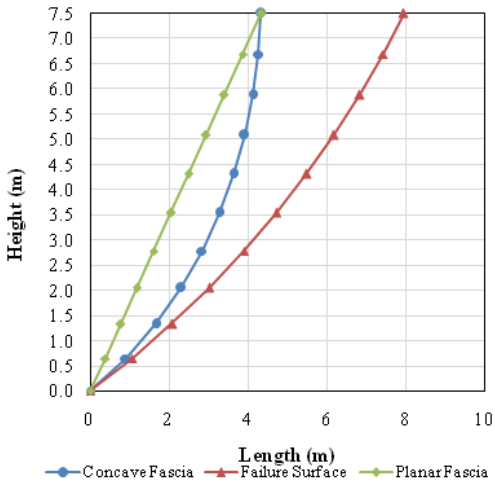


Fig. 4: Schematic Diagram of Retaining Wall Showing Planar as Well as Concave Facing Profiles

Soil Nailing

Pullout capacity of helical soil nail with multiple helix has been experimentally evaluated. The main objective of the study is to optimize the spacing of the helix. The pressure range used was in the range of 30-120 kpa. Dry cohesion less soil medium was used. The sand was poorly graded with relative density of 75 ± 4 %. The test results show that interspacing between helix more than the four times the diameter does not have any affect with each other. Spacing less than the critical spacing, an interference effect was observed and pullout capacity decreases. Therefore, from design consideration and effective helical nail design, interspacing between the helix should be equal or more than the four times the diameter of helix.

Pullout capacity of multiple helical soil nails was also investigated through experimental studies. The main objective of the study is to optimize the spacing between helical soil nails. The pressure range used in the present study is in the range of 30 -120 kPa. Dry cohesion less soil medium was used. The sand was poorly graded with relative density of 75 ± 4 %. The test results show that no interface effect is observed when the spacing between the nails is more than three times the diameter. Therefore, from design considerations vertical and horizontal nail spacing should be equal or more than the three times the diameter of helix.

Anchored Geo-Synthetic Reinforcement

The objective of the study is to evaluate the reinforcing effect of anchored geo-synthetic system on slope stability. Accordingly, experimental and numerical studies were proposed to evaluate the performance of reinforcing system. The experimental investigations on model-unreinforced slope tested under rainfall and dynamic conditions and numerical studies on model slope with and without anchored geo-synthetic reinforcement have been carried out.

For experimental study, landslide laboratory studies were performed in debris soil. The studies were performed under rainfall induced landslide testing conditions to evaluate the performance of unreinforced slope. To evaluate the effect of rainfall in slope stability, slope was prepared and tested under artificially simulated rainfall conditions. Tests were conducted on large-scale model fume having dimensions 5 m × 1.5 m × 1.0 m. For testing, slope having 2 m × 1.5 m × 1 m was constructed. The slope was subjected to a continuous rainfall for a period of 90 minutes. Slowly the slope gets saturated with time and after 20 minutes small displacement was observed at face of the slope. At 35 minutes, moderate slope displacement was observed. Due to continuous increase in pore

pressure considerable displacement resulted into shallow failure was observed on the slope. The observed slope failure is shown in Fig. 5. Additional tests are in progress varying the intensity of rainfall to evaluate the performance of the slope with and without anchored geo-synthetic reinforcement.

Fig. 5: Slope Failure Experiment under Artificial Rainfall

Concluding Remarks & Future Work

The landslide hazard assessment has been completed for a part of the study area by determining the stability of vulnerable slopes using various techniques suitable for different types of failures. Further studies are going on for identifying more potential slopes and stability analysis. A rainfall study of the area has been initiated to determine the rainfall intensity threshold which usually triggers landslide in this region. The detailed geotechnical investigation and primarily stability analysis has been carried out for an active landslide. Suitable and adoptive measures will be designed for the selected landslide under study.

A few cost effective and efficient control measures are being developed in the area of geo-synthetic reinforcement, soil nailing and retaining wall. The control measures will be designed for the selected landslide. The design guidelines of the developed control measures will also be prepared which can be used for other landslides of similar nature.

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

A. Aravind Kumar, Rajiv Kumar & Ghanshyam Mittal

Objectives:

- Experimental studies for fire hazard assessment of wall and ceiling lining materials in a full-scale realistic fire scenario in a room corner fire
- Determination of Available Safe Evacuation Time (ASET) for fire affected two storey experimental building
- Development of full-scale standard ISO 9705 experimental facility generation.

Progress Highlights:

The National Building Code of India (2016) specifies prescriptive requirements of the passive building fire safety. However, the prescriptive codes might not be suitable for new materials and design features of the building. The fire code on lining and furnishing materials is a key element for

fire safety is concerned. When the fire initiated inside the room with materials on floor, adjacent items might be ignited to give higher heat release rates. To characterize these materials a standard test method surface spread of flame BS 476 : Part 7 [8] was specified. However, this test has limitations to flame spread with very small specimen only. But this test is for assessing building materials, not on the entire building element. Therefore, specifications on suitable tests for complete fire hazard assessment should be described more clearly in the local codes.

The room/corner scenario was introduced in the 1950s in both the United States and Australia. The online measurement of the rate of heat release was made using the oxygen consumption method. The test for studying the reaction-to-fire properties of surface products has become an international standard, ISO 9705 since 1990.

ISO 9705 is a full-scale burning fire facility. The products are tested inside a room, 3.6 m × 2.4 m and 2.4 m high is as shown in Fig 1(a). The wall lining materials are covered on the walls (excluding that contains the doorway), Where as the ceiling or just be covered with standard ceiling materials. This test represents a real scale fire in a small room with combustible linings. The maximum size of the testing sample is 31.7 m^2. The results achieved are very close to that encountered in an actual fire. The ignition heat source recommended is of two types. The one more commonly used gives a thermal power of 100 kW, equivalent in intensity to a severe waste paper basket fire during the first 10 min, and 300 kW for a further 10 min. The other one provides net heat output of 40 kW during the first 5 min after ignition and a net heat output of 160 kW during the next 10 min. The heat output shall be adjusted to 25 %, 50 %, 75 % and 100 % of the maximum net heat output at 0 s, 30 s, 60 s and 90 s after ignition respectively.

The following progress has been achieved so far. The installation and commissioning of thermocouples, velocity measurement and video camera system has been carried out. A total of 60 thermocouples at ceiling, wall, door, specimen surface and hood are installed shown in Fig 1(b). The flash over fire condition will be identified based on temperature measurement at ceiling height, Heat release rate of Fuel (HRR), radiation measurement and Flames coming out of the room continuously. Velocity measurement system a total of 10 bi-directional probes at door and 1 at hood is installed is as shown in Fig 1(c). The velocity data at door to calculate the mass flow rate of air entrainment in to the system. The velocity measurement at hood will be used to calculate HRR using oxygen depletion method. The other technique for measuring the HRR is based on mass loss rate of the fuel. The MLR of the fuel measured with weight loss platform. The technique is used for the liquid and solid fuels with limitations. The oxygen depletion technique is useful for measuring the ceiling and wall lining materials. The specimen mounted on the wall as shown in Fig 1(d).

Fig. 1: (a) ISO 9705 Full-Scale Room Corner Fire Facility

Fig. 1: (b) Thermocouples Installation on Wall

Fig. 1: (c) Bi-Directional Probes at Door Centre

Fig. 1: (d) Plywood Specimen Mounting on Wall

A numerical simulation study with pyrolysis modelling has been carried out for pinewood and PMMA samples data reported in the literature. Thermo gravimetric analysis data (TGA) used to determine the reaction triplets pre exponential factor (A), order of reaction (n) and Activation Energy (E). The reaction rate kinetic data at different heating rate is correlated with regression analysis technique to predict the kinetic parameters at different heating rates. The comparison has been made with mean value of K, A and E and the values predicted at different Heating rates. It has been found that predicted values at different heating rates are found to be in good agreement with the experimental data compared to the mean values. With these kinetic triplet values, the predictions are carried out to simulate the cone calorimeter experimental facility.

The characterization of the ceiling and wall lining materials will be carried out using the experimental data of ISO 9705 room corner facility. The experiment will be repeated in two storey experimental building with the same lining materials. The thermal, toxic and visibility hazards will be predicted using the experimental data. The data generated at different locations in the building are compared with the tenability hazard limits of fire. The Available Safe Evacuation Time (ASET) will calculate based on tenability limits for different lining materials. The ASET is useful for performance-based design of the buildings for safe evacuation.

BUILDING PROCESS & AUTOMATION

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

R.S. Bisht & S.K. Panigrahi

Objectives:

- Development of mechanism and control strategies for device locomotion in complex working environment
- Design and development of mobile sensing device and field implementation of the sensing device by deploying both contact and non-contact based NDE sensors

Progress Highlights:

- Modelling, simulation and development of a prototype four-wheel locomotion based autonomous climbing device and successfully conducted laboratory and field trials for visual inspection.
- Generalized mathematical modelling and simulation of trajectory tracking for efficient path planning for field trials of a four-wheel locomotion based autonomous climbing device for visual inspection, painting and SHM applications.
- Modelling, simulation and development of a prototype hybrid (wheel and arm) locomotion based bio inspired climbing device, and developed control algorithms and successfully conducted laboratory trials.
- Tip-over stability analysis and design upgradation of the hybrid locomotion based climbing device for conducting locomotion trials in critical wall surface locomotion and field trials.
- Developed motion control strategies of the proposed mobile sensing device using hybrid locomotion for obstacle avoidance and wall-to-wall transitions situation

Three types of locomotion mechanism (Wheel 1, Wheel 2 and Wheel 3) are manufactured and compared for their working performance experimentally for climbing device locomotion trials. The Wheel 1 mechanism with mild steel (MS) hub is very compact, simple in design with easy assemble/dissemble features, and having less manufacturing cost. However, the adhesion force of the prototype wheel is comparable with already reported permanent magnet based adhesion mechanism. Wheel 1 design is further improved by developing Wheel 2 and 3 versions by changing hub material from mild steel to Aluminium. These wheel mechanisms are light in weight and more powerful to achieve maximum adhesion force i.e., 210 N and 251 N with and without rubber grip, respectively, at only 200 g wheel weight as compared to previously reported permanent magnetic adhesion mechanism. Thus, more payload carrying capacity of climbing device can be developed using these developed mechanisms for field trials. A comprehensive experimental study on the influence of rubber grip thickness, air gap, wheel tilt angle and test surface thickness variation on adhesion force of these developed wheel mechanisms have been reported. Details of these experimental results can be seen in Fig. 1-4, respectively.

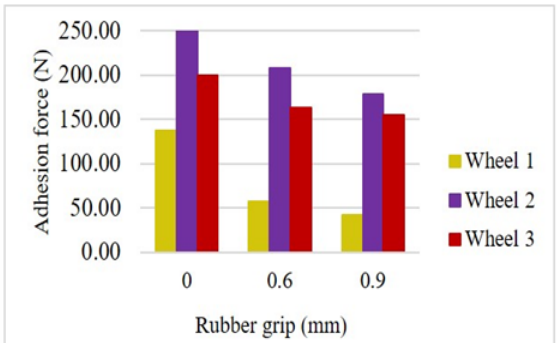


Fig. 1: Comparisons of Adhesion Force of Magnetic Wheel with & without Grips on Surface Thickness of 3 mm Thickness

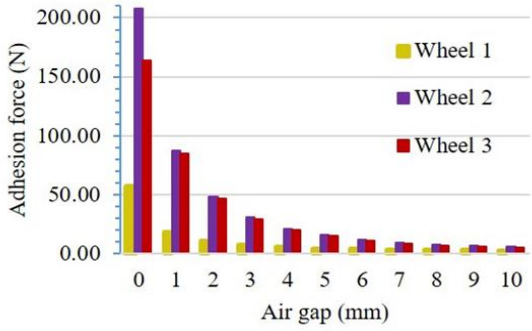


Fig. 2: Adhesion Force vs. Air Gap Between Magnetic Wheel & Ferrous Test Surface of 3 mm Thickness

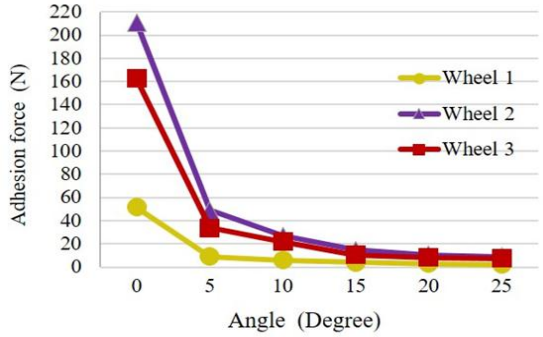


Fig. 3: Comparisons of Adhesion Force Variation vs. Wheel Tilt Angle w.r.t. Test Surface of 3 mm Thickness

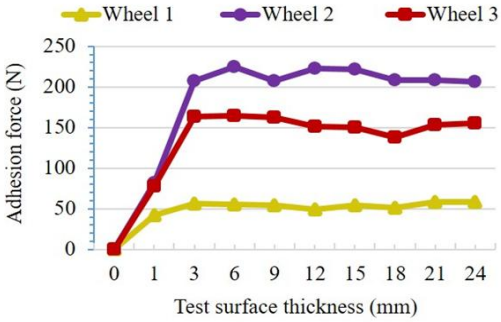


Fig. 4: Magnetic Wheel with 0.6 mm Rubber Grip on Different Thickness of Ferrous Test Surface

The influence of both static and kinetic coefficient of friction (COF) for vertical surface locomotion of climbing device has also been investigated. Details of these experimental results can be seen in Fig. 5 and 6. These developed locomotion mechanisms have been further demonstrated using a four-wheel differential drive prototype-climbing device for safe navigation testing first on a 2-D framed plane wall structure and next on a 3-D framed wall structure. It is found from the experiments and laboratory trials that based on these locomotion mechanisms, the climbing device can safely navigate remotely on hard to reach surface of steel structures and in the high pay load inspection and maintenance work in the fields.

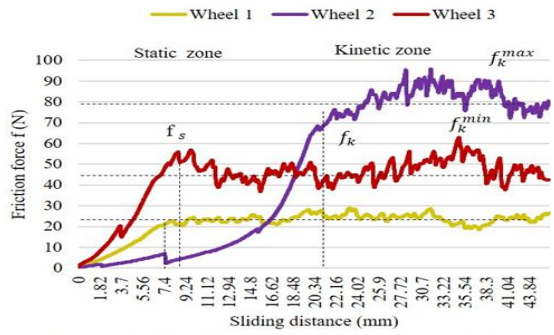


Fig. 5: Friction Characteristics (Friction Force & Sliding Distance Curve) of Magnetic Wheel without Rubber Grip

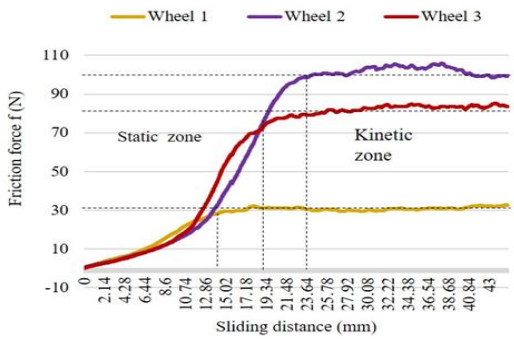


Fig. 6: Friction Characteristics (Friction Force & Sliding Distance Curve) of Magnetic Wheel with Rubber Grip (0.6 mm Thickness)

Seismic Performance Enhancement of Buildings using Smart Base Isolation

Soju J. Alexander, S.K. Panigrahi, R.S. Bisht, Subhash Chand Bose Gurram & 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:

Test setup for evaluating the dynamic characteristics of RD 8041-1 has been developed by using the existing shake table facility available with GE group as actuator. Simulation studies on damper modelling and base isolated frame structure has also been performed. The details are given below.

As a part of Smart Base Isolation, controllable dampers shall be incorporated with conventional elastomeric isolators. Semi-active dampers such as LORD RD-8041, whose damping force can be controlled by varying current input, has non-linear hysteresis dynamic behaviour. Damper models such as simple and modified Bingham and Bouc-wen, has been simulated to reproduce the model characteristics. Fig. 1-4 shows the results.

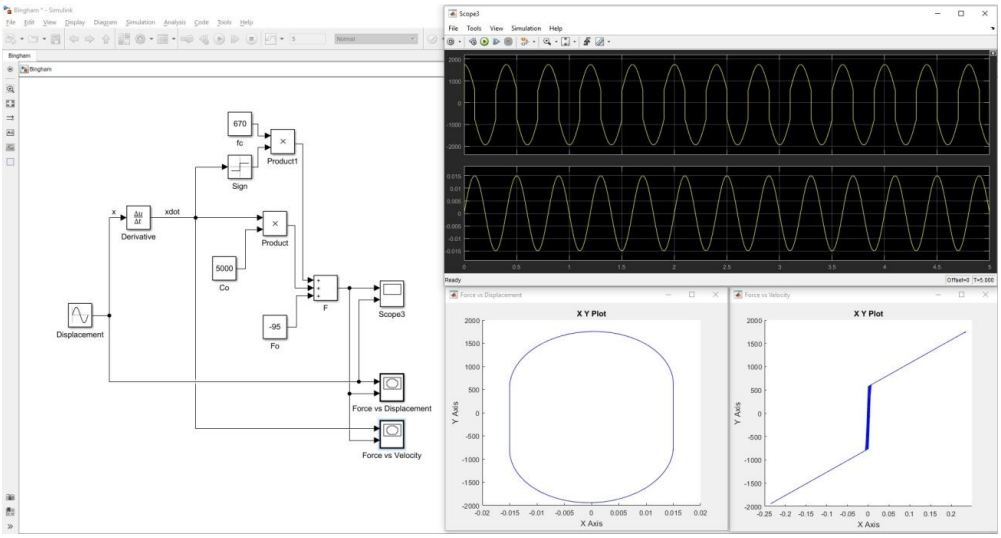


Fig. 1: Bingham Model

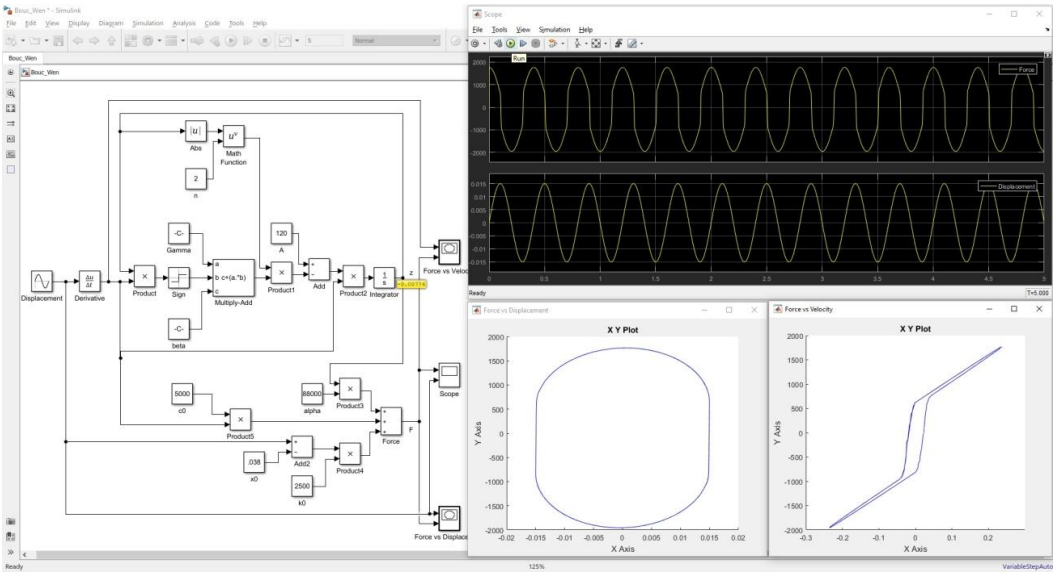


Fig. 2: Bouc-Wen Model

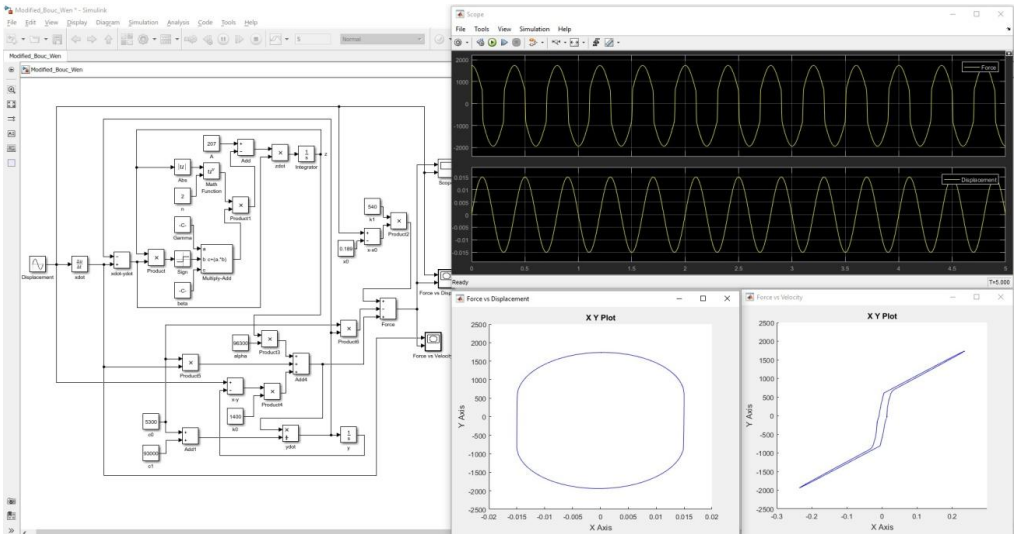


Fig. 3: Modified Bouc-Wen Model

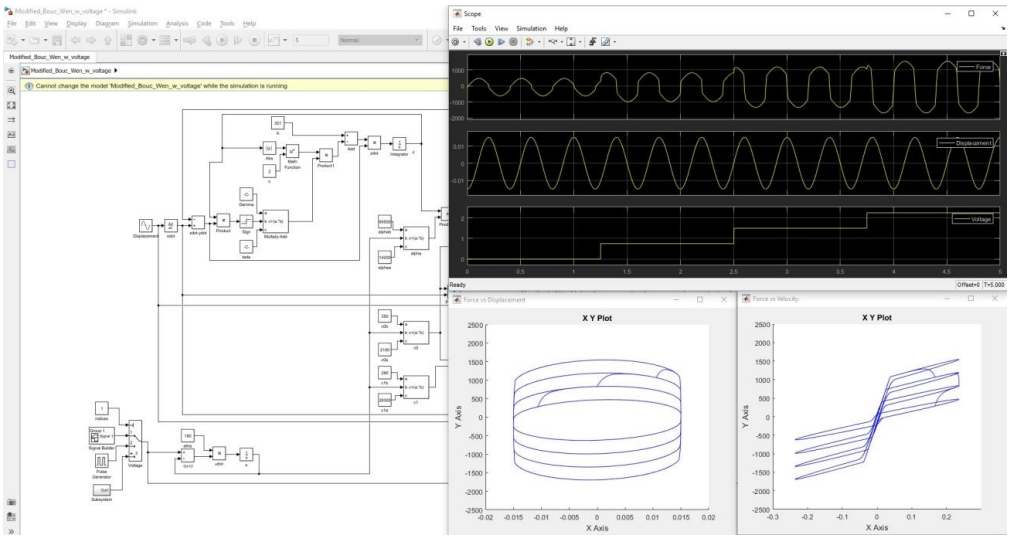


Fig. 4: Modified Bouc-Wen with Varying Current Input

Modelling of Multi-Storey Framed Structure

In order to study the effect of smart base isolation on seismic performance of structures, a five storey framed structure has been selected and the natural frequencies of the system has been obtained by using Linear Perturbation analysis in FEM software (Fig 5). This is a scaled down model of already available structure in literature.

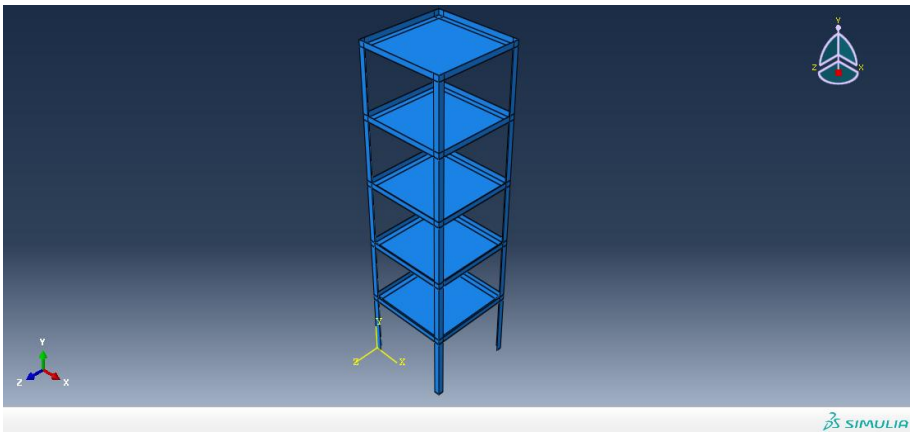


Fig. 5: Frame Structure Modelling with Shell Elements

Base Isolation Study of the Frame Structure

Analytical modelling of base isolation using High Damping Rubber (Isolators) has been carried out using Simulink/Matlab to study the effect of base isolation on inter-storey drifts. It has been observed that the drifts have reduced to some extent as seen in Fig. 6.

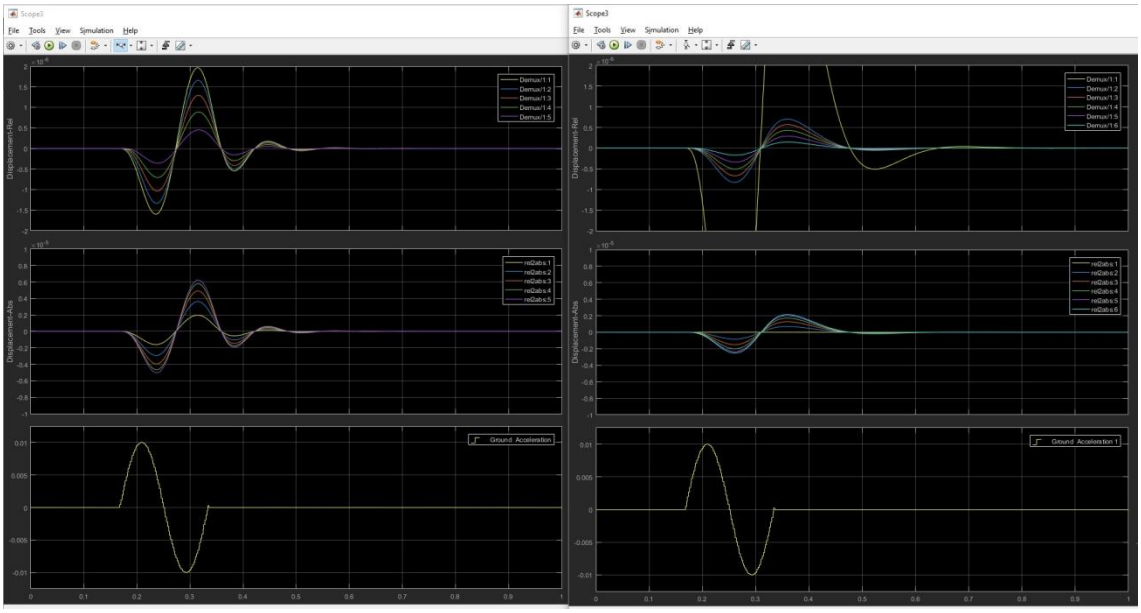


Fig. 6: Comparison of Displacements without & with Base Isolation

Characteristic Evaluation of Semi-Active Damper

In order to evaluate the dynamic parameters of RD-8041 semi-active damper, a damper characterization setup has been prepared at the shake table facility available with GE group. Shake table shall provide the sinusoidal displacement to the damper and the damper force under cyclic loading shall be measured using a load cell and a data acquisition system. Special attachments for mounting the damper in order to perform the experiment have been fabricated as shown in Fig 7.

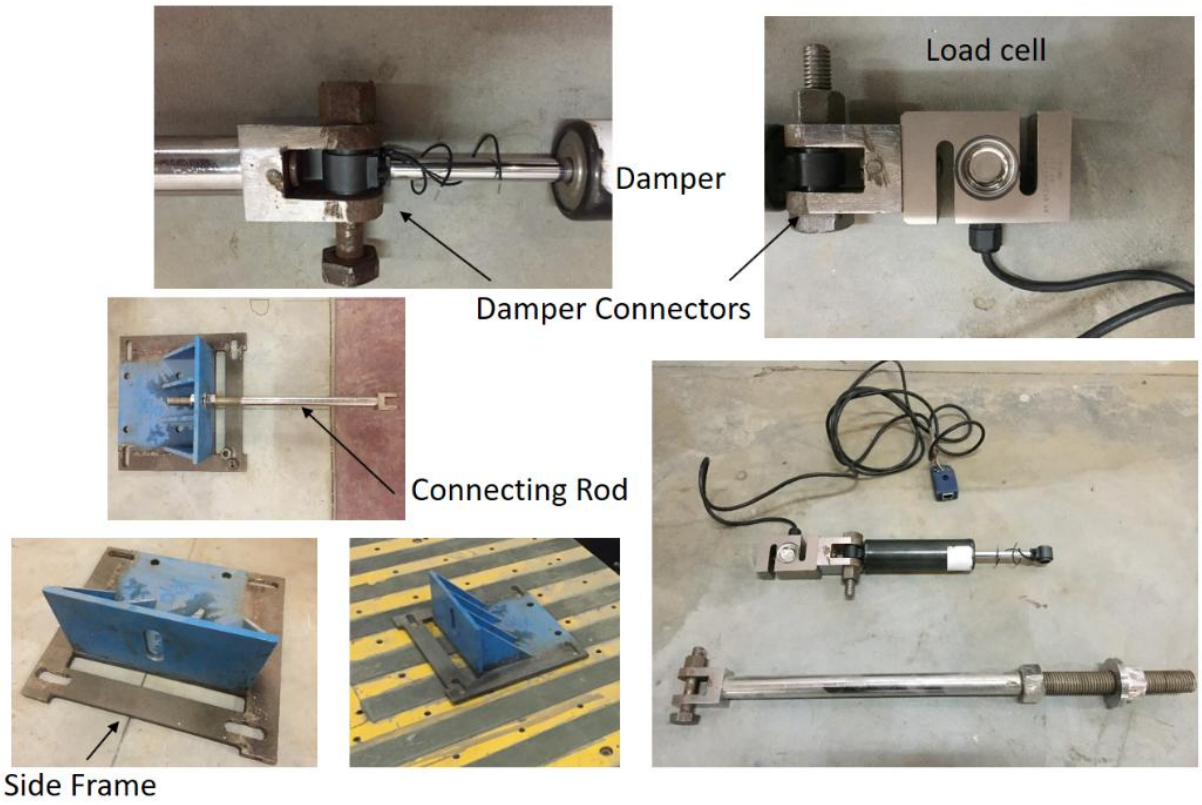


Fig. 7: Attachments Fabricated for Damper Characterization

CSIR FAST TRACK TRANSLATION (FTT) PROJECTS

Pilot Scale Preparation of Silica Nano-Particles & Their Application in Cement Based Materials

L.P. Singh & Srinivasarao Naik B.

Objective:

To design and develop a pilot plant for the preparation of silica nano-particles (SNPs)

Project Highlights:

The present invention provides an improved, facile, one-pot preparation of amorphous and dispersed SNPs of uniform morphology using cost effective water glass as precursor material. The process developed for the preparation of amorphous SNPs involves an initial step of the controlled addition of a water glass in a reacting mixture of water, mineral acid and additive, it is then stirred continuously in 70 L capacity of agitator vessel till the resultant mixture becomes basic and this process is later followed by the ageing of the resultant mixture (Fig. 1). In order to achieve the desired product the aged mixture is further stirred for a certain period and the obtained mixture is filtered through plate and frame filtration unit as per optimized operating parameters given Table 1 and then oven-dried in order to obtain the desired SNPs.

Fig. 1: Pilot Plant for Preparation of SNPs

Table 1: Optimized Operating Parameters for Agitator Vessel with Plate & Frame Filtration Unit

S. No.	Parameters	Operation Conditions
1	Working volume	50 L
2	Agitator vessel speed	700-1200 rpm
3	Pressure for filtration pump	2-3 kg
4	Temperature & pressure	Ambient & 1 atm

Characterization of SNPs

Field Emission Scanning Electron Microscope (FESEM) image as shown in Fig. 2(a) reveals the morphological properties of the SNPs. The prepared SNPs are dispersed, uniform and spherical in shape with a particle size in the range of 40-70 nm. Fig. 2(b), X-ray diffraction (XRD) results show

the amorphous nature and the specific surface area is approximately 250000 m^2/kg as evaluated by Brunauer–Emmett–Teller (BET) surface area analyser.

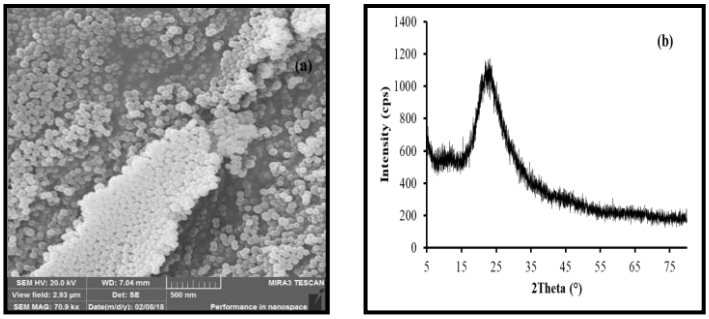


Fig. 2: (a) FESEM & (b) XRD of SNPs

A patent application (No. 201911019105) has been filed and the technology has been transferred to M/s Poysha Nanotech., LLP., India for industrial production.

Development of Bamboo Composites Structural/Semi-Structural Elements for Building Applications

Hemlata, Rakesh Paswan & Jeeshan Khan

Objectives:

- To develop bamboo composite structural/semi-structural elements for building applications.
- Upscaling and implementation of developed technology as building component.

Progress Highlights:

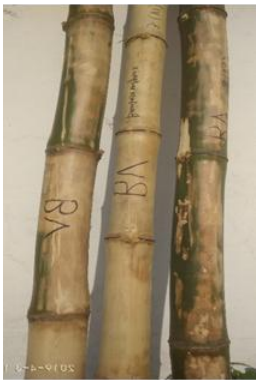
Bamboo has a huge potential as a building material. However, it has not been fully explored yet and remained under utilized due to poor market linkages and lack of technology applications for manufacture of value-added products. Therefore, it is important to upgrade the bamboo economy by bamboo product development, poverty alleviation and bamboo based handicrafts and industrial development. This aim can be met by developing bamboo composites and assisting the industries to apply modern technology for producing globally acceptable new generation bamboo products for building applications. The purpose is to provide environmentally sound construction material alternatives and to develop rural bamboo processing industry to increase the income of rural people. The novelty of the work is as follows:

- High performance bamboo polymer composite with balance level of stiffness and toughness.
- Improved flammability and weathering properties without any appreciable loss in mechanical properties.
- Cost comparable with existing products and can be used as wood substitution.

Societal Impact:

The developed bamboo composite will provide an environmentally sound construction alternative to the conventional construction materials and develop rural bamboo processing industry to increase income of rural people. In addition, it will also promote environmental conservation and fulfil the need of wood-based resource shortage.

- The different species of bamboo procured from Forest Research Institute (FRI), Dehradun for making bamboo composites are shown in the Fig 1.



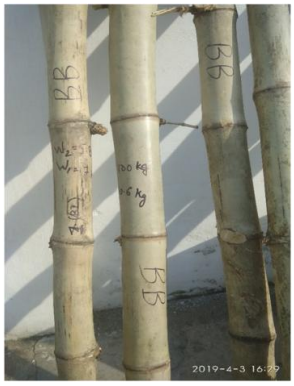
(a) Bambusa Vulgaris

(b) Bambusa Tulda

(c) Dendrocalamus Strictus

(d) Dendrocalamus Hamiltoni

(e) Dendrocalamus Giganteus



(f) Bambusa Balcooa

Fig. 1: Different Bamboo Species Procured for Making Composites

- The physico-mechanical properties of bamboo are being evaluated using methods given in IS 6874 : 2008.

- The compression and tensile testing of specimens is under progress (Fig. 2).

(a) Tensile Strength Test Specimens

(b) Compression Strength Test Blocks

Fig. 2: Tensile & Compression Test Specimens

- The bamboo fibres were first treated for lingo-cellulosic compound for better bonding with polymer matrix according to TAPPI Standard T212. The fibres were treated with NaOH solution of different concentration (0.5 %, 1% and 1.5 %) for 1 hr at 97-100 °C (Fig. 3).

- The results of FTIR are shown in the Fig. 4. Changes in peaks were observed as we increased the concentration of NaOH. The carbonyl peak observed at 1740 cm^{-1} indicates the presence of C=O stretching of the acetyl groups of hemicellulose is much reduced in case of fiber treated with 0.5 % NaOH.
- Further optimisation for removal of lingocellulosic compounds from bamboo fibers is in progress.

Fig. 3: Chemically Treated & Untreated Fibers

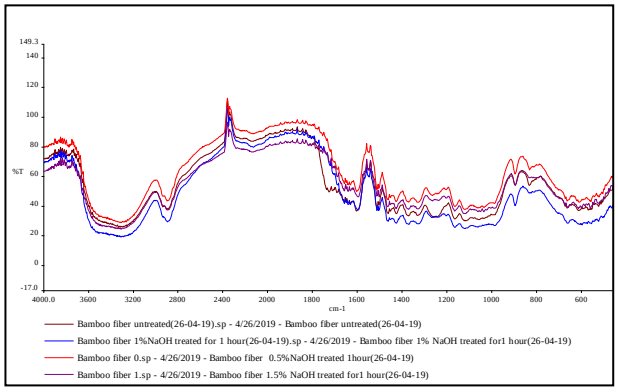


Fig. 4: FTIR Spectra of Treated & Untreated Bamboo Fibers

OTHER R&D PROJECTS

Newer Cementitious Materials using Chemically Activated LD Slag

S.K. Singh, M. Surya & Jyoti

Objective:

Developing newer cementitious binder using activated LD slag along with other pozzolans and mineral admixtures comparable to the requirement of IS 269-2015/ IS 455-2015.

Progress Highlights:

India is world's third largest steel producers with 101 million tons per year. Iron ores contain about 60-65 % of iron and the rest composition is made up of other elements resulting information of slag. The generation of LD slag is found to be in the range of 150-200 kg per ton of steel production. Collection, transport, treatment and disposal of LD slag are major environmental concerns and a big challenge.

LD slag is generated from a Linz–Donawitz process in which pig iron is processed into crude steel. The main components of slag are free lime, metallic and non-metallic iron and calcium silicates, which make it highly basic in nature. It is hard and wear resistant due to high Fe content. The compressive strength is found to be more than 100 MPa, which is close to granite stone. The physico-mechanical properties of this slag have potential to be utilized in construction. Only 25 % of total LD slag produced is used in various possible applications in India such as aggregates, soil conditioning agent, cementitious binders, building bricks, fertilizers etc. whereas, remaining 75 % are disposed off in unplanned manner as landfills. Disposal of slag by landfilling is a major concern of steel industries as its discharge cause air, water and soil pollution. The associated environmental problems are leaching of harmful metals into ground water and pollution of nearby water sources, lowering of moisture, chemical degradation and lack of aesthetics. Therefore, the gainful utilization of LD slag as construction materials will not only help in sustainable utilization of waste but also help in preserving the valuable natural resources.

In this regard, CSIR- Central Building Research Institute, Roorkee has initiated a project on "Development of Newer Cementitious Binder from Mechano-Chemical Activated LD Slag" sponsored by Ministry of Steel, Govt. of India, with JSW Steel Ltd. as industrial partner.

An experimental investigation for characterisation of slag is shown in Fig. 1. X-ray fluorescence (XRF) data shows that LD slag mainly consists of inorganic constituents such CaO, SiO_2, Al_2O_3, FeO, Fe_2O_3, MnO, MgO, in which CaO content is high.

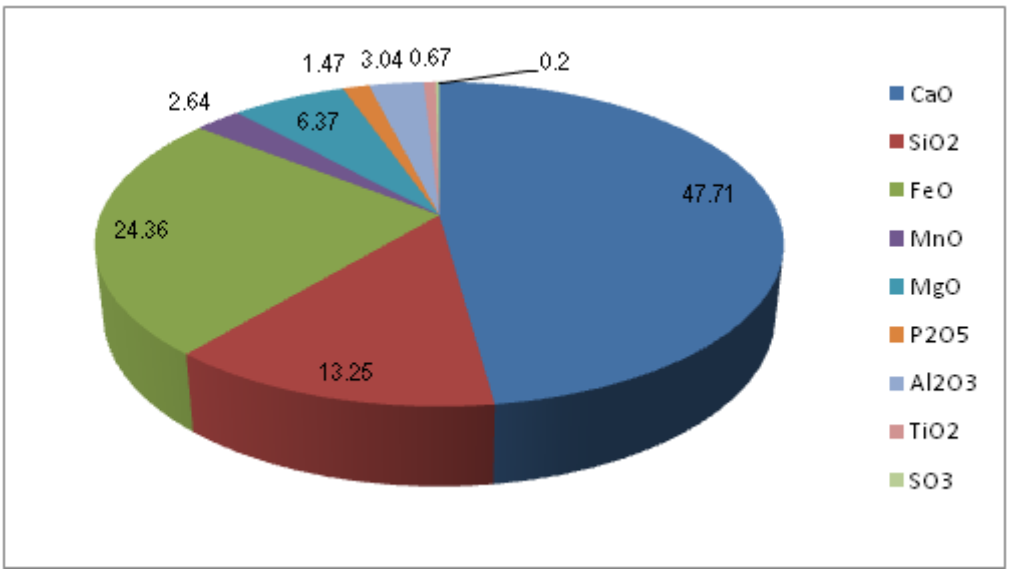
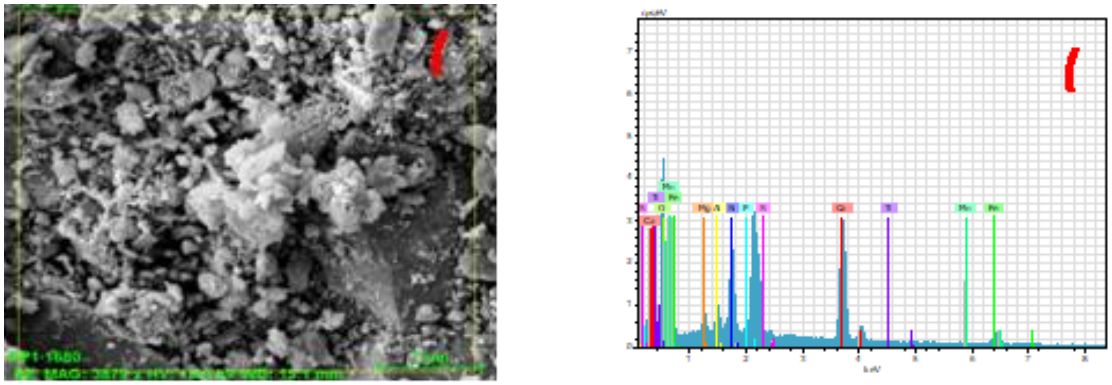


Fig. 1: Chemical Composition of LD Slag

Fig. 2(a-b) shows FE-SEM and EDAX results respectively. It appears like a loose collection of sub rounded to angular shaped granules. EDAX shows that the major phases present are CaO, FeO and SiO_2 whereas; P_2O_5, SO_3, Al_2O, MgO and MnO are present in appreciable amount. The presence of free lime and magnesia in sludge may lead to volumetric instability.



(a) **(b)**

Fig. 2: (a)FE-SEM Image of LD Slag (b) EDAX of LD Slag

Fig. 3 shows XRD pattern of LD slag. The major phases are di-calcium silicate, di-calcium ferrite and calcium hydroxides, which are accountable for its cementitious properties. It is crystalline as compare to granulated blast furnace slag, which is attributed to slow cooling. Because of its high crystallinity and poor reactivity in present form, its usage is limited to a level of 10 % in the cementitious binder.

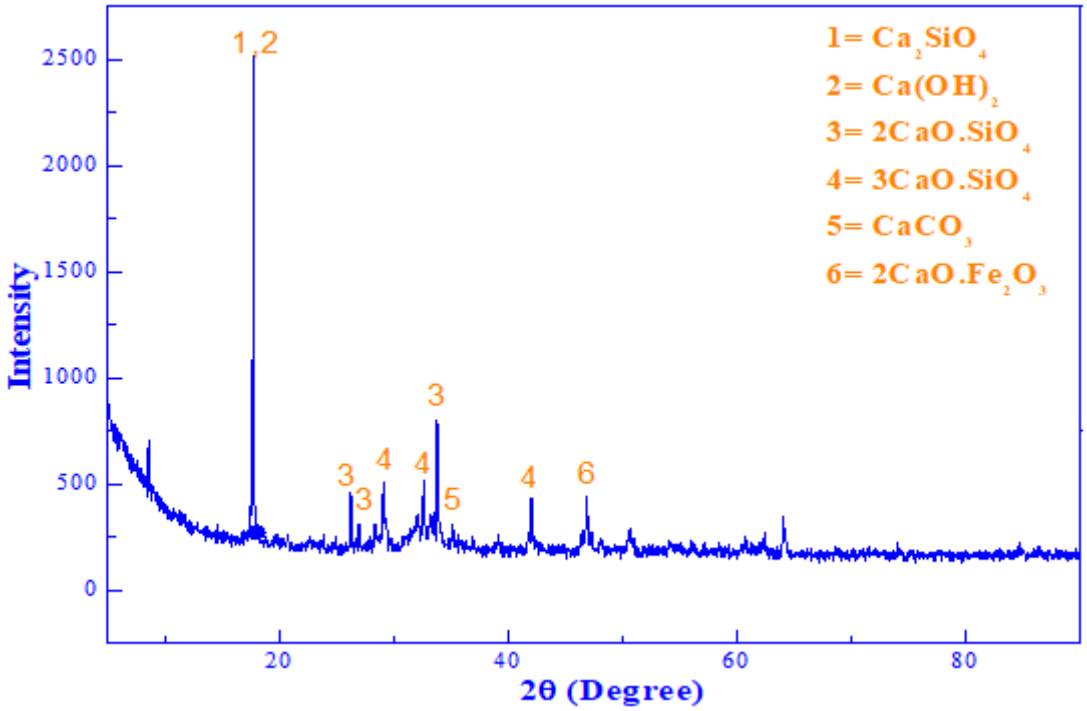


Fig. 3: XRD Pattern of LD Slag

The Methylene blue tests as shown in Fig. 4 indicated low percentages of reactive clay.

Fig. 4: Methylene Blue Test

Potential applications of LD slag in civil engineering are possible with the help of hygrothermal treatment followed by mechano-chemical activation. In case of alkali activated slag cement, free lime is converted to calcium carbonates and further converted to alkali carbonates in presence of alkali activators. The alumina-silicates formed during the activation immobilises the MgO. The fine iron shall be reclaimed using magnetic separation before the activation process. Heavy metals would immobilize in the resulting alumino-silicates of activated LD slag with alkali, which will prevent its leaching. However, the same can be ascertained only after an intensive research on use of LD slag in construction after stabilization of unstable compounds and activation of inactive crystalline components. In addition, the durability of building products with LD slag shall be studied for long term as well as aggressive conditions. The proposed newer cementitious material is envisaged by using an industrial by product as raw material, thus reduces the cost of raw materials. It also contributes to sustainability by reducing the clinker factor. The energy to attain clinkering temperature can be reduced for the percentage of replacement of cement clinker.

The present study aims at clinker replacement up to 50 % by LD slag and industrial by-products. Considering these factors the cost breakdown and reduction in costs is projected in Fig. 5. It is

expected that if the LD slag is used as a replacement of clinker the saving will be approximately 24.50 % in comparison to the original cost of Portland cement.

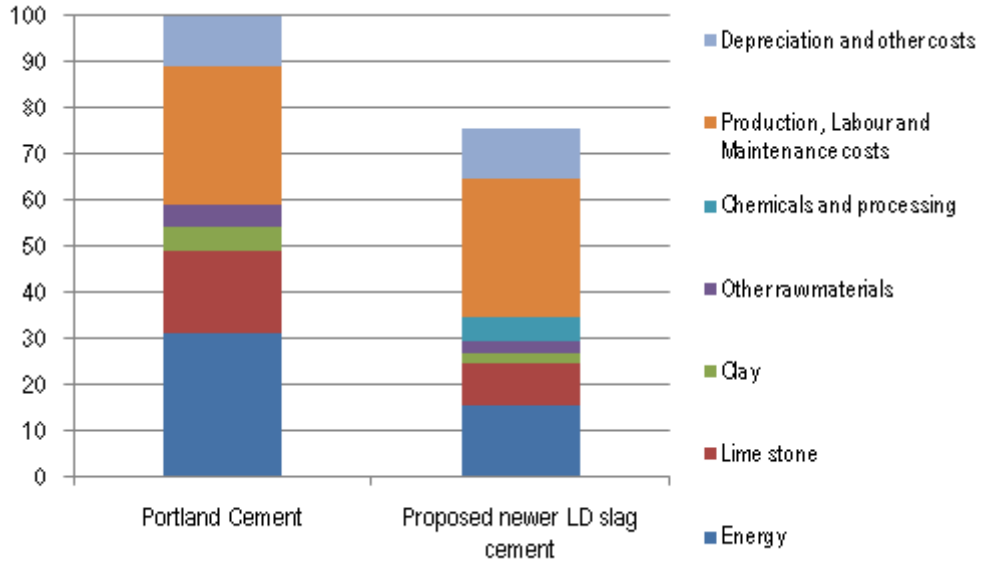


Fig. 5: Breakdown & Reduction in Costs of Cement by using LD Slag

In view of the above, LD slag obtained from Industry of size range 4 micron to 270 microns, with 90 % of the particles below 41 microns was mixed with cement in various proportions and the properties of the slag cement were studied. The standard consistency of the slag increased from 30 %-41 % with increase in percentage of slag from 10 %-50 %. The hydraulic activity of slag cement was determined using the test method given in ASTM C1073 (2018) and the slag activity index was determined using ASTM C 989, indicated encouraging results for use of LD slag in cements with further treatment and activation.

The use of steel slag as a cementing component should be given a priority from technical, economical and environmental considerations. CSIR-CBRI, Roorkee is in collaboration with industrial partner to envisage pilot scale demonstration. This research project will provide the confidence in use of slag in cement industry and hence pave the way for sustainable construction.

Characterization of Manufactured Sand & its Effective Utilization in Construction

S.K. Singh, S.K. Kirthika & M. Surya

Objective:
To characterize manufactured sand for use in construction.

Progress Highlights:
River sand is used as fine aggregate in concrete for centuries. In recent times, excessive river sand exploitation is endangering stability of riverbanks and ecosystem. Increase in demand, depletion and ban on natural sand mining stress the need for alternate options. Alternative fine aggregates/manufactured sand (MS) can be used as fine aggregate, produced from other than natural sources like old concrete, rocks, industrial wastes by processing them, using thermal or other process such as separation, washing, crushing and scrubbing. Such fine aggregates can majorly be classified

(Fig. 1) as crushed rock sand (CRS), industrial by-products (IBP) and recycled fine aggregates (RFA). Literatures have reported that crushed rock sand, copper slag, waste foundry sand, coal ash, recycle fine aggregate etc. are used in concrete as alternative to natural river sand. These are used either in full or fractional replacement of natural sand. The major benefit for using this sand is highlighted in Fig. 2.

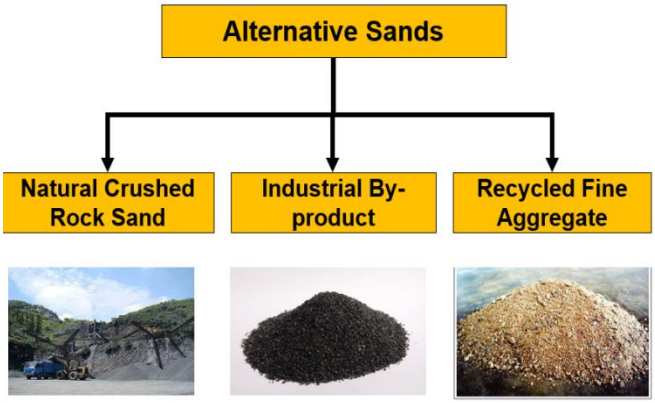


Fig. 1: Types of Alternative Sands

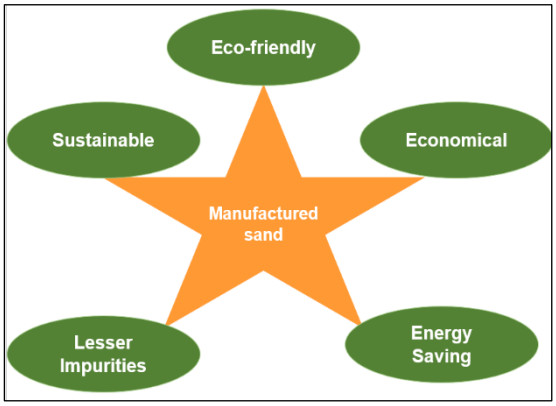


Fig. 2: Benefits of Manufactured Sand

Few researchers have worked in alternative fine aggregates, but there is no standardization of their utilization in construction industry. In addition, characterization and optimization of different types of alternative fine aggregates in concrete has to be done so that it can be utilized commercially. Very few applications of MS can be seen in the construction industry, this is because of less knowledge about the effectiveness of the different types of alternative fine aggregates in concrete and how it makes the concrete sustainable. Therefore, CSIR-CBRI is performing experimental investigations on different types of alternative fine aggregates in cement mortar and concrete jointly with M/s. NBCC, India Ltd.

On this regard, complete literature review of the usages of alternative fine aggregates in mortar and concrete across the world is done and investigations viz. physical, chemical, mechanical and durability properties of alternative fine aggregates and their corresponding mortar and concrete is carried out. Three different types of fine aggregate (FA) i.e. river sand (RS), crushed rock sand (CRS), recycled fine aggregate (RFA) and coal bottom ash (CBA) were collected from different location as shown in Fig. 3. Visual observation of the fine aggregates showed that RS, CRS, RFA and CBA were light grey, black, light red and grey in colour respectively. The texture of CBA was rough and porous. The RS, CRS, RFA and CBA had a specific gravity about 2.64, 2.57, 2.51 and 1.85 and fineness modulus about 2.31, 2.68, 2.83 and 2.38 respectively. The fine aggregates used confirmed the limits of IS 383-2016 as shown in Fig. 4 and can be categorized as Zone II. The physical properties of these alternative fine aggregates are shown in Table 1. Surface morphology of the various manufactured fine aggregate was studied by FESEM as shown in Fig. 5. The chemical and mineralogical composition of all the alternative fine aggregate were observed by X-ray fluorescence (XRF) and X-ray diffraction (XRD) respectively and shown in Table 2 and Fig. 6. It was observed that all manufactured fine aggregate consisted more percentage of SiO_2 and Al_2O_3 compared to other oxides, whereas CBA consists of more percentage of SiO_2 and FeO. XRD pattern of RFA showed the crystalline phases present were majority quartz, calcium hydroxide (CH) in the form of portlandite and calcium-silicate-hydrate (CSH). The X-ray diffractogram of CBA shows that quartz, tridymite, anorthite and mullite are the main phases present in coal bottom ash.

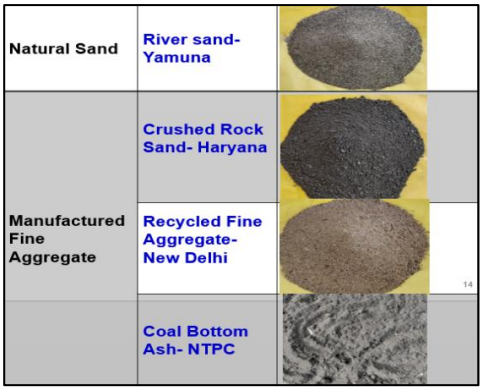


Fig. 3: Types of Fine Aggregates Used

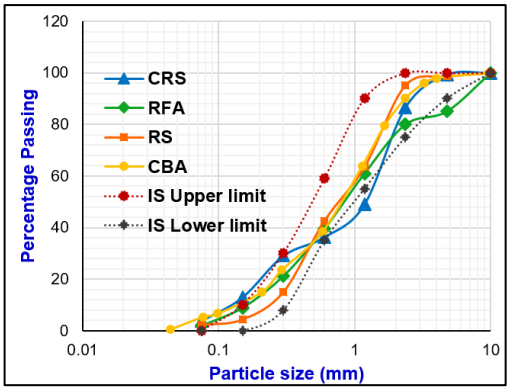


Fig. 4: Particle Size Distribution of Fine

Table 1: Properties of Fine Aggregate

Properties	Fine Aggregate			
	RS	CRS	RFA	CBA
Specific Gravity	2.64	2.57	2.51	1.87
Fineness modulus	2.31	2.68	2.83	2.36
Water Absorption (%)	0.81	2.98	10.61	8.10
Bulk Density (g/cm^3)	1.44	1.50	2.52	1.52
Silt Content (%)	3.00	5.20	4.17	2.00
Surface Area (m^2/g)	0.88	1.46	2.93	0.78

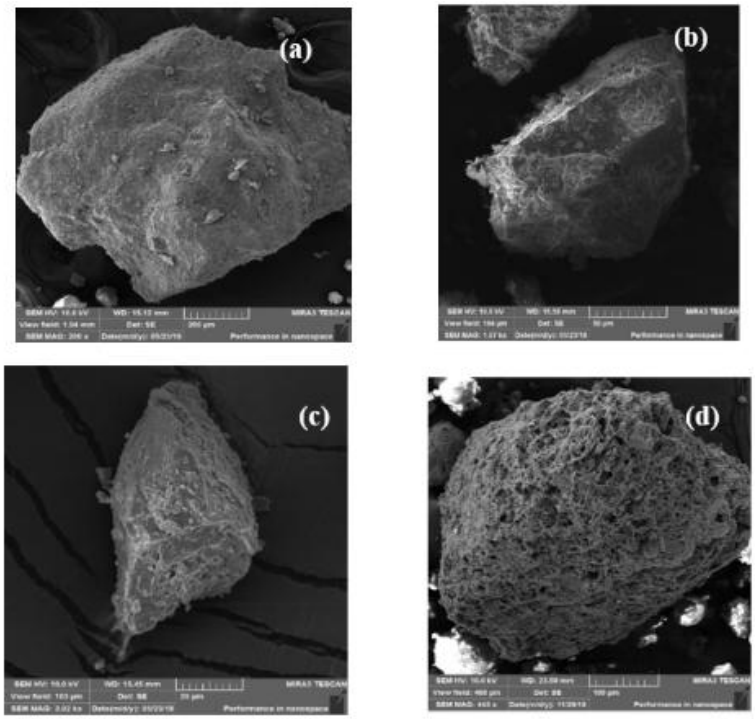


Fig. 5: Surface Morphology of Fine Aggregates (a) RS, (b) CRS, (c) RFA & (d) CBA

Methylene blue test for fine aggregates are determined by the procedure based on the standard AASHTO T300 to evaluate the amount of clay minerals in aggregate sample in terms of methylene blue value (MBV). In addition, specific surface area and cation exchange capacity is also calculated.

The results is shown in Table 3. The MBV was well within 6 mg/g corresponding roughly to a clay content of less than 5 % for all types of alternative fine aggregates indicating fewer amounts of harmful elements like clay and these sands are good to use in making concrete. Optimization of combined aggregates were done to achieve a sustainable concrete. The combination of aggregates: MS_{10}: MS_{20} for each type FA were carried out with varying quantity from 10 % to 100 %, whereas MS_{10} and MS_{20} were proportioned in the ratio 70:30 respectively. The maximum packing density of 0.902, 0.798 and 0.667 were achieved for RS, CRS and RFA respectively. The volumetric proportion of FA: MS_{10}: MS_{20} were in the ratios of 40:42:18 for RS, 30:49:21 for CRS and 30:49:21 for RFA respectively. Ordinary Portland cement (OPC) of 43 grade confirming to IS : 269-2015 was used in this study. Potable tap water was used for mixing and curing concrete specimens. Third generation carboxylic ether based superplasticizer confirming to IS : 9103 was used to increase the workability of the concrete. Crushed stone aggregate of maximum size of 20 mm having specific gravity of 2.69 and fineness modulus of 7.09 was used as coarse aggregate. Crushed stone aggregate of intermediate size of 10 mm having specific gravity of 2.60 and fineness modulus of 6.80 was used. Alternative fine aggregates used are varied about 30 %, 50 %, 75 % and 100 % as replacement percentage to natural river sand (RS) in concrete. The mix proportioning for each fine aggregates used is given in Table 4.

Table 2: Chemical Composition FA

Compound	River Sand	Crushed Rock Sand	Recycled Fine Aggregate	Coal Bottom Ash
SiO_2	84.54	63.05	70.86	45.30
Al_2O_3	9.14	24.36	12.47	18.10
FeO	1.87	6.38	6.31	19.84
K_2O	2.28	2.57	2.58	2.48
Na_2O	0.19	2.01	1.00	-
CaO	1.02	0.45	4.45	8.70
MgO	0.86	1.17	2.32	0.97

Table 3: MBV for Fine Aggregates

Sample Type	Average volume of MB consumed (ml)	MBV (mg/g)	SSA m^2/g	CEC meq/g clay
RS	2.00	1.00	244.78	31.20
CRS 30	1.50	0.75	183.58	23.40
CRS 50	1.75	0.875	214.18	27.30
CRS 75	2.00	1.00	244.78	31.20
CRS 100	3.00	1.50	367.17	46.80
RFA 30	2.00	1.00	244.78	31.20
RFA 50	3.00	1.50	367.17	54.60
RFA 75	3.50	1.75	428.37	54.60
RFA 100	5.00	2.50	611.95	78.00
CBA 30	2.50	1.25	3.05.97	19.50
CBA 50	3.00	1.50	367.17	46.80
CBA 75	4.00	2.00	489.56	62.40
CBA 100	6.00	3.00	734.45	93.60

Table 4: Mix Proportion Used for M30 Grade Concrete

Types of Fine Aggregate	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	330.00	720	729.60	486.00	165.0	1.65
CRS	320.00	666	798.00	342.00	160.0	1.60
RFA	324.64	645	722.40	309.60	162.32	1.62
CBA	333.00	722	780.00	334.50	166.50	1.66

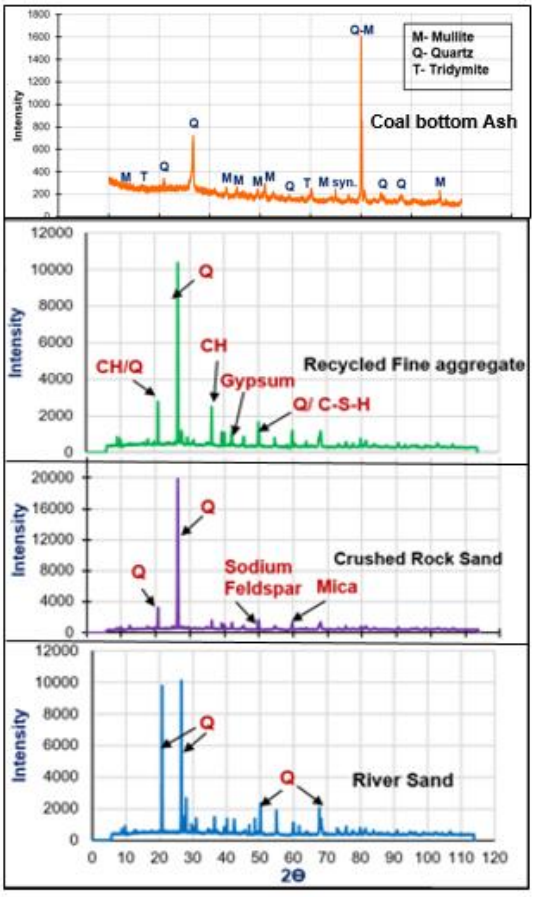


Fig. 6: XRD Pattern for Fine Aggregates

The fresh properties of mortar were tested by flow table test as per IS 1199. It was observed that as percentage of fine aggregates increased flow of the mortar decreased irrespective of w/c ratio and SP. Optimum percentage of fine aggregates with respect to flow is given in Table 5. Compressive, splitting and flexural strength of the concrete decreases with increase in volume fraction of alternative fine aggregates Table 5, however, this trend was not observed in case of CRS concrete. It was also observed the compressive strength of CBA concrete increased with age indicating increase in pozzolanic reaction. Drying shrinkage for all mixes at different ages of mortar is shown in Fig. 7. It was observed that at initial ages both RFA and CBA had higher shrinkage due to presence of old adhered mortar and porous structure, whereas rate of shrinkage reduced in later age due to effect of pozzolanic reaction at later ages. The drying shrinkage values of CRS mortars were lower than other

fine aggregates mortar irrespective of age. This is probably due to the CRS used had larger particle sizes distribution and hence lower (SSA) than that of the other fine aggregates. Surface electrical resistivity (SER) and Rapid chlorine penetration test (RCPT) results for all the mixes are shown in Fig. 8. It is observed that SER for all mixes increased as the age of the concrete mixes increases. It is observed that SER at 28 days for CBA and RFA resulted in the range of high-moderate probability of chloride ion penetration i.e. have low resistivity. However, the resistivity of CBA concrete increased at age of 56 days due the increased quantity of C-S-H product would block the ingress path and the alumina present in the CBA forms C3A and absorbs more chloride ions to form Friedel's salt ($C3A.CaC_{l2}.10H_2O$).

Table 5: Hardened Properties for Optimum % of Fine Aggregates at 28 Days

Types of Fine Aggregate	Compressive Strength (MPa)	Splitting Tensile Strength (MPa)	Flexural Strength (MPa)
RS	36.18	3.10	4.51
CRS 100	45.60	4.40	6.13
RFA 30	37.00	3.25	4.85
CBA 30	38.15	4.00	4.90

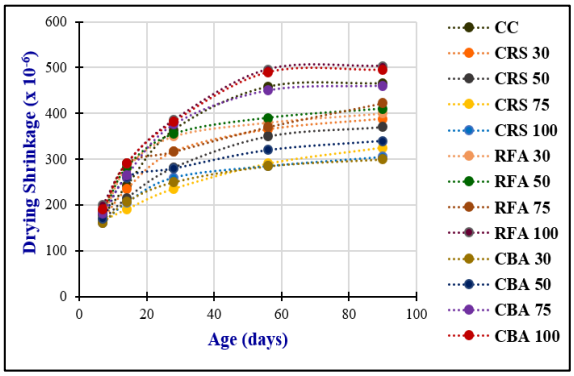


Fig. 7: Drying Shrinkage of Concrete

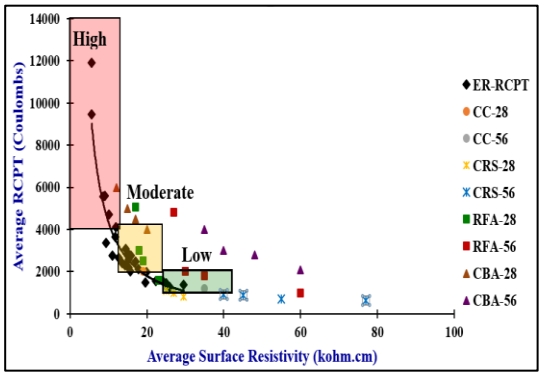


Fig. 8: SER & RCPT for all Mixes

Therefore, the idea of utilizing different alternative fine aggregates in concrete, proves from above studies that to be an inevitable replacement to river sand in construction industry. Further, properties of concrete, especially in durability studies such as acid-alkali immersion, carbonation, water permeability, porosity, thermal conductance, rheology etc. are being investigated with addition of different types of alternative fine aggregates.

Evaluation of FRP Pultruded Composite Section/Profiles & Their Use in Warehouse Construction

Rakesh Paswan, Chanchal Sonkar, Reyazur Rahman & Jeeshan Khan

Objectives:

- Physico-mechanical properties of pultruded profiles and flat sheets

- Physico-Mechanical Properties: Relative density, glass fiber content, water absorption, hardness, tensile strength, tensile modulus, flexural strength, flexural modulus, notch toughness, compressive strength and compression modulus, etc
- Thermal Properties: Coefficient of thermal expansion, thermal conductivity, curing behaviour, thermal stability etc
- Fire Test: Rate of burning, flame spread/propagation, limiting oxygen index, fire retardancy
- End Use Performance/Durability Studies: Weathering under different UV conditions, resistance to alkali, freeze-thaw etc. The exposed samples will be examined for dimension, visual appearance and loss of mechanical properties

- Structural properties of full scale pultruded profiles (3 m)
  - Members subjected to axial compression and members subjected to transverse loads will be evaluated for buckling load, modes of failure and ultimate load under uniform axial compression and three point bending respectively

Project Highlights:

The composites industry continues to evolve. The use of FRP composites has already transformed the marine, automotive and aerospace markets. Many specific applications in infrastructure and chemical processing have seen similar dramatic conversions. There is huge potential for a similar technology shift in the architectural and building and construction segments as the industry takes advantage of the design flexibility, durability, low weight, corrosion resistance, and other properties that composites offer. Industries around the world are currently producing fiber-reinforced polymeric (FRP) structural profiles of I-shapes, channels, angles, box and tubular sections, among others, in a variety of resins and fibers. These sections are manufactured by the pultrusion process. Pultrusion is a continuous process used primarily to produce long, straight shapes of constant cross-section. Pultrusion is similar to extrusion except that the composite material is pulled, rather than pushed, through a die. Pultrusion products are produced using continuous reinforcing fibers called 'roving' that provide longitudinal reinforcement, and transverse reinforcement in the form of mat or cloth materials. These reinforcements are resin impregnated by drawing through a resin wet-out station; and generally shaped within a guiding, or performing, system. They are then subsequently shaped and cured through a preheated die or set of dies. Schematic diagram of pultrusion process is shown in Fig. 1.

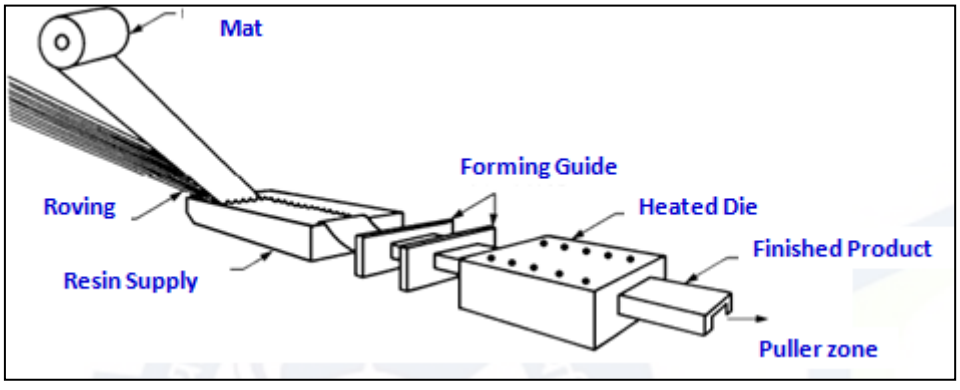
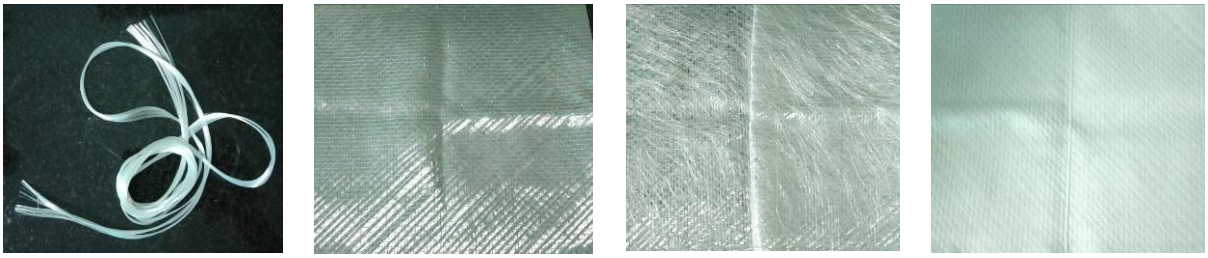


Fig. 1: Schematic Diagram of Pultrusion Process

The fibres generally used are glass, carbon, aramid, basalt or any other fiber in the form of rovings, woven fabrics, braided fabrics, stitched fabrics, continuous fiber mats and continuous strand mats of any size or weight. The fibres must be oriented in a minimum of two directions and separated by a minimum angle of 30˚. The minimum tensile strength of fibres should not be less than 2000 MPa

when tested as per ASTM D2343. The Arvind brand FRP pultruded profiles consisted of fibre volume fraction of 60 %. Out of which 40 % was continuous fiber (rovings) in the direction of the longitudinal axis and 20 % is multi-axial fabrics (Fig. 2).



(a) Rovings **(b) Multi-Axial Fabrics (± 45˚/90˚ & Chopped Fibres)** **(C) Surface Veil**

Fig. 2: Rovings & Multi-Axial Fabric Reinforcements & Surface Veil

Roving (Glass type E6 and tensile strength ~ 2600 MPa) coated with silane-based sizing and compatible with unsaturated polyester is used. The multi-axial fabrics constitute E-glass in layers oriented in directions ± 45˚/90˚ along with chopped fibres. The combination of roving and multi-axial fabrics is designed according to the requirement of individual profile. Rovings and multi-axial fabrics provide the required mechanical strength and stiffness when subjected to longitudinal and transverse loads. As the process is dynamic, the inclusion of a surfacing veil is the optimum method used to impart a wide range of properties to the surface of the pultruded profile. The surface veil provides high quality surface finish, eliminates the surface penetration of reinforcing fibres and improves corrosion resistance UV discoloration and degradation. The role of matrix or resin is to bind the composite material together and partly to hold the reinforcement in place. Commercial grade C'POL-2511 unsaturated polyester resin with higher reactivity and comparatively low viscosity is used by Arvind to produce high line speed in pultrusion process. Silent feature of the resin is it has high heat distortion temperature and good electrical and mechanical properties.

Results & Discussions

The physico-mechanical properties of pultruded FRP profiles are carried out. The standard specimens prepared from particular pultruded profiles as supplied were tested as per relevant test procedure as mentioned in ASTM and IS standards (Fig. 3). The Barcol hardness of FRP profiles was in the range of 58-65, when tested as per ASTM D2583. The Barcol hardness of materials was found to be under the limit specified in ASCE manual 2010. The density and water absorption of materials were in between 1.88 to 2.13 g/cc and 0.13 to 0.5 % (after 24 hr water immersion) tested as per ASTM D792 and D570 respectively. The average coefficient of thermal expansion was in the range of 7.92 to 11.74x10-6/°C determined between temperature of -30 to +30 °C which is in compliance with stipulated value (13.5x10-6/°C). The thermal conductivity of pultruded profiles was in the range of 0.22 - 0.29 W/m˚C. Such low thermal conductivity of material is due to low density of matrix resins used and high strength of embedded fibres. The mechanical properties tensile, compression and flexure strength of samples were tested under Universal Testing Machine (UTM) of capacity 10 T (Fig. 4). The results comply with ASCE manual 2010. The structural evaluation of FRP beams and columns is in progress.

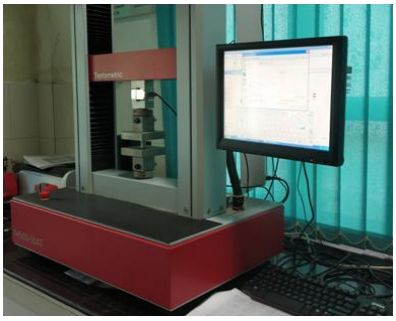
(a) Barcol Hardness Test as per ASTM D2583

(b) Glass Transition Temperature under DMA

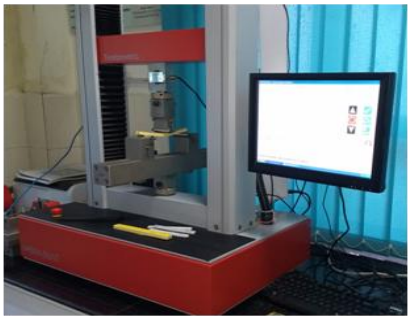
(c) Thermal Conductivity Test as per IS 3346

Fig. 3: Testing of Physical Properties of Pultruded FRP Profiles

(a) Tensile Test as per ASTM D638



(b) Compression Test as per ASTM D695



(c) Flexure Test as per ASTMD 790

Fig. 4: Testing of Mechanical Properties of Pultruded FRP Profiles

The results of physico-mechanical and thermal characterization of Pultruded FRP sections and flats are well below the values stipulated in ASCE manual (Pre-Standard for Load and Resistance Factor Design (LRFD) of Pultruded FRP Structures).

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)', which is changed to "Building Engineering & Construction Technology" from this year. The Institute is also taking Ph.D. students in the area of Engineering Sciences, Chemical Sciences and Physical Sciences. The details of different batches are given below:

M.Tech.

- 7th batch (2018-20) - ongoing

Ph.D.

- Two students joined for Ph.D. in Engineering Sciences and one for Ph.D. Chemical Sciences in August 2018.
- Three students joined for Ph.D. in Engineering Sciences in January 2019.
- Presently total 17 Ph.D. students are enrolled in AcSIR at CSIR-CBRI.

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

Orientation Programme for the New Students

Review of Progress of a Ph.D. Student by his Doctoral Advisory Committee

INFORMATION, EXTENSION & PROJECT MANAGEMENT

Publication Group

The Publication Group continued to serve as 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 CSIR-CBRI 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 Profiles, Technical and Divisional Brochures etc.; preparation of other scientific/technical reports and filling up of questionnaires; providing inputs for CSIR Annual Report as well as for CSIR News, CSIR Samachar and CSIR in Media; reporting scientific and technical work carried out at the Institute in Hindi and English; and publicity of the Institute's R&D capabilities through print media.

- **CSIR- CBRI Annual Report:**
  (available online at https://cbri.res.in/dissimination/annual-reports/)

The annual report is a reflection of the Institute's achievements throughout the year including R&D projects and highlights, research output, glimpse of activities, honours and awards, CBRI family, student-scientist connect programmes, lectures delivered, technology transferred and MoU signed, date-line and information, extension and project management etc. It is a result of intensive efforts made in manuscript evaluation, editing, graphic design, layout, illustrations, print-production, publishing, dissemination and feedback. Considerable inputs are involved in checking the output for language, page style, consistency, clarity, factual errors, adequate visual supply, technical details, colour composition and consistency, resolution of pictures, font and so on.

- **Bilingual CSIR-CBRI Newsletters/ भवनिका:**
  (available online at https://cbri.res.in/dissimination/newsletters/)

भवनिका/CBRI Newsletter
April-June 2018

भवनिका/CBRI Newsletter
July-September 2018

भवनिका / CBRI Newsletter
October-December 2018

भवनिका / CBRI Newsletter
January-March 2019

Four Issues

The publication provides a glance at the Institute activities including R&D outputs, training programmes, research publications, technology transfer, MoU signed, events, staff news etc. on quarterly basis in Hindi and English. It is resultant of extensive manuscript evaluation, editing, design, layout, illustration, print production, publishing, dissemination and feedback.

- **Technology Brochure, BRNs, Project Profiles etc.:**
  Technical, information and single-sheet project profiles, building research notes (BRNs) and brochures provide technical details of developed technologies, demonstrating reliability and excellence of Institute's work for public and consumer agencies in a sustainable, cost-effective, attractive and simple way.

- **R&D Highlights/Research Output of CSIR-CBRI in CSIR Annual Report:**
  Compiled R&D achievements of the Institute and transmitted for CSIR Annual Report covering the following items:
  - State Holder Connect for Line Ministeries
  - State Holder Connect for State Ministeries
  - ECF
  - Integrative Benefits-Cluster Wise
    - Strategic Impact
    - Societal Fulfilments
    - Environmental impact
  - Contribution to GOI Missions
    - Swachh Bharat
    - Skill India
  - Important Technological Contributions Against Sustainable Development Goals
  - High Impact Technologies Licenced/Commercialized
  - Important Scientific Achievements - Academic Impact
  - Patents
  - Publications
  - Honors and Awards
  - Important Events
  - MoUs/ Agreements

- **सीएसआईआर समाचार में सीबीआरआई :**

  CSIR releases सीएसआईआर समाचार- a newslwtter in Hindi that covers various activities of all its laboratories including R&D achievements, foundation day celebrations, programmes on important awareness days, seminars, demonstrations, training programmes, etc. Inputs are sent regularly on behalf of the Institute to the Newsletter. During the year, almost each newsletter witnessed the presence of CSIR-CBRI. Eighteen inputs of CSIR-CBRI witnessed their presence in सीएसआईआर समाचार, the same also available online at http://www.niscair.res.in/periodicals/csirsamachar

सीएसआईआर समाचार में सीबीआरआई

क्र.स.	लेख	अंक	पृष्ठ	वर्ष
1.	सीएसआईआर-सीबीआरआई द्वारा स्थापना दिवस समारोह का आयोजन	वर्ष 6 अंक 4	50-53	अप्रैल 2018
2.	सीएसआईआर-सीबीआरआई, रुड़की में बहु-आपदा रोधी आवास एंव पर्यावास विषय पर प्रशिक्षण कार्यक्रम	वर्ष 6 अंक 4	61	अप्रैल 2018
3.	सीएसआईआर-सीबीआरआई, रुड़की में सभी के लिए आवास-ग्रामीण आवासों हेतु नवीनतम प्रौद्योगिकियां विषय पर प्रशिक्षण कार्यक्रम	वर्ष 6 अंक 4	62-63	अप्रैल 2018
4.	सीएसआईआर-सीबीआरआई में सुरक्षित और सतत बुनियादी ढांचे में नवाचार विषय पर अंतर्राष्ट्रीय कार्यशाला	वर्ष 6 अंक 5	68	मई 2018
5.	सीएसआईआर-सीबीआरआई में अंतर्राष्ट्रीय महिला दिवस का आयोजन	वर्ष 6 अंक 5	69-70	मई 2018
6.	सीएसआईआर-सीबीआरआई, रुड़की द्वारा विकसित मानव निर्मित रेत: नदी के प्राकृतिक रेत का विकल्प	वर्ष 6 अंक 5	78-80	मई 2018
7.	सीएसआईआर-सीबीआरआई में जिज्ञासा कार्यक्रम का आयोजन	वर्ष 6 अंक 6	87-89	जून 2018
8.	सीएसआईआर-सीबीआरआई में राष्ट्रीय प्रौद्योगिकी दिवस समारोह	वर्ष 6 अंक 6	90-91	जून 2018

9.	सीएसआईआर-सीबीआरआई, रुड़की में कार्यशाला का आयोजन	वर्ष 6 अंक 6	92-93	जून 2018
10.	सीएसआईआर-सीबीआरआई, रुड़की में विश्व पर्यावरण दिवस का आयोजन	वर्ष 6 अंक 7	108-109	जुलाई 2018
11.	सीएसआईआर-सीबीआरआई में जिज्ञासा कार्यक्रम का आयोजन	वर्ष 6 अंक 7	110-112	जुलाई 2018
12.	सीएसआईआर-सीबीआरआई में योग दिवस समारोह का आयोजन	वर्ष 6 अंक 8	113-114	अगस्त 2018
13.	सीबीआरआई में तीन-दिवसीय राज्य-स्तरीय कार्यशाला का आयोजन	वर्ष 6 अंक 8	118-121	अगस्त 2018
14.	सीएसआईआर-सीबीआरआई में भारतीय अंतरराष्ट्रीय विज्ञान महोत्सव- 2018 अग्रगामी कार्यक्रम	वर्ष 6 अंक 10	154-156	अक्टूबर 2018
15.	सीएसआईआर-सीबीआरआई, रुड़की में सतर्कता जागरूकता सप्ताह का आयोजन	वर्ष 6 अंक 12	194-196	दिसंबर 2018
16.	डॉ. शेखर सी मांडे, महानिदेशक, सीएसआईआर द्वारा सीएसआईआर-सीबीआरआई, रुड़की का दौरा	वर्ष 7 अंक 1	9-12	जनवरी 2019
17.	सीएसआईआर-सीबीआरआई, रुड़की में स्थापना दिवस समारोह का आयोजन	वर्ष 7 अंक 2	18-20	फरवरी 2019
18.	सीएसआईआर-सीबीआरआई में दो-दिवसीय विद्यार्थी-वैज्ञानिक संयोजन कार्यक्रम	वर्ष 7 अंक 2	21-23	फरवरी 2019

- **CBRI in CSIR News:**

  CSIR releases newsletter carrying information on activities and accomplishments of its laboratories covering R&D highlights; new products and technologies; conferences, workshops, exhibitions; and major events such as Foundation Day, National Technology Day, Science Day, World Environment Day etc.

  Write-ups have been prepared and inputs on regular basis are provided for the same on behalf of the Institute. During the year, twenty-three inputs of CSIR-CBRI witnessed their presence in the newsletter; also available online at http://www.niscair.res.in/periodicals/csirnews

CBRI in CSIR News

S. No.	Article	Volume/ Issue	Page No.	Month
1.	Performance of Confined Masonry Buildings under Quasi-Static Condition: CSIR-CBRI, Roorkee	Volume 68 No. 7 & 8	63-65	April 2018
2.	CSIR-CBRI Celebrates National Science Day	Volume 68 No. 7 & 8	68	April 2018
3.	CSIR-CBRI Develops Manufactured Sand: An Alternative to Natural River Sand	Volume 68 No. 9 & 10	81-83	May 2018
4.	International Workshop on Innovations in Safe and Sustainable Infrastructure Organised by CSIR-CBRI	Volume 68 No. 9 & 10	85	May 2018
5.	Training Programme on "Housing for All – Innovative Technologies for Rural Housing"	Volume 68 No. 9 & 10	88-89	May 2018
6.	Training Programme on Multi-Hazard Resistant Housing and Habitat	Volume 68 No. 9 & 10	89-90	May 2018
7.	Training Programme on Engineering Simulations	Volume 68 No. 9 & 10	90-91	May 2018
8.	National Technology Day Celebrations at CSIR-CBRI, Roorkee	Volume 68 No. 11 & 12	108-109	June 2018
9.	Awareness Programme at CSIR-CBRI, Roorkee: Students Learn about the Wonders of Science	Volume 68 No. 11 & 12	112-114	June 2018
10.	International Women's Day at CSIR-CBRI	Volume 68 No. 11 & 12	114-115	June 2018
11.	World Environment Day at CSIR-CBRI	Volume 68 No. 13 & 14	128-131	July 2018
12.	Three-Day State-Level Student Workshop Organised at CSIR-CBRI, Roorkee	Volume 68 No. 15 & 16	145-148	August 2018
13.	PGTs from Six Regions Learn about Latest Scientific Innovations of CSIR-CBRI	Volume 68 No. 15 & 16	149-150	August 2018
14.	CSIR-CBRI Celebrates International Yoga Day	Volume 68 No. 15 & 16	154-156	August 2018
15.	IISF 2018 Precursor Events at CSIR-CBRI	Volume 68 No. 19 & 20	192-195	October 2018
16.	76th CSIR Foundation Day : CSIR-Central Building Research Institute (CSIR-CBRI), Roorkee	Volume 68 No. 19 & 20	197-199	October 2018
17.	CSIR-CBRI, Roorkee Organises Student Awareness Programme on Preservation of Ozone Layer	Volume 68 No. 21 & 22	208-209	November 2018
18.	CSIR-CBRI Organises Two-day Training Programme on Conservation of Heritage Structures	Volume 68 No. 21 & 22	211-213	November 2018
19.	DG-CSIR Visits CSIR-CBRI : Says "CSIR has Transformed Nation's Socio-Economic Scene"	Volume 68 No. 23 & 24	221-225	December 2018
20.	PGT Workshop at CSIR-CBRI	Volume 68 No. 23 & 24	234-235	December 2018

21.	CSIR-CBRI Organises Two-Day Student-Scientist Connect Programme	Volume 69 No. 1 & 2	12-15	January 2019
22.	CSIR-CBRI Foundation Day	Volume 69 No. 3 & 4	37-40	February 2019
23.	CBRI, Roorkee Organises National Workshop on Utilisation of Bamboo as Building Material in NE Region	Volume 69 No. 5 & 6	55-59	March 2019

- **CBRI in CSIR in Media:**
  CSIR, New Delhi releases an online publication "CSIR in Media" highlighting the achievements of CSIR Labs published in Newspapers for public awareness. Inputs from CSIR-CBRI, Roorkee were provided for insertion on a regular basis and are available online at https://www.csir.res.in/news-bulletin.

- **Inputs in Electronic & Print Media:**
  (available online at https://cbri.res.in/csir-cbri-in-media/)
  Newspapers, as media of mass-communication, are capable of generating scientific consciousness and rational behaviour in public. Keeping this in view, all the daily newspapers are kept in continuous dialogue and witnessed CBRI presence on regular basis.
  Various parameters-threshold, frequency, negativity, unexpectedness, unambiguousness, personalization, meaningfulness etc- are considered while preparing the news-items to be sent for dissemination. News-items for the press are cast within a short time period, ensuring publishing of the highlights of the activities held in the next day's newspapers.
  During the year, approximately 40-50 news-items (a total of about 250 news clippings) about CBRI have witnessed their presence in about 6-8 regional and national newspapers including Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Punjab Kesari, Badri Vishal, Dainik Aaj, Dainik Bhaskar, Dainik Hawk, Golden Times, Swatantra Chetna, Uttar Bharat Live, Loksatya etc.

- **Press Meets – Jan Samvad:**

  Press Meets- Jan Samvads are also organized periodically to apprise the public on the latest achievements of the Institute, important events and to broaden their horizons in the field of science.

  A press meet was organized on September 27, 2018 to apprise the public about the 4th India International Science Festival (IISF-2018) to be held during October 5-8, 2018 at Indira Gandhi Pratishthan, Lucknow. As a prelude to the event, Science Fest and Public Outreach Programme was organized on September 28, 2018 for students, teachers, public and user agencies at CSIR-CBRI, Roorkee. Press Representatives from electronic & print media including Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Dainik Aaj, Dainik Bhaskar, Dainik Hawk, Punjab Kesari, Uttar Bharat Live, Swatantra Chetna, Golden Times and Badri Vishal etc. attended the meet.

- **Visibility in Conference/Souvenir/Symposium Proceedings etc:**

Image building of the Institute by increasing visibility through advetisements etc. in Conference/ Souvenir/Symposium Proceedings etc..

- **Outreach through Articles in Magazines, Periodicals etc:**
  Articles reflecting Institute's capabilities and achievements are also published in Popular Science Magazines that are accessible to everyone including inputs in:
  - Vigyan Pragati, Vol. 66, No. 4, Page 23-26
  - Vigyan Pragati, Vol. 66, No. 5, Page 8-14
  - Vigyan Pragati, Vol. 66, No. 8, Page 16-21
  - NCHF Bulletin, Vol. 31, No. 3-4, Page 46-52
  - Vigyan Pragati, Vol. 67, No. 3, Page 24-27
  - Nirmanika 2018-2019, Page 49-51
  - Nirmanika 2018-2019, Page 58-61
  - Vigyan Vani, Year 2018, Issue 24, Page 90-93

- **Outreach Programmes:**
  During the year, more than 5000 candidates (students and teachers) from different schools and colleges have participated in 22 programmes organized by CSIR-CBRI, Roorkee, under "Jigyasa- Quest for Curiosity Student-Scientist Connect Programme".

- **India International Science Festival (IISF 2018) Precursor Events**
  - Press Meet
  - Open Day & Science Festival

Development, Construction & Extension Group

The Development, Construction and Extension Group is involved in various activities with the objective to disseminate R&D outcomes of the Institute among the user agencies for its field implementation. The Group organizes/participates in training/workshop programmes related to disaster resistant cost-effective housing, rural housing and creating awareness through exhibitions, visits of students, academic professionals and implementing agencies. The group is also involved in field implementation of rural housing schemes under PMAY-G and Biju Pucca Ghar Yojana in which over 4 lakh houses have been constructed across the state of Odisha. Some of the activities have been highlighted below:

Exhibitions:

In the year 2018-2019, the group has participated enthusiastically in three exhibitions, interacted with the masses and created the general awareness on various technical advancements of CSIR-CBRI. Details of various exhibitions are as follows:

1. Participated in 3 days exhibition of India International Science Festival during October 5-8, 2018 at Lucknow, in which CSIR-CBRI displayed its technologies.
2. Participated in 5 days exhibition at Indian Science Congress during January 3-7, 2019 at Jalandhar.
3. Participated in 2 days exhibition at Global Housing Technology Challenge-2019 during March 2-3, 2019 at Vigyan Bhawan, New Delhi, organised by Ministry of Housing and Urban Affairs.

India International Science Festival, Lucknow

Indian Science Congress, Jalandhar

Global Housing Technology Challenge-2019, New Delhi

Trainings/Workshops:

The Group has organized four training programmes and two workshops in the financial year 2018-2019. A total number of 313 persons have been trained during the training programmes. Different sponsors such as Odisha Panchayati Raj Department, TERI New Delhi, A&N State Disaster Management Authority, Ministry of Development of North Eastern Region (MDoNER) and State Centre for Climate Change & State Council for Science Technology & Environment Himachal Pradesh sponsored these four programmes. List of training programmes organised by the Group is as below:

S.No	Date	Events
1	September 17-18, 2018	Utilization of Bamboo as Building Materials in NE Region
2	September 27-28, 2018	Capacity Building of Structural Engineers on Multi Hazard Resistant Housing and Habitat of A&N Islands
3	December 18-21, 2018	Disaster Resilient Design and Construction of Building in Uttarakhand
4	December 18-21, 2018	Disaster Resilient Design and Construction of Building in Uttarakhand
5	February 18-19, 2019	National Workshop on Utilization of Bamboo as Building Material in NE Region
6	March 28-29, 2019	Master Trainers on Earthquake Resistant Constructions in Himachal Pradesh

Training for Capacity Building of Structural Engineers on Multi Hazard Resistant Housing & Habitat

Participants of Training Programme organized for Engineers of Uttarakhand Govternment

Technical Demonstration of Earthquake Resistant construction practices at Shimla

Inaugural Function of National Workshop on Utilization of Bamboo as Building Material in NE Region

Student Visits:

The Group organized technical visits for different college/school students at the Institute and a total 609 students & officials have participated in the year 2018-2019. The visitors have been briefed on the housing technologies developed by the Institute at various laboratories and rural technology park and list of the same is as follows:

S. No.	Name of Institute/Organisation	Date of Visit	Number of Visitors
1.	Moradabad Institute of Technology, Moradabad	April 10, 2018	53
2.	IIT Roorkee	April 19, 2018	32
3.	Quantum School of Technology, Roorkee	August 28, 2018	47
4.	Quantum School of Technology, Roorkee	September 6, 2018	52
5.	Roorkee College of Engineering, Roorkee	September 10, 2018	48
6.	TERI, New Delhi	October 10, 2018	45
7.	HEC Group of Institutes	February 28, 2019	50
8.	ITBP	March 1, 2019	35
9.	Shivalik Institute of Engineering, Dehradun	March 5, 2019	100
10.	World University of Design, Sonipat	March 7, 2019	15
11.	Dev Bhoomi Institute, Dehradun	March 12, 2019	87
		Total	**564**

Visit of RCE Students & Staff

Quantum School of Technology Students & Staff

Visit of TERI Students & Staff

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Knowledge Resource Centre

Knowledge Resource Centre (KRC) 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. Now it is fully automated and RFID enabled systems and services.

Acquisition:

- **Books**: KRC purchased 167 numbers of books and received 32 numbers of books on gratis basis.
- **Journals:** The library has subscribed 52 journals (21 foreign e-journals, 14 foreign print journals and 17 Indian journals). 74 volumes of journals were got bound.

Library Statistics:

The present position of library Collection:

- Books including reports; standards; conference proceedings; theses and maps: 45,100
- Bound periodicals: 20,754

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; Indian Green Building Council (IGBC), Hyderabad; and Indian Building Congress (IBC), Delhi.
- **International/Foreign:** International Union of Laboratories and 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: CBRI-KRC is maintaining continuously good 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, reference and Xeroxing services, 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, for topics of the interest of the Institute under eleven

major heads like-Building Materials; Structure and Foundation; Disaster Management: Earthquake and Landslides; Shelter Planning and Policy; Environment Science and 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 database 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), 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 CSIR-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 Week'.

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, PBD manages technology transfer to the industries, IPR management activities and execution of agreements and MoUs with various industries/institutes/organisations.

The 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:

Internal review meetings and meetings with external experts are organized for review of new R&D projects. The ongoing projects are monitored for progress and/or mid-course corrections. Comments of experts are conveyed to concern PIs and it is ensured that the same are incorporated before the projects are placed to 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.

During 2018-2019, Institute intensely involved in 15 In-house R&D, 3 CSIR Coordinated Mission Mode and 3 Fast Track Translation (FTT) projects.

Project Evaluations & Peer Reviews:

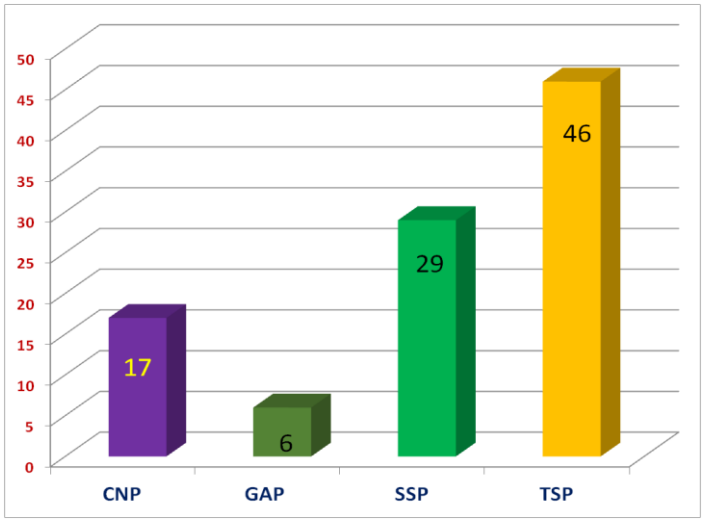
Internal and external peer review meetings and project evaluation meetings were organized for new and on-going In-house R&D projects as well as for the CSIR Coordinated & FTT Projects during the year. PBD group coordinated the scheduling of presentations and interacted with the project leaders for putting 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 56^{th} and 57^{th} 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 based on the expertise in different areas in the form of Consultancy, Sponsored, Grant-in Aid and Testing. The number of externally funded projects awarded is as below:



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.

Institute Publication:

PBD group also prepared the list of publications, published by the S&T staff members of the Institute in journals conferences, workshops and book chapters.

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), attended to RTI and Parliament questions.

Budget & ECF

CSIR Resource Input		External Cash Flow	
Revenue	3029.149 Lakh	Private	332.817 Lakh
Capital	276.015 Lakh	Government + PSU	1244.321 Lakh
Special Projects	1122.126 Lakh		
Total	**4427.290 Lakh**	**Total**	**1577.138 Lakh**

SPECIAL EVENTS

Administrative Workshop

CSIR-Central Building Research Institute, Roorkee organized an Administrative Workshop on Vigilance and Tender Process on May 1, 2018, as per the guidelines of Chief Vigilance Officer, CSIR Headquarters, with the aim to provide information regarding the rules and regulations of the Government of India and CSIR. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the workshop.

In his Presidential Address, Dr. N. Gopalakrishnan outlined the importance of the workshop and applauded the speakers for educating everyone on these important topics. He hoped that the staff would benefit from the lectures during workshop and their doubts would be resolved.


Dr. A.K. Minocha, Chief Scientist, said that we have to understand our responsibilities. He said that we should understand and consider even the minutest of detail to fulfill our objective and work towards achieving the goal. Dr. Ashok Kumar, Senior Principal Scientist welcomed everyone and conducted the workshop. Dr. Manu Saxena, Head, CSIR-HRDC, Ghaziabad highlighted the significance and relevance of the programme. Various lectures were presented during the workshop on topics including General Financial Rules (GFR 2017), Tender Process and Vigilance and Conduct Rule.

Shri Sanjay Agrawal, Director, Procurement Policy, Ministry of Finance, Government of India, highlighted the key points of "General Financial Rule 2017 (GFR 2017)" and focused on major changes made in the same. He discussed the main clauses of GFR 2017, related key points and rules, key construction points and services, exceptions, provision of booklet, claims and provisions for their disposal, provisions for advance and record destruction etc.

In addition, during his presentation on "Tendering Process", Shri Sanjay Agarwal informed about the rules and regulations related to e-tendering, e-procurement, tender process initiation, indent submission, local procurement without quotation, purchase up to 2.5 lakhs by local purchasing committee, procurement committee, receiving and opening tenders, making comparative statements and issuing orders to the firm with lowest rate etc.



Shri Rakesh Sharma, Former Senior Deputy Secretary, CSIR presented a lecture on "Vigilance and Conduct Rule" and explained the rules of conduct and key points of vigilance. He discussed in detail the importance of vigilance, highlighted the vigilance angle, talked about misconduct, explained the rules of conduct, their purpose and listed the 'to dos'/'do nots' etc.

The participants had interactive sessions during the presentations with the speakers wherein they asked questions and cleared their doubts. About 80 participants from CSIR-CBRI, Roorkee and about 40 participants of CSIR-IIP, Dehradun participated in the workshop, which included the scientific, technical and administrative staff. Shri Vinod Kumar, Administrative Officer proposed a vote of thanks.

National Technology Day

CSIR-Central Building Research Institute, Roorkee celebrated the National Technology Day on May 15, 2018. Prof. Mahesh Tandon, Managing Director, Tandon Consultants Pvt. Ltd., New Delhi graced the occasion as Chief Guest and Dr. P.K. Das, Architect, STUDIO 1860, Noida as Guest of Honor. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.

While presenting a lecture on "Sustainability in Urban Transport Structures", Prof. Mahesh Tandon, spoke about the importance of metro in urban public transport system and said that with technological development, new energy conservative and environment friendly techniques have been developed for the metro systems. He informed that the underground metro system has the least carbon emission amongst all public transport systems, due to which, for the first time in the world - carbon credits for use of underground metro systems - were given to the Delhi Metro Rail Corporation by the United Nations Climate Change Framework Convention, for minimum carbon emissions. He also explained the underground construction process of the metro transport system in detail.

Dr. P.K. Das, presented a lecture on "Rural Housing" and informed about various rural housing building techniques in India and the Prime Minister's Gramin Awas Yojna (PMAY-G) housing scheme for the construction of thirty lakh houses in the rural areas of the country in the next five years. He said that for the development of sustainable, environment friendly and budget friendly rural housing technologies, we have to develop new technologies through modern analysis of the local traditional building construction knowledge. He informed that the rural housing scheme has brought

together researchers, administrative officials, traditional knowledge skilled workers, industry and young architects, to work in synergy and provided opportunity of employment and development for all.

In his Presidential Address, Dr. N. Gopalakrishnan, highlighted various scientific achievements of CSIR-CBRI, Roorkee and explained the theme of the National Technology Day, "Science Technology for Sustainable Future". He informed that with the successful mastery of the nuclear war technology through a series of controlled tests at Pokharan, the test firing of indigenously developed 'Trishul' missile and the test flight of indigenous aircraft 'Hansa-III', on May 11, 1998, India proved its technological mantel to the world. To celebrate India's technical prowess and inspire the young minds to excel at innovations, the then Prime Minister Shree Atal Bihari Vajpayee declared May 11 as the National Technology Day of the country.

The latest edition of the Institute's quarterly bilingual publication, 'CBRI Newsletter-Bhavnika' was also released during the programme. Dr. A.K. Minocha, Chief Scientist conducted the programme and presented formal introduction of the Chief Guest. Shri Soumitra Maiti, Senior Scientist presented formal introduction of Guest of Honor and proposed a vote of thanks.

World Environment Day

CSIR-Central Building Research Institute, Roorkee along with The Institution of Engineers (India), Roorkee Local Chapter celebrated the World Environment Day on June 7, 2018. The aim was to promote awareness on preservation of bio-diversity, need to acknowledge the problem of growing levels of plastic waste that is destroying our environment and ways to take corrective action by rejecting single-use plastic items.

Dr. P.G. Rao, Former Director, CSIR-NEIST, Jorhat graced the occasion as Chief Guest and Dr. Sharad K. Jain, Director, National Institute of Hydrology, Roorkee as Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function. The celebrations began with the planting of trees by the dignitaries in CSIR-CBRI, Roorkee Lawns as a gesture of harmonious living with nature, followed by lightening of lamps.

Dr. P.G. Rao presented an intriguing lecture on "Green Technologies: Need of the Hour" and said that scientists can play a major role in saving environment from the impending doomsday conditions by developing innovative environment friendly materials and technologies from waste. He said that plastic makes up 10 % of all of the waste we generate, be it agricultural, industrial or domestic. This plastic waste is incredibly difficult to dissipate and so the focus should be to utilize this plastic waste in every way possible through new and innovative technologies.

Dr. Sharad K. Jain informed the gathering that every year, approximately 8 million tonnes of plastic end up in water bodies, destroying marine lives and disturbing the ecology. He also spoke about the

various activities being carried out to clean various water bodies of the state under Government Programmes such as Namami Gangey.

Addressing the gathering, Shri Malvinder Singh, Chairman, The Institution of Engineers (India), Roorkee Local Chapter administered an oath to beat plastic pollution by rejecting single-use plastic, refusing that which cannot be reused or recycled and working together to pave the way for a cleaner and greener world.

In his Presidential Address, Dr. N. Gopalakrishnan expressed his concerns on the disastrous impact of the overwhelming use of single-use plastic and said that this is a call to action for all of us to come together to combat one of the great environmental challenges of our time – Plastic Pollution. He asked everyone to make changes in the daily routine to ensure that our zest for material prosperity does not compromise environment and own health. While plastic has many valuable uses, we have become over-reliant on single-use or disposable plastic – with severe environmental consequences. He informed that CSIR-CBRI is working in the right direction to face these challenges by developing environment friendly building materials.

Dr. A.K. Minocha, Chief Scientist, welcomed the gathering, informed about the theme "Beat Plastic Pollution" and presented a formal introduction of Chief Guest. Dr. A.K. Mittal, Senior Principal Scientist presented a formal introduction of Guest of Honour and proposed a vote of thanks.

International Day of Yoga

CSIR-Central Building Research Institute, Roorkee observed the International Day of Yoga on June 21, 2018 with the aim to spread awareness on the importance of Yoga for physical, mental and spiritual well-being and healthy life. Yogacharya Dr. Sanjay Yogi Ji, Senior Yoga Trainer, Patanjali Yogpeeth, Haridwar guided the staff of the Institute on yoga exercises. The programme began with the Yoga Song.

Welcoming the gathering, Dr. Suvir Singh, Chief Scientist said that Uttarakhand has been the heart of yoga for many decades, where nature manifests as Yoga and Ayurveda to generate positive vibrations in every being. He said that yoga should be a part of the daily routine as it is the most economical way to achieve and maintain a healthy life.

Dr. A.K. Minocha, Chief Scientist on behalf of Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee, administered the Yoga Pledge. The participants pledged to maintain a balanced state of mind and reaffirmed their duties towards self, family, work, society and the world for the promotion of peace, health and harmony.

Yogacharya Dr. Sanjay Yogi Ji initiated the yoga training with Yoga Prayer to create a balanced atmosphere and calm mind. Yoga exercises as per the common yoga protocol including Shalabh Asana, Shashak Asana, Uttanapad Asana, Bhagiratha Asana, Kapalbhati, Anuloam Vihlom, Bhramari, Shitali, Sheetkari Pranayam etc., were demonstrated and repeated instructions motivated the participants to follow suit. Simultaneously, the right procedure, precautions and the benefits of each posture were also explained to the participants. Students of Yogacharya Dr. Sanjay Yogi Ji presented a Yoga Art Act wherein they demonstrated various yoga postures in an artful and mesmerizing manner.

Dr. Atul Kumar Agarwal, Senior Principal Scientist conducted the programme and said that constantly evolving art of Yoga, as a blend of ancient and modern art, has bonded the whole world as they welcome the rising sun with yoga, bringing the world closer to India and India closer to the world. Dr. Agrawal presented a formal introduction of Yogacharya Dr. Sanjay Yogi Ji and proposed a vote of thanks. Prior to the function, Dr. Agarwal also presented a lecture on “Healthy Mind, Healthy Body” and motivated the students to adopt a heathy lifestyle.

The staff of CSIR-CBRI, Roorkee and more than 100 students of Kendriya Vidyalaya No. 1, Roorkee along with their teachers, participated in the programme.

IPR Awareness Interactive Session

CSIR-Central Building Research Institute, Roorkee organized an IPR Awareness Interactive Session on July 13, 2018. Dr. Purnima Parida, Senior Principal Scientist and Shri Vineet Saini, Senior Scientist coordinated and conducted the programme. Shri Chetan Kumar, Chief Scientist and SIC, Innovation Protection Unit (IPU), CSIR and Shri Gaurav Krishnan, Senior Scientist, Innovation Protection Unit (IPU), CSIR were faculty of the programme.

Various topics were covered during the session basics of IPR, patentable vs non-patentable inventions, criteria of patentability: novelty, non-obviousness and industrial application, patent drafting and post grant issues (cost, renewal and review of portfolio), form 27 commercial working of inventions etc. The S&T staff of the Institute attended the programme.

Independence Day

CSIR-Central Building Research Institute, Roorkee celebrated the Independence Day of the Nation on August 15, 2018 with a deep sense of patriotism combined with gaiety at CSIR-CBRI Main Lawns. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee hoisted the National Flag, addressed the gathering and took the salute at the March Past performed by security guards. The schoolchildren from Bal Vidhya Mandir and CBRI Junior High School presented various cultural programmes on patriotic themes.

Sadbhavna Diwas

CSIR-Central Building Research Institute, Roorkee observed the Sadbhavna Diwas on August 20, 2018 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 the Sadbhavna Pledge to all the staff members of the Institute.

Team Building & Motivation Programme

CSIR-Central Building Research Institute, Roorkee in collaboration with CSIR-HRDC, Ghaziabad organized a Two-Day Programme on Team Building and Motivation during August 20-21, 2018 for young scientists and technical staff.

The programme inaugurated in the gracious presence of Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee; Shri Varun Harnal, Director, Human Training Consultants; Dr. Purnima Parida, Senior Principal Scientist, CSIR-CBRI, Roorkee; Shri Vinay Kumar, Senior Scientist, CSIR-HRDC, Ghaziabad; and Shri Vineet Saini, Senior Scientist, CSIR-CBRI, Roorkee.

Shri Varun Harnal was the resource person of the programme and delivered the lecture on personal mastery: understanding self and emotional intelligence, building positive work attitude, setting and achieving goals, building and leading team, influencing and managing conflicts etc and conducted some practical exercises related to the topics. The success of the programme could be discerned from the palpable exuberance in the face of young scientists and technical staff during the programme.

Family Get-Together & Sports Day

CSIR-Central Building Research Institute, Roorkee organized a Family Get-Together and Sports Day on August 31, 2018. CSIR-CBRI Family participated in the event with great zeal and excitement in a frolicsome atmosphere. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee inaugurated the event and participated enthusiastically in the games. He emphasized on the importance of sports in life of an individual.

The staff members and their family participated in various energizing games such as dodge ball, lemon race, tennis ball throw, tug of war and musical chair etc in different categories and set the tone for the rest of the event. Winners of each event were awarded.

Hindi Week

CSIR-Central Building Research Institute, Roorkee observed Hindi Week during September 14-20, 2018 with great zeal and enthusiasm. Dr. P.K.S. Chauhan, Principal Scientist and In-charge, Official Language Implementation coordinated the event.

On the occasion, a Hindi Book Exhibition was organized in the Knowledge Resource Centre (Library) under the supervision of Dr. S. K. Senapati, Library Officer. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee inaugurated the exhibition on September 14, 2018. A Bilingual Technical Display, prepared by Hindi Unit, also was released.

On September 20, 2018, Dr. M.R. Saklani, Ex. Secretary, Uttarakhand Hindi Academy graced the Valedictory Function as Chief Guest. Dr. A.K. Minocha, Chief Scientist chaired the function.

Address the gathering, Dr. M.R. Saklani called upon everyone for the combined responsibility to accept Hindi as Official language of our country for a comprehensive growth and development.



In his Presidential Address, Dr. Minocha 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 public.

On the occasion, a field guide on 'Termite Management in Buildings' authored by Dr. B.S. Rawat and a booklet 'CSIR-CBRI Tips for Good Construction Practices' compiled by Dr. Ajay Chaurasia and his team, were also released.

Shri Suba Singh, Hindi Officer welcomed the gathering and presented description of the Hindi activities and achievements throughout the year. Dr. Pradeep Chauhan presented a formal introduction of 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, debate competitions, poetry recitation were felicitated along with the winners of Incentive Schemes. Shri Mehar Singh, Hindi Officer proposed a vote of thanks.

Swachhta Pakhwada

CSIR-Central Building Research Institute, Roorkee observed Swachhta Pakhwada during September 15-October 2, 2018 wherein various awareness programmes were organized to spread awareness on the issue of cleanliness.

Under the supervision of Dr. Atul Kumar Agarwal, Senior Principal Scientist and Chairman Swachhta Pakhwada 2018, the Institute staff promoted the importance of cleanliness through various activities. Message of cleanliness was spread through notice boards, banners, digital displays etc. Extensive cleaning of the Institute premises, laboratories, colony, hostel, roads, dustbins, grounds, shopping complex, park etc. was carried out. The Group Leaders/ Division Heads supervised the cleaning and inspection of their respective division/group. All the doors, windows, curtains, containers, machineries, facilities and equipments were scrubbed and repaired. Obsolete and useless items, old unused files, papers, newspapers, magazines etc. were disposed. Canteen and mess at the Institute and guest houses were inspected and emphasis was given on the practice of clean and nutritious diet, plastic restriction and use of dustbin etc. Cleaning of the water installations, drinking water filters,

faucets, tank, leaking pipes toilets, sewer lines and drainage systems etc. of the Institute, residential area and school was also carried out.

CSIR-CBRI scientists visited Children's Senior Academy, Roorkee and organized a Cleanliness Drive, September 29, 2018, to spread the message of cleaniliness amongst the youth of the nation. Dr. Atul Kumar Agarwal presented a lecture on "Swachh Bharat-Swasth Bharat" and encouraged the students to adopt a clean and healthy lifestyle and work towards building a Swachh Bharat to fulfil the dream of the Father of the Nation-Mahatma Gandhi.

CSIR Foundation Day

CSIR-Central Building Research Institute, Roorkee celebrated CSIR Foundation Day on September 25, 2018 with great enthusiasm. Dr. Rajendra Dobhal, Director General, Uttarakhand State Council for Science and Technology, Dehradun graced the occasion as Chief Guest and Shri R.K. Srivastava, Executive Director, NETRA, NTPC, New Delhi as Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.

Addressing the gathering, Dr. Rajendra Dobhal stressed that for the development of a strong and technologically empowered nation, there is dire need of sincere, goal-oriented and time-managed research for the development of new and innovative technologies. In addition, these research and development works should receive proper federal funding and support for better output.

Shri R.K. Srivastava informed about the various research conducted jointly by NETRA and CSIR-CBRI to provide innovative outputs such as the Geopolymer Roads. He advised CSIR-CBRI to continue to work along with NETRA in the area of pollution control by developing low-cost advanced building materials from industrial by-products such as gypsum etc.

In his Presidential Address, Dr. N. Gopalakrishnan congratulated and thanked all the members of the CSIR family who have been a part of the glorious scientific journey of CSIR, and turned the challenges on the road into opportunities and achievements, and contributed to the development of the country.

On the occasion, two Institute publications - 'Confined Masonry' and 'Structural Designs and Detailing for Confined Masonry EWS Houses' were released.

As an important part of the day, the laboratories of CSIR-CBRI were open to the students and public at large, giving everyone the opportunity to become familiar with the R&D work of the Institute and interact with the scientists.

CSIR-CBRI staff members who completed twenty-five years' service in CSIR- Shri Himanshu Sharma, Shri Sushil Kumar and Shri Bharat Bhushan; and CSIR-CBRI staff members superannuated during the year- Shri Pradeep Kumar Yadav, Shri Subhash Chand, Shri Santosh Kumar Mishra, Shri Rizwanul Hassan, Shri Dharam Pal Singh, Shri Ramesh Kumar Johar, Smt. Neeta Mittal, Shri Dhan Prakash Yadav, Shri Amar Singh, Smt. Sunita, Dr. B.M. Suman, Shri R.C. Saxena, Shri Francis Charles, Shri Rishi Pal, Shri Vijay Kumar Sharma, Shri Raj Kumar and Shri Viswas Kumar (VRS); were felicitated.



On the occasion, Painting and Essay Competitions were organized for children of CSIR-CBRI staff. In the Painting Competition, category I with topic "Swachh Bharat" for students up to class 2, Anshu received first and Myra received second prize; and in category II with topic "Asian Games 2018" for class 3-5, Kavya received first, Aabra received second and Aarav received third prize. In the Essay Competition, category I with topic "Unity in India's Diversity" for class 2-6, Sajal won first prize; in category II with topic "Natural Disasters in India" for class 9-10, Uday won first and Simran won second prize; and in category III with topic "The Responsibility of Media in Nation's Development" for class 11-12, Nancy won first prize.

The superannuated staff of the Institute and over 100 students from Kendriya Vidyalaya No. 1, Roorkee and Kendriya Vidyalaya No. 2, Roorkee along with their faculty also graced the occasion besides other dignitaries.



Dr. A.K. Minocha, Chief Scientist conducted the function and presented formal introduction of Chief Guest. Dr. Suvir Singh, Chief Scientist presented formal introduction of Guest of Honor and proposed a vote of thanks.

Training Programme on Conservation of Heritage Structures

CSIR-Central Building Research Institute, Roorkee organized a Two-Day Training Programme on Conservation of Heritage Structures "BHAGVAN –A Search" during October 3-4, 2018.

Inaugurating the programme, Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee emphasized that in the modern world where the value of the rich cultural heritage is continuously decreasing, the importance of training the young minds to protect and preserve our heritage is quite prudent.

Dr. A.K. Mittal, Senior Principal Scientist and Programme Coordinator conducted the function and informed that the aim of the programme is to train students to search, study, explore, appreciate, research and conserve heritage structures and is named "BHAGVAN- Bharat Heritage And Grandeur reVitalizing National Assets". The programme provided information on study of scientific facts through training and research, exploration of knowledge and implementation of the project, understanding the characteristics of heritage structures, possibilities of research in CSIR laboratories/research in IIT, preservation of valuable assets for future generations etc.



Course Material/Proceedings of the Training Programme titled "BHAGVAN –A Search" was also released on the occasion.

Commencing the technical session, Dr. N. Gopalakrishnan presented a lecture on "Heritage Structure: Mechanics, Materials, Monitoring and Other Challenges". In addition, Dr. A.K. Mittal and Ms. Priyanka presented a lecture on "Introduction to Indian Heritage"; Shri Siddharth Behera on "Analysis of Heritage Structural Systems" and "Probable Causes of Distress in Heritage Structures"; Ms. Hina Gupta on "Online Monitoring of Heritage Structures" and "Repair and Restoration of Heritage Structural Components"; Dr. L.P. Singh on "Construction Materials and Issues"; Ms. Aswathy on "Effect of Excavation and Underground Tunneling"; Dr. P.K.S. Chauhan on "In-accessible Foundation Studies of Cultural Heritage Sites using Non-Invasive Techniques"; Shri Debadatta Ghosh on "Non-Destructive Techniques (NDT) for Heritage Structures"; Dr. A.K. Mittal on "Superiority Features in Heritage Buildings" and "Case Studies for Heritage Structures by CBRI"; Dr. Rajesh K. Verma on "Problem of Fungi on Heritage Structures and its Treatment"; Shri Micky Dalbehera on "Effects of Natural Disasters on Heritage Structures"; Dr. Rajni Lakhani and Shri Rajesh Sharma on "Strategies for the Restoration of Heritage Buildings: Material Issues"; and Shri I.A. Siddiqui presented lecture on "Importance of Heritage Data-Field Investigation and Data Collection Methodology".

Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the Valedictory Session. In his Presidential Address, Dr. Gopalakrishnan said that India has been an architectural genius since the Vedic times. This excellence is reflected in its heritage structures that have stood the test of time. This training programme is a tribute to the nation's architectural brilliance, a testimony to the great engineering skills of our ancestors who had incorporated such strength, beauty and details into the structures even before the modern technology and have even greatly documented them. He said that participants of the programme would act as ambassadors who will collect information of the various heritage structures near them and provide them to the Institute for detailed research.

Dr. A.K. Mittal briefed the objective of the programme and Shri I.A. Siddiqui proposed a vote of thanks. Certificates were also distributed to the participants. The training programme was attended by about 100 participants including students from Greater Noida, Lucknow, Hamirpur, Sikkim, Himachal, Delhi, Dehradun, Noida and project assistants of CSIR-CBRI Roorkee.

Training Programme on Affordable Housing in Disaster Prone Area

CSIR-Central Building Research Institute, Roorkee in association with NITTTR, Chandigarh organized a Short Term Training Programme on Affordable Housing in Disaster Prone Area during October 8-12, 2018. Dr A.K. Minocha, Chief Scientist inaugurated the programme.

During the programme, CSIR-CBRI scientists and experts - Dr. Suvir Singh, Dr. S. Sarkar, Dr. Ashok Kumar, Shri S.K. Negi, Dr. S.R. Karade, Dr. A.P. Chaurasia, Dr. S. Ganesh Kumar and Dr. R. Siva Chidambaram- delivered lectures on various aspects of affordable housing and disaster mitigation such as fire, landslide, earthquake, corrosion etc. Dr. Amit Goyal of NITTR also delivered lectures.

During the Valedictory Session, Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee addressed the participants and interacted with them. He emphasized upon the importance of quality of teaching and advanced level knowledge inputs to students for their career building. Dr. S.R. Karade and Dr. R. Siva Chidambaram coordinated the training programme.

About 30 participants from various engineering institutes attended the course, while other NITTTRs were connected through video conferencing.

Vigilance Awareness Week

CSIR-Central Building Research Institute, Roorkee observed the Vigilance Awareness Week with the theme “Eradicate Corruption: Build a New India” during October 29-November 3, 2018. Dr. Suvir Singh, Chief Scientist coordinated the event.

Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee inaugurated the program.me by administrating the Vigilance Oath. The scientists and staff took the pledge to maintain honesty and transparency, to work unstintingly for eradication of corruption in all spheres of life, to remain

vigilant and work towards the growth and reputation of our organization and through collective efforts, bring pride to the Institute by providing value based service to the nation.

An Essay Writing Competition and Poster Competition were organized in various categories for the students in the schools of the villages - Government Higher Secondary School, Beldi-Haridwar and Government Model Primary School, Belda I Roorkee.

In the winners of Essay Writing Competition, in category I for students of class IX-X, students of Government Higher Secondary School, Beldi- Ruksar came first, Vani Thakur placed second and Nisha came third; in category II for class VI-VIII, students of Government Higher Secondary School, Beldi- Ashish Kumar came first, Alka placed second and Alisha came third; and in category III for students of class V, students of Government Model Primary School, Belda I- Alkma came first, Rajni placed second and Elma received the third prize.

In the winners of Poster Competition, in category I for students of class VI-VIII, students of Government Higher Secondary School, Beldi- Ikra came first, Tamnna placed second and Kafia came third; whereas in the category II for class III-IV, students of Government Model Primary School, Belda I- Sadiya came first, Arshlan placed second and Sofiya received the third prize.

Under the guidance of Dr. Atul Kumar Agarwal, Senior Principal Scientist, a Debate Competition and Quiz Competition was organized for the students of class 11 at CSIR-CBRI, Roorkee. About 200 students from Kendriya Vidhyalaya No. 1, Children's Senior Academy, Greenway Modern Senior Secondary School, Doon Public School and Army Public School 2, Roorkee participated in the programme.

In the winners of Debate Competition, Vartika Chauhan of Doon Public School came first, Sharad Singh from Army Public School 2 placed second, Khushi Bhatia from Greenway Modern Senior Secondary School came third and Kavita Lohan from Children's Senior Academy received the fourth place. Shri S. K. Negi, Chief Scientist and Dr. L.P. Singh, Principal Scientist judged the event.

In the winners of Quiz Competition, team of Gargi and Aakansha from Kendriya Vidyalaya No. 1 placed first, team of Nandani Mittal and Suraj Setu from Greenway Modern Senior Secondary School placed second, and team of Nancy Patel and Akhilesh Singh from Army Public School 2 received the third place.

A Slogan Writing competition for the employees of CSIR-CBRI Roorkee and a Poster Competition for the children of Institute staff up to class 5, were also organized.

Dr. Atul Kumar Agarwal presented a lecture on "Eradicate Corruption: Build a New India" to sensitise the employees on the issue of corruption. He said that corruption has spread all over the world, but it has taken deeper roots in India. It is disheartening to know that in the fight against corruption India ranks at 81st position in a list of 180 countries and is considered one of the worst offenders in the Asia-Pacific Region. He emphasized on fighting corruption with unity, by bringing transparency and accountability in the work and explained the various rules and laws implemented by the government to achieve the same. Corruption is not just bound by office boundaries it can take place anywhere as it is the result of two corrupt minds. He said that time has come to restore our values and honour honesty, to prove that it is more valuable than a corrupt person's earnings. This will eradicate the termite of corruption from our nation. We have to unite to fight corruption just as we did for the polio eradication campaign. Dr. Agrawal also explained the rules and provisions of the Right to Information Act in simple words.

During the Valedictory Function, posters and banners made in different competitions during the week were displayed. Dr. S.K. Jain, Director, National Institute of Hydrology, Roorkee, graced the occasion as Chief Guest and Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.

Dr. Ashok Kumar, Chief Scientist conducted the programme and Shri Anil Kumar, Administrative Officer proposed a vote of thanks. Vigilance Awareness Week concluded with the prize distribution to winners of various programmes organized during the week.

Training Programme on Disaster Resilient Design & Construction of Buildings in Uttarakhand Projects

CSIR-Central Building Research Institute, Roorkee in association with The Energy and Resource Institute, New Delhi organized a Four-Day Training Programme on Disaster Resilient Design and Construction of Buildings in Uttarakhand Projects during December 18-21, 2018. The course aimed at enhancing knowledge and skills on planning and designing, construction techniques, quality control and construction of buildings to mitigate the risk in existing buildings by the field level machineries. The programme was conducted in two parts i.e. a One-Day Training Programme for Contractors on December 18, 2018 and a Three-Day Training Programme for Engineers and Architects during December 19-21, 2018.

Training Programme for Contractors:

The programme was inaugurated Dr. A.K. Minocha, Chief Scientist. During the Inaugural Session, Dr. A.K. Minocha expressed the importance of practical experience of contractors that helps them to deal with challenges of hilly terrain. By combining this practical experience with some technical interventions and suggestions on disaster safe resistant construction practices, the quality of the housing construction systems would immensely enhance and fulfill needs of hilly terrain in building the safe and sustainable houses. Shri S.K. Negi, Chief Scientist and Programme Coordinator welcomed the participants and briefed about the programme. Dr. Ajay Chourasia, Shri H.K. Jain and Shri Ashish Pippal were also present during the session. Dr. R. Dharmaraju, Programme Coordinator proposed a vote of thanks. The programme was attended by 14 contractors of Uttarakhand.


During the technical sessions, Dr. Ajay Chourasia and Shri H.K. Jain explained the different structural failures of buildings, earthquake resistant building designs and codal provisions, quality construction and general precautions taken during the construction of houses in different localities. Subsequently, various model shelters/houses/buildings made for demonstration purposes such as mud house, green building, pre-fabricated temporary shelters for disaster victims, low cost affordable housing and two-pit sanitation facility etc were demonstrated to the participants at Rural Technology Park. The participants showed keen interest for the adaptation of such technologies in field under different programme of government with the help of CSIR-CBRI, Roorkee.

Training Programme for Engineers and Architects:

The programme was inaugurated by Dr. Suvir Singh, Chief Scientist. While addressing the participants, Dr. Suvir Singh expressed the importance of construction of disaster resistant houses and mitigation of disaster risks in Uttarakhand. He mentioned that CSIR-CBRI is always ready to provide the technical support on building science, needed for local administration, for development of sustainable built environment. He also said that this could be achieved by enhancing knowledge and skills of implementing authorities by providing training/demonstration/skill developmental activities to filed level functionaries.


Dr. R. Dharmaraju, Programme Coordinator welcomed the participants and briefed about the programme. Shri S.K. Negi, Programme Coordinator proposed a vote of thanks. Dr. Ajay Chourasia, Shri H.K. Jain andShri Ashish Pippal were also present during the session. About 23 officers from

different departments of Uttarakhand Govt. consisting directors, executive engineers, assistant engineers, junior engineers, IT professionals and research associates, attended the programme.


About twelve technical sessions were planned in the training programme along with the visits to different laboratories and Rural Technology Park. During the technical sessions, the topics on earthquake resistant design and construction, building failure, codal provisions, interventions on design of low cost housing, fire safety in buildings, disaster management, flood risk mitigation, landslide control measures etc were covered by Dr. Ajay Chourasia, Shri H.K. Jain, Dr. R. Dharmaraju, Dr. Suvir Singh, Prof. R.K. Jain, Dr. S. Sarkar, Shri Ashish Pippal and others.

During the Concluding Session, participants expressed the usefulness in adaptation of latest scientific knowledge on disaster resistant building construction at grass root level with the technical support of CSIR-CBRI scientific community. The session concluded with the distribution of certificates to the participants.

Dr. Shekhar C. Mande, DG CSIR Visits CSIR-CBRI, Roorkee

Dr. Shekhar C. Mande, Director General, CSIR and Secretary DSIR, reviewed the R&D activities of CSIR-Central Building Research Institute, Roorkee during the visit on December 24, 2018 and encouraged the scientists, staff and students to generate cutting-edge technologies and transfer them to the society.


Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee welcomed the Director General and said that he is honoured and humbled by the DG's presence and inspiration.



Addressing the gathering, Dr. Shekhar C. Mande acknowledged the glorious history and contributions of CSIR. An unsung hero of nation's development, CSIR has transformed the nation's socio-

economic scene since independence. When India was denied the technologies at the global front, CSIR took on the challenge and generated world-class technologies indigenously; earning world respect and transforming India into the self-reliant tech nation it is today. Continuing into the IP era and understanding the power of knowledge, CSIR built and protected the nation's intellectual wealth, making it the largest IP holder in the country. Now in the age of globalization, CSIR has taken on the challenge to generate knowledge and technologies at the global level.

Elaborating the vision and mission of CSIR, Dr. Mande explained that the organization works on everything in terms of science and technology. Every CSIR lab has a niche and a strong base of excellent scientists who are contributing their excellence for the society, in the domain of their knowledgebase. CSIR is one of the world's largest publicly-funded R&D organisations contributing in every area of science. It connects academia, researchers, scientists and industry, building an ideal platform for fundamental, societal and translational research. In this regard, Dr. Mande encouraged the scientific staff of CSIR-CBRI to work along with the young researchers for advanced exploratory research. The research should be examined to identify societal impact, compared with existing technologies and analysed for technological readiness. The Institute must then collaborate with the industries to translate such feasible and scalable technologies to fulfil the nation's unmet needs. He discussed several missions undertaken by CSIR to translate the research from lab to land in terms of marketable, value-added technologies.

Dr. Shekhar C. Mande encouraged CSIR-CBRI, Roorkee to work in the direction of Green Technologies. He appreciated the Institute's work in the direction of affordable housing, disaster mitigation, and waste to wealth generation and urged to take it forward with focus on value-added products from regional waste, green development and green technologies. The issues of climate change, environment protection and preservation have been acknowledged at the global level. CSIR as a whole needs to build affordable green technologies to reduce the carbon footprint of the nation, he said.

Focusing on the need to bring science to the society, Dr. Mande stressed that for larger societal impact people need to be aware of the exemplary technologies being developed for the benefit of the masses. This can be achieved through effective science communication. Dr. Mande emphasized on the need of building a talented pool of science journalists and communicators who would bridge the gap between the scientific and non-scientific communities, through modern awareness tools such print and e-publications, science films, awareness and outreach programmes etc. In addition, Dr. Mande also insisted on working closely with academic institutes, state universities etc. to upgrade the skills of their young researchers from an early age by sharing of appropriate resources, expertise and technical

support. He highlighted the success of various CSIR schemes such as Jigyasa Student-Scientist Connect Programme and Skill Development Programme, to achieve these goals.

Earlier, Dr. N. Gopalakrishnan gave a presentation on the R&D activities, public interactions and novel products developed by CSIR-CBRI, Roorkee. He presented a brief account of the Institute's facilities, laboratories, ongoing work and CBRI's plan for the years to come. Director General, Dr. Shekhar C. Mande, met with the Institute scientists and discussed their views for roadmap of the R&D plans.

On the occasion, Dr. Mande released the latest edition of the quarterly bilingual CBRI Newsletter-Bhawnika. A book on 'Superiority Features of Indian Heritage Structures' and its website was also launched by Director General, Dr. Shekhar C. Mande.

Dr. Mande also inaugurated the "CSIR-CBRI Construction Technology Demonstration Park for Mass Housing". The technologies developed by the Institute under rural housing, affordable mass housing, C&D waste management, dry construction, utilization of bamboo in construction etc. were demonstrated through models and technical charts. Live demonstrations of CBRI developed machineries and technologies such as boring machine, robotic technology for periodic inspection of civil structures, mini crane advanced versions etc. were appreciated by the Director General. Dr. Mande also showed keen interest in the models developed under PMAGY, conservation of heritage structures and mass housing projects.

Dr. Mande laid the foundation stone for the new facility on "Construction of Pseudo-Dyanamic Test Facility for Buildings" and inaugurated the newly developed "Intelligent Building" and "Cement Concrete and Composites Lab".

DG, CSIR also visited the various laboratories of CSIR-CBRI, Roorkee including the Fire Research Lab, Landslide Experimental Lab etc. and also inspected the recently laid high strength fly ash based Geopolymer Concrete Road developed by CSIR-CBRI in collaboration with NTPC-NETRA. Dr. Mande also planted trees in the Institute campus and encouraged green living.

Training Programme on Landslide Mitigation & Detailed Project Report (DPR) Preparation

CSIR-Central Building Research Institute, Roorkee organized a Two-Day Training Programme on Landslide Mitigation and Detailed Project Report (DPR) Preparation during January 17-18, 2019, sponsored by National Disaster Management Authority (NDMA), New Delhi.

The programme was inaugurated by Dr. Suvir Singh, Chief Scientist; Dr. D.P. Kanungo, Senior Principal Scientist and Course Coordinator; Dr. Ravinder Singh, Consultant – Landslides and Avalanches, NDMA, New Delhi; along with other scientists, resource persons and participants from different states.

The aim of the programme was to make the participants and officials more familiar with landslides, detailed understanding of the initiation mechanism and mitigation measures of landslide disaster and most importantly the preparation of Detailed Project Report (DPR).

The programme consisted of various technical sessions focusing on presentations and deliberations by experts including discussion with Dr. Ravinder Singh on the aim, objective and the stages involved in DPR preparation; deliberations by Dr. D.P. Kanungo on various topics such as "Surface and Subsurface Investigation of Landslides" and "Landslide Instrumentation and Monitoring"; and invited presentations/deliberations from CSIR-CBRI Resource Persons- Dr. Anindya Pain, Dr. P.K.S. Chauhan, Shri Manojit Samanta, Dr. S. Ganesh and Shri Koushik Pandit on varied topics including "Identification, Description, Classification, Causes, Effects of Landslides", "Landslide Hazards in India with Special References to Indian Himalayas", "Surface and Sub Surface Investigation of Landslides", "Geological and Geotechnical Investigation of Landslide", "Geophysical Investigation of the Landslide Area", "Numerical Modelling for Landslide Stability Analysis", "Landslides: Control and Management Techniques" and case studies of "Landslide Mitigation Measures for Slopes Surrounding Tungnath Temple", "Landslide Stabilization Measures at KM 9-10 of Aglar-Thatyur Motor Road of Tehri Garhwal" and "DPR of Kohima-Thizama Road Landslide of Nagaland". Shri Vijay Dangwal, RVNL, Rishikesh was also invited to deliberate on case study of landslide mitigation measures.

Apart from the presentations and discussions, a Geotechnical Engineering Laboratory Visit Session was also arranged for the participants, to share the information on facilities available in CSIR-CBRI, Roorkee. The last session was designed specifically for participants' problem presentation, discussion and interaction with the subject experts and their feedback. Various difficulties faced during the preparation of DPR and field study were discussed. The opinions of all the participants regarding the training programme and the scope for the betterment of future programmes were also collected in the form of feedbacks.

Dr. R.S. Chimote, Chief Scientist, graced the Valedictory Function. The participation certificates, mementoes and course materials were also distributed to the participants during the session. About 25 participants from five different states - Goa, Uttarakhand, Himachal Pradesh, Sikkim and Kerala- working on landslide disaster mitigation participated in the training programme.

Republic Day

CSIR-Central Building Research Institute, Roorkee celebrated the Republic Day of the Nation on January 26, 2019 with a deep sense of patriotism combined with gaiety at CSIR-CBRI Main Lawns. Dr. A.K. Minocha, Chief Scientist, 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.

CBRI Foundation Day

CSIR-Central Building Research Institute, Roorkee celebrated its Foundation Day with great enthusiasm on February 13, 2019. Shri Durga Shankar Mishra, Secretary of Housing and Urban Affairs, Government of India graced the occasion as Chief Guest and Dr. Shailesh Kumar Agarwal, Executive Director, BMTPC, Housing and Urban Affairs, Government of India as Guest of Honour. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function. The programme inaugurated with the lightening of lamps by the dignitaries.

Speaking on the occasion, Shri Durga Shankar Mishra communicated the Prime Minister's vision of New India 2022 and said that it envisions India not as a developing but a fully developed nation- a nation devoid of poverty, dirt, discrimination and hunger; a global leader in terms of GDP and economy; a country with equal rights and opportunities; and most importantly, a nation with adequate Housing for All. As a premier Institute of the Government of India, CSIR-CBRI has a vital role to play in achieving this dream. Housing is a basic human necessity - a protection from nature's wrath- and understanding this need of its people the nation's first Prime Minister laid the foundation of CSIR-CBRI. Since its inception, CSIR-CBRI has made sterling contributions in the fields of building materials, construction technology and processes, auxiliary equipment research etc.

Shri Mishra said that the growing urban population is the major challenge of the housing construction sector today. Most of the villagers who migrate to the city in search of fairer opportunities create

unauthorized and inadequate houses that lack even the basic supply and sanitation facilities and cannot withstand weather changes. CSIR-CBRI needs to take up the challenge to create a whole ecosystem of affordable housing for the urban area, to tackle this problem.

Commending the Institute on its achievements, Shri Durga Shankar Mishra said that as India closes in to celebrate its Platinum Jubilee, CSIR-CBRI is also nearing its 75 years of service to the nation. To celebrate this milestone, the Institute should work to achieve the goal of providing affordable housing to the bottom 800 million of the pyramid, at the fastest pace. India is a nation of diverse geographical features, varying climates and different disaster zones and CSIR-CBRI needs to create varying housing construction designs to fulfil the requirements of all. He also informed about the achievements of various programmes initiated by the Prime Minister of India including Swachh Bharat Abhiyan, Housing for All, Smart Cities etc. He also gave a review of development of 151 aspirational districts under the NITI Ayog.

In his Presidential Address, Dr. N. Gopalakrishnan congratulated and thanked everyone who has contributed to its success directly or indirectly. He said that the Institute has faced and overcome many challenges during this glorious journey, though 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.

The Diamond Jubilee Best Research Paper was awarded jointly to Shri Manojit Samantha, Shri Piyush Punetha, Dr. Shantanu Sarkar, Shri Ajay Dwivedi and Shri Mahesh Sharma for their paper titled “Slope Stability Assessment and Design of Remedial Measures for Tungnath Temple at Uttarakhand India: A Case Study” and Shri S.K. Singh, Ms. Shilpa Kulkarni, Shri Vivek Kumar and Shri Prabhat Vashisht for their paper titled “Sustainable Utilization of Deinking Paper Mill Sludge for the Manufacture of Building Bricks”. The Diamond Jubilee Technology Award having Maximum Societal Impact was awarded to three technologies- “Process Know-how of Manufacture of Building Components i.e. Power Blocks, Tiles and Bricks from Construction and Demolition Waste” by Dr. A.K. Minocha, Shri Soumitra Maiti, Dr. Neeraj Jain, Ms. Monalisa Behera and Shri Santha Kumar; “Interpenetrating Polymer Network (IPN) Coating for the Protection of Reinforcement in Concrete” by Dr. Rajani Lakhani, Shri K.K. Asthana, Shri Francis Charles and Shri Shahnawaz Khan; and

"Round Boulders Mortar (RBM) Units for Hilly Regions" by Dr. Ajay Chaurasia, Dr. S.K. Panigrahi, Shri Jalaj Parashar and Shri Shubham Singhal.

The winners of the Debate Competition organized for the staff of Institute on the topic "Vedic Science: Truth or Fiction", under the supervision of Shri Aman Kumar, were also felicitated during the programme. Shri Arpan Maheshwari stood first, Shri Shaksham Bharadwaj placed second, Shri Sushil Kumar stood third and Shri Ashish Kharkwal received the consolation prize. Dr. Atul Kumar Agarwal, Senior Principal Scientist, CSIR-CBRI, Roorkee and Shri Alok Gupta, Kendriya Vidyalaya No. 1 adjudged the competition.

Dr. A.K. Minocha, Chief Scientist conducted the function and Dr. Suvir Singh, Chief Scientist proposed a vote of thanks. Shri Chandresh Yadav, ADM Haridwar; Mrs. Nikita Khandelwal, IAS, Joint Magistrate Roorkee; and Smt. Jaishree Gopalakrishnan also graced the event. The superannuated employees of the Institute were also present on the occasion.

The dignitaries visited CSIR-CBRI Construction Demonstration Park for Mass Housing and reviewed the Institute's R&D achievements. The demonstration park displayed a wide array of technologies developed by the Institute- from technologies suitable for both rural and urban spaces to those for different climatic regions, testing facilities, special equipments etc.

Shri Durga Shankar Mishra also chaired a meeting with Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee; Prof. Ajit Chaturvedi, Director, IIT Roorkee; the team of CBRI Scientists and team of IIT Professors; on "Global Housing Technology Challenge India" and discussed the roles, responsibilities and expectations in swift technology transition endeavour and the new eco-system

being built to promote innovations, enterprises and keeping abreast with the latest technological breakthroughs.

National Workshop on Utilization of Bamboo as Building Material in NE Region

CSIR-Central Building Research Institute, Roorkee organized the 2nd National Workshop on Utilization of Bamboo as Building Material in NE Region during February 18-19, 2019. Shri Saurabh Endley, Joint Secretary, Ministry of Development of North Eastern Region, New Delhi graced the Inaugural Function as Chief Guest and Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.


In his Inaugural Address, Shri Saurabh Endley said that his pleasure on organizing such workshop as bamboo construction in NE region is a logical fit. He requested the delegates to remove the misconceptions about bamboo and propagate the advantages in terms of better sound absorption, fire resistance, less damage during earthquakes.



In his Presidential Address, Dr. N. Gopalakrishnan stressed upon the challenges with bamboo construction such as non-homogeneity. He suggested focusing on research that can lead to make bamboo composites with the desired properties.

On the occasion, the latest edition of the quarterly bilingual publication- CBRI Newsletter/ Bhawnika was also released. Dr. R. Dharmaraju, Senior Principal Scientist and Convenor conducted the programme; Dr. A.K. Minocha, Chief Scientist presented the formal introduction of Chief Guest and Shri S.K. Negi, Chief Scientist and Convenor proposed a vote of thanks.



The workshop consisted of 6 technical sessions wherein 17 presentations were made by the eminent scientists, architects, practitioners and entrepreneurs. The participants also visited the various R&D laboratories and Construction Demonstration Park of CSIR-CBRI, Roorkee and witnessed the activities of the Institute.

The workshop aims to share the experiences of experts, researchers and professionals working on bamboo utilization for different building purposes with focus on advanced practices, techniques and case studies in conjunction with sustainability and economy covering social aspects as well. The outcome of the workshop will prove to be the backbone for updating the action plans for better utilization of bamboo as construction material.

CSIR-CBRI, Roorkee has been associated with North Eastern Council and Ministry of Development of North Eastern Region, under the aegis of Science and Technology Interventions in NE Region, to provide S&T interventions on comparative study of Bamboo versus Conventional Construction Systems and organizing the National Workshops on Bamboo as Building Material for North Eastern Region. In this direction, CSIR-CBRI had successfully organized the 1st Workshop on Utilization of Bamboo as Building Material in NER at Aizawl on September 18, 2018 wherein fruitful recommendations were brought out to promote Bamboo usage as building material in NE region.

The Valedictory Function was graced by Dr. B.B. Singh, IFS, Additional Principal Chief Conservator of Forest and Director, State Bamboo Mission, Madhya Pradesh; Shri R.S. Sinha, Additional Commissioner, Natural Resources Management, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, New Delhi, Government of India; and Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee.

Dr. Ajay Chaurasia, Senior Principal Scientist discussed the specific recommendations made during the workshop such setup of a full-scale test facility for bamboo buildings and products; CSIR-CBRI to become nodal agency to provide architectural, structural designs and technical assistance for the construction of aspirational bamboo demo display/information centres being constructed in all the 7 states of NE region under the financial support of NEC and MDoNER support; networking on bamboo construction practices involving all the professional as participating partners with CSIR-CBRI as nodal agency; BIS standardization on strength and stability of bamboo walls, roofs, flooring,

and joints; inclusion of bamboo based items in schedule of rates of the government construction departments; wider dissemination of information about advantages of bamboo construction by showing the beautiful bamboo structures and overcoming the misconceptions by using slogans like "Bamboo is Beautiful" and "Bamboo brings Blessings"; creation of centralized data base on bamboo species and products; development of understanding of thermal comfort in bamboo housing; design of curriculum for various levels of courses, such as ITI, Diploma and B. Tech. to develop skilled manpower such as artisans and engineers; development of a comprehensive road map for next 10 years at national and state level for wider applications of bamboo in construction; studies on reaction to fire and fire performance of selected bamboo species; and data generation on demand supply of bamboos for different levels of the industries.

Dr. S.R. Karade, Senior Principal Scientist presented a summary of proceedings of workshop based on the technical sessions and views of experts. Dr. Suvir Singh, Chief Scientist conducted the programme. Shri S.K. Negi and Shri Ashish Pippal, Organizing Secretary coordinated the workshop and Dr. R. Dharmaraju proposed a vote of thanks. The workshop was attended by more than 70 participants from 16 states of India.

Training Course at CSIR-CGCRI, Kolkata

CSIR-Central Building Research Institute, Roorkee organized a Two-Day Training Programme on BHAGVAN- A SEARCH (Bharat Heritage And Grandeur reVitalizing National Assets) during February 27-28, 2019 at CSIR-Central Glass and Ceramic Research Institute (CGCRI), Kolkata.

Dr. K. Muraleedharan, Director, CSIR-CGCRI, Kolkata inaugurated the event and emphasized on the importance of training the youth to protect and preserve the heritage of our nation. He appreciated the efforts made by CSIR-CBRI, Roorkee in organizing such type of training programmes.

Welcoming the gathering, Dr. Achal Mittal, Programme Coordinator briefed about the need and details of the training programme. He informed that CSIR-CBRI, Roorkee is organizing this course in four different zones of India - first course was organized at CSIR-CBRI, Roorkee during October 3-4, 2018; second course was held at CSIR- NCL, Pune during December 12-13, 2018; and third course was held at CSIR-SERC, Chennai during January 10-11, 2019. The current workshop is the fourth in the series.

CSIR-CBRI team of scientists and technical experts comprising of Dr. L.P. Singh, Dr. P.K.S. Chauhan, Shri Siddharth Behera, Shri I.A. Siddiqui, Ms. Priyanka Soni and Shri Raj Shekhar delivered lectures on various topics of heritage structure and their conservation. Dr. Jiten Ghosh, CSIR-CGCRI, Kolkata proposed a vote of thanks.

The training programme is also a part of the Skill Development Programme under the Mission Mode Project from Government of India. The programme is especially designed for civil and architecture students to study, explore, appreciate, research, conserve and preserve heritage structures of our

country, under the aegis of Heritage Mission Project (HCP - 0018), with the aim to digitize the information of heritage structures by allotting the participants a heritage structure for which a project report has to be submitted after completion of the programme. Many participants from the first, second and third course have taken up their final year dissertation on the conservation and restoration of the heritage structures.


The training programme was attended by 35 participants of civil engineering, architecture and planning backgrounds from different parts of country. The participants were shortlisted by a team of experts from CSIR-CBRI, Roorkee.

International Women's Day

CSIR-Central Building Research Institute, Roorkee celebrated International Women's Day on March 26, 2019. Dr. Charu Chaturvedi graced the occasion as Chief Guest, Dr. Shikha Jain as Guest of Honour and Dr. Jyotsna Agarwal as Invited Speaker. Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the function.


Smt. Jaishree Gopalakrishnan, First Lady of CSIR-CBRI, Roorkee encouraged women to be more concerned about their health. She cited a sholka from Manusmriti that says God resides where women are worshiped.

Dr. Charu Chaturvedi, First Lady of IIT Roorkee, emphasized on the importance of making society safe for women. She spoke about the need to remove taboos regarding issues pertaining to women's health and hygiene and creating an environment of openness.

Dr. Jyotsna Agarwal, a practicing Gynaecologist and Obstetrician, presented her address on Cancer Awareness – Gynecological and Breast Cancer. She told about the various symptoms, self tests and other tests to be performed to detect cancer. She emphasized the need of regular check up by females.

Dr. Shikha Jain, Counselor for students of IIT Roorkee talked about importance of curbing wastage and role of women in minimizing wastage.

Dr. N. Gopalakrishnan urged the females to undergo regular health check ups as early detection is very essential for curing any disease. He plans to conduct regular health check ups at CSIR-CBRI for all the employees, irrespective of gender.

Dr. Purnima Parida, Senior Principal Scientist conducted the programme and talked about what women want. She told time has changed and now women are moving ahead and marching along with men , but still much more needs to be done for gender equality. All the female employees and spouses of CSIR-CBRI staff attended the programme.

Training Programme on Earthquake Resistant Constructions in Himachal Pradesh

CSIR-Central Building Research Institute, Roorkee organized a Two-Day Training Programme for Master Trainers on Earthquake Resistant Construction in Himachal Pradesh during March 28-29, 2019 at RIPA, Shimla, under the CSIR Integrated Skill Initiative Programme, in association with State Centre for Climate Change and State Council for Science Technology and Environment, Himachal Pradesh. The programme aimed to sensitize the working professional from the educational institutions/implementing agencies of the government department on advanced earthquake resistant construction practice.

The programme was inaugurated by Ms. Manisha Nanda, IAS, Additional Chief Secretary, Government of Himachal Pradesh. Ms. Jyoti Rana, Joint Director, RIPA; Dr. S.S. Randhawa, Principal Scientific Officer, HPSCST&E; and Scientists of CSIR-CBRI, Roorkee also graced the occasion.


The training programme was planned to provide not only theoretical knowledge but also practical experience through live demonstration. The programme aimed to prepare master trainers in the state of Himachal Pradesh to impart training to people working under various departments and at various levels to bring the need of Earthquake Resistant Construction Techniques into ground reality.


During the programme, several technical presentations and field demonstration on construction practice were made by CSIR-CBRI, Roorkee. About eight technical sessions on topics including

CSIR-CBRI Initiative of Skill Development for Construction Industry; Earthquake, Wind and Snow Resistant Design of Houses; Earthquake Risk Mitigation and Management; Design of Confined Masonry Buildings in Earthquake Zone IV and V; Failure Analysis and Retrofitting of Earthquake Affected Buildings in the Hilly Terrain; Quality Assurance in Construction of Earthquake Resistant Structures; and Demonstration of Earthquake Resistant Construction Buildings in Hilly Area etc. were covered by CSIR-CBRI experts - Shri S.K. Negi, Chief Scientist; Dr. R. Dharmaraju, Senior Principal Scientist; Dr. Ajay Chourasia, Senior Principal Scientist; and Shri H.K. Jain, Retired Principal Technical Officer and Shri Vishal Singh.

During the Concluding Session, participants expressed the value in adaptation of latest scientific knowledge on disaster resistant building construction at grass root level with technical support of CSIR-CBRI scientific community. The session concluded with distribution of certificates to the participants.

The programme was attended by about 58 participants from different Polytechnic Colleges/IITs and State Government departments of Himachal Pradesh.

STUDENT-SCIENTIST CONNECT PROGRAMMES

Student-Scientist Connect Programmes

CSIR-Central Building Research Institute, Roorkee organized various scientific programmes at the Institute premises and at various schools of Roorkee under the aegis of JIGYASA: Student-Scientist Connect Programme. The Institute, under the leadership of Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee, has taken up the responsibility to motivate the youth and develop scientific thinking in children at the school level, as a Scientific Social Responsibility (SSR).

Dr. Atul Kumar Agarwal, Senior Principal Scientist & CSIR-CBRI Jigyasa Nodal Officer coordinated the several student-scientist and scientist-teacher interactions under the programme with the aim to develop scientific consciousness in young minds. Students were introduced to the latest innovative research and techniques of building and construction science including building materials, health monitoring and rehabilitation of the structures, disaster mitigation, fire safety, energy efficient rural and urban housing etc. Teachers were encouraged to include interactive science learning tools such as humour, stories and experiments in classrooms to reduce monotony and encourage students to adopt a scientific approach in life.

Highlights of the programmes:

- Dr. N. Gopalakrishnan, Director, CSIR-CBRI, Roorkee presided over the programmes and encouraged the students to participate in activities with enthusiasm.
- Shri Somit Shrivastav, Deputy Commissioner, Kendriya Vidyalaya Sangathan, Dehradun Region, Uttarakhand graced the Inauguration Ceremony of Three-Day State Level Students Workshop at CSIR-CBRI, Roorkee to encourage the students.
- Live demonstration of CSIR-CBRI technologies and hands-on experiments.
- CSIR-CBRI technologies explained through technical charts in CBRI Technology Gallery.
- Introduction to affordable rural housing technologies by visit to CBRI Rural Technology Park.

- Visit to CSIR-CBRI laboratories- Fire Research, Environment Science and Technology - Clay Products, Efficiency in Building, Organic Building Materials, Geo-Technical Engineering, Solar Panel and Structural Engineering etc and interaction with scientists/experts.
- Lectures on varied aspects to building science and technology by CSIR-CBRI scientists/experts: Shri R. S. Chimote, Chief Scientist; Dr. Suvir Singh, Chief Scientist; Dr. S. Sarkar, Chief Scientist; Dr. Atul Kumar Agarwal, Senior Principal Scientist; Dr. Achal Kumar Mittal, Senior Principal Scientist; Dr. S.R. Karade, Senior Principal Scientist; Dr. L. P. Singh, Principal Scientist; Mr. Soju Alexander, Scientist; and Dr. Tabish Alam, Scientist.
- Lectures on varied topics of science by external experts: Dr. Kulwant Singh, Scientist H, BARC, Mumbai; Dr. R.K. Goel, Chief Scientist and Scientist in-charge, CSIR-CIMFR Regional Centre, Roorkee; Dr. R.D. Dwivedi, Principal Scientist, CSIR-CIMFR Regional Centre, CBRI Campus, Roorkee; Dr. Mahesh Bhatt, President, VIBHA Dehradun Region, Uttarakhand; and B.K. Lakshmi Chand Bhai, Mount Abu Rajasthan.
- Motivational lectures on time, stress and memory management, perseverance etc.
- Q&A and Interactive Panel Sessions to clear doubts and encourage discussions.
- Display of science films highlighting the achievements of CSIR & CBRI.
- Science Exhibitions & Seminars by Students to present their understanding of scientific concepts through models, oral presentations, survey reports etc.
- Science Songs and Educational Skits on Digital India, Swachh Bharat etc. by students.
- Inter-school science competitions such as written science questionnaires, oral science quiz, debate etc. to evaluate students' knowledge and encourage learning through healthy debate, interaction and discussions amongst peers. Meritorious students felicitated.
- Prayer meet, thought of the day etc. to instill a positive atmosphere to the programmes.
- Plantation drive to explain the importance of environment to the students.
- Students encouraged to read popular science magazines to update themselves on current research and scientific output around the globe.

List of Programmes during the year:

Date	Programmes	No. of Schools/ Students/Teachers
May 3, 2018	Student Awareness Programme at CSIR-CBRI, Roorkee	2 / 100 / 5
May 12, 2018	Lecture at Children's Senior Academy, Roorkee	1 / 50 / 25
May 24-25, 2018	Lectures to PGTs of KVs from 6 Regions attending the In-service Course at Kendriya Vidyalaya No. 1, Roorkee	39 / - / 39
May 28, 2018	Exposure to CSIR-CBRI Labs to PGTs of KVs from 6 Regions attending the In-service Course at KV, Roorkee	39 / - / 39
June 21, 2018	International Yoga Day at CSIR-CBRI, Roorkee	1 / 100 / 2
July 3, 2018	Science Exhibition & Seminar at St. J.P. Convent Public School, Roorkee	1 / 300 / 30
July 18-20, 2018	Three-Day State Level Students Workshop at CSIR-CBRI, Roorkee	11 / 102 / 18
August 15, 2018	Motivational Lecture during Independence Day Celebrations at Children's Senior Academy, Roorkee and Mahavir International School, Roorkee	2 / 1000 / 30
August 30, 2018	Motivational Lecture at Cantonment Board Senior Secondary School, Roorkee	1 / 100 / 4
September 25, 2018	Awareness Programme on CSIR 76th Foundation Day Celebrations at CSIR-CBRI, Roorkee	2 / 98 / 4
September 27-28, 2018	Science Fest as Precursor Event to IISF 2018 at CSIR-CBRI, Roorkee	7 / 400 / 14

September 29, 2018	Cleanliness Drive at Children's Senior Academy, Roorkee	1 / 500 / 12
October 5, 2018	Student Awareness Programme on Preservation of Ozone Layer at CSIR-CBRI, Roorkee	2 / 200 / 4
October 29, 2018-November 3, 2018	Student Awareness Activities during Vigilance Awareness Week at CSIR-CBRI, Roorkee, Government Higher Secondary School, Beldi-Haridwar and Government Model Primary School, Belda I Roorkee	7 / 300 / 20
November 24, 2018	Scientific Consciousness- Know Your Surroundings at Doon Public Senior Secondary School, Roorkee	5 / 400 / 25
December 26, 2018	PGT Workshop at CSIR-CBRI, Roorkee for PGTs of KVs from 4 Regions attending the In-service Course at KV, Roorkee	36 / - / 40
December 30, 2018	Courage to Question at Ally Public School, Roorkee	1 / 100 / 18
January 24-25, 2019	Two-Day Student Scientist Connect Programme at CSIR-CBRI, Roorkee	5 / 400 / 10
January 26, 2019	Republic Day Celebrations – Scientific Heritage of India at Children's Senior Academy, Roorkee	1 / 500 / 30
February 7, 2019	Government Inter College, Daulatpur Students Visit CSIR-CBRI, Roorkee	1 / 80 / 4
February 9, 2019	Build on Failure : Success Mantra at Children's Senior Academy, Roorkee	1 / 200 / 15
February 23, 2019	Knowledge is Power at New Era Public School, Roorkee	1 / 350 / 15
		167 / 5280 / 403

List of Participating Schools:

Students and/or teachers from the following schools from across the nation participated in the programmes:

Kendriya Vidyalaya Sangathan Schools: No. 1 & 2 Roorkee, Pauri, Lansdowne, Raiwala, Almora, Gauchar, Srinagar, Haldwani Shift I & II, BHEL Haridwar, No. 1 Hathibarkala Dehradun, Kashipur, OLF Dehradun, NHPC Banbasa, No. 1 Ajmer, Baran, Churu, Deogarh, No. 5 Jaipur Shift I, Jhunjhunu, No. 1 Kota, Banar Jodhpur, Sri Ganganagar Cantt, Sikar, No.1 Udaipur, Skungarh, Itrana Ajwar, STPS Suratgarh, Sunjuwan, Miran Sahib, No. 2 Jammu, NRC Fatehgarh, Pilibhit, RDSO Lucknow, No. 1 Armapur Kanpur, IIT Kanpur, IIM Lucknow, AFS Bareilly, No. 1 & 3 AFS Chakeri Kanpur, AMC Lucknow and Faizabad Cantt

Government Schools: Cantonment Board Senior Secondary School Roorkee, Government Inter College Daulatpur, Sri Sanatan Dharam Prakash Chand Girls College Roorkee, Government Higher Secondary School Beldi-Haridwar, Government Model Primary School Belda I Roorkee, Arya Kanya Pathshala Inter College Roorkee, Gandhi Mahila Shilp Vidyalaya Inter College Roorkee and Methodist Girls College Roorkee

Other Schools: Children's Senior Academy Roorkee, St. J.P. Convent Public School Roorkee, Mahavir International School Roorkee, New Era Public School Roorkee, College of Advanced Technology Roorkee, Motherhood University Roorkee, Phonics Group of Institutes Roorkee, Greenway Modern Senior Secondary School Roorkee, Doon Public Senior Secondary School Roorkee, Army Public School No. 2 Roorkee, Sarvagya Public School Roorkee, Shivalik Public School Roorkee, Ally Public School Roorkee and Adarsh Bal Niketan Roorkee.

PROJECTS

In-house R&D Projects

S. No.	Project No.	Title of the Project	Principal Investigator Co-Investigator	Duration
HOUSING-STRUCTURE & FOUNDATION				
1.	HCP 0015	Development of Fast, Durable & Energy Efficient Mass Housing Scheme	Dr. Ajay Chourasia Dr. Ashok Kumar	0418-0320
Science & Technology Intervention for Development of Safe & Sustainable Building Infrastructure in NE Region			**Mr. M. Samanta** **Mr. Soumitra Maiti**	
2.	OLP 0412	**WP 1: Sustainable Materials & Technologies** 1.1: Architectural & Structural Engineering Interventions in Housing Stock of NE Regions 1.2.1: Development of Wood Plastic Composite Bamboo Fiber & 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	Mr. Soumitra Maiti Ms. Sayantani Dr. Hemlata Mr. Santha Kumar G. Dr. S. Ganesh Kumar Dr. Chandan S. Meena	0118-1220
3.	OLP 0413	**WP 2: Disaster Assessment & Mitigation in NE Himalayas**	Dr. D.P. Kanungo Dr. S. Sarkar Mr. M. Samanta	0118-1220
4.	OLP 0414	**WP 3: Societal Dissemination – Demonstration, Training & Skill Development for the NE Region**	Dr. R. Dharmaraju Mr. S.K. Negi	0118-1220
5.	OLP 0415	Development of Innovative Hybrid Connections for Pre-Cast Concrete Construction	Dr. S.R. Karade Dr. R. Siva Chidambaram	1117-1020
6.	OLP 0416	Prefabricated Ferro Cement Sandwich Panel Based Housing System	Mr. S.K. Singh Mr. Subash C.B. Gurram Ms. Surya M.	1017-0320
7.	OLP 0424	Development of a New Constitutive Relationship for 1D Nonlinear Site Response Analysis	Dr. Anindya Pain	0418-0320
CONSERVATION OF HERITAGE STRUCTURES				
8.	HPC 0018	Conservation & Restoration of Heritage Structure	Dr. A.K. Mittal	0418-0320

INNOVATIVE BUILDING MATERIALS				
9.	OLP 0418	Process Technology Development of Geopolymer Concrete with Varying Classes of Fly Ash for Use in Precast Building Components	Md. Reyazur Rahman Mr. Rakesh Paswan	1017-0920
10.	OLP 0419	Recyclability of Marble Waste in Concrete Production & Other Building Products	Dr. Rajni Lakhani Mr. Rajesh Kumar	0917-0820
11.	OLP 0420	Development of Self Compacting Recycled Aggregate Concrete for Precast Building Components	Ms. Monalisa Behra Mr. Santha Kumar G. Md. Reyazur Rahman	1017-0919
12.	OLP 0421	Development of Cost Effective Material for Sound Absorption with Partial Air Purification Properties	Mr. Siddharth Mr. S. Maiti	1017-0919
13.	OLP 0426	Development of Cement-Admixture System for Low Temperature Concreting	Dr. Jeeshan Khan Dr. Hemlata Mr. Rakesh Paswan Md. Reyazur Rehman	0418-0321
ENERGY EFFICIENT SYSTEM				
14.	OLP 0422	Efficient Solar Thermal Collector	Mr. Nagesh B. Balam Dr. Tabish Alam Dr. C.S. Meena	1017-0919
DISASTER MITIGATION				
15.	HCP 0017	Safety & Security of Vital Installations	Dr. Suvir Singh Dr. S. Sarkar	0418-0320
BUILDING PROCESS & AUTOMATION				
16.	OLP 0423	Development of Mobile Sensing Device for Complex Working Environment of Civil Structures	Mr. Ravindra S. Bisht Dr. S.K. Panigrahi	1017-0919
17.	OLP 0425	Seismic Performance Enhancement of Buildings using Smart Base Isolation	Mr. 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	Duration
1.	MLP 0511	Building Product using Kota Stone Cutting & Slurry Waste	Dr. Rajni Lakhani Mr. Rajesh Kumar	10.08.2016 to 09.08.2018
2.	MLP 0514	Pilot Scale Preparation of Silica Nanoparticles & their Applications in Cement Based Materials	Dr. L.P. Singh (PI) Mr. Srinivasarao Naik B. (Co-PI)	01.09.2018 to 31.08.2020
3.	MLP 0109	Development of Bamboo Composite Structural / Semistructural Elements for Building Application	Dr. Hemlata Dr. Rakesh Paswan	24.08.2018 to 31.03.2020

Externally Funded Projects

S. No.	Project No.	PI	Party Name	Title
1.	GAP0018	S.K. Singh	Nodal Officer, Chief General Manager, NBCC (India) Ltd., NBCC Bhawan, Lodhi Road, New Delhi	Characterisation of Manufactured Sand & its Effectie Utilization in Construction
2.	GAP0028	Anuj Kumar	Dr. J.B.V.Reddy, Principal Scientific Officer/Scientist-D, Govt. of India, Dept. of Science & Technology, Ministry of Science & Technology, Technology Bhawan, New Mehrauli Road, New Delhi	Indoor Environmental Quality (IEQ) Monitoring & Control System Based on Wireless Sensor-Actuator Network for Smart Indoor Enironments
3.	GAP0068	D.P. Kanungo	Director I/C & Nodal Officer, NMHS-PMU, G.B.Pant National Instituite of Himalayan Environment and Sustainable Development (GBPNIHESD), Kosi-Katarmal, Almora	Evaluation & Design of Low Cost Ground Instrumentation with Real-Time Monitoring for the Development of Landslide Early Warning System
4.	GAP0806	Ashok Kumar	Executive Director, IUSSTF, New Delhi	Improving Building Energy Efficieny (Indo-US Project)
5.	GAP0657	Ashok Kumar	Dr. J.B.V.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 Design for India (Indo-UK Project)
6.	GAP0218	A.K. Mittal	Chief Operating Officer, Dean's Complex, Foundation of Innovation & Technology Transfer, Indian Institute of Technology, Hauz Khas, New Delhi	A Digital Mini-Spectacle for Showcasing the Glory of Hampi
7.	GAP0228	A.K. Mittal	Chief Operating Officer, Dean's Complex, Foundation of Innovation & Technology Transfer, Indian Institute of Technology, Hauz Khas, New Delhi	Augmented Reality Interaction with Physical Modes of Monuments

8.	GAP0688	S.K. Singh	Joint Secretary, Technical Division, Ministry of Steel, Udyog Bhawan, Maulana Azad Marg, New Delhi	Development of Newer Cementitious Materials using Chemically Activated LD Slag
9.	SSP0038	Ajay Chourasia	Project Manager, BRIDCUL, Dehradun	Proof Checking/Verifying Structure Design for SDRF, Jolly Grant, Dehradun
10.	SSP0048	A.K. Mittal	DRM (Works), Bombay Division, Annexe Building, Central Railway, CST, Mumbai	Technical Examination on Structural Safety of UNESCO World Heritage CSTM Building (GM Building), Mumbai
11.	SSP0058	A.K. Mittal	DRM (Works), Bombay Division, Annexe Building, Central Railway, CST, Mumbai	Technical Examination on Structural Safety of Heritage DRM Building (Annexe Building), Mumbai
12.	SSP0078	A.K. Mittal	Deputy Program Director, Uttarakhand Urban Sector Development Agency, 777, Saatvik Tower, Kaulagarh Road, Rajendra Nagar, Dehradun	Structural Assessment & Rehabiliation of Buildings Affected during Construction of Wet Well at Mahigran, Roorkee
13.	SSP0088	Ajay Chourasia	Dy. Manager (Civil), NTPC, Kaniha, Dist. Angul	Detailed Condition Assessment of Structures of Stage I of TSTPS, Kaniha
14.	SSP0098	Ajay Chourasia	AGM (CHP), NTPC, Kaniha, Dist. Angul	Detailed Condition Assessment of Steel & Concrete Structures at Coal Handling Plant of NTPC, Kaniha
15.	SSP0148	Koushik Pandit	IDIPT, Uttarakhand Tourism Development Board, Govt. of Uttarakhand, Pandit Deendayal Upadhaya, Paryatan Bhawan, Garhi Cantt, Dehradun	Geotechnical Investigation & Suggestive Measures for Tehsil Building at Champawat, Uttarakhand
16.	SSP0158	S.K. Singh	Executive Engineer, CPWD, Delhi Aviation Division, East Block-3, Level-7, R.K. Puram, New Delhi	Condition Assessment of Type II & Type III Quarters & Suggesting Repair/Renovation /Upgradation of Quarters at SPG Complex, Dwarka, New Delhi
17.	SSP0208	Jeeshan Khan	Sr. Manager Technology, Research and Technology Center, Asian Paints Limited, Plot No. C-3B/1, TTC Industrial Area, MIDC Pawane, Thane-Belapur Road, Navi Mumbai	Evaluation of Smartcare Branded Water Proofing Coating

18.	SSP0258	H.C. Arora	General Manager, Artificial Limbs Manufacturing Corporation of India, G.T. Road, Kanpur	Technical Examination & Quality Inspection of Modernization & Upgradation at ALIMCO, Kanpur & Ujjain
19.	SSP0278	Suvir Singh	M/s Andhra Polymers Pvt. Ltd., Plot No. 2, Phase-VIDA, Jeedimetla, Hyderabad	Fire Performance Assessment of Load Bearing Aerolite Ceiling Tiles
20.	SSP0298	S.K. Singh	Vice President/Executive Director, Ruchira Papers Ltd., Trilokpur Road, Kala-Amb, Dist. Sirmour	Development of Building Products/Building Materials from Paper Mill Lime Sludge in form of Technology
21.	SSP0308	S. Sarkar	GM, Airport Authority of India (AAI), Operational Officers, Rangpuri Gurgaon Road, New Delhi	Instrumentation & Monitoring of Reinforced Soil Structure at Pakyong Airport, Sikkim
22.	SSP0318	Soumitra Maiti	Manager-Technical Service, SRF Limited, Village & PO Jhiwana, Tehsil Tijara, Dist Alwar	Feasibility Studies on Development of Value Added Building Components Using Fluro Gypsum
23.	SSP0328	Rajesh Deoliya	Director, National Institute of Communication Finance (NICF), Dept. of Telecom Ministry, Ghitorni, New Delhi	Third Party Inspection/Quality Assurance for Setting Up of Physical Infrastructure of NICF at Ghitorni, New Delhi
24.	SSP0408	Suvir Singh	Head-R&D, EDRC-RBU, TC-2,4th Floor, L&T Construction, Manapakkam, Chennai	Fire Performance Assessment of Load Bearing Walls
25.	SSP0428	Rajesh Deoliya	Executive Engineer, Education Project Division-I, PWD, Vikas Bhawan-II, Civil Lines, New Delhi	Third Party Inspection/Quality Assurance for the Work of East Delhi Campus of Guru Govind Singh Indraprastha University at Surajmal Vihar, Shadara, New Delhi
26.	SSP0488	Rajesh Deoliya	Executive Engineer, Delhi High Court Civil Dvn (M-341), PWD (GNCTD), Near Gate No. 6, Jawahar Lal Nehru Stadium, New Delhi	Third Party Inspection/Quality Assurance for the Work of Construction of New High Court Building S-Block for Delhi High Court, Zakir Hussain Marg, New Delhi

27.	SSP0568	Ajay Chourasia	HOD Civil, Projects & Development India Limited (PDIL), Vadodara	Structure Evaluation & Retrofit Suggestion of Apartment Building at PDIL Colony, Vadodara
28.	SSP0598	Navjeev Saxena	Deputy Commissioner, Special Bureau, Govt. of India, F-11/2, D-Block, Indira Nagar, Lucknow	Feasibility Study for Adding One Storey Above Existing Single Storey Office Building of Special Bureau, Lucknow
29.	SSP0658	Suvir Singh	The Imperial, North Tower, Level 2, B.B. Nakashe Marg, Tardeo, Mumbai	Fire Performance Assessment of Fire Doors
30.	SSP0708	Ishwarya G.	M/s SHK Polymer Industries, Plot No. 111/A, Opp. Mayur Dye Chem Ltd., GIDC Estate, Vatva, Ahmedabad	Evaluation of SHK Brand PPR Pipes & Fittings
31.	SSP0718	Soumitra Maiti	M/s Team Energy Systems, SCO 87, 2nd Floor, Sector 4, Panchkula	Design Adequacy cum Completion Report for High Draught Brick Kiln (Zig-Zag Setting) for the State of Punjab
32.	SSP0728	A.A. Ansari	Senior Accounts Officer, SPRE Accounts, 70 Acres, Thiruvanathapuram	Reaction to Fire Characteristic Studies of Virgin Foam Samples & Flame Proof Material Impregnated Foam Samples
33.	SSP0758	Ajay Chourasia	DDA, North Zone, New Delhi (Client: M/s B.G. Shirke Construction Technology Pvt. Ltd., 98/1308, Hemkunt Tower, Nehru Place, New Delhi)	Expert Services for Investigations of Cracks Observed in Erected Precast Pannels
34.	SSP0789	Pradeep Kumar	Secretary, Meerut Development Authority (MDA), Meerut	Quality Assessment of LIG Houses at Pandav Nagar, Meerut
35.	SSP0838	S. Ganesh Kumar	Chief Executive Officer, Shri Badrinath-Kedarnath Temples Committee, Maa Chandrabadani Temple, Kargi Chowk, Dehradun	Geotechnical Investigations for Building Construction around Omkareshwar Temples, Ukhimath, Uttarakhand
36.	SSP0908	Navjeev Saxena	Ex. Engineer ©, Health Maintenance Division (North), PWD, Dr. B.S.A. Hospital Complex, Sector-6, Rohini, Delhi	Distress Diagnosis & Suggestions of Rehabiliation Measures for Old Hospital Block & 48 Type-I Quarters of SGMH
37.	SSP0978	Ajay Chourasia	Shri Prasad Chavan, Office of the Chief Executive Officer, Cantonment Board, Meerut	Expert Review on Architectural Structural Drawings of Defence Estate

38.	CNP0248	S.K. Singh	Executive Engineer, CPWD, New Delhi Project Division-II, 3 B.D.Marg, New Delhi	Water Permeability Test of Concrete Specimens of MP Flats New Delhi as DIN 048
39.	CNP0288	H.C. Arora	Joint Project Director (RUSA), RUSA Project Directorate, Uttarakhand Dept. of Higher Education, Doon University, Kedarpuram, Dehradun	Technical Examination & Quality Inspection of Governement School Building at Mazra Mahadev
40.	CNP0348	S.K. Singh	Executive Engineer, Lucknow Central Division-I, Central Public Works Department (CPWD), 4th Floor, Kendriya Bhawan, Sector H, Aliganj, Lucknow	Condition Assessment & Study of Cracks Developed in Income Tax Office Building at Ashok Marg, Lucknow & Suggesting Remedial Measures
41.	CNP0398	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 Tunneling Work at Rameshwar Nagar, New Delhi
42.	CNP0458	Harish Arora	Chief Engineer, PTPS, Haryana Power Generation Corporation Ltd., Panipat	Structural Health Assessment & Suggesting Remedial Measures for Buildings of PTPS Colony, Panipat
43.	CNP0528	H.C. Arora	Registrar, Gurukul Kangri Vishwavidyalaya, Haridwar	Technical Assistance & Quality Inspection of Construction Works of Gurukul Kangri Vishwavidyalaya, Haridwar
44.	CNP0538	H.C. Arora	Regional Director, Regional Office, ESIC, Pachdeep Bhawan, Wing No. 4, Shivpuri, Prem Nagar, Dehradun	Structural Assessment of Regional Office & Staff Quarters of Employees State Insurance Corporation, Dehradun
45.	CNP0588	A.K. Mittal	Project Manager-3A, Delhi Metro Rail Corporation Ltd. (DMRC), Office of Chief Project Manager-3/Lane-7, Ground Floor, Mayur Vihar Phase-I, Metro Station, Delhi	Strutural Assessment of Buildings Damaged by DMRC Tunneling Work at Defence Colony, New Delhi
46.	CNP0768	I.A. Siddiqui	Sanrachana Structural Strengthening Pvt. Ltd., 103-104, Monalisa CHS, Harinivas Circle, Thane (W)	Evaluation of Methodology used for Strengthening of RC Component for MIL Station, Suratgarh

47.	CNP0778	A.K. Mittal	Rebuild Technologies Services Pvt. Ltd., #602, 6th Floor, Tulsee Chambers, Thane (W)	Evaluation of Methodology used for Strengthening of RC Component for OTM ACCN (Ph-II) for MH Bikaner
48.	CNP0808	S.K. Singh	Superintending Engineer, Central Public Works Department (CPWD), Shimla Central Circle, Kennedy Cottage, Shimla	Inspection of ARTRAC Building at Shimla & Technical Advice
49.	CNP0828	Manojit Samanta	M. K. Khullar, Lt. Col., Officer Commanding, 1442 BCC (GREF), PIN-931442, C/O 56 APO, Border Road Organization	Investigation & Design of Remedial Measures for Slope Protection at Holiday Home, Mussoorie
50.	CNP0858	Soumitra Maiti	M/s Team Energy Systems, SCO 87, 2nd Floor, Sector 4, Panchkula	Design Adequacy cum Completion Report for High Draught Brick Kiln (Zig-Zag Setting) for the State of Punjab
51.	CNP0868	Soumitra Maiti	M/s Pollution Consultants & Engineers, 22C, Pocket-8, SRS Royal Hills, Sector-87, Faridabad	Design Adequacy cum Completion Report for High Draught Brick Kiln (Zig-Zag Setting) for the State of Punjab
52.	CNP0898	A.K. Mittal	Project Manager-6A & 6B, Office of the Chief Project Manager/6, Press Enclave Road, Near Metro Station, Malviya Nagar, Delhi Metro Rail Corporation Ltd. (DMRC), New Delhi	Structural Assessment of Buildings Damaged by DMRC Tunneling Work at Street No. 1, Sarvapriya Vihar, New Delhi
53.	CNP0938	Neeraj Jain	M/s Team Energy Systems, SCO 87, 2nd Floor, Sector 4, Panchkula	Physical Verification of High Draught Zig-Zag Brick Kilns in Punjab State for Issue of Adequacy cum Completion Certificate as per CBRI Design
54.	CNP0968	S.K. Singh	Superintending Engineer, Central Public Works Department (CPWD), Shimla Central Circle, Kennedy Cottage, Shimla	Performance Evaluation/Testing of Materials Including Steel etc to Various Technical Specifications
55.	TSP0108	A.A. Ansari	Executive Assistant, Façade One Systems Pvt. Ltd., 201, Dosti Pinnacle, Wagle Industrial Estate, Road No. 22, Plot No. E-7, Thane	Fire Performance Characteristics Studies of Swiss Clad

56.	TSP0128	Suvir Singh	M/s Koleshvari Steel Industries, Plot No. 298, Road No. 4, Kathawada, GIDC, Ahmedabad	Fire Performance Assessment of Fire Door
57.	TSP0138	Suvir Singh	Shri Sushil Kumar, 82/8, Govind Vihar, Karawal Nagar, New Delhi-110094 C/o Office of the Asst. Engineer (Civil), Civil Health Main Sub Station-V (East), Public Works Department, Dr. Hedgewar Arogya Sansthan, Karkardooma, Delhi	Fire Performance Assessment of Glazed Fire Door
58.	TSP0168	Suvir Singh	M/s Kone Elevator India Pvt. Ltd., One Indiabulls Park Tower-B, 3rd Floor No. 14, 3rd Main Road, Ambattur Industrial Estate, Chennai	Fire Performance Assessment of Elevator Landing Door
59.	TSP0178	Suvir Singh	M/s USG Boral Building Products (India) Pvt. Ltd., Plot No. 610-13, 6th Floor, Vipul Trade Centre, Sector 48, Sohna Gurgaon Road, Gurgaon	Fire Performance Assessment of USG Boral Board Partition System
60.	TSP0188	Suvir Singh	M/s Techno Doors Pvt. Ltd., Plot No. L1, SIPCOT Industrial Park, Mambakkam & Pondur A Village, Sriperumbudur Taluk, Kancheepuram District, Tamilnadu	Fire Performance Assessment of Lift Landing Door
61.	TSP0198	Suvir Singh	M/s Teknopoint Control Equipments, 5, Triputi Industrial Estate, Bandup Village Road, Subhash Nagar, Bandhup (W), Mumbai	Fire Performance Assessment of Fire Dampers
62.	TSP0238	A.A. Ansari	M/s ERCON Composites, F-123, Phase-II, MIA, Basni, Jodhpur	Fire Performance Characteristics Studies of FRP/GRP Panels
63.	TSP0268	Suvir Singh	M/s Ozone Overseas Ltd., Trilokpur Road, Kheri, Kala Amb, Nahan, Dist. Srimour	Fire Performance Assessment of Fire Door
64.	TSP0338	Nagesh Babu Balam	M/s Twiga Fiber FOR Dy. Chief, Chemist & Matellurgist, Integral Coach Factory, Chennai	Evaluation of Thermal Conductivity of Glasswool Material as per IS3346 Standard
65.	TSP0358	Suvir Singh	M/s Adiba Fire Doors, #47/48, Byraveshwara Indl. Estate, Andrahalli Main Road, Behind Sushruthi Bank, Peenya 2nd Stage, Bangalore	Fire Performance Assessment of Fire Door

66.	TSP0368	Suvir Singh	M/s CS Components Pvt. Ltd., Plot No. 194/195/196, GIDC, Umbergaon, Dist. Valsad	Fire Performance Assessment of Fire Door
67.	TSP0378	Suvir Singh	M/s Navair International Pvt. Ltd., Plot No. 468, HSIDC Industrial Area Phase-I, Barhi, Sonipat	Fire Performance Assessment of Steel Fire Door
68.	TSP0388	Srinivasarao Naik	M/s Dalmia Cement (Bharat) Ltd., 11th & 12th Floor, Hansalaya Building, 15 Barakhambha Road, New Delhi	Characterisation of Samples by Instrumental Techniques
69.	TSP0418	Suvir Singh	M/s UltraTech Cement Ltd., Ahura Centre, A Wing, 3rd Floor, Opp. MIDC Office, Andheri (E), Mumbai	Fire Performance Assessment of Ultra Tech Wall
70.	TSP0438	A.A. Ansari	Director, M/s BNAL Prefabs Pvt. Ltd., Chandigarh	Fire Performance Characteristic Studies of Puf Panel
71.	TSP0448	Suvir Singh	M/s Globe Civil Projects Pvt. Ltd., B-28, Shivalik, New Delhi	Fire Performance Assessment of Fire Rated Door
72.	TSP0468	Suvir Singh	M/s Visaka Industries Ltd., Visaka Towers, 1-8-303/69/3, S.P.Road, Secunderabad	Fire Performace Assessment of Fire Wall
73.	TSP0478	Suvir Singh	M/s Vandere Sales Service (I) Ltd., D-75, MIDC, Shendra, Aurangabad	Fire Performance Assessment of Fire Retardant Cable Coating
74.	TSP0498	Suvir Singh	O/o Executive Engineer, CPWD, INA Colony, New Delhi	Fire Performance Assessment of Fire Door
75.	TSP0508	Soumitra Maiti	M/s Disha Ecoloc Pavers, Chawhan Products, Gomti Chaya, Tilak Nagar, Amravati Road, Nagpur	Testing of Paver Blocks as per Indian Standard
76.	TSP0518	Nagesh Babu Balam	M/s Larsen & Toubro Limited, CAPFIMS Project, Maidan Garhi, New Delhi	Evaluation of Thermal Conductivity of Calcium Silicate Board
77.	TSP0548	Suvir Singh	M/s Airpro Engg. Pvt. Ltd., 301, Mohan Ashish, Dr. Almeda Road, Panchpakhadi, Thane	Fire Performance Assessment of Fire Damper
78.	TSP0558	Suvir Singh	M/s Visaka Industries Ltd., Visaka Towers, 1-8-303/69/3, S.P.Road, Secunderabad	Fire Performace Assessment of Fire Wall
79.	TSP0578	Suvir Singh	M/s Mangla Sons Pvt. Ltd., C-85 Industrial Area, Phase-7, Kohali, Punjab	Fire Performance Assessment of Fire Door

80.	TSP0608	Shermi C.	Vice President (Engg., Planning & Design), B.G. Shirke Const. Tech. Pvt. Ltd., 72-76, Mundhawa Industrial Estate, Pune	Functionality Test on 3S Pre Cast Building System
81.	TSP0618	Suvir Singh	M/s Horizon Chutes Pvt. Ltd., S.No. 11/16/2 Village Nanded, Phata, Sinhagad Road, Pune	Fire Performance Assessment of Fire Doors
82.	TSP0628	A.A. Ansari	M/s E.I. Dupont India Pvt. Ltd., Dupont Knowledge Centre (DKC), DS-9 & DS-10, ICICI Knowledge Park (IKP), Survey No. 542/2, Genome Valley, Turkapally Village, Shameerpet Mandal, Rangya Reddy Dist., Hyderabad	Surface Spread of Flame Studies of Acrylic Solid Surfaces
83.	TSP0638	Suvir Singh	M/s Millennium Engineers & Contractors Pvt. Ltd., Office No. 501-504, 5th Floor Transbay, Opp. SKP Campus, Sr. No. 3, Balewadi, Pune	Fire Performance Assessment of Fire Door
84.	TSP0648	Suvir Singh	M/s Integrated Cleanroom Technologies Pvt. Ltd., #303, Surabhilotus, Nagarjuna Nagar Colony, Ameerpet, Hyderabad	Fire Performace Assessment of Composite Panels
85.	TSP0668	A.A. Ansari	M/s AET Building Products (Western India) Pvt. Ltd., Plot No. 14 & 15, Gopi Industrial Estate, B/H Ramdev Masala, Village Changodar, Taluka - Sanand, Dist. Ahmedabad	Fire Performance Characteristic Studies on Flexi False Floor Panel
86.	TSP0678	A.A. Ansari	M/s Paramount Intercontinental Pvt. Ltd., M 2, Industrial Area, Sonepat	Reaction to Fire Characteristics Studies on Reflective Insulation Material
87.	TSP0698	Suvir Singh	M/s Ozone Overseas Ltd., Trilokpur Road, Kheri, Kala Amb, Nahan, Dist. Srimour	Fire Performance Assessment of Fire Door
88.	TSP0738	A.A. Ansari	M/s Hira Technologies Pvt. Ltd., Plot No. I-02, (Part-II), Khed Industrial Park DTA, Village Kanhersar, Tal-Khed, Dist Pune	Fire Performance Characteristic Studies on Aerofoam XLPE with N Clad Foil
89.	TSP0748	Suvir Singh	M/s Paramount Polytreat Chemicals Pvt. Ltd., 2/10, Second Floor, Sarai Jullena, Opp. Surya Hotel, New Friends Colony, New Delhi	Fire Performance Assessment of Ventilation Duct

90.	TSP0768	Suvir Singh	M/s Galaxy Fire Protection Co., Plot No. 1, Block No. 1, Street No. 24, 2nd Floor, Tanki Road, Hari Nagar Extn., Jaitpur, Badarpur, New Delhi	Fire Performance Assessment of Fire Door
91.	TSP0778	Suvir Singh	M/s Iclean Hollow Metal Systems Pvt. Ltd., Door No. 54-16-3/1, Plot No. 20, First Floor, Central Excise Colony, Near Loyola College Gate, Vijayawada	Fire Performance Assessment of Glazed Fire Door
92.	TSP0788	Suvir Singh	M/s Asharam Engineering & Firestop (P) Ltd., Vrindavan Complex, Opp. Ravi Furniture, JSPL Road, Raigarh	Fire Performance Assessment of Cable Firestop
93.	TSP0798	Suvir Singh	M/s Sehgal Doors, B-133, Phase-I, Industrial Area, Mayapuri, New Delhi	Fire Performance Assessment of Fire Door
94.	TSP0818	Suvir Singh	M/s Veer-O-Metals Pvt. Ltd., Plot # 87-A, Jigani 1st Phase Industrial Area, Jigani Hobli, Anekal Taluk, Bangalore	Fire Performance Assessment of Fire Door
95.	TSP0848	Suvir Singh	M/s CS Components Pvt. Ltd., Plot No. 194/195/196, GIDC, Umbergaon, Dist. Valsad	Fire Performance Assessment of Fire Door
96.	TSP0888	Suvir Singh	M/s Johnson Lifts Pvt. Ltd., 53, Pitamber Plaza, Ground Floor, Shastri Nagar, Hardwar Road, Dehradun	Fire Performance Assessment of Lift Landing Door
97.	TSP0918	Suvir Singh	M/s Radiant Safedoors Pvt. Ltd., 539, Phase-II, GIDC, VAEVA, Ahmedabad	Fire Performance Assessment of Fire Door
98.	TSP0928	A.A. Ansari	GM Marketing, M/s Narendra Flexi Pack Co. Pvt. Ltd., Plot No. 4, Sector 4, Ballabgarh, Faridabad	Fire Performance Charateristic Studies of Chemically Cross Linked Closed Cell Polyethylene Foam
99.	TSP0948	Suvir Singh	M/s Kone Elevator India Pvt. Ltd., 50, Vanagaram Road, Ayanambakkam, Chennai	Fire Performance Assessment of Glass Landing Door
100.	TSP0958	Suvir Singh	M/s Kone Elevator India Pvt. Ltd., 50, Vanagaram Road, Ayanambakkam, Chennai	Fire Performance Assessment of Glass Landing Door

CBRI FAMILY

CBRI Family

Group-IV-Scientific Staff

S. No.	Name	Designation
1.	Dr. N. Gopalakrishnan	Director
2.	Mr. R.S. Chimote	Chief Scientist
3.	Dr. Suvir Singh	Chief Scientist
4.	Dr. Ashok Kumar	Chief Scientist
5.	Mr. S.K. Negi	Chief Scientist
6.	Dr. Shantanu Sarkar	Chief Scientist
7.	Dr. Harpal Singh	Chief Scientist
8.	Dr. R. Dharmaraju	Sr. Principal Scientist
9.	Dr. Pardeep Kumar-I	Sr. Principal Scientist
10.	Dr. Atul Kumar Agarwal	Sr. Principal Scientist
11.	Dr. Purnima Parida	Sr. Principal Scientist
12.	Mr. A.A. Ansari	Sr. Principal Scientist
13.	Dr. D.P. Kanungo	Sr. Principal Scientist
14.	Dr. Achal Kumar Mittal	Sr. Principal Scientist
15.	Dr. Rajni Lakhani	Sr. Principal Scientist
16.	Mr. S.K. Singh	Sr. Principal Scientist
17.	Dr. S.R. Karade	Sr. Principal Scientist
18.	Dr. Rajesh Deoliya	Sr. Principal Scientist
19.	Dr. A.P. Chourasia	Sr. Principal Scientist
20.	Mr. Nadeem Ahmed	Sr. Principal Scientist
21.	Dr. P.C. Thapliyal	Sr. Principal Scientist
22.	Dr. Sujit Kumar Saran	Principal Scientist
23.	Dr. Navjeev Saxena	Principal Scientist
24.	Dr. B.S. Rawat	Principal Scientist
25.	Dr. L.P. Singh	Principal Scientist
26.	Dr. Shorab Jain	Principal Scientist
27.	Dr. S.K. Panigrahi	Principal Scientist
28.	Dr. Rajesh K. Verma	Principal Scientist
29.	Dr. P.K.S. Chauhan	Principal Scientist
30.	Dr. Leena Chaurasia	Principal Scientist
31.	Dr. H.C. Arora	Principal Scientist
32.	Dr. Neeraj Jain	Sr. Scientist
33.	Mr. Vineet Kumar Saini	Sr. Scientist
34.	Mr. Manojit Samanta	Sr. Scientist
35.	Mr. Soju Joseph Alexander	Sr. Scientist
36.	Mr. Ravindra Singh Bisht	Sr. Scientist
37.	Mr. Soumitra Maiti	Sr. Scientist
38.	Mr. Srinivasarao Naik B.	Sr. Scientist
39.	Mr. Nagesh Babu Balam	Sr. Scientist
40.	Mr. Subash Chandra Bose Gurram	Scientist
41.	Dr. A. Aravind Kumar	Scientist
42.	Dr. Anindya Pain	Scientist
43.	Mr. Mickey Mecon Dalbehera	Scientist

44.	Mr. Piyush Mohanty	Scientist
45.	Mr. Siddharth Behera	Scientist
46.	Ms. Ishwarya G.	Scientist
47.	Ms. Monalisa Behera	Scientist
48.	Mr. Rajesh Kumar Sharma	Scientist
49.	Mr. Rakesh Paswan	Scientist
50.	Mr. Chanchal Sonkar	Scientist
51.	Md. Reyazur Rahman	Scientist
52.	Mr. Santha Kumar G.	Scientist
53.	Mr. Koushik Pandit	Scientist
54.	Ms. Sayantani Lala	Scientist
55.	Ms. Hina Gupta	Scientist
56.	Mr. Debdutta Ghosh	Scientist
57.	Ms. Surya M.	Scientist
58.	Mr. Ashish Pippal	Scientist
59.	Ms. Shermi C.	Scientist
60.	Dr. S. Ganesh Kumar	Scientist
61.	Mr. Chandan Swaroop Meena	Scientist
62.	Dr. Banti A Gedam	Scientist
63.	Dr. Kishor S. Kulkarni	Scientist
64.	Dr. Jeeshan Khan	Scientist
65.	Mrs. Aswathy M.S.	Scientist
66.	Dr. Tabish Alam	Scientist
67.	Dr. R. Siva Chidambaram	Scientist
68.	Mrs. Hemlata	Scientist
69.	Mr. Siddharth Singh	Scientist
70.	Mr. M. Vinoth	Scientist

Group III Technical Staff

71.	Mr. D.K. Sehgal	Principal T.O.
72.	Mr. Narendra Kumar	Principal T.O.
73.	Mr. Rajesh Kumar Tyagi	Principal T.O.
74.	Dr. P.K. Yadav	Principal T.O.
75.	Dr. S.K. Senapati	Principal T.O.
76.	Mr. Dalip Kumar	Principal T.O.
77.	Mr. Rajeev Kumar Sharma	Sr. T.O. (3)
78.	Mr. Sushil Kumar	Sr. T.O. (3)
79.	Mr. Zamir Ahmad	Sr. T.O. (3)
80.	Dr. M.K. Sinha	Sr. T.O. (3)
81.	Mr. Rakesh Kumar –II	Sr. T.O. (3)
82.	Mr. Vivek Sood	Sr. T.O. (3)
83.	Mr. Jalaj Parashar	Sr. T.O. (3)
84.	Mr. Ram Ashray Rai	Sr. T.O. (2)
85.	Mr. Bharat Bhushan	Sr. T.O. (2)
86.	Mr. Naresh Kumar	Sr. T.O. (2)
87.	Mr. Rajesh R. Ghadse	Sr. T.O. (2)
88.	Mr. B.K. Kalra	Sr. T.O. (1)
89.	Mr. Itrat Amin Siddiqui	Sr. T.O. (1)

90.	Mrs. Gayatri Devi	Sr. T.O. (1)
91.	Mr. Amit Kush	Sr. T.O. (1)
92.	Mrs. Deepti Karmakar	Sr. T.O. (1)
93.	Mr. Ajay Dwivedi	Sr. T.O. (1)
94.	Mr. Sameer	T.O.
95.	Mr. D.S. Dharamshaktu	T.O.
96.	Mr. Sugam Kumar	T.A. Gr. III (2)
97.	Mr. Amit Prakash Bhadula	T.A. Gr. III (2)
98.	Mr. Sachin Kumar	T.A. Gr. III (2)
99.	Ms. Bhawna	T.A. Gr. III (2)
100.	Mr. Dinesh Kumar	T.A. Gr. III (2)
101.	Mr. Anil Kumar	T.A. Gr. III (2)
102.	Mr. Seraj Alam	T.A. Gr. III (2)

Group II

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. Rishi Pal Singh	Sr. Tech. (2)
110.	Mr. Sushil Kumar	Sr. Tech. (2)
111.	Mr. Himanshu Sharma	Sr. Tech. (2)
112.	Mr. Manmeet Singh	Sr. Tech. (2)
113.	Mrs. Urmila Kotnala	Sr. Tech. (2)
114.	Mr. Amar Singh	Sr. Tech. (1)
115.	Mr. B.S. Bisht	Sr. Tech. (1)
116.	Mr. Rajeev Bansal	Sr. Tech. (1)
117.	Mr. Pradeep Kr. Kapooria	Sr. Tech. (1)
118.	Mr. Arvind Saini	Sr. Tech. (1)
119.	Mr. Harish Kumar	Sr. Tech. (1)
120.	Mr. Sukhbir Sharma	Sr. Tech. (1)
121.	Mr. Arvind Kumar	Sr. Tech. (1)
122.	Mr. Sharad Kumar	Sr. Tech. (1)
123.	Mr. Mam Chand Agarwal	Sr. Tech. (1)
124.	Mr. Arvind Kumar Sharma	Sr. Tech. (1)
125.	Mr. Tahir Husain	Sr. Tech. (1)
126.	Mr. Ghanshyam Mittal	Sr. Tech. (1)
127.	Mr. Kedar Nath	Sr. Tech. (1)
128.	Mr. Iqubal Ahmed	Sr. Tech. (1)
129.	Mr. Manoj Kumar Tyagi	Sr. Tech. (1)
130.	Mr. Jai Pal	Sr. Tech. (1)
131.	Mr. Shorab Khan	Sr. Tech. (1)
132.	Mr. Jameel Hasan	Sr. Tech. (1)
133.	Mr. U.C. Bhatnagar	Sr. Tech. (1)

Group I Supporting Staff

134.	Mr. Gurucharan Singh	Lab. Asstt.
135.	Mr. Rajeshwar	Lab. Asstt.
136.	Mr. Vijay Kumar	Lab. Asstt.
137.	Mr. Jagdish Pal	Lab. Asstt.
138.	Mr. Rajesh Kumar	Lab. Asstt.

Administrative Staff /House-Keeping

139.	Shri Vinod Kumar	CoA
140.	Shri Anil Kumar	CoA
141.	Mr. J.K. Chaurasia	F&AO
142.	Mr. Ajay Kumar Sharma	S&PO
143.	Mr. Mehar Singh	Hindi Officer
144.	Mr. Suba Singh	Hindi Officer
145.	Mr. V.P.S. Rawat	Security Officer
146.	Mr. S.K. Jakhwal	S.O. (G)
147.	Mr. Constan Kujur	S.O. (G)
148.	Mr. Lekh Raj Kaushik	S.O. (S&P)
149.	Mr. K. Arora	P.S.
150.	Mr. Satya Pal	P.S.
151.	Mr. Davender Rai	P.S.
152.	Mr. Naresh Yadav	Sr. Steno
153.	Mrs. Archana	Sr. Steno
154.	Mr. Arvind Kumar	Sr. Steno
155.	Mr. Dalpat Singh	Sr. Steno
156.	Mr. Dharam Singh Negi	Sr. Steno
157.	Mrs. Nisha Tyagi	Asstt. (G) Gr. I
158.	Mrs. Sarita Khanna	Asstt. (G) Gr. I
159.	Mrs. Sheema Farhat	Asstt. (G) Gr. I
160.	Mr. Sudhir Kumar	Asstt. (G) Gr. I
161.	Mr. Shiv Kumar	Asstt. (G) Gr. I
162.	Mr. Pawan Kumar	Asstt. (G) Gr. I
163.	Mrs. Mamta Sharma	Asstt. (G) Gr. I
164.	Mrs. Savita Vishwakarma	Asstt. (G) Gr. I
165.	Mr. Sushil Kumar	Asstt. (G) Gr. I
166.	Mr. Sanjay Kr. Tyagi	Asstt. (G) Gr. I
167.	Mr. Virendra Singh	Asstt. (F&A) Gr. I
168.	Mr. Aman Kumar	Asstt. (F&A) Gr. I
169.	Mr. Vipin Kumar Sharma	Asstt. (F&A) Gr. I
170.	Mr. Suraj Pal Singh	Asstt. (F&A) Gr. I
171.	Mr. Satyarth Prakash	Asstt. (F&A) Gr. I
172.	Mrs. Rubina Zaidi	Asstt. (F&A) Gr. I
173.	Mr. Sanjeev Bansal	Asstt. (S&P) Gr. I
174.	Mrs. Anju Rani Simon	Asstt. (S&P) Gr. I
175.	Mr. Arpan Maheshwari	Asstt. (S&P) Gr. I
176.	Mr. Kalam Singh Chauhan	Asstt. (S&P) Gr. I
177.	Mr. Vishwash Tyagi	Asstt. (S&P) Gr. I

Group C

178.	Mrs. Seema Ahuja	Asstt. (G) Gr. II
179.	Mr. Ravinder Kumar	Asstt. (G) Gr. II
180.	Mr. Mukesh Kumar	Asst. (S&P) Gr. III
181.	Mr. Subhan Singh	JSA
182.	Mr. Mehraj Deen Khan	JSA
183.	Mr. Radhey Shyam	Driver
184.	Mr. Satya Pal	MTS
185.	Mr. Subhash Chand	MTS
186.	Mrs. Usha	MTS
187.	Mrs. Bala	MTS
188.	Mr. Desh Raj	MTS
189.	Mr. Rakesh Kumar	MTS
190.	Mr. Ramesh Kumar	MTS
191.	Mr. Santosh Kumar	MTS
192.	Mr. Rakesh Kumar	MTS
193.	Mr. Devendra Kumar	MTS
194.	Mr. Krishna Gopal Thakur	MTS
195.	Mr. Radhey Shyam	MTS
196.	Mrs. Prakash Kaur	MTS
197.	Mr. Rohitash Kumar	MTS
198.	Mrs. Anju	MTS
199.	Mr. Ranbeer Singh	MTS
200.	Mr. Anit Kumar Pal	MTS
201.	Mr. Pritam Giri	MTS
202.	Mr. Pooran Vassi	MTS
203.	Mr. Kirat Pal	MTS
204.	Mr. Rajesh Kr. Yadav	MTS
205.	Mr. Jai Prakash	MTS
206.	Mr. Ranjeet Singh	MTS
207.	Mr. Satya Pal	MTS
208.	Mr. Satya Pal Singh	MTS
209.	Mr. Sunil Kumar	MTS
210.	Mr. Kiran Pal	MTS
211.	Mr. Amit Kumar	MTS
212.	Mr. Rakesh	MTS
213.	Mr. Arun Kumar	MTS
214.	Mr. Ravinder Kumar	MTS
215.	Mr. Dil Bahadur	MTS
216.	Mr. Rajinder Pal	MTS
217.	Mr. Malkhan Singh	MTS
218.	Mr. Dheer Singh	MTS

Transfer & Posting

1.	Mr. Anil Kumar	Controller of Administration from CSIR-IITR, Lucknow to CSIR-CBRI, Roorkee	20.08.2018

2.	Mr. M. Vinoth	Scientist from CSIR-CRRI, New Delhi to CSIR-CBRI, Roorkee	31.08.2018
3.	Mr. Vinod Kumar	Administrative Officer from CSIR-CBRI, Roorkee to CSIR-CEERI, Pilani	14.09.2018
4.	Mrs. Rashmi Rathore	Section Officer from CSIR-CBRI, Roorkee to CSIR-IITR, Lucknow	30.11.2108
5.	Mr. Sukhvir Singh	Section Officer (S&P) from CSIR-CBRI, Roorkee to CSIR-HRDC, Ghaziabad	18.01.2019

Appointments

1.	Mr. Amit Kumar	MTS	16.05.2018
2.	Mr. Sugam Kumar	Technical Assistant Gr. III (2) (Civil Engineering)	04.06.2018
3.	Mr. Sachin Kumar	Technical Assistant Gr. III (2) (Electronics Engineering)	06.06.2018
4.	Mr. Amit Prakash Bhadula	Technical Assistant Gr. III (2) (Civil Engineering)	06.06.2018
5.	Ms. Bhawna	Technical Assistant Gr. III (2) (Mechanical Engineering)	08.06.2018
6.	Mr. Dinesh Kumar	Technical Assistant Gr. III (2) (Mechanical Engineering)	14.06.2018
7.	Mr. Anil Kumar	Technical Assistant Gr. III (2) (Civil Engineering)	20.06.2018
8.	Mr. Seraj Alam	Technical Assistant Gr. III (2) (Civil Engineering)	28.06.2018

Transfer on Promotion

1.	Mr. Vinod Kumar	Controller of Administration From CSIR HQTRS, New Delhi to CSIR-CBRI, Roorkee	29.06.2018

Promotion

1.	Dr. Shantanu Sarkar	Senior Principal Scientist to Chief Scientist	25.07.2014
2.	Dr. Ashok Kumar	Senior Principal Scientist to Chief Scientist	05.07.2015
3.	Mr. S.K. Negi	Senior Principal Scientist to Chief Scientist	09.07.2015
4.	Dr. Harpal Singh	Senior Principal Scientist to Chief Scientist	03.07.2016
5.	Dr. Rajesh Deoliya	Principal Scientist to Senior Principal Scientist	29.07.2014
6.	Mr. A.K. Sharma-I	Principal Scientist to Senior Principal Scientist	12.12.2014
7.	Dr. A.P. Chourasia	Principal Scientist to Senior Principal Scientist	01.01.2015
8.	Mr. Nadeem Ahmed	Principal Scientist to Senior Principal Scientist	19.05.2015
9.	Dr. P.C. Thapliyal	Principal Scientist to Senior Principal Scientist	23.03.2017
10.	Dr. Leena Chaurasia	Senior Scientist to Principal Scientist	19.12.2014
11.	Dr. H.C. Arora	Senior Scientist to Principal Scientist	01.01.2015
12.	Mr. Soju J. Alexander	Scientist to Senior Scientist	13.08.2015
13.	Mr. Manojit Samanta	Scientist to Senior Scientist	13.08.2015
14.	Mr. Soumitra Maiti	Scientist to Senior Scientist	16.08.2015
15.	Mr. R.S. Bisht	Scientist to Senior Scientist	16.08.2015

16.	Mr. Srinivasarao Naik B.	Scientist to Senior Scientist	26.08.2015
17.	Mr. Nagesh B. Balam	Scientist to Senior Scientist	27.08.2015

Superannuation

1.	Mr. Francis Charles	Senior Technician	31.05.2018
2.	Mr. Rishipal	Technician	30.06.2018
3.	Mr. Vijay Kumar Sharma	Section Officer (G)	31.07.2018
4.	Smt. Arun Lata	Sr. Sec. Assistant	29.08.2018
5.	Mr. Raj Kumar	Junior Guard	31.08.2018
6.	Dr. Rajiv Kumar	Mechanical Engineer	30.11.2018
7.	Dr. A.K. Minocha	Chief Scientist	28.02.2019
8.	Mr. Deepak Kumar Sharma	Lab Assistant	31.03.2019

VRS

1.	Mr. Kishwas Kumar	Lab Assissttant	01.06.2018

Resignation

1.	Mrs. Swati Kulashri	Scientist	27.04.2018
2.	Dr. Shailza Singh	Scientist	30.06.2018

Obituary

1.	Dr. Abha Mittal	Senior Principal Scientist	24.12.2018

RESEARCH PAPERS

International Journals

1. A. Chaurasia, S.K. Panigrahi and S.S. Patel, "Damage Identification of Reinforced Concrete Beam using Modal Curvature Approach", Journal of Scientific & Industrial Research, Vol. 77, June 2018, pp. 337-341.

2. A. Kumar, A. Singh, A. Kumar, M.K. Singh, P. Mahanta and S.C. Mukhopadhyay, "Sensing Technologies for Monitoring Intelligent Buildings: A Review", IEEE SENSORS Journal, Vol. 18, No. 12, June 15, 2018, pp. 4847- 4860. (IF: 3.076)

3. A. Singh, D.P. Kanungo and S. Pal, "A Modified Approach for Semi-Quantitative Estimation of Physical Vulnerability of Buildings Exposed to Different Landslide Intensity Scenarios", Georisk, Vol. 13, No. 1, July 25, 2018 (online), pp.66-81, DOI: https://doi.org/10.1080/17499518.2018.1501076.

4. A. Singh, D.P. Kanungo and S. Pal, "Physical Vulnerability Assessment of Buildings Exposed to Landslides in India", Natural Hazards (Springer Netherlands), Vol. 96, No. 2, March 2019, pp. 753–790, DOI: https://doi.org/10.1007/s11069-018-03568-y.

5. B. Chauhan, G.J. Joshi, P. Parida, "Driving Cycle Analysis to Identify Intersection Influence Zone for Urban Intersections under Heterogeneous Traffic Condition", Journal of Sustainable Cities and Society (Elsevier, Science Direct), Vol. 41, August 2018, pp 180-185.

6. D. Ghosh, K. Rahul, D. Roy, A. Ganguli, S. Tuli, and A. Mukherjee, "Combination of Thermal and Ultrasonic Imaging Techniques for Detection of Sub-Surface Defects in Concrete", The e-Journal of Nondestructive Testing, Vol. 23, No. 4, ISSN 1435-4934.

7. D. Ghosh, H. Gupta, A. Mittal and R. Shekhar, "Inspection of Heritage Structure using Infrared Thermography", The e-Journal of Nondestructive Testing, Vol. 23, No. 4, ISSN 1435-4934.

8. D. Ghosh, S. Beniwa, A. Ganguli and A. Mukherjee, "Reference Free Imaging of Subsurface Cracks in Concrete using Rayleigh Waves", Structural Control and Health Monitoring, Vol. 25, No. 10, August 7, 2018 (online), pp. 1-16, DOI: https://doi.org/10.1002/stc.2246. (IF: 3.722)

9. G. Ishwarya, B. Singh, S. Deshwal and S.K. Bhattacharyya, "Effect of Sodium Carbonate/Sodium Silicate Activator on the Rheology, Geopolymerization and Strength of Fly Ash/Slag Geopolymer Pastes", Cement and Concrete Composites, Vol. 97, March 2019, pp. 226-238.

10. H. Gupta, D. Ghosh, S. Behera and A.K. Mittal, "Comparative Study Between ERS Sensors and VWSG", The e-Journal of Nondestructive Testing, Vol. 23, No. 4, ISSN 1435-4934.

11. K.S. Kulkarni, S.C. Yaragal and B. Narayan S.K., "Core Recovery: A Damage Diagnosis Tool for Thermally Deteriorated Concrete", Journal of Structural Fire Engineering, Vol. 10, No. 2, March 2019 (online), pp. 126-137. DOI: https:doi.org/10.1108/jsfe-03-2018-0008.

12. L. Chaurasia, V. Bisht, L.P. Singh and S. Gupta, "A Novel Approach of Biomineralization for Improving Micro and Macro-Properties of Concrete", Construction and Building Materials, Vol. 195, January 20, 2019, pp. 340-351. (IF: 4.046)

13. L.P. Singh, D. Ali, I. Tyagi, U. Sharma, R. Singh and P. Hou, "Durability Studies of Nano-Engineered Fly Ash Concrete", Construction and Building Materials, Vol. 194, January 10, 2019, pp. 205-215. (IF: 3.5)

14. L.P. Singh, V. Bisht, M.S. Awasthy, L. Chaurasia and S. Gupta, “Studies on Performance Enhancement of Recycled Aggregate by Incorporating Bio and Nano Materials”, Construction and Building Materials, Vol. 181, August 30, 2018, pp. 217-226.

15. M. Samanta, P. Punetha, S. Sarkar, A Dwivedi and M. Sharma, “Slope Stability Assessment and Design of Remedial Measures for Tungnath Temple at Uttrakhand, India: A Case Study”, Natural Hazards (Springer Netherlands), Vol. 96, No. 1, March 2019, pp. 225-246, DOI: doi.org/10.1007/s11069-018-3538-y. (IF: 2.319/2018, Springer Publication)

16. M. Samanta, P. Punetha and M. Sharma, “Effect of Roughness on Interface Shear Behavior of Sand with Steel and Concrete Surface”, Geomechanics and Engineering (Techno Press South Korea), Vol. 14, No. 4, April 2018, pp. 387-398, DOI: http://dx.doi.org/10.12989/gae.2018.14.4.387. (IF: 1.818/2017, Techno Press)

17. M. Samanta, P. Punetha and M. Sharma, “Influence of Surface Texture on Sand-Steel Interface Strength Response”, Geotechnique Letters, Vol. 8, No. 1, April 30, 2018 (online), pp. 40-48, DOI: https://doi.org/10.1680/jgele.17.00135. (IF: 1.641/2017, ICE Publication, UK)

18. M. Sharma, M. Samanta and S. Sarkar, “A Study on Interface-Shear Behavior of Soil Nails from Pullout and Direct Shear Tests”, International Journal of Physical Modelling in Geotechnics, December 12, 2018 (online), pp. 1-14, DOI: doi.org/10.1680/jphmg.18.00031. (IF: 1.067/2018, ICE, UK,)

19. M. Sharma, M. Samanta and S. Sarkar, “Novel Laboratory Pullout Device for Conventional and Helical Soil Nails”, Geotechnical Testing Journal (ASTM), Vol. 42, No. 5, August, 2018, pp. 1314-1335, DOI: doi.org/10.1520/GTJ20170319. (IF: 1.295/2018, ASTM, UK)

20. M. Sharma, M. Samanta and P. Punetha, “Experimental Investigation and Modeling of Pullout Response of Soil Nails in Cohesionless Medium”, International Journal of Geomechanics (ASCE), Vol. 19, No. 3, March 2019, pp. 1-16, DOI: doi.org/10.1061/(ASCE)GM.1943-5622.0001372. (IF: 2.450/2018, ASCE, USA)

21. P. Hou, R. Li, H. Li, N. Xie, X. Cheng and L.P. Singh, “The Use of Hydrophobicity and Pozzolanic Reactivity of the PMHS/Nanosilica Hybrid Composites on the Water Absorption of Cement Mortar”, Journal of Thermal Analysis and Calorimetry, Vol. 134, No. 3, December 2018, pp. 1775-1784, DOI: https://doi.org/10.1007/s10973-018-7320-x. (IF 2.0)

22. P. Punetha, M. Samanta and P. Mohanty, “Evaluation of Dynamic Response of Geosynthetic Interfaces”, International Journal of Physical Modelling in Geotechnics, Vol. 19, No. 3, April 2018, pp. 141-153, DOI: https://doi.org/10.1680/jphmg.17.00045. (IF: 0.794/2017, ICE Publication, UK)

23. R.S. Bisht, P.M. Pathak and S.K. Panigrahi, “Experimental Investigations on Permanent Magnet Based Wheel Mechanism for Safe Navigation of Climbing Robot”, Procedia Computer Science, Vol. 133, July 20, 2018 (online), pp. 377–384.

24. R.S. Chidambaram and P. Agarwal, “Performance Evaluation of Metallic and Synthetic Fiber Hybridization on the Cyclic Behavior of Exterior Beam-Column Joint”, Advances in Civil Engineering Materials (ASTM), Vol. 7, No. 1, August 16, 2018, pp. 381-402.

25. Siddharth et al., "Effect of K doping on Mo^{6+} Stability and Ionic Conductivity Study in $La_2Mo_2O_9$ as Oxide-Ion Conductor", Materials Research Express (IOP), Vol. 6, No. 5, February 13, 2019, pp. 056203 (1-14).

26. Siddharth et al., "Effect of Grain Boundary and Ar-H_2 Atmosphere on Electrical Conductivity of Bulk $La_2Mo_2O_9$ Studied by Impedance and X-Ray Photoelectron Spectroscopy", Materials Research Express (IOP), Vol. 6, No. 3, December 5, 2018, pp. 035505(1-18).

27. Siddharth et al., "X-ray Photoelectron Spectroscopy and Ion Dynamics Study of W^{6+} Doped $La_2Mo_2O_9$ as SOFC Electrolyte", Materials Research Bulletin (Elsevier), Vol. 105, September 2018, pp. 36-44.

28. S.K. Singh, S. Kulkarni, V. Kumar and P. Vashistha, "Sustainable Utilization of Deinking Paper Mill Sludge for the Manufacture of Building Bricks", Journal of Cleaner Production, Vol. 204, December 10, 2018, pp. 321-333. (IF: 5.651)

29. S. Nimbalkar, A.V.S. Ramakrishna and A. Pain, "A Simplified Approach to Assess Seismic Stability of Tailings Dams", Journal of Rock Mechanics and Geotechnical Engineering (Elsevier), Vol. 10, No. 6, December 2018, pp. 1082-1090, DOI: 10.1016/j.jrmge.2018.06.003.

30. S.S. Patel, A. Chourasia, S.K. Panigrahi, S.K. Bhattacharyya and J. Parashar, "A Study on Efficacy of Wavelet Transform for Damage Identification in Reinforced Concrete Buildings", Journal of Vibration Engineering & Technologies, Vol. 6, No. 2, April 2018, pp. 127-138.

31. S. Singh, M. Soumitra, H. Raj, R.S. Bisht, A.K. Minocha, S.K. Panigrahi, S.J. Alexander, S. Yadav and M. Singh, "X-ray Photoelectron Spectroscopy Study on Adsorption Property of Harmful Air Pollutants on Zeolite Prepared from Fly Ash", Materials Research Express (IOP), Vol. 5, No. 8, July 25, 2018, pp. 085507 (1-13).

32. S. Singhal, A. Chourasia, S. Challapa and J.Parashar, "Precast Reinforced Concrete Shear Walls: State of the Art Review", Structural Concrete, Vol. 20, No. 3, March 28, 2019 (online), pp. 886-898. DOI: 10.1002/suco.201800129. (IF: 1.885)

National Journal

1. A. Kumar, S. Lala, K.S. Kulkarni, S.K. Negi and N. Saxena, "Conceptual Development of Industrialized Building System (IBS) for Mass Housing", Institute of Steel Development and Growth (INSDAG) Yearbook 2017-18, November 2018, pp. 121-131.

2. A. Pain, A.V.S. Ramakrishna and S. Sarkar, "Seismic Stability Analysis of Municipal Solid Waste Landfills using Strain Dependent Dynamic Properties", Indian Geotechnical Journal, Springer, Vol. 49, No. 2, May 26, 2018, pp. 204-215, DOI: 10.1007/s40098-018-0314-6.

3. D. Ghosh, S. Beniwal, A. Ganguli and A. Mukherjee, "Simulation of Ultrasonic Rayleigh Wave Based Damage Detection in Concrete Structures", Indian Journal of Non-Destructive Testing & Evaluation, Vol. 17, No. 16, March 2019, pp. 15-19.

4. N. Karar and S.K. Singh, "Effects of Local Chemical Mineralogy on the Long-Term Durability of Reinforced Concrete Structures- Effects of Calcium Carbonate: An Indian Perspective using XRF", Indian Concrete Journal, Vol. 93, No. 2, February 2019, pp. 31-37.

5. S.K. Singh, S. Kirthika and M. Surya, "Agenda for Use of Alternative Sand in India", Indian Concrete Institute Journal, Vol. 19, No. 3, October-December 2018, pp. 34-43.

6. S. Kirthika, S.K. Singh and M. Surya, "Durability Properties of Basalt Fiber Reinforced Concrete", Indian Concrete Journal, Vol. 92, No. 4, April 2018, pp. 45-55.

7. S. Kirthika and S.K. Singh, "Experimental Investigations on Basalt Fibre Reinforced Concrete", Journal of the Institute of Engineers (India): Series A (Springer India), Vol. 99, No. 4, December 2018, pp. 661–670.

8. S. Sarkar, K. Pandit., M. Sharma and A. Pippal, "Risk Assessment and Stability Analysis of a Recent Landslide at Vishnuprayag on the Rishikesh–Badrinath Highway Uttarakhand, India", Current Science, Vol. 114, No. 7, April 10, 2018, pp. 1527-1533. (IF: 0.843)

9. V. Srinivasan and S.K.Singh, "Application of Recycled Aggregates in Building Construction", Shelter (Hudco Publication), Vol. 19, No. 1, April 2018, pp. 82-90.

Papers Presented/Published in Conference/Workshop/Seminar etc.

1. A.K. Agarwal, "Interlinking Science & Society: Developing Scientific Temper in Youth", 13th Uttarakhand State Science and Technology Congress, February 26-28, 2019, pp. 244, UCOST Campus, Vigyan Dham, Dehradun.

2. A.K. Agarwal, "Science Journalism: Communicating Science to the Society", 18th Indian Science Communication Congress (ISCC-2018), December 20-21, 2018, CSIR-National Institute of Science Communication and Information Resources (NISCAIR), New Delhi.

3. अतुल कुमार अग्रवाल, "सीएसआईआर-सीबीआरआई : एक प्रबुद्ध समाज के निर्माण की ओर अग्रसर", विज्ञान एवं समाज के अंतराफलक पर कार्यशाला, दिसंबर 14, 2018, पृ .210, विज्ञान भारती, दिल्ली एवं सीएसआईआर-राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।
   A.K. Agarwal, "CSIR-CBRI: Building an Enlightened Society", Workshop on the Interface of Science and Society (Focus: Navati Felicitation for Prof. K I Vasu), December 14, 2018, pp. 210, Swadeshi Science Movement of India, Delhi and CSIR-National Physical Laboratory, New Delhi.
4. अतुल कुमार अग्रवाल, "वैज्ञानिक चेतना से पोषित युवामन : भविष्य की प्रौद्योगिकी का सृजनकर्ता", प्रौद्योगिकी दूरदृष्टि 2035 -चुनौतियाँ एवं अवसर, राष्ट्रीय हिंदी तकनीकी संगोष्ठी, अगस्त 13-14, 2018 , पेपर आई.डी - .एन.एच.एस .006, पृ .15, सीएसआईआर-संरचनात्मक अभियांत्रिकी अनुसंधान केंद्र, चेन्नई एवं सीएसआईआर मद्रास काम्प्लेक्स, तारामणी, चेन्नै ।

5. अतुल कुमार अग्रवाल, "आओ भविष्य के आवास के विषय में सोचें", प्रौद्योगिकी दूरदृष्टि 2035 -चुनौतियाँ एवं अवसर, राष्ट्रीय हिंदी तकनीकी संगोष्ठी, अगस्त 13-14, 2018 , पृ .29, सीएसआईआर-संरचनात्मक अभियांत्रिकी अनुसंधान केंद्र, चेन्नई एवं सीएसआईआर मद्रास काम्प्लेक्स, तारामणी, चेन्नै ।

6. अतुल कुमार अग्रवाल, "युवाओं में वैज्ञानिक चेतना : सुदृढ़ देश का आधार", वार्षिक हिंदी संगोष्ठी -अंश, "मेक इन इंडिया :सामाजिक महत्व की प्रौद्योगिकियां "विषय पर राष्ट्रीय संगोष्ठी, मई 17-18, 2018, पृ . 252-259, सीएसआईआर-राष्ट्रीय वांतरिक्ष प्रयोगशालाएं, बेंगलूरु।

7. A. Bhawani, A.K. Minocha, S.C.B. Gurram and S. Maiti, "Flow Behaviour and Compressive Strength of Bagasse Ash Blended Mortar with Microstructural Study", International Conference on Industry 4.0 and Advancements in Civil Engineering, March 21-23, 2019, pp. 324, PSG

Institute of Technology and Applied Research, Salem-Coimbatore Highway, Avinashi Road, Neelambur, Coimbatore.

8. A. Bhawani, A.K. Minocha, S.C.B. Gurram and S. Maiti, "Study on the Durability Properties of Concrete with Bagasse Ash as Partial Replacement to Cement", National Seminar on New Trends in Building Materials and Sustainable Technology March 14-15, 2019, organized by Gautam Buddha University.

9. A. Chourasia and S. Singhal, "Pull-out Behaviour of Headed Bars Embedded in Concrete", 8th International Engineering Symposium, March 5-7, 2019, pp. 1- 6, Kumamoto University, Japan.

10. A. Rawat, S.R. Karade and P.C. Thapliyal, "Eco-Friendly Corrosion Inhibitors for Steel Reinforced Concrete", International Conference on Corrosion (CORCON-2018), September 30-October 3, 2018, Paper No. RCC 18, Jaipur.

11. A. Srivastava and S.K. Singh, "Seismic Assessment of Heritage Masonry Structures: A Review", 16th Symposium on Earthquake Engineering, December 20-22, 2018, pp. 1-11, organized by IIT Roorkee and ISET at IIT Roorkee,.

12. B. Chauhan, G. Joshi and P. Parida, "Speed Trajectory of Vehicles in VISSIM to Recognize Zone of Influence for Urban Signalised Intersection", 3rd Conference of Recent Advances in Traffic Engineering (RATE 2018), August 11-12, 2018, pp. 13-22, SVNIT, Surat.

13. B. Thamizhinian, D. Ghosh, H. Gupta and A.K. Mittal, "Seismic Pounding Effect on Midrise Buildings and its Control", 16th Symposium on Earthquake Engineering, December 20-22, 2018, Paper No. 335, Roorkee.

14. क्षितिज जैन, अशोक कुमार एवं निष्ठा सक्सेना, " भवनों में इस्तेमाल कृत्रिम उपकरण के ऊर्जा कुशल डिज़ाइन व् सुधार के लिए एंड्रॉइड ऐप", अभियांत्रिकी समस्याओं के लिए निदर्शन, इष्टतमीकरण एवं अभिकलन: वैज्ञानिक तथा तकनीकी शब्दावली का प्रयोग विषय पर राष्ट्रीय सम्मलेन, अक्टूबर 12-14, 2018, पृ. 26-27, आईआईटी, रुड़की।

15. D. Ghosh, H. Gupta and A.K. Mittal, "Imaging of Concrete Structures using Active Thermography", Conference and Exhibition on Non Destructive Evaluation, December 19-21, 2018, Mumbai.

16. D. Ghosh, Rahul, A. Ganguli and A. Mukherjee, "Ultrasonic Imaging as a Diagnostic Tool for Detection of Rebar Corrosion", 7th Asia-Pacific Workshop on Structural Health Monitoring, Vol. 4, November 12-15, 2018, pp. 1- 9, Hong Kong SAR, P.R. China.

17. D. Ghosh, S. Beniwal, A. Ganguli, A. Mukherjee and S. Bishnoi, "Cross-Correlation based Imaging of Defects in Plate using Ultrasonic Lamb Waves", Conference and Exhibition on Non Destructive Evaluation, Vol. 6, December 19-21, 2018, pp. 1- 9, Mumbai.

18. D.P. Kanungo, R.K. Dash and R.K. Choudhary, "Earth Dam Surveillance using Wireless Instrumentation and Real Time Monitoring", International Dam Safety Conference (IDSC), February 13-14, 2019, pp. 464-471, KIIT Bhubaneswar.

19. G. Santha Kumar, P.K. Saini, A.K. Minocha and S.R Karade, "A Comprehensive Review on the Characterization of Recycled Concrete Sand", 3rd R.N. Raikar Memorial International

Conference and Gettu-Kodur International Symposium on Advances in Science & Technology of Concrete, December 14-15, 2018, pp. 242-259 , Mumbai.

20. H. Athar, S. Deshwal, J. Khan, G. Ishwarya and B. Singh, "Investigations on Improving Water Permeability of Concrete Through Crystalline Admixture", SEC18: 11th Structural Engineering Convention- 2018, December 19-21, 2018, pp. CT106-111, Kolkata.

21. H.K. Verma, R.K. Tiwary, P.P. Roy, A. Swarup, P.K. Singh and S.K. Singh, "Impact of Mining Operations on Surrounding Environment and Structural Health of Monuments", International Conference and Exhibition on Energy and Environment: Challenges and Opportunities (ENCO2019), Vol. I & II, February 20-22, 2019, pp. 346–356, organised by CSIR-CIMFR, Dhanbad at Vigyan Bhawan, New Delhi, India.

22. K. Upadhyay, E. Rajasekar, V. Gupta and Ashok Kumar, "Effect of Intra-Climate Variation in Thermal Performance of Public Housing in Composite Climate of India", International Conference on Passive and Low Energy Architecture (PLEA 2018), Vol. 1, December 10-12, 2018, pp. 439-444, Hong Kong.

23. M. Advani, P. Parida and N. Sharma, "Estimation of Fuel Consumption during Idling of Vehicles at Bhikaji Cama Intersection and Savings after Employing Suitable Mitigation Measures", International Conference on Transportation Infrastructure Projects, Conception to Execution, (TIPCE), January 7-10, 2019, IIT Roorkee.

24. M. Behera, A.K. Minocha, S.K. Bhattacharyya and M.R. Rahman, "Studies on the Flow Properties of Self-Compacting Concrete with Recycled Fine Aggregate", Structural Engineering Convention, December 19-21, 2018, pp. 129-137, Jadavpur University, Kolkata.

25. M. Behera, A.K. Minocha, S.K. Bhattacharyya and M.R. Rahman, "Influence of SCMs on Flow Properties of Self-Compacting Mortar Made with Recycled Fine Aggregate", International Conference on Smart Cities: Opportunities and Challenges, March 14-16, 2019, Jamia Millia Islamia, New Delhi.

26. Md. Firoj and S.K. Singh, "Response Spectrum Analysis for Irregular Multi-Storey Structure in Seismic Zone V", 16th Symposium on Earthquake Engineering, December 20-22, 2018, pp. 1-9, organized by IIT Roorkee & ISET at IIT Roorkee.

27. M.S. Aswathy, A.K. Mittal and S. Behera, "Effect of Excavation on Settlement of Adjacent Structures", Indian Geotechnical Conference, December 13-15, 2018, Bangalore.

28. N. Gopalakrishnan, "Policy Interventions for Inclusive and Sustainable Development", North-East Sustainable and Inclusive Development Summit, April 26-28, 2018. (Also delivered Keynote Lecture)

29. N. Gopalakrishnan, "Performance of Materials with Reference to Thermal Performance of Building Envelopes", Faculty Development Programme on Climate Responsive Architecture, July 26, 2018. (Also delivered Keynote Lecture)

30. P.C. Thapliyal, S.R. Karade, Vibhrant, A. Dixit and R. Kumar, "Role of Renewable Materials in Development of Protective Coatings", NACE NIGIS CORCON 2018, September 30-October 3, 2018, pp. RCC21, Jaipur.

31. P.C Thapliyal, Vibhrant, A. Dixit and R. Kumar, "Influence of Renewable Materials on Physical Properties of Polymeric Coatings", Recent Innovations in Advanced Materials: Physics of Advanced Materials (RIAM-2018), September 18-19, 2018, Bhopal.

32. P.C. Thapliyal, Vibhrant and A. Dixit, "Environmental Issues Associated with Nanomaterials", National Conference on Emerging Challenges of Environmental Health, Society and Policies, February 15-16, 2019, pp. 10, Delhi.

33. P.O. Falae, D.P. Kanungo, P.K.S. Chauhan and R.K. Dash, "Landslide Investigation using Electrical Resistivity Tomography: A Non-Invasive Technique", 4th World Congress on Disaster Management (4WCDM), January 28-February 1, 2019, IIT Bombay, Powai, Mumbai.

34. R.K. Dash, D.P. Kanungo and P.O. Falae, "Landslide Risk Assessment in India: Recent Trends and Future Challenges", 4th World Congress on Disaster Management (4WCDM), January 28-February 1, 2019, IIT Bombay, Powai, Mumbai.

35. R. Kumar and R. Lakhani, "Cement Concrete Interlocking Paver Blocks using Kota Stone and Marble Slurry", Advances in Building-Road Materials and Construction Engineering (ABRMCE-2019), March 25 - 26, 2019, pp. 25-34, MNIT Jaipur, Rajasthan.

36. R. Paswan, B. Singh and Md. R. Rahman, "Effect of Elevated Temperature on Compressive Strength and Bond Strength of Geopolymer Concrete", 3rd R.N. Raikar Memorial International Conference and Gettu-Kodur International Symposium on Advances in Science and Technology of Concrete, Vol. 2, December 14-15, 2018, pp. 57-64, Mumbai.

37. R.S. Chidambaram and P. Agarwal, "Influence of Fiber Hybridization on the Cyclic Behavior of Exterior Beam-Column Joint", National Conference on Advanced Structures, Materials and Methodology in Civil Engineering, November 3, 2018, pp. 110-116, NIT Jalandar**.**

38. R.S. Bisht, S.K. Panigrahi, D. Kumar, N. Kumar, P. Kumar, S.S. Ali, Sameer and A.P. Chourasia, "Dynamic Analysis of Mini Climbing Crane", WMVC, November 26-28, 2018, pp. 259-269, NIT Rourkela**.**

39. R.S Bisht, P.M. Pathak and S.K Panigrahi, "Development of a Climbing Robot Based on Multi-Suction Cups Mounted on Timing Belt Mechanism", IFToMM Asian Mechanism and Machine Science Asian MMS, December 17-20, 2018, pp. 1-10, Indian Institute of Science (IISc), Bengaluru, India.

40. R.S Bisht, P.M. Pathak and S.K Panigrahi, "Development of Magnetic Adhesion Based Wheel-Driven Climbing Machine for Ferrous Surface Applications", ASME 2018 Dynamic Systems and Control Conference, September 30–October 3, 2018, Paper No. DSCC2018-9181, V001T04A016, Georgia, DOI: 10.1115/DSCC2018-9181.

41. R. Tiwari, K. Puntambekar and P. Parida, "Redefinig the Service Level Benchmarking for Public Transport System in India", ASCE International Conference on Tranportation & Development (ICTD 2018), July 15-18, 2018, pp. 229-237, Pittsburgh Pennsylvania, USA.

42. R. Tiwari, K. Puntambekar and P. Parida, "Gender Preference to Parameters of Public Transport Evaluation-A Case of Bhopal", 3rd Conference of Recent Advances in Traffic Engineering (RATE 2018), August 11-12, 2018, pp. 34-44, SVNIT, Surat.

43. S. Kirthika and S.K. Singh, "Optimization of Combined Coarse and Alternative Fine Aggregate for Sustainable Concrete", 3rd R.N. Raikar Memorial International Conference and Gettu-Kudur International Symposium on Advances in Science and Technology, Vol. I, II & III: Session 2B, December 14-15, 2018, pp. 217–225, organized by India Chapter of ACI at Mumbai.

44. S.K. Singh and H.K. Verma, "Underground Constructions in Urban-Built Environment- Some Key Insights", International Conference and Exhibition on Energy and Environment: Challenges and Opportunities (ENCO2019), Vol. I & II, February 20-22, 2019, pp. 898–906, organized by CSIR-CIMFR, Dhanbad at Vigyan Bhawan, New Delhi, India.

45. S.K. Singh and S. Kirthika, "Seepage and Efflorescence in Buildings and Control Measures", Anti Salinity & Efflorescence Measures, October 30, 2018, pp. 1-14, organized by MES under the aegis of Chief Engineer-South Western Command, Jaipur.

46. S.K. Singh, "Innovation in Repair and Rehabilitation of Structures", Anti Salinity & Efflorescence Measures, October 30, 2018, pp. 21-29, organized by MES under the aegis of Chief Engineer-South Western Command, Jaipur.

47. S.R. Karade, "Bamboo-Plastic Composites: Issues & Prospects", National Workshop on Utilization of Bamboo as Building Material in NE Region, February 18-19, 2019, CSIR-CBRI, Roorkee**.**

48. S.R. Karade, P.C. Thapliyal and A. Rawat, "Corrosion Control in Steel Reinforced Concrete Structures: Green Approaches", 19th National Conference on Corrosion Control, December 5-7, 2018, pp. CC-03, Bhubaneswar.

49. S.R. Karade, "Corrosion of Steel in Concrete Structures-Causes & Remedies", Seminar on Seepage and Efflorescence in Buildings and Control Measures, October 30, 2018, pp. 47-53, organised by MES at Jaipur.

50. S.R. Karade and A. Rawat, "Electrochemical Techniques for Corrosion Control in Steel Reinforced Concrete Structures", NACE NIGIS CORCON 2018, September 30- October 3, 2018, pp. RCC17, Jaipur.

51. S. Singh and A. Kumar, "Energy Performance of Commercial Buildings in India: A Review on Benchmarking Systems", Meta Green Dimensions International Convention on Performance of Built Environment, Vol. 12, pp. 63-67, ISBN No. 978 -93-5300-345-6.

52. S. Singhal and A. Chourasia, "Seismic Resistance of Precast Reinforced Concrete Shear Walls: Experimental and Analytical Study", March 13-15, 2019, pp. 1- 6, 8th International Engineering Symposium, Kumamoto University, Japan.

53. S. Singhal and A. Chourasia, "Joint Connections for Precast Structural Concrete Components", 16th Symposium on Earthquake Engineering, December 20-22, 2018, pp. 1-10 ,Indian Institute of Technology, Roorkee.

In Magazines

1. अतुल कुमार अग्रवाल, "सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की :प्रकाशन समूह की गतिविधियां", निर्माणिका, 2018-2019, पृ .49-51, सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की।

2. अतुल कुमार अग्रवाल, "आओ हिंदी को राष्ट्रभाषा बनाएं", निर्माणिका, 2018-2019, पृ .58-61, सीएसआईआर-केंद्रीय भवन अनुसंधान संस्थान, रुड़की।

3. अतुल कुमार अग्रवाल, "विलुप्तता की ओर हाथी", विज्ञान प्रगति, वर्ष 67, अंक 3, पूर्णांक 778, मार्च 2019, पृ .24-27, वैज्ञानिक तथा औद्योगिक अनुसन्धान परिषद, नई दिल्ली।

4. अतुल कुमार अग्रवाल, "सीबीआरआई का पर्यावरण संरक्षण में योगदान", विज्ञान वाणी, अंक 24, वर्ष 2018, पृ. 90-93, सीएसआईआर- राष्ट्रीय वानस्पतिक अनुसंधान संस्थान, लखनऊ।

5. अतुल कुमार अग्रवाल, "नगरपालिका ठोस अपशिष्ट प्रबंधन", विशेष अंक - विश्व आवास दिवस 2018, एन.सी.एच.एफ .बुलेटिन, खंड 31, संख्या 3-4, सितंबर-अक्टूबर 2018, पृ .46-52, नई दिल्ली।

6. अतुल कुमार अग्रवाल, "आतंकवादी दीमक", विशेष लेख, विज्ञान प्रगति, वर्ष 66, अंक 8, अगस्त 2018, पृ. 16-21, वैज्ञानिक तथा औद्योगिक अनुसन्धान परिषद, नई दिल्ली।

7. अतुल कुमार अग्रवाल, "मोबाइल फ़ोन -कल, आज और कल", आमुख कथा, विज्ञान प्रगति, वर्ष 66, अंक 5, मई 2018, पृ14-8 ., वैज्ञानिक तथा औद्योगिक अनुसन्धान परिषद, नई दिल्ली।

8. अतुल कुमार अग्रवाल, "स्वास्थ्य का संकट- मोबाइल फ़ोन", विज्ञान प्रगति, वर्ष 66, अंक 4, अप्रैल 2018, पृ. 23-26, वैज्ञानिक तथा औद्योगिक अनुसन्धान परिषद, नई दिल्ली।

9. M. Behera and A.K. Minocha, "Recycling and Reuse of C&D Waste-A Paradigm in Construction Industry", Shashwat Annual Griha Magazine, 5th Edition, Vol. 4, No. 5, December 2018, pp. 23-26, Bhubaneswar.

10. S.K. Singh, and G. Rai, "Repair & Rehabilitation of Concrete Structures –A Paradigm Shift", NBM&CW, Vol. 24, No. 8, February 2019, pp. 152-160.

11. राकेश कुमार एवं अ.अ. अंसारी, "शाकाहार-प्रकृति का वरदान", मंथन, वर्ष 2018, अंक 16, पृ. 18-23, भारतीय प्रौद्योगिकी संस्थान, रुड़की।

In Book Chapter

1. A. Singh, S. Pal and D.P. Kanungo, "Site Specific Vulnerability Assessment of Buildings Exposed to Rockfalls", In: J. Chattopadhyay, R. Singh & O. Prakash (eds) Renewable Energy and its Innovative Technologies, Springer, Singapore**,** 2019, October 11, 2018 (online), pp. 1-11, ISBN: 978-981-13-2115-3, DOI: https://doi.org/10.1007/978-981-13-2116-0_1.

2. D. Ghosh, A.K. Mittal, S.K. Bhattacharyya and S. Behera, "The Effect of Macroroughness in Front of Building for Tsunami Pressure Dissipation—A Numerical Study", In: A. Rao, K. Ramanjaneyulu (eds) Recent Advances in Structural Engineering, Vol. 1, Lecture Notes in Civil Engineering, Vol. 11, Springer, Singapore, August 2, 2018(online), pp. 1013-1024.

3. D.P. Kanungo, "Ground Based Real Time Monitoring System using Wireless Instrumentation for Landslide Prediction", In: S. Pradhan, V. Vishal, T. Singh (eds) Landslides: Theory, Practice and Modelling, Advances in Natural and Technological Hazards Research, Vol. 50, Springer, Cham, June 29, 2018 (online), pp. 105-120, DOI: https://doi.org/10.1007/978-3-319-77377-3.

4. H. Gupta, D. Ghosh and A.K. Mittal, "Seismic Performance of a Heritage Rubble Stone Masonry Building-A Case Study", In: A. Rao, K. Ramanjaneyulu (eds) Recent Advances in

Structural Engineering, Vol. 2, Lecture Notes in Civil Engineering, Vol. 12, Springer, Singapore, August 2, 2018 (online), pp. 317-328.

5. K. Pandit, S. Sarkar and M. Sharma, "Optimization Techniques in Slope Stability Analysis Methods", In: S. Pradhan, V. Vishal, T. Singh (eds) Landslides: Theory, Practice and Modelling, Advances in Natural and Technological Hazards Research, Vol. 50, Springer, Cham, June 29, 2018 (online), pp. 227-264, DOI: 10.1007/978-3-319-77377-3_11.
6. M. Sharma, M. Samanta and S. Sarkar, "Soil Nailing: An Effective Slope Stabilization Technique", In: S. Pradhan, V. Vishal, T. Singh (eds) Landslides: Theory, Practice and Modelling, Advances in Natural and Technological Hazards Research, Vol. 50, Springer, Cham, June 29, 2018 (online), pp. 173-199, DOI: 10.1007/978-3-319-77377-3_9.
7. P.K.S. Chauhan, A. Mittal, G. Devi and P.O. Falae, "2-D Earth Resistivity Imaging for Subsurface Characterization in Srinagar, Garhwal Himalaya", In: N. Sundararajan, M. Eshagh, H. Saibi, M. Meghraoui, M. Al-Garni, B. Giroux (eds) On Significant Applications of Geophysical Methods, CAJG 2019, Advances in Science, Technology and Innovation (IEREK Interdisciplinary Series for Sustainable Development), Springer, Cham, February 14, 2019 (online), pp. 77-80, DOI: https://doi.org/10.1007/978-3-030-01656-2_17 .
8. P.O. Falae, D.P. Kanungo, P.K.S. Chauhan and R.K. Dash, "Recent Trends in Electrical Resistivity Tomography for Landslide Study", In: J. Chattopadhyay, R. Singh & O. Prakash (eds) Renewable Energy and its Innovative Technologies, Springer, Singapore, October 11, 2018 (online), pp. 195-204, ISBN: 978-981-13-2115-3, DOI: https://doi.org/10.1007/978-981-13-2116-0_1.
9. P. Punetha, M. Samanta and S. Sarkar, "Bioengineering as an Effective and Eco-friendly Soil Slope Stabilization Method: A Review", In: S. Pradhan, V. Vishal, T. Singh (eds) Landslides: Theory, Practice and Modelling, Advances in Natural and Technological Hazards Research, Vol. 50, Springer, Cham, June 29, 2018 (online), pp. 201-224, DOI: 10.1007/978-3-319-77377-3_10.
10. S. Sarkar, M. Samanta, M. Sharma, A. Dwivedi," Slope Stability Analysis and Suggestive Measures for an Active Landslide in Indian Himalaya", In: J. Wasowski, T. Dijkstra (eds) Recent Research on Engineering Geology and Geological Engineering, GeoMEast 2018, Sustainable Civil Infrastructures, Springer, Cham, November 8, 2018 (online), pp. 1-9, DOI: doi.org/10.1007/978-3-030-02032-3_1.

TECHNOLOGY TRANSFERRED
&
MoU SIGNED

The following technology has been transferred by CSIR-CBRI, Roorkee:

- Coating for Wood & Wood Based Interiors' to M/s Paramount Intercontinental Pvt. Ltd, Sonepat on February 2, 2019.

The following MoUs/Agreements have been signed by CSIR-CBRI, Roorkee:

S. No.	Name of the Agency	Purpose of the MoU/ Technology Transferred	Date of Execution
1.	M/s Dalmia Cement (Bharat) Ltd., New Delhi	Characterization of Products/Materials/Samples received from DBCL	01.06.2018
2.	M/s Reliable Building Solutions, Noida, UP	Evaluation of Insulated Concrete Formwork Technology	24.08.2018
3.	M/s Tvasta Manufacturing Solutions Pvt. Ltd., Bengaluru	3D Printing Technology	09.10.2018
4.	M/s Disha Ecoloc Pavers Pvt. Ltd., Nagpur	Utilization of Construction & Demolition Waste	10.10.2018
5.	Manipal Institute of Technology, Mahe, Manipal	Academic Interaction	29.10.2018
6.	Indian Institute of Technology, Bombay	Academic Interaction	30.10.2018
7.	M/s JSW Steel Limited (India)	Development of Cementitious Binder from LF Slag & Improvement of LF Slag & EAF Slag for Use as Aggregates in Concrete	05.12.2018
8.	Madhya Pradesh State Bamboo Mission, Bhopal	Bamboo Construction Studies within MP	17.01.2019
9.	M/s Oorja Energy Engg. Services Hyd. Pvt. Ltd., Hyderabad	Enhancing R&D in the Area of Solar Engg. & Efficient Building Systems	11.02.2019
10.	Indian Institute of Technology, Roorkee	For Academic Interaction	25.03.2019

Photographs of Transfer of Technology to M/s Disha Ecoloc Pavers, Nagpur

MoU Signed between CSIR-CBRI & M/s JSW Steel Limited

PATENTS/COPYRIGHTS

Patents/Copyrights

S. No.	Title	Inventors	Filing Date	Grant Date	Application/ Patent No./ Registration No.
Patents Filed and Granted					
1.	An End Openable Helical Anchor & the Mechanism Thereof	Manojit Samanta, Ajay Dwivedi, Piyush Punetha, Mahesh Sharma, Shantanu Sarkar	06.03.2019	-	201911008656
2.	Round Boulders Mortar (RBM) Units & Production Method Thereof	Ajay Chourasia, S.K. Panigrahi, Jalaj Parashar, Shubham Singhal	29.03.2019	-	201911012435
3.	A Device Useful for Making Horizontal Bores Under the Ground	Dinesh Kumar Gautam, Narendra Kumar, Saroj Kumar Panigrahi, Ashok Kumar Sharma, Sameer	09.03.2010	28.12.2018	305105
4.	Grooved Building Blocks for Concealed Utility Services	Rakesh Kumar, Tribhuvan Pati Sharma, Suvir Singh, Brij Bhushan Lal, Ahmed Abdul Aziz Ansari, Sushil Kumar	19.09.2008	06.02.2019	306940
Copyrights Filed and Granted					
1.	App for Integrating with Artificial Lighting for Improving Building Energy of Residential & Commercial Buildings During Daytime in All Sky Conditions of United Kingdom	Ashok Kumar, Anuj Kumar, Kshitiaj Jain	03.12.2018	-	SW-12453/2019
2.	App for Integrating Daylight for Improving Building Energy System During Daytime in All Climates	Ashok Kumar, Anuj Kumar, Kshitij Jain	21.08.2017	22.01.2019	SW-12111/2019

HONOURS & AWARDS

Honours & Awards

1. सीएसआईआर - सीबीआरआई, रुड़की को नराकास हरिद्वार द्वारा वर्ष 2017-2018 के लिए हिंदी भाषा में उत्कृष्ट कार्य हेतु प्रथम पुरस्कार से सम्मानित किया गया।

2. IGS-YGE Best Paper Biennial Award-2018 for the paper titled, "A Laboratory Study on Inclined Pullout Capacity of Helical Anchors in Sand Medium" by Mahesh Sharma, Manojit Samanta, Shantanu Sarkar and Ajay Dwivedi presented to M. Sharma at IISc Bangalore, December 2018.

3. Dr. Ganesh Kumar received Best Paper Award on March 30, 2019, for the paper titled, "I-g Shaking Table Tests on Prefabricated Vertical Drains for Liquefication Mitigation" at National Conference on Geotechnical Applications, GeoApps-2019 held at IIT Hyderabad.

4. Dr. Atul Kumar Agarwal, Senior Principal Scientist was awarded "Vigyan Bharti Delhi Samman 2018" by Swadesi Science Movement of India (Vigyan Bharti, Delhi) 2018 on December 14, 2018 at CSIR-NPL, New Delhi for India Science Popularisation and Promotion.

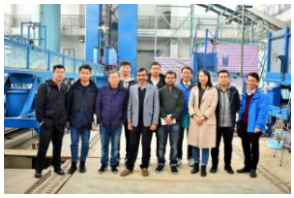
5. Dr. S.R. Karade, Senior Principal Scientist was awarded:
   a. "Outstanding Concrete Technologist" by Indian Concrete Institute and UltraTech Cement on 'Concrete Day' function at Dehradun on October 5, 2018.
   b. "Meritorious Award" of National Corrosion Council of India during the 19th National Corrosion Control Conference at Bhubaneswar during December 5-7, 2018. Hon. Shri Dharmendra Pradhan, Union Cabinet Minister for Oil & Natural Gases presented the award.

6. Dr. P.C. Thapliyal, Senior Principal Scientist received Best Technical Paper Award from Secretary, NACE International on October 3, 2018 for the paper titled "Role of Renewable Materials in Development of Protective Coatings", in CORCON 2018 during September 30-October 3, 2018.

VISITS ABROAD

Visits Abroad

1. Dr. Shantanu Sarkar, Chief Scientist and Mr. Koushik Pandit, Scientist visited China Academy of Science and attended the International Symposium on "Mountain Resourses, Environment and Disasters in the Himalayas" at Chongqing, China during November 25-30, 2018, where Dr. Sarkar delivered an invited talk on "Landslide Hazards in India Himalayas: Issues, Challenges and Opportunities". They had interaction and meeting with the faculty and researchers of "Institute of Mountain Hazards and Environment", Chinese Academy of Science at Chengdu. Dr Sarkar and Mr. Pandit presented the Institute's research activities related to landslide disaster mitigation and discussed about the possible collaboration in future.




2. Dr. Ashok Kumar, Chief Scientist visited Germany during September 23-30, 2018 for Knowledge Transformation Programme-cum-field visit for Energy Efficient Built Environment in India 2020 – The Success Story of EnEv and Passive Building Design.

3. Dr. Ashok Kumar, Chief Scientist visited Fraunhofer Institutes in Germany during March 4-5, 2019 as part of CSIR delegation led by DG CSIR & Secretary DSIR to identify synergistic partnership opportunities in terms of R&D cooperation areas/topics of mutual interest and realize mechanisms.


4. Mr. S.K. Singh, Senior Principal Scientist attended a Training cum Workshop on Repair & Rehabilitation of Structures during May 29-31, 2018, Ilchester, Yeovil, Somerset, UK and delivered a lecture on "Repair & Conservation of Fire Damaged Structures- A Case Study" on May 30, 2018.



5. Dr. R. Siva Chidambaram, Scientist visited Nepal during July 24-29, 2018 for reconstruction of School Building Project sponsored by MEA, India.

6. Mr. Debdutta Ghosh, Scientist visited Bundesanstalt für Materialforschung und-prüfung (BAM), Berlin, Germany for Workshop and Advanced Training on Non-Destructive Testing in Civil Engineering (NDT-CE) during June 26-July 4, 2018.

LECTURES DELIVERED

Lectures Delivered

1. Dr. Atul Kumar Agarwal, Senior Principal Scientist, delivered lectures on
   - "Knowledge is Power", Annual Day Celebrations, February 23, 2019, New Era Public School, Roorkee.
   - "Build on Failure: Success Mantra", Science Exhibition, February 9, 2019, Children's Senior Academy, Roorkee.
   - "Vedic Science: Hidden Treasure", February 8, 2019, CSIR-Central Building Research Institute, Roorkee.
   - "Scientific Heritage of India", Republic Day Celebrations, January 26, 2019, Children's Senior Academy, Roorkee.
   - "Scientific Temper for Intellectual Development", Two-Day Student-Scientist Connect Programme, January 25, 2019, CSIR-Central Building Research Institute, Roorkee.
   - "The Scientific Journey of CSIR and CBRI", Two-Day Student-Scientist Connect Programme, January 24, 2019, CSIR-Central Building Research Institute, Roorkee.
   - "Courage to Question", Annual Day Celebrations, December 30, 2018, Ally Public School, Roorkee.
   - "Inclusion of Storytelling and Humour to Reduce Monotony for the Development of Scientific Temper", PGT Workshop for PGTs of KVs from 4 Regions attending the In-service Course at KV, Roorkee, December 26, 2018, CSIR-Central Building Research Institute, Roorkee.
   - "Scientific Consciousness – Know Your Surroundings", November 24, 2018, Doon Public Senior Secondary School, Roorkee.
   - "Eradicate Corruption: Build a New India", Vigilance Awareness Week, November 1, 2018, CSIR-Central Building Research Institute, Roorkee.
   - "Swachh Bharat-Swasth Bharat", Cleanliness Drive, September 29, 2018, Children's Senior Academy, Roorkee.
   - "Youth for Science: Scientific Careers", IISF 2018 Precursor Events: Public Outreach Programme, September 28, 2018, CSIR-Central Building Research Institute, Roorkee.
   - "Scientific Temper: Quality Education and Fight against Superstitions", IISF 2018 Precursor Events: Public Outreach Programme, September 28, 2018, CSIR-Central Building Research Institute, Roorkee.
   - "Failure-The Key to Success", August 30, 2018, Cantonment Board Senior Secondary School, Roorkee.
   - "India-Cradle of Knowledge", Independence Day Celebrations, August 15, 2018, Children's Senior Academy, Roorkee.
   - "Goal India 2030-Global Guru", Independence Day Celebrations, August 15, 2018, Mahavir International School, Roorkee.
   - "Career Opportunities", Three-Day State-Level Student Workshop for KV Students, July 20, 2018, CSIR-Central Building Research Institute, Roorkee.
   - "Positive Attitude: Every Obstacle is an Opportunity", Three-Day State-Level Student Workshop for KV Students, July 19, 2018, CSIR-Central Building Research Institute, Roorkee.
   - "CSIR and CBRI: A Scientific Journey ", Three-Day State-Level Student Workshop for KV Students, July 18, 2018, CSIR-Central Building Research Institute, Roorkee.
   - "Scientific Temper: Need of the Hour", July 3, 2018, St. J.P. Convent Public School, Roorkee.
   - "Healthy Body, Healthy Mind", International Yoga Day, June 21, 2018, CSIR-Central Building Research Institute, Roorkee.
   - "CSIR and CBRI: A Scientific Journey", In-Service Course for PGTs of 6 KV Regions, May 24, 2018, Kendriya Vidyalaya No. 1, Roorkee.
   - "Time Management", May 12, 2018, Children's Senior Academy, Roorkee.

- "CSIR-CBRI: A View", Students Awareness Programme, May 3, 2018, CSIR-Central Building Research Institute, Roorkee.

2. Dr. S.R. Karade, Senior Principal Scientist delivered lectures on
   - "Corrosion of Steel Reinforcing Bars and Techniques for Protection", Training Course on Construction Practices for Sustainable and Resilient Buildings for the Engineers of Tata Steel, February 1, 2019, organised by IIT Roorkee.
   - Keynote Lecture on "Corrosion of Steel in Concrete Structures-Causes and Remedies", Seminar on Seepage and Efflorescence in Buildings and Control Measures, October 30, 2018, organised by MES at Jaipur.
   - "Durability and Corrosion Control Measures in Steel Reinforced Concrete Structures", Short Term Course on Affordable Housing in Disaster Prone Areas, October 9, 2019, organized jointly by NITTTR, Chandigarh and CSIR-CBRI, Roorkee.
   - "Sustainability and Service Life of Concrete Structures", Workshop on Sustainable and Affordable Construction, August 10, 2018, organised by IIT Roorkee and NBCC, New Delhi.

3. Mr. S.K. Singh, Senior Principal Scientist delivered a keynote address on
   - "Seepage and Efflorescence in Buildings and Control Measures", Seminar on Anti Salinity & Efflorescence Measures, organized by MES under the aegis of Chief Engineer-South Western Command, Jaipur on October 30, 2018.
   - "Manufactured Sand an Alternative to Natural River Sand in Production of Concrete", Ultratech Cement Technical Symposium on March 1, 2019, Moradabad, Uttar Pradesh.


4. Dr. R. Siva Chidambaram, Scientist delivered lectures on
   - Keynote Lecture on "Mechanical Rebar Splice and its Effectiveness in Structural Application", National Conference on Advanced Structures, Materials And Methodology in Civil Engineering, November 3-4, 2018, organised by NIT Jalandar, Punjab.
   - Invited Talk on "Seismic Effects on Precast Structure", Seminar on Pre-Fabricated Structures Including Multi Storeyed Buildings with Seismic Zone Modification, March 13, 2018, organised by Military Engineering Services, Chandigarh.
   - Invited Talk on "High Performance Materials and its Structural Application" July 18, 2018, organised by AVIT, Chennai.

5. Dr. Tabish Alam, Scientist delivered lectures on
   - Invited Lecture on "Solar Thermal Collectors", October 31, 2018, College of Engineering Roorkee.
   - "Solar Thermal Collectors", May 25, 2018, Kendriya Vidyalaya No. 1, Roorkee.
   - "Solar Collectors", July 18, 2018, CSIR-Central Building Research Institute, Roorkee.

6. Dr. Kishor Kulkarni delivered Invited Lecture on "Building Energy Simulation", Faculty Development Programme on Climate Responsive Architecture, July 26, 2018, College of Architecture Trivandrum, Kerala.

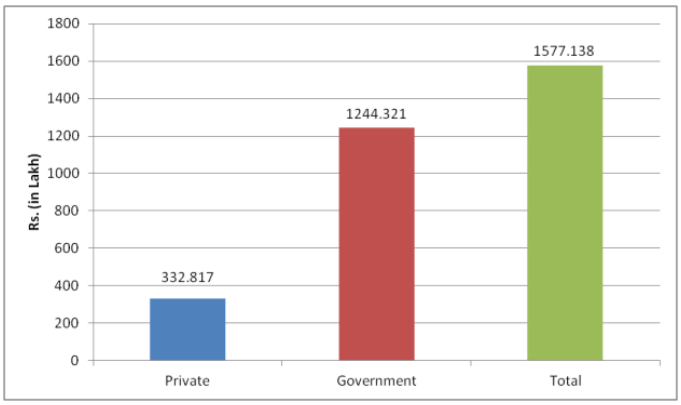
DATE LINE

Date Line

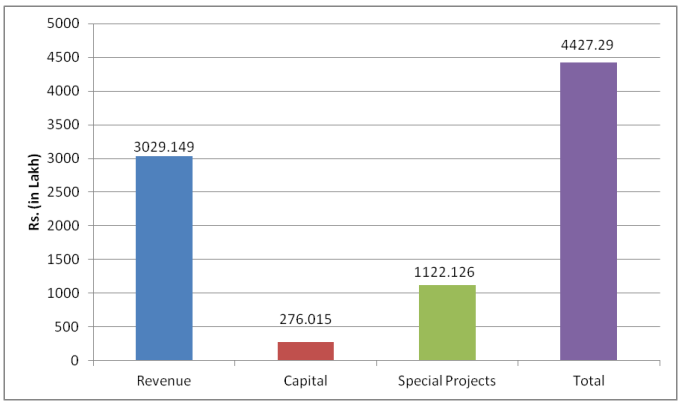
S. No.	Date	Event
1.	May 1, 2018	Administrative Workshop
2.	May 3, 2018	Student Awareness Programme
3.	May 12, 2018	Motivational Lecture at Children's Senior Academy, Roorkee
4.	May 15, 2018	National Technology Day
5.	May 24-25, 2018	Lectures to PGTs of KVs from 6 Regions attending the In-service Course at KV, Roorkee
6.	May 28, 2018	Exposure to CSIR-CBRI Labs to PGTs of KVs from 6 Regions attending the In-service Course at KV, Roorkee
7.	June 7, 2018	World Environment Day
8.	June 21, 2018	International Day of Yoga
9.	July 3, 2018	Science Exhibition by Students at St. J.P. Convent Public School, Roorkee
10.	July 13, 2018	IPR Awareness Interactive Session
11.	July 18-20, 2018	Three-Day State Level Students Workshop
12.	August 15, 2018	Independence Day Celebrations at CSIR-CBRI, Roorkee
13.	August 15, 2018	Independence Day Celebrations at Children's Senior Academy, Roorkee and Mahavir International School, Roorkee
14.	August 20, 2018	Sadbhavna Diwas
15.	August 20-21, 2018	Program on Team Building & Motivation
16.	August 30, 2018	Motivational Lecture at Cantonment Board Senior Secondary School, Roorkee
17.	August 31, 2018	Family Get together and Sports Day
18.	September 14-20, 2018	Hindi Week
19.	September 15-October 2, 2019	Swachhta Pakhwada
20.	September 25, 2018	CSIR Foundation Day
21.	September 27-28, 2018	IISF 2018 Precursor Events: Press Meet & Science Fest
22.	October 3-4, 2018	Two-Day Training Programme on Conservation of Heritage Structures
23.	October 5, 2018	Student Awareness Programme on Preservation of Ozone Layer
24.	October 8-12, 2018	Training Programme on Affordable Housing in Disaster Prone Area
25.	October 16, 2018.	Dr. Shekhar C. Mande Takes over as Director-General of CSIR Family
26.	October 29-November 3, 2018	Vigilance Awareness Week
27.	November 24, 2018	Scientific Consciousness- Know Your Surroundings at Doon Public Senior Secondary School, Roorkee

28.	December 5, 2018	Kick-off Meeting, CSIR-CBRI & JSW Steel Ltd Joint Collaborative Project on Development of Newer Cementitious Materials Using Steel Slags and its Use in Concrete
29.	December 18-21, 2018	Training Programme on Disaster Resilient Design & Construction of Buildings in Uttarakhand Projects
30.	December 21-22, 2018	Workshop on Improving Building Energy Efficiency
31.	December 24, 2018	Dr. Shekhar C. Mande, DG CSIR visits CSIR-CBRI, Roorkee
32.	December 26, 2018	PGT Workshop
33.	December 30, 2018	Courage to Question at Ally Public School, Roorkee
34.	January 17-18, 2019	Training Programme on Landslide Mitigation and Detailed Project Report (DPR) Preparation
35.	January 24-25, 2019	Two-Day Student Scientist Connect Programme
36.	January 26, 2019	Republic Day Celebrations at CSIR-CBRI, Roorkee
37.	January 26, 2019	Republic Day Celebrations – Scientific Heritage of India at Children's Senior Academy, Roorkee
38.	February 7, 2019	Government Inter College, Daulatpur Students visit CSIR-CBRI, Roorkee
39.	February 9, 2019	Build on Failure : Success Mantra at Children's Senior Academy, Roorkee
40.	February 13, 2019	CBRI Foundation Day
41.	February 18-19, 2019	National Workshop on Utilization of Bamboo as Building Material in NE Region
42.	February 23, 2019	Knowledge is Power at New Era Public School, Roorkee
43.	February 27-28, 2019	Training Programme on BHAGVAN- A Search at CSIR-CGCRI, Kolkata
44.	March 2-3, 2019	Construction Technology India – 2019 Expo-cum-Conference (GHTC, India), at Vigyan Bhawan, New Delhi
45.	March 26, 2019	International Women's Day
46.	March 28-29, 2019	Training Programme on Earthquake Resistant Constructions in Himachal Pradesh

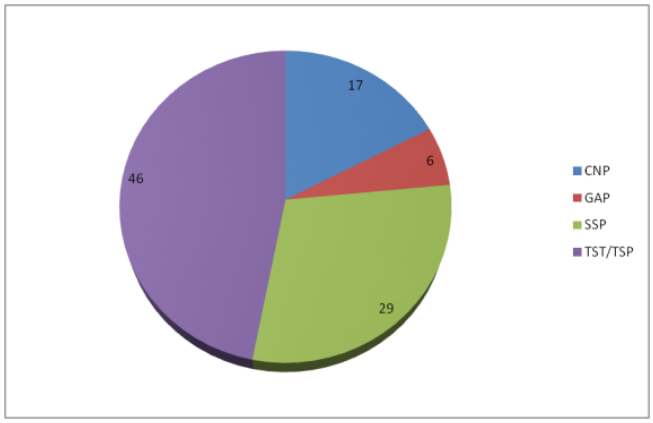
Performance/ Projects/ Human Resource



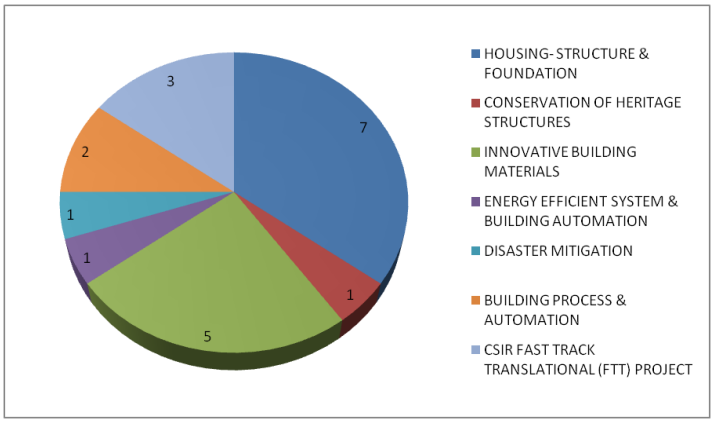
ECF



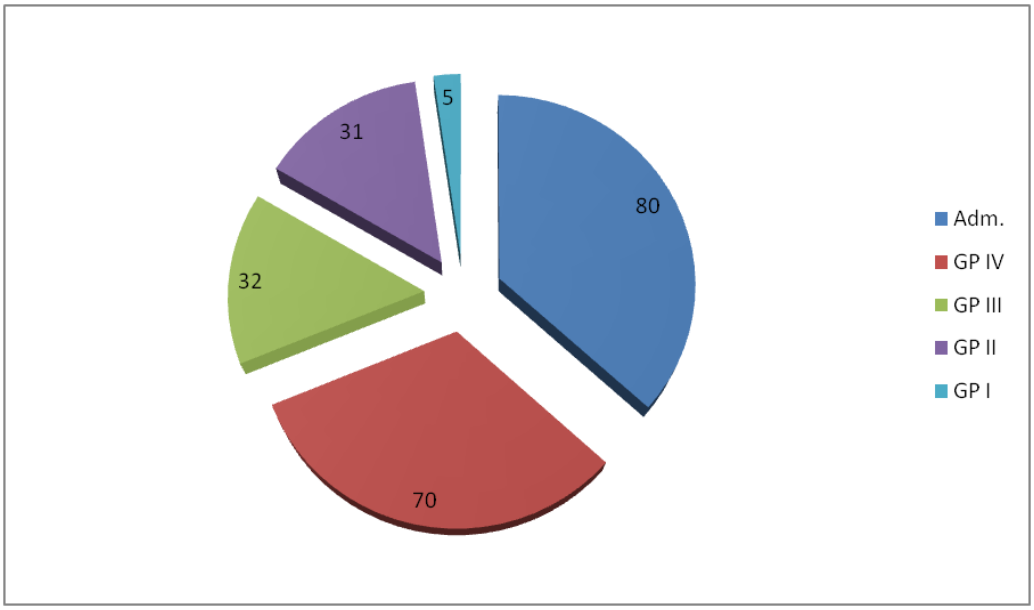
CSIR Resource Input



Externally Funded Projects



In-House R&D Projects



Human Resource

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