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Network Project (ESC 0102)

Engineering of Disaster Mitigation & Health Monitoring For Safe & Smart Built Environment (EDMISSIBLE)

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WP-6: Intelligent Building System for Model Residential Unit

Network Projects

(CSIR- CBRI as a Participating Laboratory)

R&D Projects

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viu vkjEHk dky l] lh,lvkbvkj&lhchvkjvkb ,d gh mn'; Þfuek.k lkefx;k] fuek.k ik|kfxdh] Hkouk dh LokLF; fuxjkuh] vfXu vfHk;kf=dh RkFkk vkink U;uhdj.k lfgr Hkou@vkokl fu;ktu rFkk fuek.k d ik;% lHkh {k=k e lek/kku miyC/k djku d fy, fo'o J.kh d Kku vk/kkj d :i e dk; djukß] dh ikfIr d fy, fujUrj dk;jr gA

bl vof/k e LkLFkku u nk egRoi.k ifj;ktukvk ij dk; fd;k g&,d lik lLFkkxr uVod ifj;ktuk (SINP)] tk LkLFkku dh ie[k leFkrk d {k= l lcf/kr g RkFkk nljh uVod ifj;ktuk d leUo; l lcf/kr g] ft le cgr lh lg;kxh i;kx'kkykvk u ifrHkkfxrk dh gA

lik lLFkkxr uVod ifj;ktuk (SINP) d vrxr fofHkUu od idtk d ek/;e l **'uDlV tuj'ku xhu fcfYMXl'** (INMATE) gr uohu lkexh ,o ik|kfxd;k ij dk; ixfr ij gA *uuk ik|kfxdh d ek/;e l lkexh d fu"iknu e of}^] od idt d vrxr flfydk uuk d.kk dh dyf'k;e r= e ek=k fu/kkj.k ,o vudyu ij v/;;u] uuk ik|kfxdh d mi;kx l cg&dk;kRed yik dk fodkl] Åtk n{k Hkouk gr Qt pt lkexh ij v/;;u fd, x,A *l/kkj.kh; fuek.k d fy, uDlV tuj'ku ddhV] d idt e] icfyr ft;kifyej ddhV d ljpukRed 0;ogkj ij v/;;u] lYQ ghfyx lkexh d :i e to ddhV d 0;ogkj ij v/;;u RkFkk io'; ddhV d fodkl dk dk; fd;k x;kA ^xhu fcfYMXl ik|kfxdh^ d idt d vrxr] dk;ky;k d Hkouk d fy, xhu jVkfQV uhfr;k ij v/;;u] 'khr tyok; {k= d fy, lkyj foMk fLkLVe dk fodkl] de ykxr d mRiknk d fy, dPp eky d :i e fo/ol vif'k"Vk dk mi;kx] lkyj Fkey ,;j dMh'kuj] mMu jk[k@/kku dh Hkh] lxejej dh /ky ij vk/kkfjr vk|kfxd vif'k"Vk d mi;kx l gYd Hkkj oky Cykdk dk fodflr dju dh nf"V l n'k d fofHkUu Hk&tyok; {k=k gr 'kgjh {k=k e tu vkokIk d fy, ik|kfxdh idt] Lopkfyr [kk[ky ftlle iuy cuku dh e'khu] ljpukRed nhed ic/ku RkFkk gYdh feVVh d fy, etcr uho dk fodkl l lcf/kr dk; fd, x,A *tkf[ke U;uhdj.k gr lkefx;k ,o ik|kfxd;k'] od idt e] LVhy icfyr ddhV ljpukvk d fy, Lon'kh dFkkfMd lj{k.k i.kkyh ij v/;;u] icfyr ddhV ?kVdk dk iHkko 0;ogkj] vfXu ljf{kr ikfyefjd dEikftV iuy RkFkk fufer lk;koj.k 'olu d.kk dk de dju d fy, mUur lokru i.kkyh d vfHkdYi ,o fodkl dju d mn'; l LoPN fufer i;koj.k gr dk; fd, x,A

fofHkUUk idtk d ek/;e l 'ljf{kr ,oe LekV fufer i;koj.k d fy, vkink U;uhdj.k ,oe LokLF; fuxjkuh vfHk;kf=dh' (EDMISSIBLE)] ij uVod ifj;ktuk ij dk; tkjh jgkA HkL[kyu vkink U;uhdj.k vfHk;kf=dh d vrxr db lg;kxh i;kx'kkykvk u ifrHkkfxrk dhA fofHkUUk ifrHkkxh i;kx'kkykvk }kjk dh xb xfrfof/k;k e pekyh&tk'kheB {k= ¼x<oky fgeky;½ dk HkL[kyu tkf[ke eY;kdu idTk ¼lh,lvkbvkj&lhchvkjvkb½] pekyh&tk'kheB {k=] x<oky fgeky; e tkf[ke fu/kkj.k gr io prkouh midj.k ,o fu.k; idt ¼lh,lvkbvkj&lhchvkjvkb½] pekyh&tk'kheB {k=] x<oky fgeky; e tkf[ke fu/kkj.k gr thih,l vk/kkfjr lefUor HkdEi ifr:i.k ¼lh,lvkbvkj&4 ihvkb½] ,l-,-vkj bVjQjkeVh d mi;kx l HkL[kyu fuxjkuh ¼lh,lvkbvkj&lh-,l-vkb-vk½] HkL[kyu fuxjkuh d fy, vkflVdy Qkbcj vk/kkfjr eYVhlyDl llj uVod flLVe dk fodkl ¼lh,lvkbvkj&,u-b-vkb-,l-Vh½] pekyh&tk'kheB {k= x<oky fgeky; e ogr Hk&vUo"k.k RkFkk HkL[kyu d fu;=.k mik; ¼lh,lvkbvkj&lhchvkjvkb½] HkL[kyu vkink lpuk i.kkyh rFkk HkL[kyu fu;=.k vfHkdYi d vfHkuo mik; ¼lh,lvkbvkj&lh-vkj-vkj-vkb½ ,o igkMh {k=k e HkL[kyu U;uhdj.k RkFkk <yku fLFkjrk LkeL;kvk d fy, Qk;VkjehfM,'u vkl'ku ¼lh,lvkbvkj&Ukhjh½ }kjk ifrHkkfxrk dh xbA

'HkdEi vkink U;uhdj.k vfHk;kf=dh'; d idt e Jhuxj] mŸkjk[k.M d Hkdih; l{e vu{k= ij v/;;u] xfrd ik'oHkkj.k d vrxr ikbyk dk Hkdih; 0;ogkj RkFkk fofHkUu v{kh; ruko d vrxr ifj:} fpukb Hkouk dk HkdEi ifrjk/ku ij dk; fd;k x;kA 'vfXu vkink U;uhdj.k vfHk;kf=dh'] d od idt e] ljpukRed rRok dk vfXu fu"iknu eY;kdu ,oe iuokl ij dk; py jgk gA 'vkink i'pkr vkJ; ifj;ktuk'] d od idt d vrxr if'peh fgeky; {k= e xkeh.k {k=k e vkink i'pkr vkJ; ifj;ktuk gr dk; ixfr ij gA 'Hkouk d LokLF; fuxjkuh gr ok;jyl llj uVod]' od idt e] ok;jyl llj uVod dk mi;kx djr g, LokLF; fuxjkuh d nf"Vdk.k d dk;kUo;u ij v/;;u] jh;y&ykbQ fcfYMxl ij U;efjdy ,ukfyfll ,o ekMy viMfVx rFkk bVyhtV fcfYMx Qkj ekMy jftMfl;y ;fuV*] d od idt e bVxfVx bVyhtV fcfYMx Qhpl ,o Xykl QdM Dyhfux jkckfVd flLVe ij v/;;u dk dk; ixfr ij gA

uVod ifj;ktuk ftle] lh,lvkbvkj&Lkhchvkjvkb ,d lgHkkxh i;kx'kkyk g] mMu jk[k mi;kx djd ikuh l Hkkjh /kkrvk dk gVkuk RkFkk bl mi;kxh Hkou ?kVdk d fuek.k e mi;kx djuk ¼ukMy i;kx'kkyk lh,lvkbvkj&uhjh½] x<oky fgeky; dh Hki"Bh; fodfr dk v/;;u x<oky d igkMh {k=k d fy, fd;k tk jgk g ¼ukMy i;kx'kkyk lh,lvkbvkj&4 ihvkb½A vPNh x.koŸkk oky ch tk dh cjcknh o [kjkc gku l cpku d fy, fu;f=r i;koj.k d lkFk Åtk n{k cht HkMkj.k Hkou dk fodflr dju dk dk; Hkh fd;k tk jgk g ¼ukMy i;kx'kkyk lh,lvkbvkj&lh,lvkbvk½A flfoy ljpukvk d vuj{k.k ,o l{e fujh{k.k dh nf"V l Hkouk ,o vU; ljpukvk gr lfol jkckV ifj;ktuk ,d cgr gh mi;kxh ifj;ktuk g ¼ukMy i;kx'kkyk lh,lvkbvkj&lh,ebvkjvkb½A

lLFkku 'Hkou vfHk;kf=dh ,o vkink U;uhdj.k' ¼ch-b-Mh-,e½ d {k= e lefUor LukrdkŸkj&ih-,p-Mh dk;de pyk jgk gA dk;de d ikpo cp d fo|kFkh 'kk/k ic/k r;kj dj jg gA vxLRk 2015 e ih-,p-Mh- d fy, vfHk;kf=dh foKku e 04 RkFkk Hkkfrd foKku e ,d fo|kFkh dk lfEefyr fd;k x;kA oreku e dy 17 ih-,p-Mh- fo|kFkh ,lh,lvkbvkj] lh,lvkbvkj&lhchvkjvkb e ukekfdr gA

Lkh,lvkbvkj&lhchvkjvkb u xr o"kk dh Hkkfr vud viu lkLFkkfud ¼bugkÅl½ vul/kku ,o fodkl dk;dek d lkFk&lkFk cgr lh lfonk vul/kku ifj;ktukvk ij ik"kk.kh;rk ¼lLVufcfyVh½ d LkHkh igyvk dk /;ku e j[kr g, dk; fd;k gA lLFkku u 9 bugkÅl vul/kku ,o fodkl ifj;ktuk,] 14 ijke'kh] 12 lgk;rk vunku] 30 ik;kftr RkFkk 81 ijh{k.k ifj;ktukvk ij dk; fd;k gA

lLFkku u o"k 2015&2016 d nkjku ljdkjh] lkotfud ,o futh {k= dh ,tfl;k@lxBuk dk lfonk vul/kku ,o fodkl lgk;rk vunku] ijke'kh dk; RkFkk rduhdh lok, inku djd 7-93 djkM :i, dh /kujkf'k vftr dhA bl vof/k e] lEeyuk dh dk;okgh ¼ikflfMX½ d lkFk&lkFk fofHkUu tuyk e dy 68 'kk/k i= idkf'kr fd, x,A

lLFkku u jk"Vh; foKku fnol] fo'o i;koj.k fnol] jk"Vh; ikn;kfxdh fnol] lh,lvkbvkj LFkkiuk fnol RkFkk lh,lvkbvkj&lhchvkjvkb LFkkiuk fnol ij lLFkku dh vul/kku ,o fodkl xfrfof/k;k d fo"k; e fo|kfFk;k RkFkk tulkekU; dk tkudkjh nu d fy, bu fnolk ij 'vkiu&M' euk;kA lLFkku dk vke turk d fy, [kyk j[ku d vfrfjDr bu voljk ij fofHkUu dk;dek] LFkkiuk fnol 0;k[;kuk] fofHkUu jk"Vh; fnolk ij bu fnolk d egRo dh tu lkekU; dk tkudkjh nu d mn'; l ifrf"Br 0;fDr;k d 0;k[;ku djk, x,A lLFkku e] LkHkh /kek] Hkk"kkvk RkFkk jkT;k e lnHkkouk dk c<kok nu d mn'; l lnHkkouk fnol dk vk;ktu fd;k x;kA lLFkku e fgUnh fnol vR;Ur g"k vkj mYykl d lkFk euk;k x;kA lLFkku }kjk Mk- ch- vkj- vEcMdj dh 125oh o"kxkB ij lfo/kku fnol d ekd ij 26 uoEcj 1949 e viu n'k d lfo/kku dk vfHkxg.k dk mRlo euk;k x;kA

Mk- g"ko/ku] ekuuh; dUnh; foKku] ik|kfxdh ,oe Hk&foKku e=h u 23 vxLr 2015 dk lh,lvkbvkj&lhchvkjvkb dk nkjk fd;k RkFkk oKkfudk dk Hkou m|kx e v{k;] i;koj.k d'ky ,o mUur lkefx;k ,o ik|kfxfd;k d mi;kx dh lykg nhA lLFkku e 12oh ipo"kh; ;ktuk d vrxr fofHkUu vul/kku ,oe fodkl dk;dek e dk; 'k: fd;k x;kA bu ifj;ktukvk d ifj.kke d iHkkoh mi;kx d fy, rFkk ikdfrd vkinkvk ,oe tyok; ifjoru l mRiUu ub pukfr;k dk lkeuk ,oe fujh{k.k d fy, vud eFku l=k jk"Vh; lEeyuk ,oe vk|kfxd cBdk dk vk;ktu lh,lvkbvkj&lhchvkjvkb e fd;k x;k ftle 18 ekp 2016 dk lLFkku d lHkh oKkfudk vkj vul/kku ifj"kn d lnL;k d lkFk fopkj foEk'k gr vk;kftr fo'k"k vul/kku ifj"kn dh [kyh cBd Hkh lfEefyr gA

lLFkku dh uohu ik|kfxfd;k ,oe fodkl dk;k ftue lLFkku }kjk lkLdfrd fojklrk tl fpŸkkMx< dk fdyk] drc ehukj] dnjukFk] rktegy] dk'kh fo'oukFk efnj] dk.kd l; efnj] xkVu dkly f'keyk] bfM;u bLVhV;V vkQ ,MokLM LVMht f'keyk bR;kkfn l lcf/kr dk;k dh tkudkjh ehfM;k d ek/;e l tuekul dk voxr djku gr i=dkj lEeyu "tu lokn" d vk;ktu fd; x;A

n'k&fon'k d ykxk d lkFk fujrj lokn ,o lpkj cuk, j[ku d de e lLFkku u cMh l[;k e Hkou ,o fuek.k {k= dh fofHkUuk leL;kvk lc/kh iNrkN d mŸkj fn,A depkfj;k] fo|kfFk;k] vke turk rFkk lekt dk cMh ek=k e mRlkfgr dju d fy, fofHkUu dk;de vk;kftr fd, x, vkj Hk"Vkpkj l yMu e ik|kfxdh dk mi;kx fdl idkj fd;k tk ldrk g ij eFku] Hkou fuek.k d {k= e] u, vul/kku ,o ik|kfxfd;k d fo"k; e vke Tkurk d chp tkx:drk ink dju d mn'; l in'ku lg if'k{k.k dk;dek] rduhdh in'kfu;k vkfn dk vk;ktu fd;k x;kA

LkLFkku u fnYYkh fLFkr viu ilkj dn d lkFk feydj n'k Hkj e dnh;] jkT;] lkotfud@futh {k=k d lxBuk d lkFk lEid cuk, j[kkA ;|fi ;g o"k gekj fy, pukfr;k RkFkk miyfC/k;k l Hkjk jgk g] ge viuh miyfC/k;k l vkRelr"V ugh g RkFkk ge Hkfo"; e vku okyh pukfr;k ,o ftEenkfj;k dk lkeuk dju d fy, rRij gA

Ek>] lh,lvkbvkj&lhchvkjvkb dh okf"kd fjikV 2015&2016 dk iLrr djr g, xo dh vuHkfr gk jgh g tk gekj oKkfud vul/kkuk RkFkk lcf/kr miyfC/k;k dk n'kkrh gA bl fjikV e n'kk;k x;k mPp xo.krk oky dk; dk J;] lkFkh oKkfudk] rduhdh vf/kdkfj;k RkFkk i'kkfud dkfedk d dr0;fu"B ,o bekunkj i;klk dk tkrk g] ftUgku viu dk;

dk lQyrk iod dju d fy, dfBu ifjJe fd;k gA Ek mu lHkh dh gkfnd i'klk djr g, mUg 'kHkdkeuk, nrk gA gekjh vul/kku ifj"kn d v/;{k vkj lnL;x.k viu veY; ijke'k] ekxn'ku ,o lgk;rk d fy, fo'k"k /kU;okn d ik= gA e lh,lvkbvkj d egkfun'kd RkFkk lh,lvkbvkj e[;ky; d viu lkfFk;k dk] mud fujrj lg;kx ,o ekxn'ku d fy, lnHkkoiod /kU;okn nrk gA e viu LkHkh lkfFk;k dk mud lg;kx d fy, vkHkkj 0;Dr djrk g] ftUgku e> ej nkf;Rok dk fuHkku e ejh enn dh gA

lLFkku e bl o"k fu;Dr g, uokxUrd ;ok oKkfudk dk Lokxr djr g, e> vR;Ur g"k gk jgk gA bl u, ifjokj dk lkFk ydj ge jk"V ,oe ekuo lok e u, mRlkg d lkFk lno dk;jr jgxA bl okf"kd ifronu d fy, vko';d lpuk miyC/k djku oky lgdfe;k RkFkk bldh mŸke iLrfr d fy, lEiknd dk Ek gkfnd /kU;okn nrk gA vr e] viu eY;oku xkgdk] ik;k tdk] 'kHk fprdk RkFkk lh,lvkbvkj&LkhchvkjvkbZ d lokfuoŸk dkfedk d lg;kx RkFkk lgk;rk dk Lej.k djuk ej fy, ilUurknk;d iy gA

Hkou fuek.k ,o voljpkuRed m|kx e of} d lkFk ge mTToy Hkfo"; dh vkj vxlj gA

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From the Director's Desk

It is my great pride & privilege to present the Annual Report of CSIR-Central Building Research Institute, Roorkee for the year 2015-2016. The Institute has been vested with the responsibility of generating, cultivating and promoting building science and technology in the service of nation and has contributed immensely in scientific research and development, technology development, technology dissemination, social activities, human resource development and national planning for building research in order to sustain the building and construction industries.

Since its inception, CSIR-CBRI has worked untiringly to attain the objective "To work as world class knowledge base for providing solutions to almost all area of Building / Habitat planning and construction including building materials, construction technology, health monitoring, fire engineering and disaster mitigation."

During this period, the Institute pursued two important projects- One Supra Institutional Network Project (SINP) in core competency area of the institute and the other as Network Project being coordinated by the institute with number of other sister laboratories as partners.

A Supra Institutional Network Project (SINP) on '**Innovative Materials & Technologies for Next Generation Green Buildings (INMATE)**' was continued through different work packages. In work package, '**Performance Enhancement of Materials through Nanotechnology**', studies on optimization of silica nanoparticles dosage in cementitious system, development of multifunctional coatings using nanotechnology, phase change materials for energy efficiency in buildings were carried out. In work package, '**Next Generation Concrete for Sustainable Construction'**, studies on structural behaviour of reinforced geopolymer concrete, bio-concrete as self-healing material and development of pervious concrete were carried out. Under the work package, '**Green Building Technologies'**, studies on green retrofit strategies for office buildings, development of solar window system for cold climatic region, demolition wastes as raw materials for low cost construction products, solar thermal air-conditioner, technology packages for mass housing in urban areas with a view to develop blocks using different industrial wastes based on fly-ash/ rice husk ash/ marble dust using non-autoclaving technique, development of an automatic hollow gypsum panel making machine, structural termite management and development of robust foundation for difficult soils were carried out. In work package, '**Materials & Technologies for Hazard Reduction',** studies on indigenous cathodic protection system for steel reinforced concrete structures, development of fire safe polymeric composite panel, impact behavior of reinforced concrete elements and improved ventilation system for cleaner built environment with an objective to design & develop improved ventilation system for cleaner built environment have been carried out.

Network Project on **'Engineering of Disaster Mitigation & Health Monitoring for Safe & Smart Built Environment' (EDMISSIBLE)** was continued through different work packages. Under **Engineering of Landslide Disaster Mitigation**, different sister laboratories are participating. The activities taken up by different participating laboratories include landslide hazard & risk assessment of Chamoli-Joshimath region, Garhwal Himalayas (CSIR-CBRI), Early warning instrumentation & decision package for a landslide in Chamoli-Joshimath region, Garhwal Himalayas (CSIR-CBRI), GPS based integrated landslide modelling for hazard assessment in Chamoli-Joshimath Region, Garhwal Himalaya (CSIR-4PI), Landslide monitoring using SAR interferometry (CSIR-CSIO), Development of optical fibre based multiplex sensor network system for landslide monitoring (CSIR-NEIST), Comprehensive Geo-Investigation and Control Measures of Landslide in Chamoli-Joshimath Region, Garhwal Himalaya (CSIR-CBRI), Landslide hazard Information System and Design of Innovative Measures for Landslide Control (CSIR-CRRI), Bio-Engineering – A Phytoremediation Option for the Mitigation of Landslide and Slope Stability Problems in the Hilly Regions (CSIR-NEERI).

In work package, **'Engineering of Earthquake Disaster Mitigation**', studies on seismic microzonation of Srinagar, Uttarakhand, seismic behaviour of piles under dynamic lateral loading in layered sandy soil and seismic resistance of confined masonry constructions under different axial stress were continued. In work package, '**Engineering of Fire Disaster Mitigation**', fire performance evaluation of structural elements and rehabilitation have been progressing. In work package, '**Post Disaster Shelter Planning',** post disaster shelter planning for rural areas in the Western Himalayan region was continued. In work package, '**Health Monitoring of Buildings using Wireless Sensor Network', i**mplementation of health monitoring approach using wireless sensor network, numerical analysis & modal updating on real-life buildings & under work package, '**Intelligent Building System for Model Residential Unit',** studies on architectural planning and design of a residential unit for integrating intelligent building features & glass facade cleaning robot are progressing.

In a **Network Project** where CSIR-CBRI is a participating laboratory, studies on removal of heavy metals from water using Fly Ash and its subsequent use in the production of value added building components (Nodal lab CSIR-NEERI) is being carried out. Estimation of crustal deformation of Garhwal Himalaya (Nodal lab CSIR-4PI) is being carried out in the hilly regions of Garhwal. Studies to develop energy efficient seed storage structure with controlled environment to avoid spoilage and deterioration of quality of seeds (Nodal lab CSIR-CSIO) are also being carried out. Robotic technology for periodic inspection civil infrastructure (Nodal lab CSIR-CMERI) is also very useful project for precise inspection and maintenance of buildings.

The Institute is offering Integrated Masters-Ph.D. programme in the area of **"Building Engineering and Disaster Mitigation"** (BEDM**)**. The fifth batch of the programme is currently carrying out their dissertation. Four students have joined for Ph.D. in Engineering Sciences and one student in Physical Sciences in August 2015. Presently total 17 Ph. D. students are enrolled in AcSIR at CSIR-CBRI.

CSIR-CBRI, as in the previous years has handled a number of its own in house R&D programmes and many other contract research projects giving due consideration to all aspects of sustainability. The Institute handled 9 in-house R&D projects, 14 consultancy, 12 grant-in-aid, 30 sponsored and 81 testing projects.

The Institute registered an external cash flow of nearly Rs. 7.93 crore during 2015-16, earned through contract R&D, grant-in-aid, consultancy assignments and technical services, carried out for government, public & private sector agencies/organization. During the period, a total of 68 research papers has been published in various journals as well as conference proceedings.

The Institute observed open days on National Technology Day, World Environment Day, CSIR Foundation Day, and CSIR-CBRI Foundation Day to make the students and public aware with the R&D activities of the Institute. Apart from keeping the institute open for general awareness, different programmes, foundation day lectures, lectures by eminent personalities on different National days to make people aware of the importance of the National days were arranged. The Institute observed Sadbhavna Diwas with a view to promote harmony amongst people of all religion, languages and states and goodwill towards everyone.The Institute also celebrated Hindi Diwas with great zeal and enthusiasm.The Institute observed Constitution Day on the 125th Birth Anniversary of Dr. B.R. Ambedkar to celebrate the adoption of the Constitution on November 26, 1949.

Dr. Harsh Vardhan, Hon'ble Minister of Science & Technology and Earth Sciences visited CSIR-Central Building Research Institute, Roorkee on August 23, 2015 to urge the scientists to use renewable, green and innovative materials and technologies in the Building Industry. The Institute has undertaken various R&D programmes under the 12th Five Year Plan. For effective utilization of the outcome of these projects and to observe new faced challenges posed by natural disasters and climate change, several brainstorming sessions, national conferences, and industrial meetings were held at CSIR-CBRI, including a special Research Council meeting on March 18, 2016 in which deliberations were held with all scientists and RC members.

The Institute also organized two Press Meets "Jan Sanvad" to apprise about the new technologies and development of the institute to the media such as the institute's works related to cultural heritage sites like Chittaurgarh Fort, Qutab Minar, Taj Mahal, Kashi Vishwanath Temple, Sun Temple, Gorten Castle Shimla, Indian Institute of Advanced Studies Shimla and Kedarnath etc.

To maintain regular interaction and communication with the people of India and abroad, the Institute addressed various inquiries pertaining to various problems of Building and Construction sector. Several programmes were organized to sensitize the employees, students, public and society at large about how technology can be used in combating corruption. Demonstration cum training programmes, technical exhibitions etc. were also organized to create awareness for general public about the new research and technologies in the field of building sector.

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

I am honoured to present this CSIR-CBRI Annual Report 2015-2016, which reports the scientific research output and related achievements. The volume of high quality work reported goes to the credit of the sincere and honest efforts made by fellow scientists, technical officers and administrative staff who

worked hard in successfully completing the works assigned to them. I record my deep appreciation and best wishes to all of them. The Chairman and the Members of our Research Council deserve special thanks for their valuable advice, guidance and support. I extend my sincere thanks to Director General, CSIR and other colleagues from CSIR Head quarters for their continuous support and guidance. I wish to acknowledge with gratitude the unstinted co-operation of my colleagues which has helped me to discharge my duties to the best of my ability.

I am pleased to welcome the young new scientists to our institute. With them and our already embedded staff, we look forward to work with each other and everyone in our quest for serving the nation and mankind. I thank my colleagues for providing the necessary inputs and editor for bringing out this annual report in an elegant manner. Last but not the least, it is a happy moment for me to remember the support and co-operation provided by our valued customers, sponsors, well wishers and ex-colleagues of CSIR-CBRI.

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

Dated: 08/04/2016

(Yadvendra Pandey)

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INNOVATIVE MATERIALS & TECHNOLOGIES FOR NEXT GENERATION GREEN BUILDINGS (INMATE)

WP-1: Performance Enhancement of Materials through Nanotechnology.

PI: L. P. Singh

- Nano-Engineered Cementitious Materials PI: L. P.Singh & Team
- Multifunctional Coating using Nano-Technology, PI: P.C.Thapliyal & Team
- Phase Change Materials PI: Srinivasarao Naik B & Team

WP-2: Next Generation Concrete for Sustainable Construction.

PI: S. K. Singh

- Structural Behaviour of Reinforced Geopolymer Concrete
- Bio-Concrete as Self Healing Material PI: Leena Chourasia
- Pervious Concrete for Tropical Climate PI: R. Deoliya & S. C. Gurram

WP-3: Green Building Technologies.

PI: Ashok Kumar

- Green Retrofit Strategies for Office Buildings,PI: Ashok Kumar, & Team
  - Development of Solar Window System for Cold Climatic Region, PI: Neeta Mittal & B.M.Suman
- Demolition Wastes, PI: A. K. Minocha, & Team
- Solar Thermal Air Conditioner, PI: Nagesh B. Balam
- Technology Packages for Mass Housing in Urban Areas, PI: Ashok Kumar, & Team
  - To Develop Light Weight Blocks using Different Industrial Wastes based on flyash/rice husk ash/marble dust, PI: Vivek Sood & Ashok Kumar
  - Development of an Automatic Hollow Gypsum Panel Making Machine, PI: S.K.Panigrahi & Team
  - Development of Anti Termite Barrier for New Buildings, PI: B.S.Rawat & Team.
- Robust Foundation for Difficult Soils, PI: Pradeep Kumar

WP-4: Materials & Technologies for Hazard Reduction.

PI: S.R. Karade

- Indigenous Cathodic Protection System, PI: S.R. Karade & Team
- Impact Behaviour of RCC, PI: A.K. Mital & Team
- Fire Safe Polymeric Composite Panels, PI: Harpal Singh
- Improved Ventilation System, PI: Syed Ibrahim Sohel, & Team

WP-1 Performance Enhancement of Materials through Nanotechnology

L. P. Singh

Studies on Optimization of Silica Nanoparticles Dosage in Cementitious System

L. P. Singh, S. R. Karade & Team

Increasing use of nanotechnology in cementitious materials is gaining widespread attention as remarkable improvement in mechanical properties has been reported. Among the various nano particles viz. silicon oxide, titanium oxide, zirconium oxide, aluminum oxide, carbon nano tube, etc. explored, silica nano particles (SNPs) have gained extensive attention as they provide improved mineralogical and morphological characteristics. During the last one decade, numerous research papers have reported varying amount of SNPs dosage ranging from 0.5 to 10% in different cementitious systems such as paste, mortar and concrete. It has been reported that the mechanical properties such as compressive strength decreases beyond the optimized dosage apart from the problems of agglomeration of nano particles, improper mixing, etc. Only a little is available to explain the role of SNPs at early stage of hydration.

For the present study, the ordinary Portland cement (OPC) with Blaine fineness 390 m^2/kg, confirming to IS 8112:1989 was used and the tricalcium silicate (C_3S) & SNPs were prepared in the laboratory. To understand the early hydration process in presence SNPs, experiments were carried out on C_3S phase. Different dosages of SNPs (1, 3 5 and 10%) were added by the weight of C_3S and total water binder ratio (w/b) was kept 0.4 for all the samples. The hydration process was stopped at different time intervals starting from 1 to 24 h. For the cement paste studies, the content of SNPs was varied from 1 to 5% by the weight of cement and the samples were prepared into a standard cube molds (25 × 25 × 25 mm) using w/b ratio 0.4.

The amount of CH was calculated directly from the TG curves using the following equation:

$$CH\ (\%) = WL_{(CH)}\ (\%) \times \frac{MW_{(CH)}}{MW_{(H)}} \qquad \text{eq. (1)}$$

Where $WL_{(CH)}$ corresponds to the weight loss attributable to CH dehydration and $MW_{(CH)}$ and $MW_{(H)}$ are the molecular weights of CH (74 g/mol) and water (18 g/mol), respectively.

The acceleration in hydration rate of C_3S has been observed in presence of SNPs in XRD and TGA analyses. The CH peak at $2\theta = 18.02°$ represents the crystalline portlandite formed during hydration. In C_3S samples, the intensity of CH peak increases as the hydration proceeds, however, in presence of SNPs, the intensity of CH peak was higher than the control at 8 h of hydration and the intensity also increases with the higher dosage of SNPs (Fig 1(a)). This is due to the nucleation effect of SNPs. While at 24 h of hydration, the intensity of CH peak is decreased with higher dosage of SNPs,

attributing to the pozzolanic effect (Fig 1(b)). Similar results were obtained from TGA analyses, wherein the CH content is also increased in presence of SNPs from 12 to 61% showing the higher rate of nucleation effect with higher dosage of SNPs (Fig 2). However, the nucleation effect with 5 and 10% SNPs addition was found to be almost constant showing the optimized effect of SNPs. Further, FTIR results reveal that in presence SNPs (up to 5% SNPs addition), C-S-H gel shows more resemblance with jennite like structure, while with 10% SNPs addition, C-S-H gel shows more resemblance with tobermorite like structure (Fig 3). Thus, in presence SNPs more polymerized and ordered C-S-H is formed, which leads to the formation of more compact and dense microstructure, which improves the early age mechanical strength and also responsible for the lower mechanical strength at later age, because the availability of water for further hydration will be lower and the possibility of higher amount of unhydrated grains may increased with higher dosage of SNPs. With these studies it can be revealed that ~5% addition of SNPs is the optimized dosage in C_3S because conversion of C-S-H into tobermorite like structure leads more stiffness into microstructure. In case of OPC, the C_3S content varies from 50-70%, therefore, the optimum dosage of SNPs in OPC will be 2-3%. The compressive strength results show good agreement with this data as the compressive strength of cement paste with different dosage of SNPs. At 1 & 3 days of hydration, the compressive strength

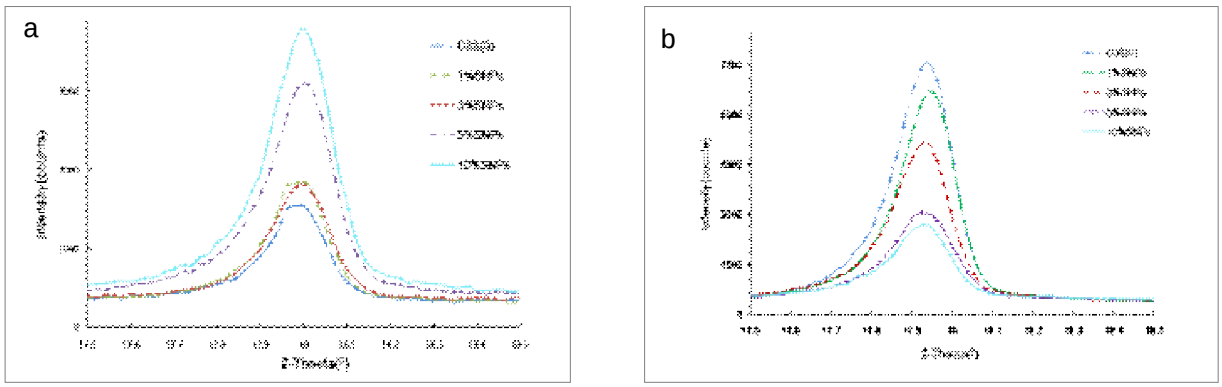


Fig. 1: CH Peak at 2θ=18.02° in Pure and SNPs incorporated C_3S Samples at 8h (a) and 24h (b) of Hydration

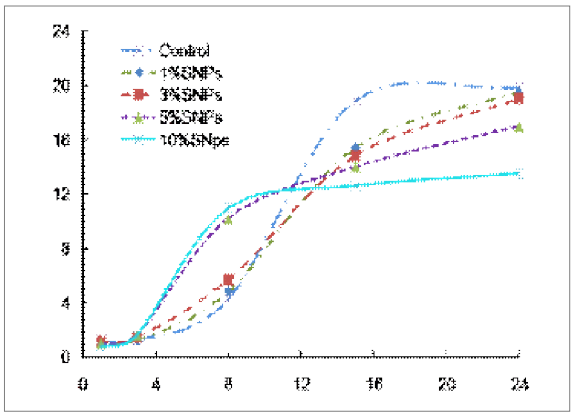


Fig. 2: Quantification of CH (%) in Pure and SNP incorporated C_3S at Various Time Intervals

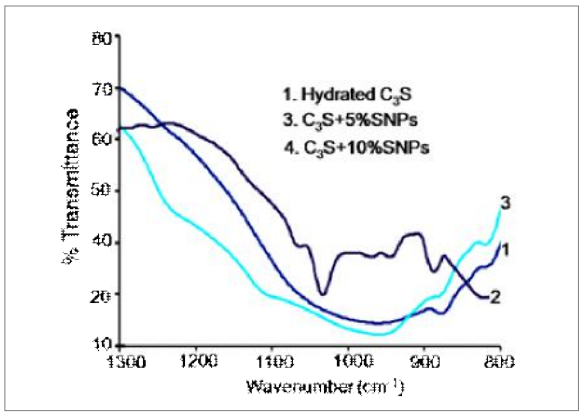


Fig. 3: FTIR Spectra of SNPs incorporated C_3S at 24h of Hydration Various Time Intervals

was found to be significantly higher in all SNPs incorporated samples than the control due to the formation of additional C-S-H through nucleation and pozzolanic reaction of SNPs (Fig 4(a)). However, at 7 & 28 days of hydration, the compressive strength increases with 3% SNPs addition, while with 5% addition (Fig 4(b), compressive strength was slightly decreased showing the optimized effect of SNPs in cement paste.

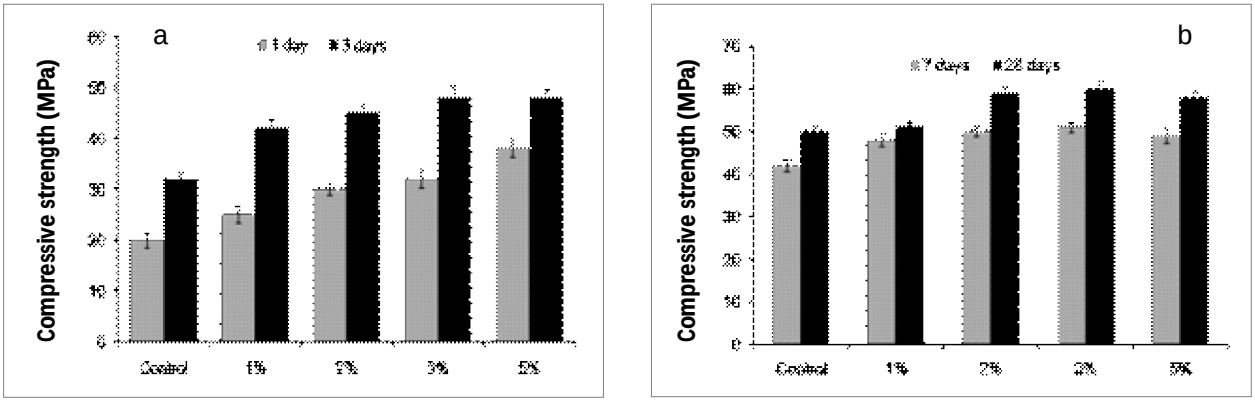


Fig. 4: Compressive Strength of Cement Paste at 1 and 3 Days (a) and 7 and 28 Days (b) of Hydration with Varying Dosage of SNPs

Development of Multifunctional Coatings using Nanotechnology

P.C. Thapliyal

The project was started with the objective to develop multifunctional (water resistant, energy efficient, anticorrosive) coatings for mortar and concrete. Twelve coatings were formulated and characterized by mineralogical, morphological and physico-mechanical studies to establish coating structures. Addition of nano additive was found to influence the properties of coatings especially in terms of heat build-up. Work on the performance evaluation of coatings for corrosion resistance and water resistance etc. is in progress (Table 1). Some of the observations and results obtained so far has already been communicated /accepted for publication in reputed research journals and conferences.

Few more studies like studies on effect of nano additives and performance evaluation in terms of durability studies of the coatings will be carried out this year by using at least two nano additives with different shape. Optimization of coatings will be done with the help of DOE software also and results will be analyzed for multifunctional aspect. Further, determination of other coating's properties such as solar absorptivity, R values etc. will be completed.

Table 1: Effect of nano additive on accelerated weathering of coatings

Coating	A1	A1N	A11N	A2	A2N	A21N	A3	A3N	A31N	A4	A4N	A41N
Immersion in water	No change after six months											
Immersion in 5% NaCl	No change after six months											
Immersion in sat. Urea	No change after six months											
Immersion in 30% NaOH	No change after six months											
Immersion in 5% HCl	Discolouration after one month						Discolouration after 15 days					
Humidity Cabinet (RH 100%, 45±5 ^{0}C	No change after three months											

Phase Change Materials for Energy Efficiency in Buildings

Srinivasrao Naik B.

FTIR of Encapsulated Phase Change Material (EPCM):

The FTIR Fourier Transform Infra Red spectra of Melamine-Formaldehyde (MF) pre-polymer as shell, lauric-capric acid Eutectic mixture as core material and EPCM samples are presented in Fig 1.The strong and wide peaks absorption peaks at approximately 3520 cm^{-1} of core material is assigned to O-H stretching vibration. The multiple strong peaks at 2924 cm^{-1} and 2857 cm^{-1} are associated with aliphatic C-H starching vibrations of methyl and methylene group. The moderate strong peak at 1053 $cm^{-1}$is related to C-OH stretching vibration of primary alcohol (Fig 1(a)). The strong and wide absorption peaks at approximately 3268 cm^{-1} and 3440 cm^{-1} are attributed to the superposition of O-H and N-H stretching vibrations (Fig 1(b)). The peak at 1528 cm-1 is due to –C=N ring vibration. The characteristic peaks of core material at approximately 2924 cm^{-1}, 2857 cm^{-1} and 1053 cm^{-1} are observed in microcapsule containing core material, indicating that core material has encapsulated with no reaction between core material and MF polymer (Fig 1(c)).

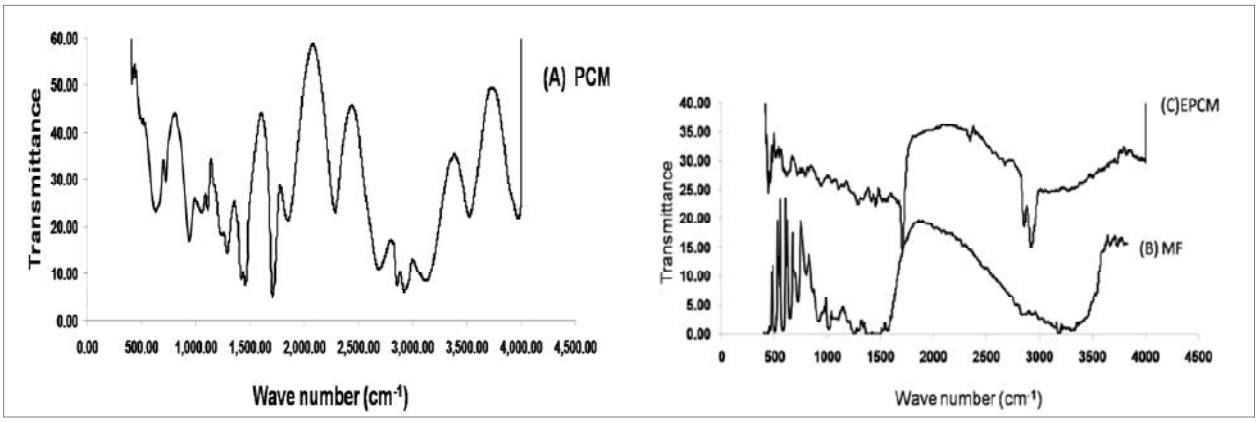


Fig 1: FTIR Spectra of (a) PCM (b), MF & (c) EPCM

Activation Energy of MF Polymer:

Activation energy represents, energy required to deformation of MF polymer or thermal stability. Thermo-gravimetric analysis of EPCM was conducted for determining kinetic parameter such as activation energy at different heating rates 10, 15, 20 and 25 ºC/min in the presence of 200 ml/min nitrogen flow rates. Different kinetic models such as the Flynn-Wall- Ozawa and Kissinger's analysis were adopted for determining kinetic parameter.

The Flynn-Wall-Ozawa plot and Kissinger's model of EPCM (Fig 2 & Fig 3) exhibited a

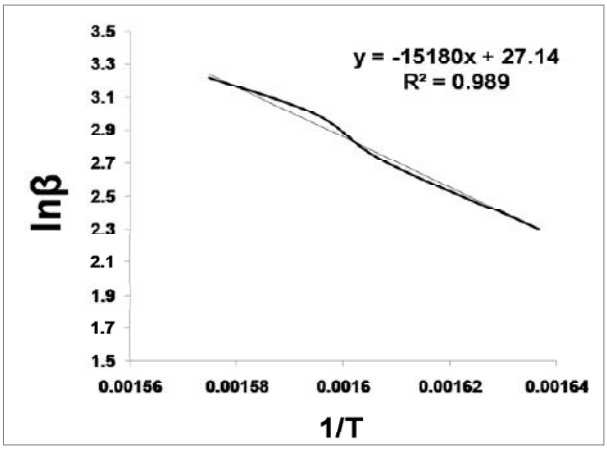


Fig 2: Flynn-Wall-Ozawa Model

good linear relationship indicating that Flynn-Wall-Ozawa and Kissinger analysis are effective with good linear relationship. The Ea values of MF polymer estimated from the Flynn-Wall- Ozawa and Kissinger analysis are shown in Table 1.

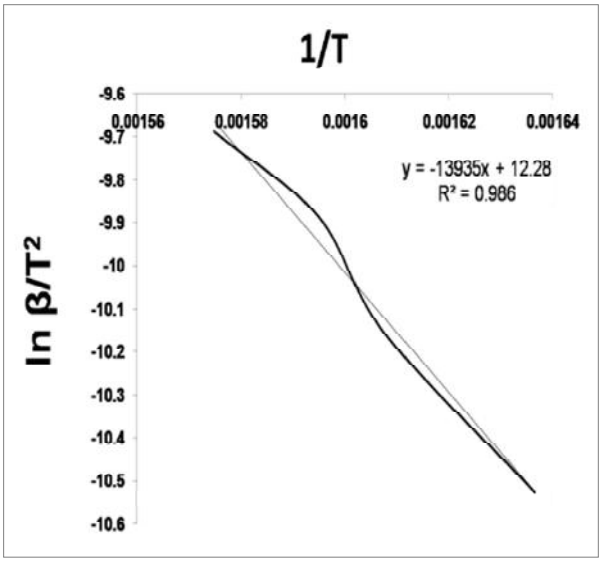


Fig 3: Kissinger's Model

Table 1: The Values of Activation Energy Obtained

Sample	Activation Energy kJ/mol	
	Flynn-Wall Ozawa Method	Kissinger Method
MF Polymer	119	116

Incorporation EPCM into Brick:

Three chambers (Size: 1m x 1m x 1m) were constructed at CSIR-CBRI of ordinary brick, grooved brick and EPCM incorporated grooved brick. Observed indoor time- temperature profile of three chambers in the month of March 2016 is given in Fig 4.

From the graph, it has been found that the temperature difference between ordinary and grooved chamber is 1°C and heat transfer delayed in grooved chamber is 1:30 hrs due to the low heat transfer coefficient of air. Also, the temperature difference between ordinary and EPCM incorporated chamber is 2.2°C and heat transfer delayed in EPCM incorporated chamber is 2:30 hrs due to PCM.

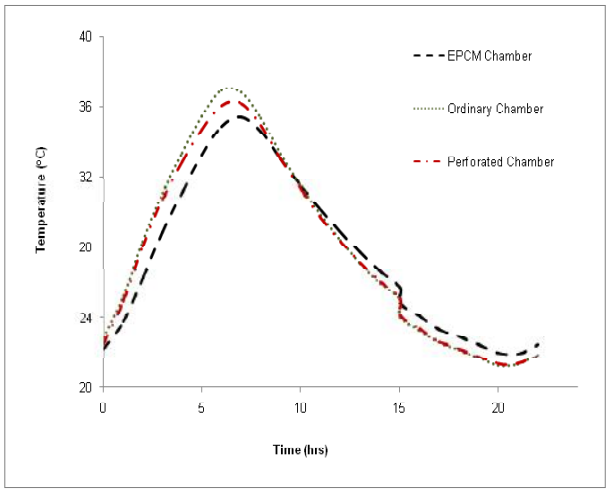


Fig 4: Temperature Profile of Three Chambers

WP-2

Next Generation Concrete for Sustainable Construction

S. K. Singh

Structural Behaviour of Reinforced Geopolymer Concrete

B. Singh, Md. Reyazur Rahman, Rakesh Paswan, Ishwarya G. & Humaira Ather

The mix proportioning of geopolymer concrete with a compressive strength of 40MPa was carried out using fly ash based composite binder. The ideal gradation curve was used to proportion different size of aggregates. Water-geopolymer solid ratio in the mix was kept at 0.21. The aggregate-paste ratio was optimized at a level of 0.36. The developed mix was characterized for its strength characteristics such as compressive strength, flexure strength and elastic modulus, ITZ, age hardening and drying shrinkage. This mix was used for casting of reinforced concrete beams of size 100 x 150 x 1800 mm. All the beams were doubly reinforced. The beams were designed as per IS 456 guidelines. Reinforcement percentage in the beams was 1.42%, 1.88 % and 2.20 % respectively. The balance reinforced beam and under reinforced beams were chosen for this study. All the beams were designed to fail in flexure mode.

The cast reinforced concrete beams were tested under flexure. The beam was simply supported and loaded under two-point that were kept at 550 mm apart on a span of 1650 mm. All the measurements, including deflections, strain values, and crack propagation were recorded at regular load intervals until the beam failed. The failure modes and crack patterns of the beams were also recorded. The ultimate load carrying capacity of beams ranged between 44 and 54kN. (Fig 1) The beam having higher percentage of reinforcement had more load carrying capacity. The theoretical deflections were matched with the experimental results at the service load. The average flexural capacity ratio of experimental value to the calculated value was ~1.5 showing that the calculated values were more conservative than the experimentally obtained values. Limit state theory has been used to construct stress block (Fig 2) and strain diagram. The neutral axis shifted towards extreme compression fiber on application of load thereby, reducing the total compression zone and increased more bending resistance. It was also observed that with increase in the tension reinforcement, the curvature ductility index of the beam decreased from 6 for 1.41% reinforcement

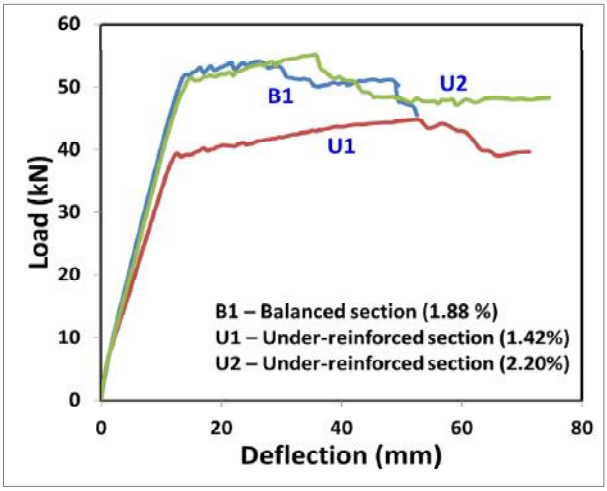


Fig 1: Load-Deflection Curves of Reinforced Geopolymer Concrete

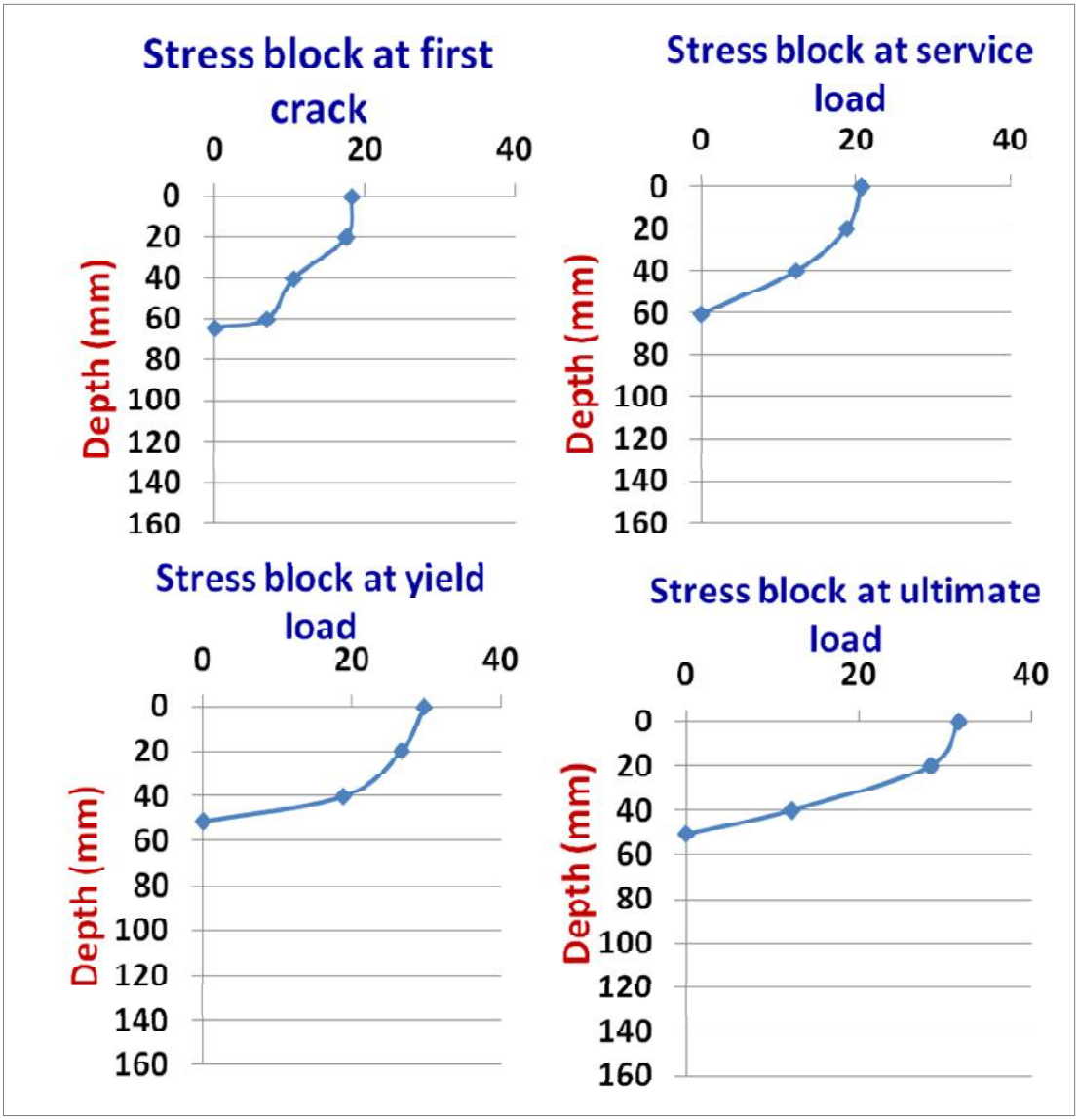


Fig 2: Stress Block of Reinforced Geopolymer Concrete

to 3.5 for 1.88% reinforcement. Above 1.88% reinforcement, the ductility of beam increased due to the increase of compression reinforcement. The initial crack in the beams occurred between 9 and 13kN loads. The crack width size at failure was found to be in the range of 1-2 mm. When compared with the OPC concrete, the crack width size was less although crack patterns were somewhat similar as per the reported literature. The existing guidelines for reinforced OPC concrete can be used to design reinforced geopolymer concrete flexural members.

The repeated impact drop weight test as per ACI 544.2R-89 was conducted to compare the relative impact resistance of various geopolymer concrete mixes prior to their use in the reinforced beams/ slabs (Table 1). Results of number of blows necessary to cause the prescribed level of distress in the specimens can be useful to ascertain their impact resistance behavior. It was found that the impact strength of plain concrete increased with an increase of compressive strength. The impact energy of concrete varied from 1900 J to 4500 J. The energy absorbed by 28 days cured specimens

Table 1: Impact Test Results of Geopolymer Concrete for 7 & 28 Days as per ACI 544.2R-89

Compressive Strength (MPa)	Age	Number of blows		Impact energy (J)	
		First crack	Ultimate crack	First crack	Ultimate crack
29	7 days	69	74	1407.8	1512.9
	COV	20	19	20	19
	28 days	93	96	1886.1	1947.1
	COV	15	16	15	16
35	7 days	131	134	2656.1	2730.8
	COV	10	10	10	10
	28 days	142	147	2890.2	2995.4
	COV	15	14	15	14
42	7 days	168	171	3412.6	3473.6
	COV	11	10	11	10
	28 days	220	227	4471.0	4613.5
	COV	10	10	10	10

was 32% more than the 7 days cured specimens (42MPa). Knowing the variability of result in the test, scattering of data in terms of coefficient of variance was 10-20%. To obtain more precise data, subsequent experiment was performed with the Instrumented drop weight type system on reinforced geopolymer concrete beams.

The impact response of reinforced geopolymer concrete beams (100 x 150 x 1800 mm) was studied under falling weight impact test at various heights and repeated blows. A hammer (75 mm hemispherical tip) with a mass of 100 kg was dropped (0.65, 1.0 and 1.25 m) onto the simply supported beams with a span of 1600 mm. The parameters studied are: time history of dynamic response, impact force, reaction force, mid-span deflection, crack patterns and impact response and static flexural capacity correlation. The results indicated that the impact force on the beams ranged between 161kN and 220kN for a drop height of 0.65 m to 1.25 m. The initial response peak increased with an increase of drop height. The reaction force of beams ranged between 96kN to 125kN. The negative reactions observed were more in higher drop height than the lower ones due to lifting of beam end as a result of rebound of applied impact load. The deflection obtained on the beams was in the range of 16 to 29 mm. As the number of blows increased, the impact load and reaction force decreased and mid-span deflection increased. The beam having higher reinforcement exhibited higher impact and reaction forces than the beam containing low percentage of reinforcement. The mid-span deflection reduced with the increase of reinforcement percentage in the beam. The amount of longitudinal reinforcement significantly affected the failure mode of beams under impact loading.

A correlation between the impact response and static flexural capacity of reinforced geopolymer concrete was also attempted. It was observed that the maximum impact force and reaction force increased with an increase of static flexural load carrying capacity. Increasing input impact energy increased static flexural load carrying capacity of the beams. It was also noted that the mid-span deflection during impact decreased with the

increase of static flexural load carrying capacity. A comparison on the impact behavior of reinforced geopolymer concrete and OPC concrete was made with respect to impact force, reaction force and deflection (Fig 3). The results are encouraging.

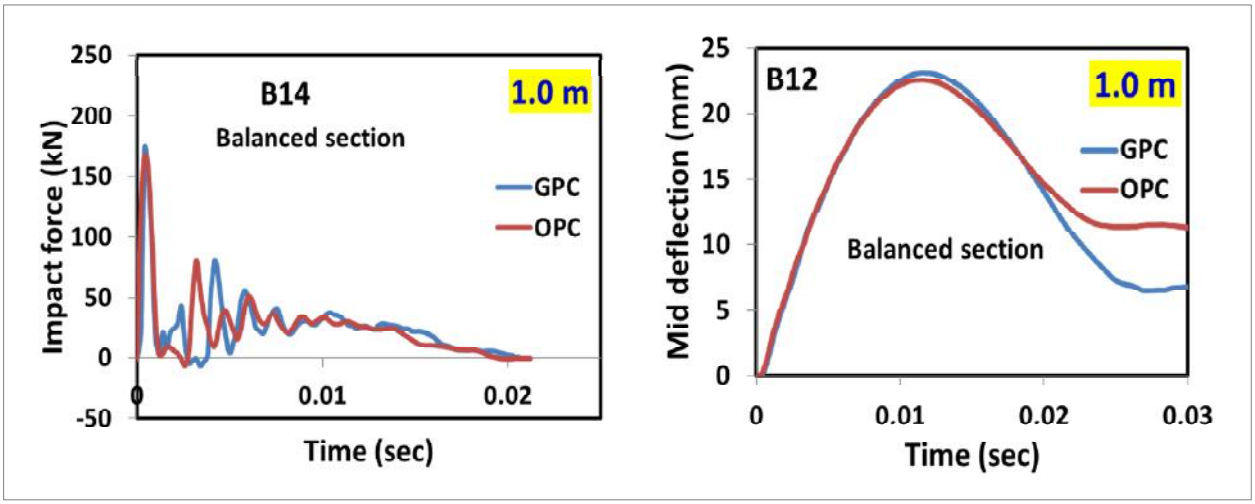


Fig 3: Comparative Evaluation of Impact Response on Reinforced GPC & OPC Concrete

Bio Concrete as Self Healing Material

Leena Chaurasia

- Species of calcifying bacteria have been maintained for study.
- % Water absorption in control and Bio-admixture treated concrete discs

Concrete discs (392 mm^3) were casted with and without bio-admixture. Optimized dose of bio-admixture was incorporated into concrete specimens and the discs were tested for water absorption (ASTM C 642-13). The result showed significantly less % water absorption as compared to control specimens. It was found that bio-admixture incorporated concrete specimens absorbed ~ 22% less water than conventional concrete after immersion of oven dried specimens and ~ 18% less water absorption after immersion and boiling of specimens (Table 1).

- % Porosity and % Voids of bio-admixture treated and untreated concrete discs

% Porosity and volume of permeable pore space(voids) % of casted concrete discs was calculated as per the ASTM C642-13 and the treated discs showed ~19 % and ~33% decrease in %porosity and % voids respectively, indicating the deposition of a layer of calcium carbonate on the surface and inside pores of the concrete specimens. Once the pores are sealed, reduction in water ingress is observed. Therefore, MICP, a microbial run mechanism can be used to decrease the pore size by depositing calcite inside the concrete microstructure (Fig 1).

Table 1: Loss in Water Absorption (%)

S. No.	Test performed	Control	Bio-admixture	% Water absorption decrease in Bio-admixture
1.	Water absorption after immersion of specimens (%)	7.9	6.1	22.7
2.	Water absorption after immersion and boiling (%)	6.0	4.9	18.3

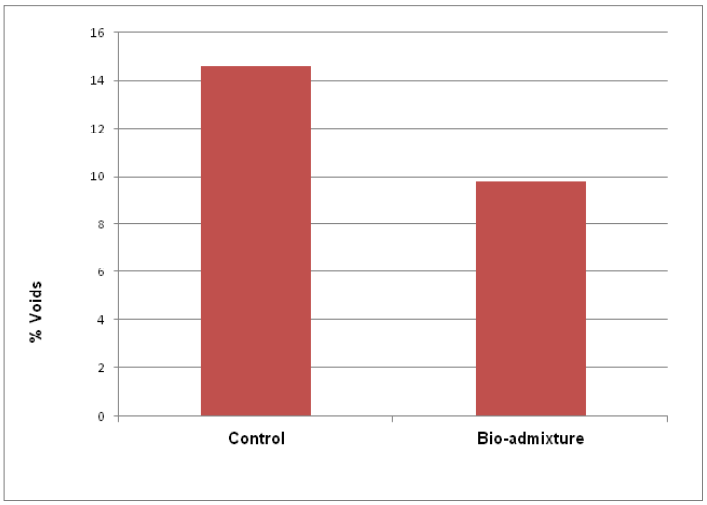


Fig 1: Volume of Permeable Pores (Voids) % in Bio-Admixture Treated & Untreated Concrete Discs

This bio-deposition can seal the pores, voids and micro cracks, because of the bacterial action at micro level. Hence, the presence of a layer of carbonate crystals on the surface by bacterial cells has the ability to improve the resistance of cementitious materials towards degradation (Fig 2).

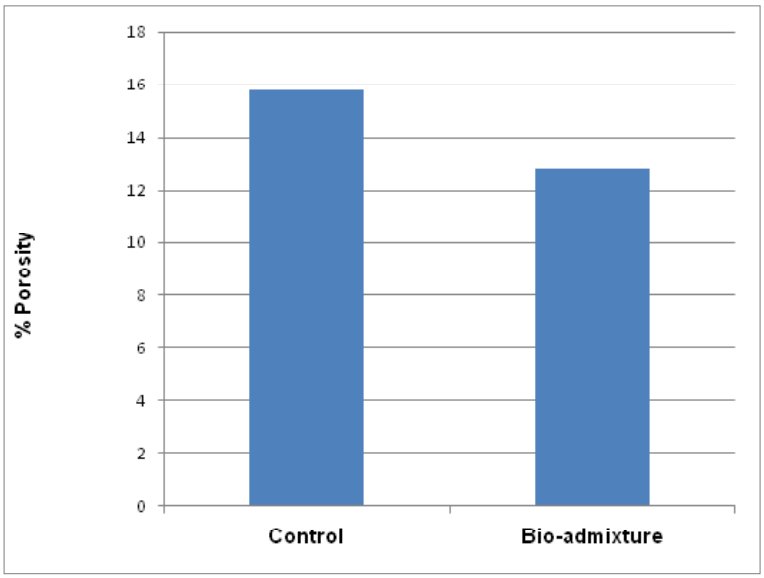


Fig 2: % Porosity in Bio-Admixture Treated & Untreated Concrete Disc

- Calcite quantification by EDTA Titration (Table 2)
- FESEM - EDX Analysis

FESEM-EDX analysis was carried out on the tested samples of the concrete cubes at 28 days of hydration. Fig 3(a), Fig 3(b) and Fig 3(c) is electron micrograph of control, bacterial concrete and bio-admixture (bacterial culture + calcium lactate) concrete respectively and the results show that in bacterial incorporated concrete rod shaped bacteria were embedded in cement sand matrix. EDX results show that the calcium content in concrete samples is ~4%, while in bacterial concrete and bio-admixture (bacterial culture + calcium lactate) concrete it is ~14.54 and 28.32%, respectively showing higher calcium content in bacterial incorporated samples.

Table 2: EDTA Titration for Quantification of Calcite

S. No	Titrant	Aliquot(ml)/Amount(gm)	EDTA Consumed (ml)	$CaCO_3$(mg/l)/ppm
1.	Tap water	10 ml	6.2	62.06
2.	Bacterial culture	10 ml of 1000µl (1 ml) standard sol.	47.6	476.47
3.	Bacterial pellet	10ml of 1 gm wet pellet standard sol.	33.5	335.33
4.	Bacterial powder	10ml of 0.1 gm containing standard sol.	41.4	414.41
5.	Bacterial powder	10ml of 0.5 gm containing standard sol.	140	1401.4
6.	Supernatant	10 ml	3	30.03

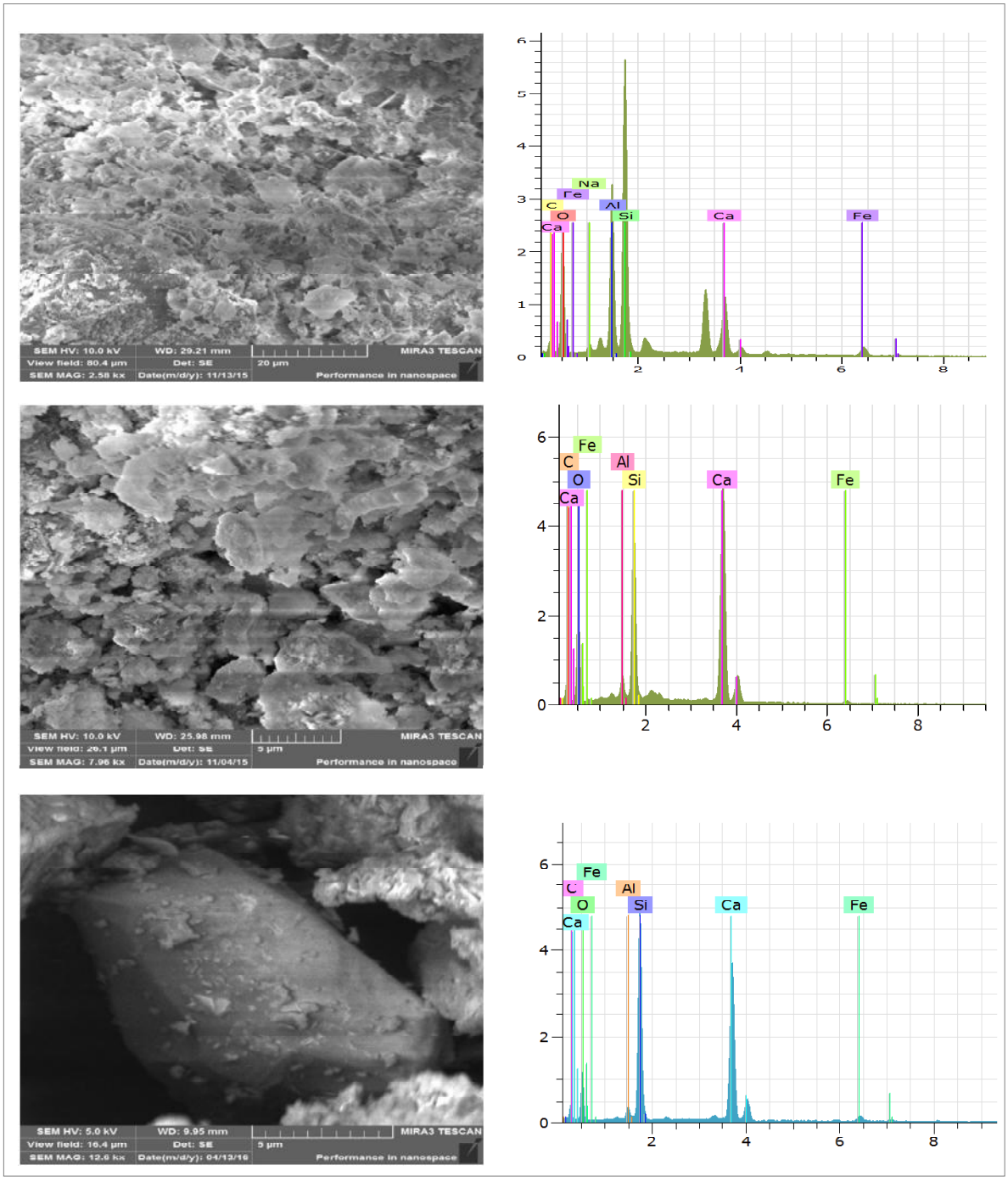


Fig 3: Scanning Electron Micrographs & EDEX of (a) Control & (b, c) Micrographs of the Treated Concrete Specimen Prepared with Incorporation of *B.cohnii* (Bacterial Culture) & Bio-Admixture (Bacterial Culture + Calcium Lactate)

Development of Pervious Concrete

Subash Chandra Bose Gurram & Rajesh Deoliya

Pervious concrete is a kind of concrete with little or no fine aggregate and has high interconnected porosity. Cement paste flow characteristics should be such that paste accumulation does not take place at the bottom while compacting. Volume of cement paste should be enough to bind aggregate together and it should not fill the empty space between aggregate particles completely. This facilitates high interconnected porosity. Because of its high permeability, pervious concrete is being used widely in parking lots and pathways to allow rain/storm water runoff to permeate into the ground.

The objective of the project is to develop pervious concrete having 10-25% porosity with 10-25 MPa compressive strength using locally available materials. Effect of fine aggregate content on compressive strength, porosity, abrasion resistance and split tensile strength are evaluated and discussed in this report. In first series of experiments, volume of fine aggregate was increased up to 0.1 m^3 while two water-cement ratios were considered i.e., 0.3 and 0.32. In second series, pervious concrete with water-cement ratio varying from 0.28 to 0.34 was cast with and without fine aggregate and super plasticizer. Fine aggregate content and super plasticizer dosage were kept constant at 50 kg/m^3 and 0.2% of cement by weight respectively. Cement content and aggregate quantity were 400 kg/m^3 and 1500 kg/m^3 in the first series, and 500 kg/m^3 and 1300 kg/m^3 in the second series respectively. Ordinary Portland cement was used. Aggregate was mixture of 6.35-10 mm and 10-12.5 mm sizes in equal proportions by weight. Standard cube and cylinder specimen were cast. Compressive strength and porosity tests were conducted as per IS 516 and ASTM C1754 respectively. Porosity is found decrease with increase in w/c ratio and/or fine aggregate content when all other parameters are kept constant because volume of solids in mix has increased. Slight increase in strength is observed in mixes with fine aggregate when compared with mixes without fine aggregate. Cylinder specimens of the above mixes were tested for abrasion resistance as per ASTM C 1747 and one such specimen after the test is shown in Fig 1(a). It is observed that mass loss decreases with increase in compressive strength as shown in Fig 1(b) and Fig 2(b).

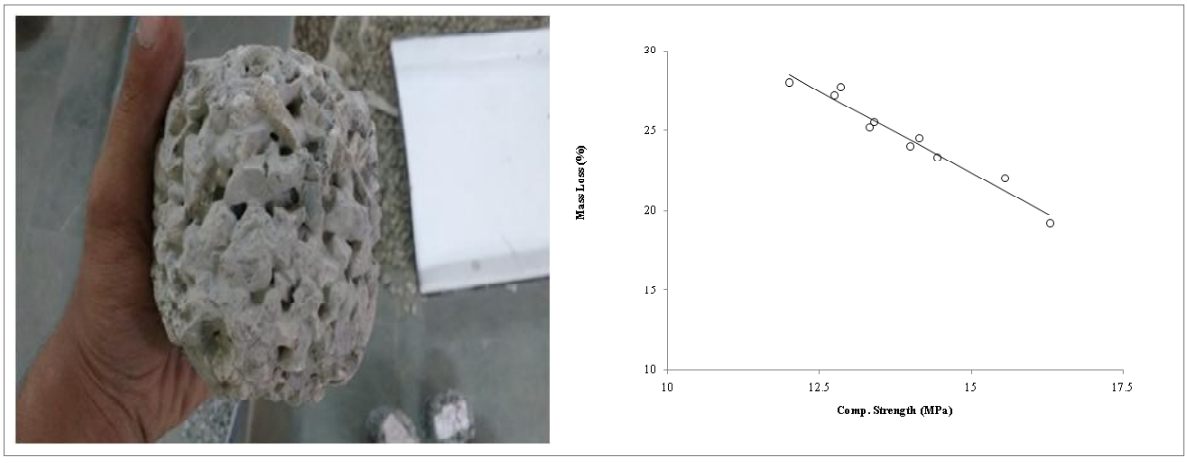


Fig 1: Abrasion Resistance Test (a) Specimen after the Test (b) Mass Loss Variation with Compressive Strength in First Series of Experiments

In second set of experiments, compressive strength has been found to increase slightly with decrease in porosity as shown in Fig 2(a). Decrease in porosity was observed due to increase in cement mortar content when w/c ratio, super plasticizer and fine aggregate were increased.

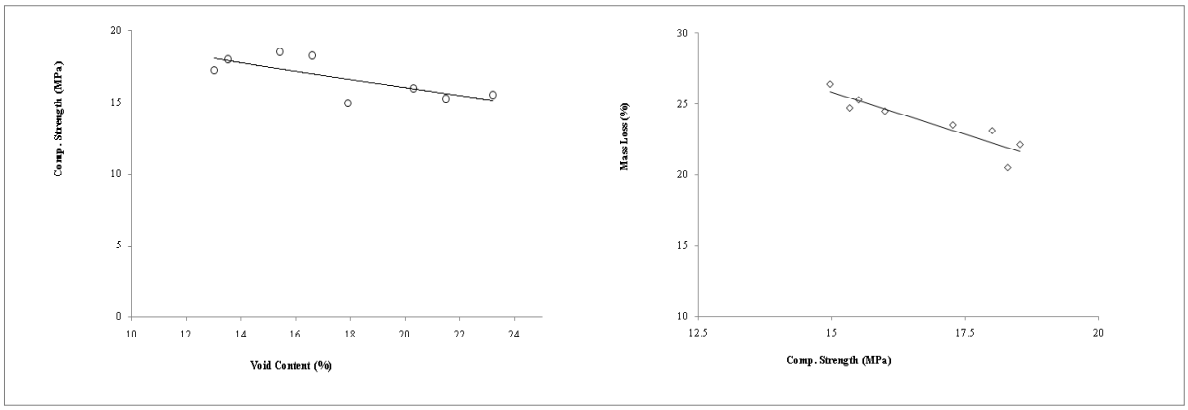


Fig 2: Comparison of (a) Compressive Strength with Porosity (b) Mass Loss Variation with Compressive Strength in Second Series of Experiments

Tensile strength of pervious concrete is also one of important properties governing failure in the cases where tensile stresses are induced. Hence, split tensile strength of the mixes of second series was evaluated at 28 days as per IS 5816 because separate tensile test standard was not yet available for pervious concrete. It is seen that split tensile strength increases with increase in compressive strength as shown in Fig. 3(b) and crack patterns in specimen are shown in Fig 3(a).

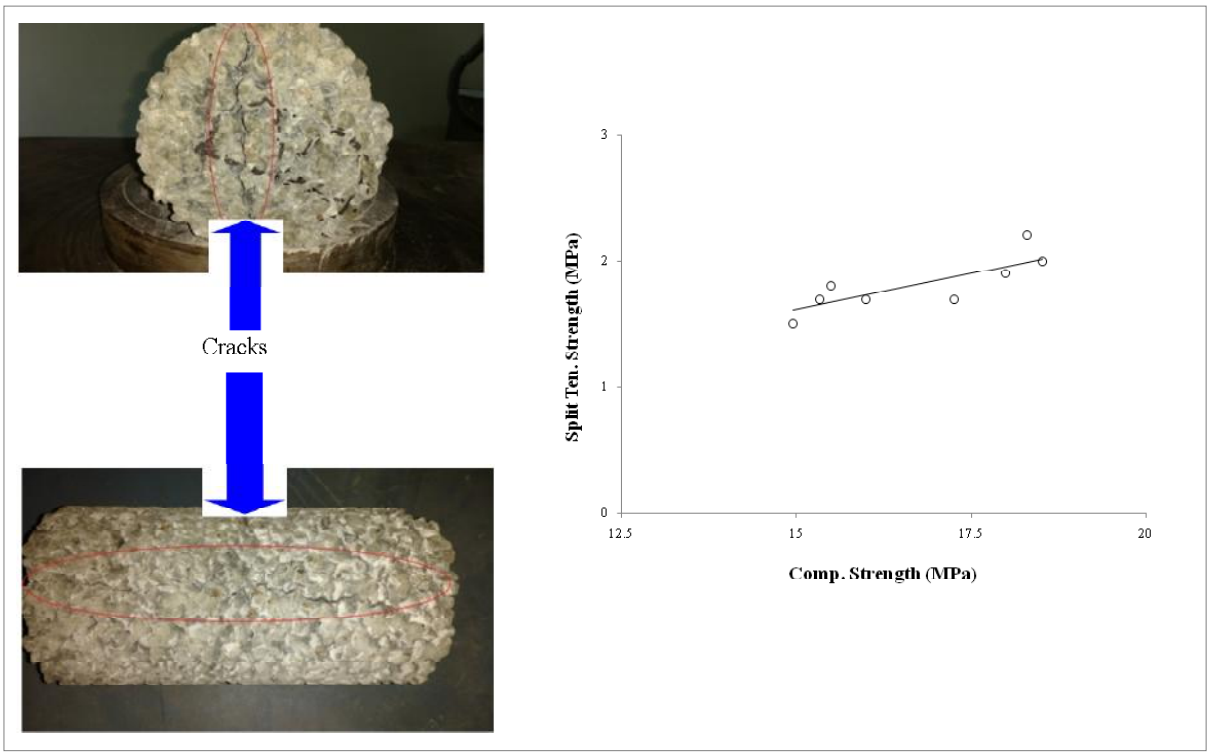


Fig 3: Split Tensile Strength Test (a) Specimen with Cracks after the Test (b) Tensile Strength Comparison with Compressive Strength in Second Series of Experiments

WP-3 Green Building Technologies

Ashok Kumar

Green Retrofit Strategies for Office Buildings

Ashok Kumar & Team

During the period, two identical buildings - one as baseline model and second as retrofit model are studied to know the thermal performance for twelve months (Fig 1 & Fig 2). The real-time indoor temperature data with respect to ambient outside is also studied in all the surfaces of both the models.

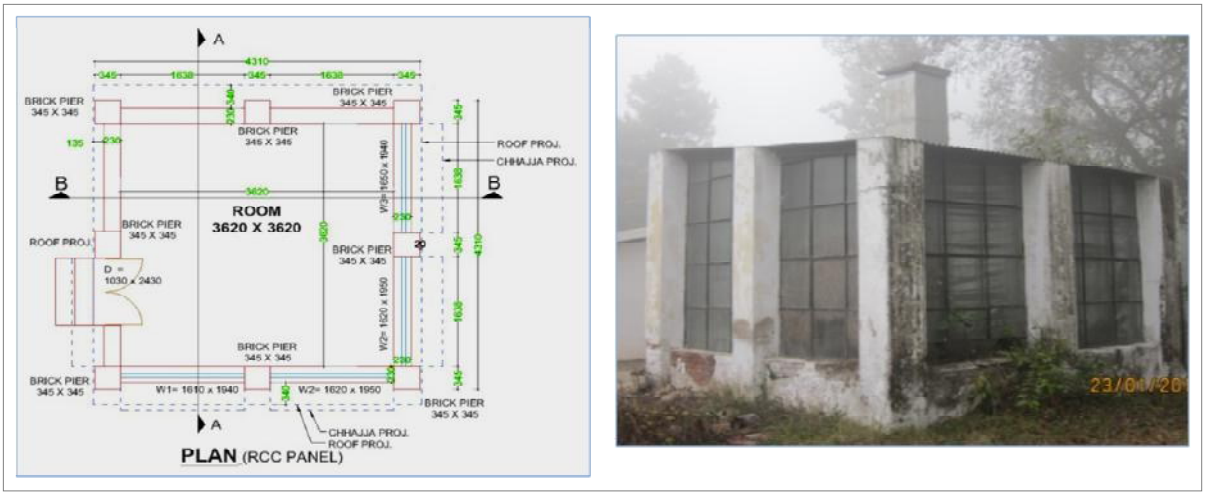


Fig 1: Existing Prototype Building for Green Retrofitting at Rural Park, CSIR-CBRI, Roorkee

Fig 2: Two Identical Prototypes as Study Beds at Rural Park, CSIR-CBRI, Roorkee

The effect of each retrofitting intervention in improving the thermal and energy performance is compared to the baseline model without retrofit. It is observed that in both the test rooms, the indoor air temperature at 600mm above the floor level is in close agreement with each other. During summer, the heat flow through the roof and exposed walls in south-east, south-west and north-west directions is quite significant compared to north-east and the remaining surfaces.

Similarly, the peak heat flux through north- west wall of 229 mm thickness is reduced by about 35% by providing external wall insulation of polyurethane foam, 50 mm thickness finished with cement plaster and white reflective paint and by keeping an air gap of 20mm between the existing wall assembly and retrofit insulation panels. This signifies that external insulation is quite effective in reducing both inside surface temperature and heat flux. Similarly, the surface temperature variation of south-east and south-west walls of 229 mm thickness reduces the inside peak surface temperature by about 3^0C.

The results indicate that the thermal mass provided by 229 mm thick brick wall, and 100mm thick precast RC planks and joists roof along with retrofit wall insulation externally and over deck insulation on roof plus vermiculite tiles and reflective coating finish in retrofit model seem to be adequate and no great advantage accrues if the thickness of walls is increased from 229mm to 345mm. The results indicate that an increase in the thickness of the roof does not alter the mean internal temperature much, irrespective of the season.

It is also established that green roofs with grass carpets are suitable for reducing the energy demand for space cooling during hot summer. Similarly, during cold winter, these are useful for reducing the heating demand. Hence, green roof retrofits can be used efficiently in existing buildings in India, where the additional load carrying capacity of buildings about 100-130 kg/m^2 is permissible. The six retrofit interventions tested in the experimental model contribute to overall site energy savings of about 34 % and peak energy reduction by about 24%. The payback period is three to four years. Similarly, the effect of each retrofit intervention is established and depending on the funds available, the retrofit interventions may be adopted individually or collectively. The experimental results are compared with the energy simulation using Design Builder software and are in close agreement.

Therefore, the test bed is being converted into real-time study to retrofit the Library Block of the Main CBRI building. Several retrofit design options are being explored to optimize the retrofit design with a pre-condition that the overall form or aesthetics of the building do not change.

Development of Solar Window System for Cold Climatic Region

Neeta Mittal & B.M. Suman

The Solar Passive Window has been designed and developed indigenously at CSIR-CBRI, Roorkee. The viability of solar passive window for achieving indoor thermal comfort of a building situated in cold climate has been studied. Field experiments were carried out to find out its thermal performance. Two rooms identical in all respect are considered for the experiment. A solar passive window of size (1.8x1.2) cm was provided on south wall of one of the identical room and an ordinary window of same size was provided on south wall of other room which is considered as reference room. The solar passive window system is working on the principle of trapping total solar energy passing through the window glass with greenhouse effect. In the system a selective black coated perforated metal sheet has been used inside the room, 10cm apart from the window glass. The black coated metal sheet act as absorber by absorbing solar energy passing through windows glass. The maximum difference between air temperature of both the treated room and reference room is found 8.8°C. There is always higher air temperature of treated room as observed than the reference room.

Demolition Wastes as Raw Materials for Low Cost Construction Products

A.K. Minocha & Team

In India, projections for building material requirement of housing sector indicates a shortage of aggregates by up to 55000 million cubic meters (TIFAC ED 2003). Studies have showed that the concrete portion of the demolition waste constitutes of about 65-70% by volume of natural aggregate and 30-35% of cement. Recycling of aggregates from demolition wastes as raw materials for sustainable construction products waste may bridge this gap between supply and demand. Proper recycling and management of demolition wastes can generate a high quantity of recycled aggregates which can be used further in structural concrete and building components such as bricks, blocks and tiles. Main objective of the current investigation is to use demolition wastes as raw materials for low cost construction products. Therefore the present work is focused for reuse of demolition waste as low cost construction product by converting it into recycled coarse aggregate (RCA).

- The physical and mechanical properties of recycled and natural coarse aggregates like crushing value, impact value, water absorption, specific gravity, elongation Index and Flakiness are determined in accordance with IS:2386-1963 and compared and presented in Table 1.

Table 1: Physical & Mechanical Properties of Coarse Aggregate

S. No.	Physical Properties	Natural Aggregate	Recycled Aggregate
1	Type of aggregate	Mainly quartzite type	Mainly concrete waste including tile waste(less)
2	Shape of aggregate	Angular	Angular
3	Surface texture	Rough	Rough and porous
4	Fineness modulus (< 20mm)	6.98	6.96
5	Fineness modulus (< 10mm)	6.49	6.07
6	Water absorption (< 20mm)	0.4%	3.95%
7	Water absorption (< 10mm)	0.6%	4.07%
8	Specific gravity (< 20mm)	2.67	2.514
9	Specific gravity (< 10mm)	2.65	2.443
10	Loose Bulk density (kg/lt)	1.452	1.289
11	Compact Bulk density (kg/lt)	1.531	1.405
12	Flakiness index (%)	8.178	15.838
13	Elongation index (%)	12.241	15.857
14	Crushing value	17.07%	26.30%
15	Impact vale	16.53%	28.57%
16	Abrasion value	19.22%	31.98%

The cement concrete paver blocks of Grade M30 and size 200x160x75 mm have been prepared by compaction technique using different proportions of cement, sand and natural aggregate (size passing 10μ IS sieve and retained over 4.75μ IS sieve). The natural aggregate was replaced by 0, 25, 50, 75 and 100% unwashed and washed recycled aggregate. Mix proportion of paving blocks using washed and unwashed recycled coarse recycled aggregates has been given in Table 2.

Table 2: Mix Proportion of Paving Blocks using Recycled Coarse Recycled Aggregates

Mix Designation	Proportion (%) by weight			
Cement	NFA	RFA	NCA	RCA
A-0 (control)				
Top layer	33.3	66.7	---	---
Bottom layer	20.0	20.0	---	60.0
B-25				
Top layer	33.3	50.0	16.7	---
Bottom layer	20.0	20.0	45.0	15.0
C-50				
Top layer	33.3	33.3	33.3	---
Bottom layer	20.0	20.0	30.0	30.0
D-75				
Top layer	33.3	16.7	50.0	---
Bottom layer	20.0	20.0	15.0	45.0
E-100				
Top layer	33.3	66.7	---	---
Bottom layer	20.0	20.0	---	60.0

Fig 1 shows the photograph of the two layered interlocking paving made with recycle aggregate. Compressive and flexural strength of concrete paving blocks has been determined after 28 days of curing and presented in Fig 2. It can be seen that the compressive strength and flexural strength of concrete blocks decreased with replacement of natural aggregate and water absorption of the blocks increased with an increase in the content of recycled aggregate. Moreover, an appreciable enhancement in strength of paver blocks i.e. 20% were observed with 100 % washed recycled aggregate as compared to unwashed aggregate and water absorption reduced up to 9%. Further, it has also been observed that the compressive strength of all the blocks prepared using recycled aggregates meet the 28-day target strength of 36.7MPa required for light traffic purpose as per IS:15658. The 28 days strength of mixes BW-25 (45.2MPa) using washed recycled aggregates is comparable.

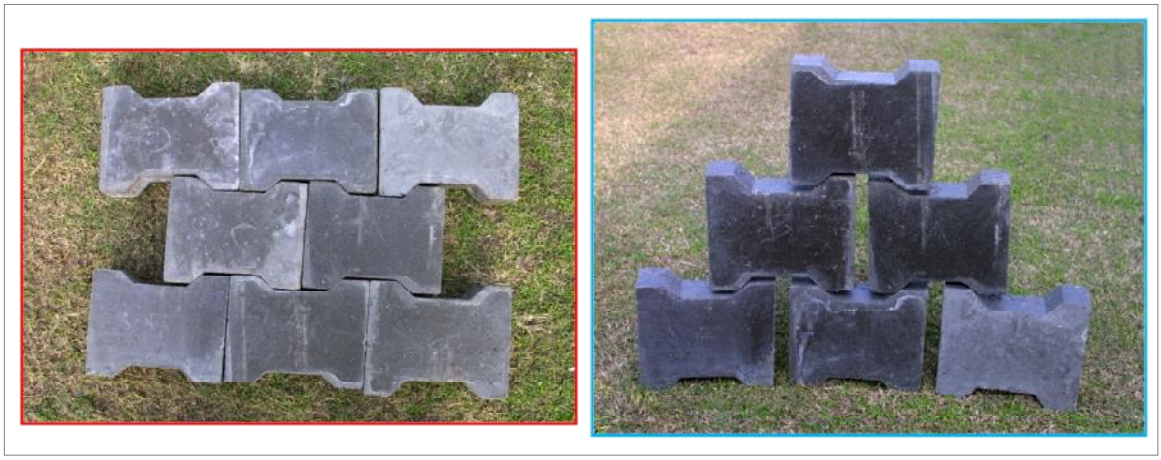


Fig 1: Two layered Interlocking Paving Prepared of Recycle Aggregate

The 28-day flexural strength of paving blocks (Fig 2) using recycled aggregates in series I and II are higher than control specimens. Further, it is observed that flexural strength decreases with increase in recycled aggregate content. High flexural strength with recycled aggregates may be accompanied with the angular shape and rough surface of the recycled aggregates which is generally beneficial for good bond between the crushed aggregates and the cement paste to that of control mix (46.5MPa). The strength of blocks prepared with unwashed recycled aggregates is about 9-21% less as compared to control specimens. The mixtures B-25, BW-25, CW-50, DW-75 and EW-100 can also be recommended for medium traffic purpose as these are satisfying the minimum strength requirements of M-40 grade as per IS: 15658.

From this study it was concluded that, construction and demolition waste can be used for production of low cost building material. Different Municipal Corporation has stated using his waste for production of building components. IL&FS Environment Infrastructure Services Limited (IEISL) set up a 500 TPD capacity processing plant in Delhi to utilize construction and demolition waste as resource material.

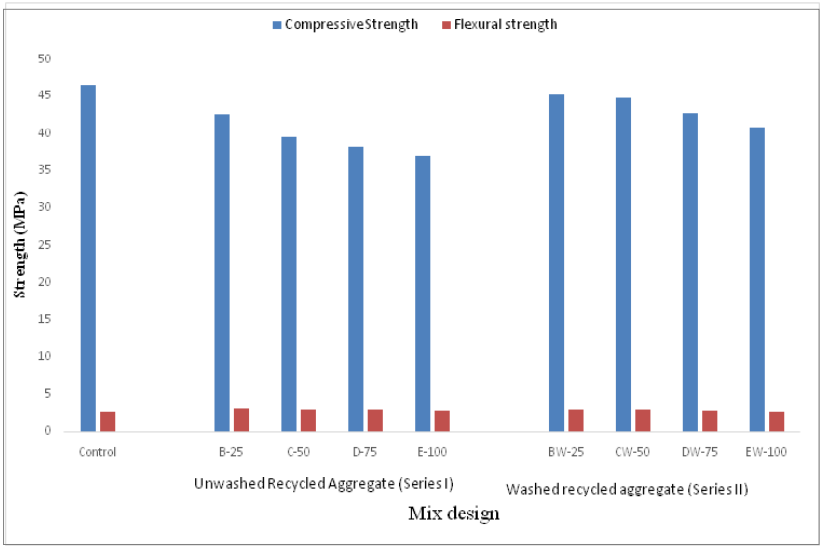


Fig 2: Compressive & Flexural Strength of Concrete Paving Blocks Determined after 28 Days of Curing

Solar Thermal Air Conditioner

Nagesh Babu Balam & Somya Srivastava

Objective

To design & develop an air conditioner energized by solar energy for residential buildings

Deliverables

- Novel Solar Power Generation System - 30% conversion Efficiency.
- Solar Adsorption Cooling System

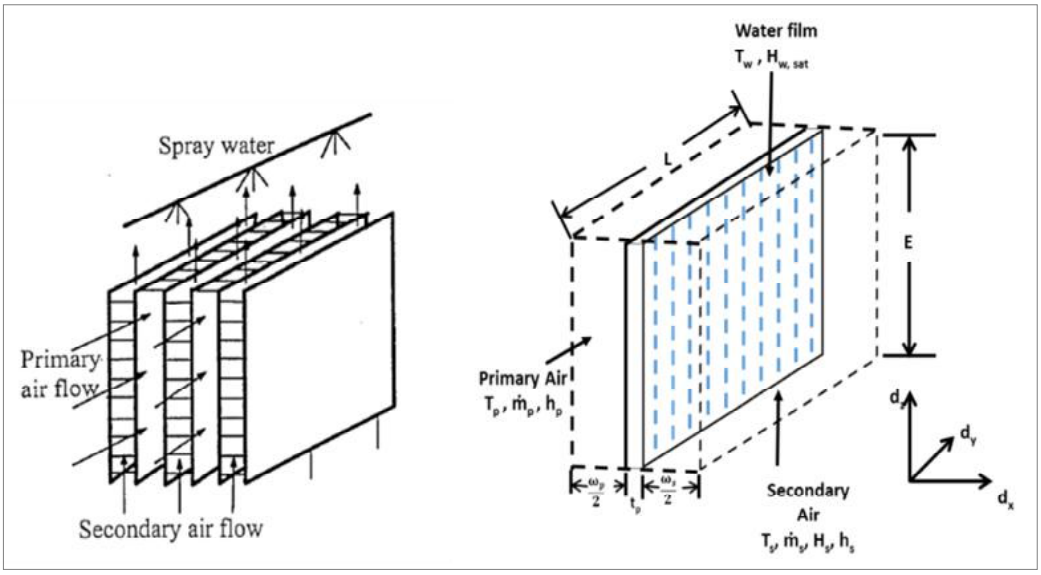


Fig 1: Cross Flow Parallel Plate Heat & Mass Exchanger Type IEC

Progress

Evaporative cooling is one of the most efficient space cooling technologies for buildings and is very effective for hot dry climatic conditions. Evaporative cooling though has very high coefficient of performance, but increases the humidity level inside the buildings. Indirect evaporative coolers work on similar operating principles as evaporative cooler but do not increase the humidity of the conditioned space inside the buildings. Operating IEC in regenerative mode could further bring down the temperatures below wet bulb temperatures and theoretically down to dew point temperature of ambient air conditions. The cross flow parallel plate heat and mass exchanger type IEC is shown in Fig 1. This cooling methodology has the potential to achieve substantial energy savings and reducing the greenhouse gas emission.

1-D Mathematical Model to Analysis the Heat and Mass Transfer Process in IEC:

The 1-D mathematical model to analyze the heat & mass transfer process in IEC is shown in Fig 2. The following assumptions are used for simplification of the mathematical model and the error introduced by these assumptions is very small. Similarly, 2-Dimensional study is necessary for design of high cooling capacity IEC systems.

(i) 1-Dimensional heat transfer in the HMX

(ii) Air never becomes over saturated

(iii) Lewis factor is unity

(iv) Inlet temperature and outlet temperature of the water is same ($T_{wo} = T_{wi}$)

(v) Air water interface temperature is equal to water film temperature ($T_i = T_w$)

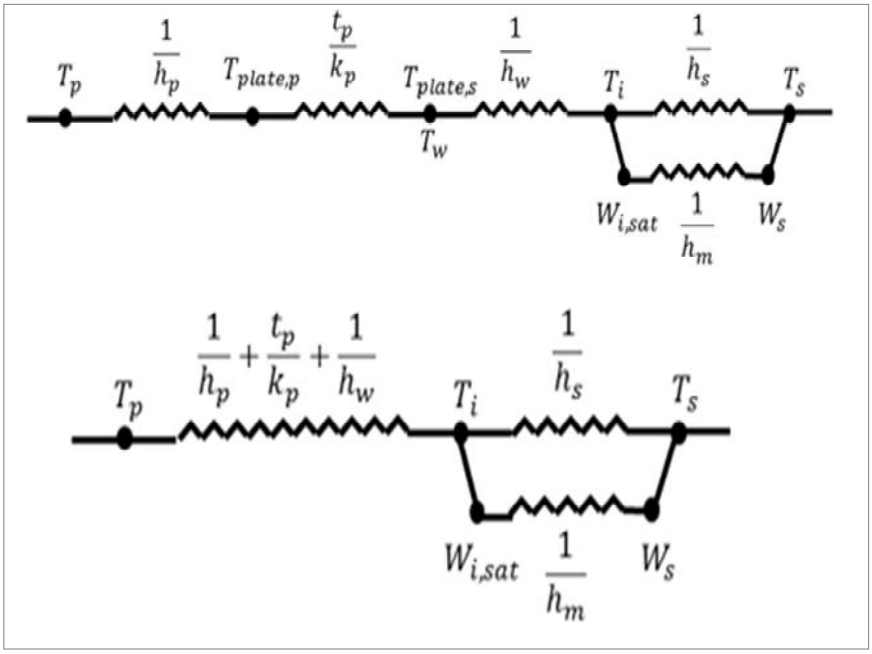


Fig 2: (a) Thermal Resistance Network showing the Heat & Mass Transfer from Primary to Secondary Air Stream; (b) Simplified Equivalent Thermal Resistance Network by introducing Overall Heat Transfer Coefficient U_o. (Note: *W* = function (*T*))

Thus, from the above results, shown in Fig 3, Fig 4 & Fig 5, it is concluded that, lower inlet relative humidity in the secondary air stream, higher mass flow rate ratio of secondary to primary air stream, lower velocity in primary air stream improves the performance of the cooler by reducing the outlet primary air temperature and increasing the effectiveness of the cooler.

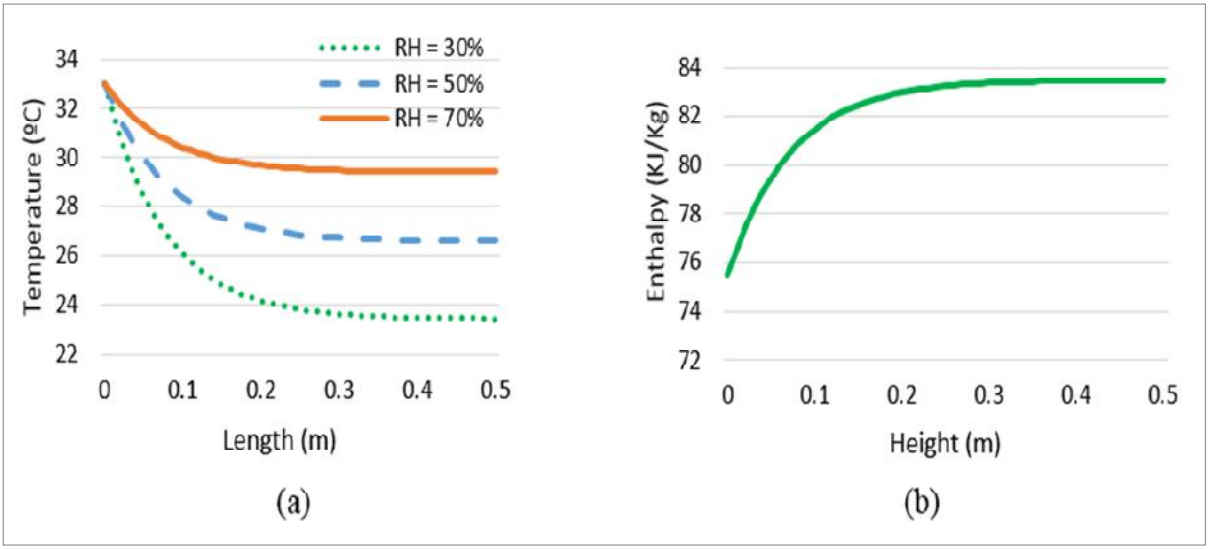


Fig 3: (a) Primary Air Stream Temperature Variation along the Length of the Primary Channel; (b) Enthalpy Exchange in Secondary Air Stream along the Length of the Secondary Channel.

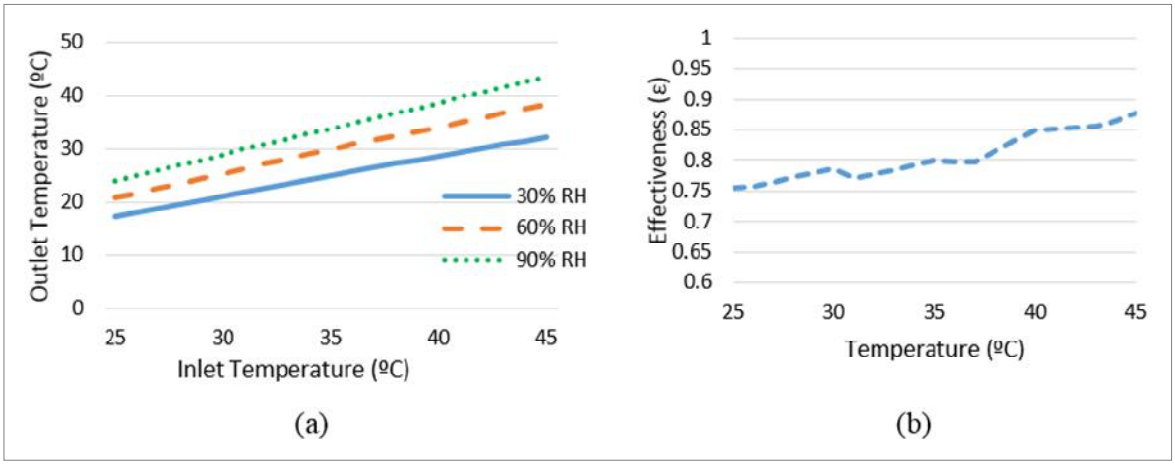


Fig 4: (a) Effect of Inlet Temperature on the Outlet Temperature for Primary Air Stream for Various Humidity Levels; (b) Effect of Inlet Air Temperature of the Primary Air Stream on the Heat Transfer Effectiveness of the Cooler.

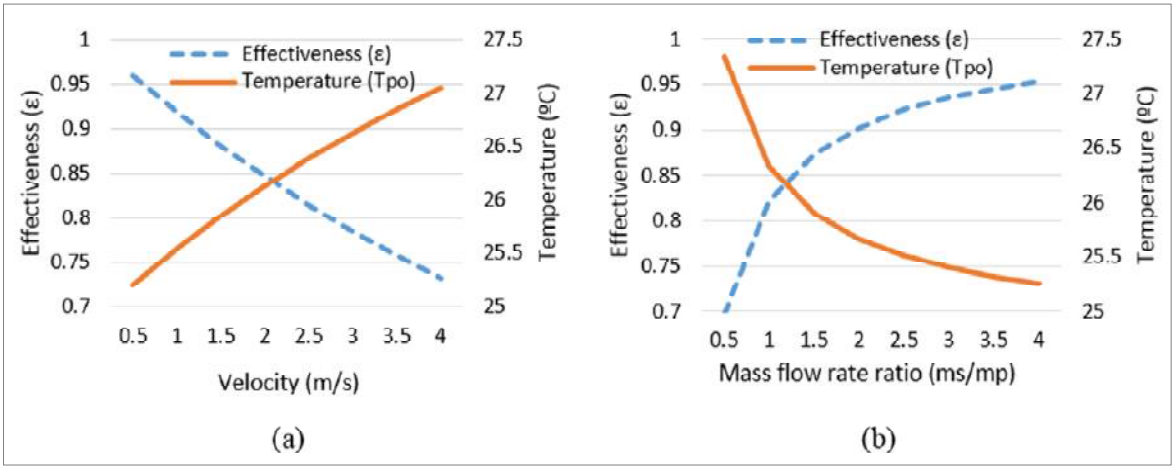


Fig 5: (a) Effect of Inlet Velocity of the Primary Air Stream on the Heat Transfer Effectiveness of the Cooler; (b) Effect of Ratio of Secondary to Primary Inlet Air Mass Flow Rate on the Heat Transfer Effectiveness of the Cooler.

Technology Packages for Mass Housing in Urban Areas

Ashok Kumar & Team

Objective

Development of energy efficient, environmentally, socially & economically sustainable and affordable mass housing.

During the period, a pilot of the precast model room of size 3000 mm x 3600 mm (inner dimensions) has been considered at Rural Park CSIR-CBRI, Roorkee. This project comes under the umbrella of affordable housing and defines a new technology keeping in mind affordability and time of construction.

The precast foundation is to be cast using concrete of M25 grade. The mix design of the concrete is done and it is thereby checked for various tests according to the Indian Codes.

Mix Design:

M25 grade concrete is used for casting of precast pedestal with the ratio (1:2.06:3.14) as obtained by mix design. The mix design is done by using the provisions of IS: 456- 2000 and IS: 10262 2009.

w/c ratio	=	0.5
Maximum water content	=	208
Water content	=	178.88
Cement content	=	357.76
Volume of C.A.	=	0.6
Volume of F.A.	=	0.4
Volume of concrete	=	1
Volume of cement	=	0.114
Volume of water	=	0.18
Volume of admixture	=	0.0016
Volume of all in aggregate	=	0.71
Mass of cement	=	357.76
Mass of C.A.	=	1122.40
Mass of F.A.	=	735.56
Mass of admixture	=	1.7888
Slump in mm	=	85-90
Ratio	=	1:2.06:3.14
Reduction in water content by mixing super-plasticizer	=	14%
Super plasticizer	=	0.5
Maximum size of Aggregate	=	12.5

Test for Workability & Compressive Strength of M25 Grade Concrete:

Tests conducted on the specimen (cube of size 150 mm x 150 mm x 150 mm) are; (i) Slump tests for workability; and (ii) Compressive strength tests for the determination of 7 day compressive strength. The results obtained by the testing satisfy IS 456: 2000 for workability and compressive strength (Table 1).

M25 grade concrete with ratio 1:2.06:3.14 is used for casting the precast components of the prefab model room because it is the best fit considering the properties of strength and workability.

Foundation Details up to Plinth Level:

The details of the foundation up to plinth level consist of formwork and casting of pedestal system and plinth beam. The formwork needed for casting of hollow pedestal system is unique and prepared by using plywood, battens, steel plate, hinges and nut bolts (Fig 1). The formwork obtained is used for casting of foundation system and the final product is ready for the analysis.

Table 1: Results of Tests Conducted for Workability & Compressive Strength

Grade of Concrete	Mix Proportion	Slump, mm	7 days Compressive Strength, N/mm²	% of Admixture by wt. of Cement	W/C ratio	Date of Casting
M25	1:2.11:3.51	Nil	24.45	1.0	0.43	25-09-2015
M25	1:2.13:3.53	Nil	26.43	0.3	0.43	29-09-2015
M25	1:2.08:3.47	10-15	24.78	0.5	0.45	08-10-2015
M25	**1:2.06:3.14**	**85-90**	**16.55**	**0.5**	**0.5**	**09-10-2015**
M25	1:1.63:3.22	20-30	20.91	0.75	0.4	12-10-2015

Fig 1: Formwork Preparations & Casting of Precast Pedestal System on Site at Rural Park, CSIR-CBRI, Roorkee

Precast Hollow Pedestal System:

Pedestal system consists of footing and a stem column portion which is to be used for the foundation system of the prefabricated model room. The footing portion consists of a cross base which has four handles on each wing for placing the pedestal in the trench safely and easily. The pedestal system developed, has to be placed manually in the trench so the weight of the pedestal is of great concern. To address this challenge, different alternatives have been prepared and used for the same purpose. Similarly, different alternatives of the precast hollow pedestal with and without precast footing have been designed.

Precast Plinth Beam:

Plinth beam is provided at the ground level to connect substructure and superstructure. The ends of plinth beam are provided with anchorage bars which are to be placed in the notch provided in the stem column pedestal.

The hollow portion is to be filled with in-situ concrete of M20 grade. The precast members are made of M25 grade concrete as they have to bear the higher stresses.

Walling System:

The walls are to be made by using light weight fly-ash blocks or precast gypsum blocks of dimensions 600 mm x 300 mm x 150 mm and 300 mm x 300 mm x 150 mm.

Precast Roofing Units:

The roofing unit consists of precast RC planks and joist system in which the length of RC planks has been modified to 2400mm. This scheme results in overall cost saving of 20% as compared to conventional R.C.C. slab floor / roof.

Development of Blocks using Different Industrial Wastes based on Fly Ash, Rice Husk Ash & Marble Dust using Non-Autoclaving Technique

Vivek Sood & Ashok Kumar

Objective:

To develop light weight blocks using different industrial wastes.

Progress/ Highlights / Significant Achievements:

During the period, blocks of different sizes using Rice husk ash have been developed.

A trial test such as compressive strength at various replacement levels at 56 days to 90 days is shown in Fig 1. The average density of block is 800 kg/m^3 for 600 x 300 x 200 mm & 600 x 200 x 150 mm. Other value added building components such as bricks and pavers using rice husk ash as a waste have also been developed as shown in Fig 2.

Finalization of composition of various ingredients for development of blocks has been done. Similarly, utilization of marble dust which is a waste during dressing and cutting of marble blocks in Rajasthan in the development of light weight blocks is under progress.

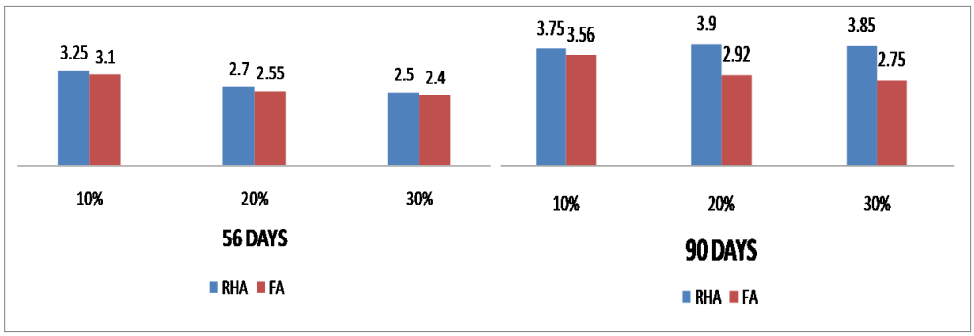


Fig 1: Comparative Compressive Strength (MPa) of Fly Ash & RHA at 56 & 90 Days

Fig 2: Blocks/ Bricks/Pavers using RHA as a Waste

Development of an Automatic Hollow Gypsum Panel Making Machine

S.K. Panigrahi & Team

To design and develop an automatic machine for producing Hollow Gypsum Panels to be used in non-load bearing walls.

Scope:

- To produce five panels in one batch.
- Automation of the machine.
- The machine to be flexible for any changes in panel geometry.

Work Done Till Date:

The following activities have been carried out:

- Production of Gypsum Panel (Fig 1) from single mould system.
- Assembly of pressure plate, Hydraulic Jacks on the main frame.
- Alignment of sub-assemblies.
- Preparation for trials.

Fig 1: Fluro-Gypsum Panel

Structural Termite Management

B.S. Rawat

Termites are among the most economically important insects in the world. The widespread damage by termites, high constructional cost of buildings have necessitated evolving suitable measures for preventing access of termites to structures. Once the termites have ingress into the building, they keep on multiplying and destroy all the materials of organic origin with cellulose base including some non-cellulosic substances like rubber, leather, plastics, neoprene as well as lead coating of underground cables and as such it becomes essential to take measures for protection against termites (Fig 1).

Integrated Pest Management (IPM) approach is the best way for management of structural termites which combines the use of multiple available control methods including sanitation, exclusion, structural modification, physical barrier and chemical techniques. IPM focuses on optimization of termite management in an ecologically and economically sound manner. Extensive R&D work was carried out in CSIR-CBRI, Roorkee for the development of pesticide free anti-termite barrier from industrial waste. Recently, an Indian Patent has also been filed for the same.

Fig 1: The Damage caused by Structural Termites

Development of Robust Foundation for Difficult Soils

Pradeep Kumar

Granular Anchor Pile (GAP) technique of ground improvement has picked up the tempo in the past two decades after which the innovation came into existence. Details are available separately. However, CSIR-CBRI, Roorkee has also initiated research on this topic in the institute with its basic studies carried in the Lab and then attempt to study them in actual field conditions has also been done during the recent one year.

The objective of this project is to develop an analytical model for design of foundations subjected to tensile forces in weak soils. As reported in the earlier progress, laboratory tests to evaluate few relevant parameters have been carried out. Conclusions from the laboratory studies are now presented in the following sections.

A small-scale laboratory testing was conducted to investigate the behaviour of GAP in loose sandy soil. The finite-element analysis was conducted using PLAXIS 3D to study the performance of the GAP system in loose sandy soil. The effects of key parameters, such as length, diameter of the pile and elastic modulus of the surrounding soil, on the uplift capacity of a GAP were examined. The load-displacement response and ultimate pullout capacity of the GAP were also analyzed. Based on the present study, the following conclusions can be made:

- The uplift resistance of the GAP system in a loose sandy soil increases with the embedded length, diameter of the pile, and elasticity modulus of soil.
- The uplift capacity of a pile improves significantly with increase in the length of pile up to a length equal to or greater than 10 times its diameter, after which the increase in the length does not show significant effect on the load sharing of the pile. The critical length of the pile is approximately 10 times the diameter of pile.
- The bulging failure occurs in the GAP system for higher modulus ratios, but the shaft failure occurs for lower values of the modular ratio for a constant elastic modulus of a pile.
- The uplift capacity is higher due to densification of the surrounding soil.
- Relative density of surrounding soil has considerable impact on the ultimate capacity. Increase in ultimate capacity is almost linearly varying with the increase in relative density.
- A simple mathematical expression was developed that relates with the dependent variable normalized uplift capacity (P/EA) to the L/D ratio as the independent variable.
- A more general relationship is suggested to account for the range of soil and pile module. The normalized uplift capacity is related to the modular ratio and is represented through a hyperbolic relationship.

Details about results are discussed in the research paper published in ASCE (May 2016) Journal.

Field Testing Programme:

In order to validate the Lab testing results, a Field Testing Set-up, as shown in Fig 1, has been designed, fabricated and applied on the GAP installed in the actual ground. The load capacity of the set up is up to 100 Tons.

Fig 1: Field Testing Set-up for GAP

Suitable Testing Site for application of above test set up has been used as shown in Fig 2 (CBRI institute premises). Soil investigation to evaluate the soil properties to be utilised for the analysis, has also been completed.

Fig 2: **Project Site (CBRI institute premises)**

Construction material for the proposed GAP system - MS Anchor (25 cm diameter and 2m, 3m and 4m long), Well graded crushed stone aggregate of 3 sizes - (45 mm, 25mm &10mm) & sand have been procured as shown in Fig 3 & Fig 4 .

Fig 3: **Construction material for GAP**

Fig 4: **MS Anchors**

Steel ribs with MS Anchors have been provided for more strength to the joint at bottom of GAP. GAP of various sizes and depths (as above) has also been installed in the ground and tested by applying axial uplift loads through a remote control Hydraulic jack connected to the MS pullout frame attached to the GAP's. The plotting of this data generated through field testing is presently under progress.

During this period, laboratory test results have already been published in a research paper (International Journal - ASCE). A mathematical model for analysis using PLAXIS 3D model incorporating the Lab test results and GAP parameters has been developed and have been reported in the paper. Soil properties of the field testing site have now been obtained and are ready for utilising them for the evaluation of field test results also. These shall be reported subsequently.

WP-4

Materials & Technologies for Hazard Reduction

S. R. Karade

Indigenous Cathodic Protection System for Steel Reinforced Concrete Structures

S.R. Karade & Team

A large number of steel reinforced concrete (RC) structures are deteriorating in India due to corrosion of rebar. To protect the steel bars from corrosion various measures are adopted. However, the current measures have certain limitations. For chloride affected RC structures, cathodic protection (CP) has been found the best option. R&D work is in progress on developing an indigenous CP system. In this system the steel bars are protected by making them cathode with the help of primary and secondary anodes. For this purpose the present study aims to develop conductive cementitious (secondary) anodes using conductive fillers such as carbon fiber (CF), graphite powder (GP), coke breeze (CB) and Pyrolytic carbon black (PCB). These fillers replace sand in concrete except CF, which is addition by volume of the composite. These anodes are being developed for Impressed Current Cathodic Protection (ICCP). The optimum composition has been found by evaluating mechanical, electrical and hydration properties of these cementitious anodes.

Bond Strength: A review of literature revealed that in current practice the proper bond between the surface applied anodes and uniform current distribution in a reinforced concrete CP system is difficult to achieve due to complex nature and varying microstructure of concrete. The evaluation of bond strength between cementitious overlay and substrate is very important as it is the basic property that determines the long term performance of anode overlay. The bond strength was evaluated using a pull out test method, in which the anode overlay is pulled to determine its bond strength with the substrate. For this purpose, mortar substrate in the form of cubes of size $50 \times 50 \times 50$ mm^3 with a steel bar of 8 mm were cast containing 5% sodium chloride contamination as shown in Fig 1. The substrate was cured for 28 days then; the cementitious anode overlay of 50 mm diameter and 20 mm thick was placed on it and cured for 28 days. Sand was replaced by carbon black, graphite powder and coke breeze in the ratio 0.15, 0.20 and 0.15, respectively. Whereas carbon fiber concentration used was 0.6% by volume of the composite.

In the first part of the experiment the bond strength was tested for a current supply of a 100μA/cm^2 for 30 days. Corrosion current measurements were carried for all specimens until 15μA/cm^2 current density of steel was reached. In the second part the bond strength was checked for different current densities. The current density applied to the specimens was 10μA/cm^2, 40μA/cm^2 and 60μA/cm^2 for 15 days. The bond strength was also calculated for specimens not subjected to any current supply. The accelerated corrosion technique was followed in which steel bar was connected to the positive terminal of the rectifier and the titanium wire was connected to the

negative terminal for 15 days. Later the specimens were subjected to cathodic protection where the steel bar was connected to the negative terminal for 28 days. After the completion of current supply the specimens were attached to the metallic disc of 50 mm diameter as shown in Fig 2 by using epoxy, it was kept for 24 hours. Bond strength was performed using the equipment Proceq DYNA Z6 having maximum capacity of 19.62 kN. The pull off force was manually applied on the disc until the failure of bond was achieved.

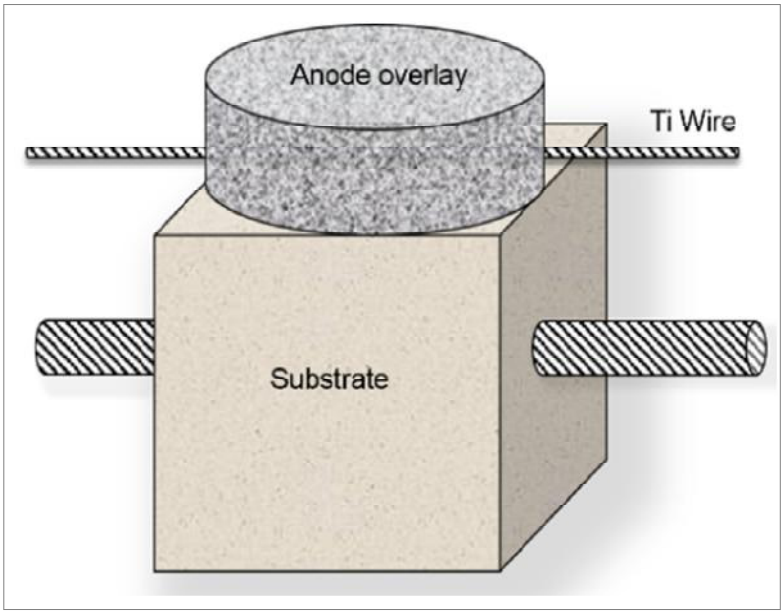


Fig 1: Specimen used for Bond Strength

Fig 2: Experimental Setup

When the current is applied in ICCP, the bond between the cementitious anode overlay and substrate is expected to vary because of presence of chloride ions in the substrate, the anodic reaction involves chlorine gas evolution at high current densities.

The failure patterns are shown in Fig 3 & Fig 4.

Fig 3: Overlay-Substrate Interface Failure

Fig 4: Substrate Failure

In the experiment there were cases where the failure occurred in the substrate whose images are also shown in Fig 4.

From the results (Fig 5 & Fig 6), it is evident that the bond strength between cementitious anode overlay and substrate decreases, after the current was applied. One of the possible reasons for this decrement in strength may be that, when the substrate is operated at high current density with chloride ions in the substrate, the anodic reactions involve chlorine gas evolution. The chlorine gas reacts with the substrate pore water solution and forms hydrochloric acid at the cementitious anode-substrate interface. Above certain concentrations, acid build up can lead to damage at the cementitious anode-substrate interface. Eventually the interface becomes sufficiently deteriorated such that the contact between the anode and substrate is reduced leading to increased localized resistance. This in turn can result in increase in current flow in

other parts of the anode circuit, thus raising the current density in these areas, and in extreme cases it can cause significant damage to the substrate.

Out of all the fillers used for preparation of secondary anode, carbon fiber showed the highest bond strength.

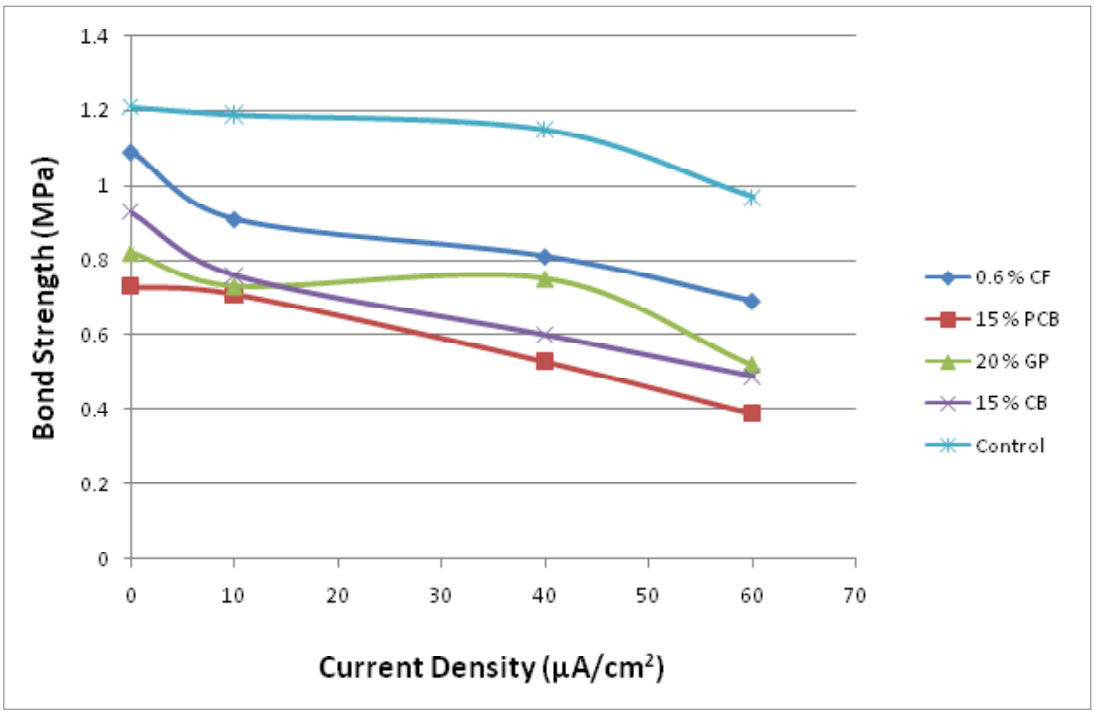


Fig 5: Bond Strength vs. Corrosion Current

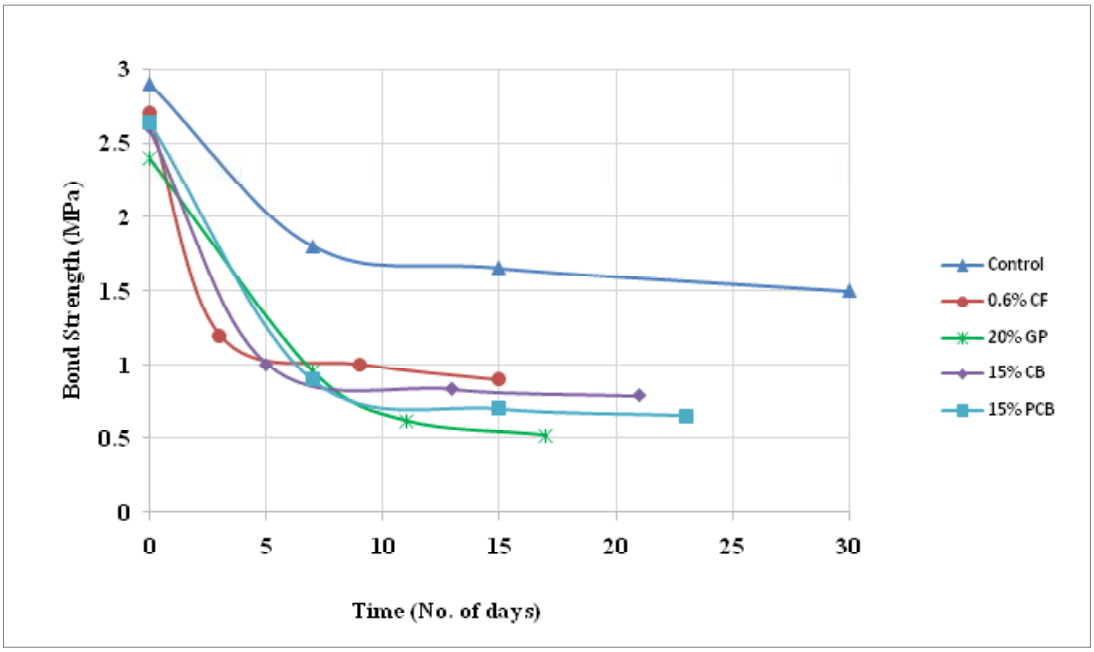


Fig 6: Bond Strength vs. Time

Development of Power Supply system for CP:

Attempts have been made to develop a power supply system for cathodic protection in concrete. For this purpose two schemes were proposed:

- In the first scheme, as shown in Fig 7, 0-30V dc power supply was developed which provided the maximum and minimum output voltage of 27.9V and 1.25V, respectively.
- In the second scheme, as shown in Fig 8, 0-30V stabilized power supply was developed with a current control of 0.002-3A was drawn but it has certain errors in its output. The maximum output voltage obtained is 11.36V. Work is in progress to develop an efficient current supply system.

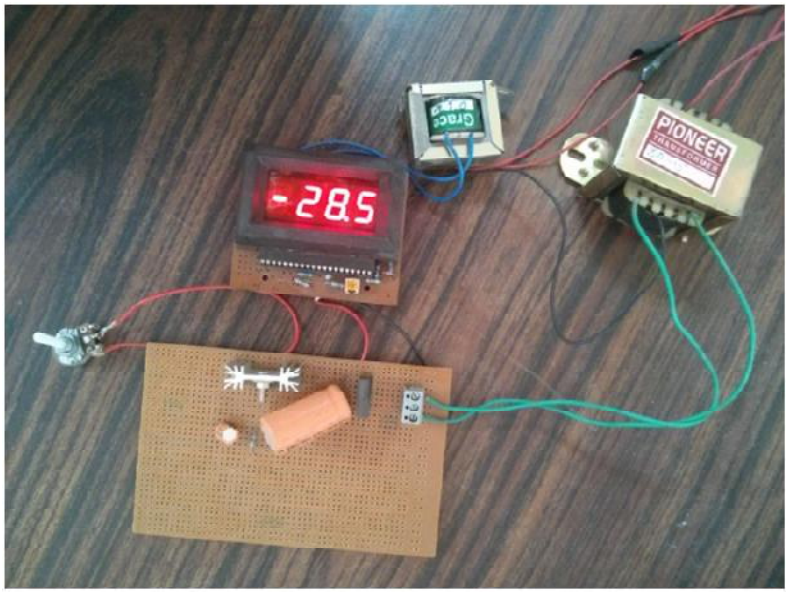


Fig 7: 0-30V DC Power Supply

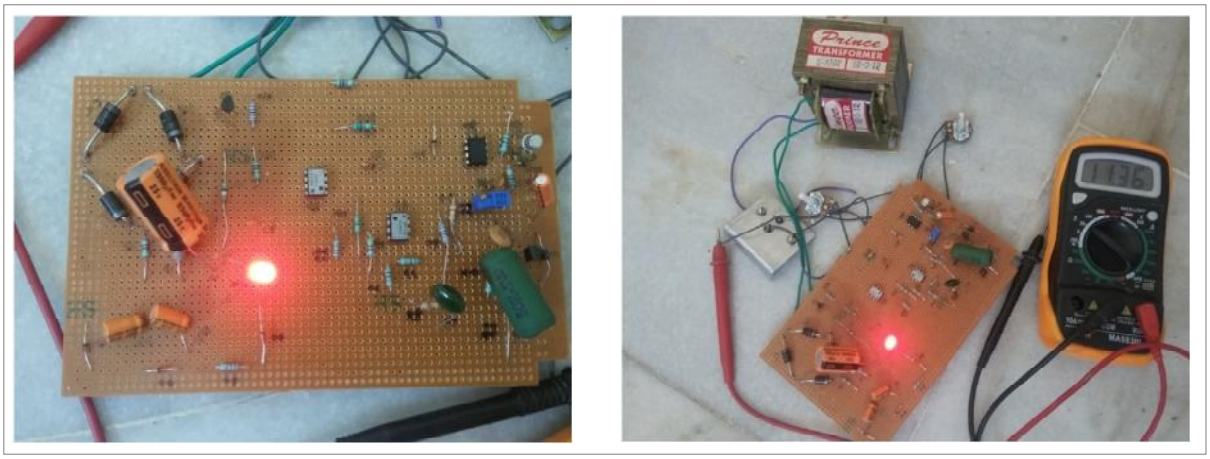


Fig 8: 0-30V Stabilized DC Power Supply with Current Control

Development of Fire Safe Polymeric Composite Panels

Harpal Singh

Objective

To develop fire retardant composite panels with reduced smoke and toxicity.

Composite panels of dimension 300x300x50 mm were prepared in an open wooden mould. The internal walls of wooden mould were lined with galvanized iron sheets of 0.3 mm thickness. All the core material ingredients were mixed together under overhead electric stirrer at about 3000 rpm to get homogenous mixture. The reaction mixtures of control and fire retardant core material were poured between two galvanized iron sheets which were placed at a distance of 50 mm from each other. Reaction mixture was allowed to rise in the open and vertical direction in the beginning and after some time some pressure was applied on the top surface to achieve smooth surface of the composite panel. Cured and dimensionally stable composite panel was removed from the mould after some time. A composite panel consists of two thin and stiff outer and inner face sheets bonded to a thick low density core, forming a lightweight efficient structure. The final properties of a composite panel depend on the core type, outer and inner face sheets type and face-to-core bonding. Rigid polyurethane foam is the first choice as core material in a composite panel due to its predominately low-density cellular structure, low thermal conductivity and good dimensional stability. The properties of composite panel having rigid polyurethane foam as core material need to be improved are its thermal insulation value and flammability. The applications of such composite panels are in the building construction and industries as lining material and industrial buildings. The other important applications are in telecommunication shelters, defense shelters and cold storage industry etc. Fire performance test of prepared core material and some significant achievements on the important properties of composite panels such as thermal conductivity and fire retardancy are presented.

Fire performance was investigated by exposing control and fire retardant core material samples to non-luminous 100 mm LPG flame under similar condition. Control core material sample was burn to entire length very quickly whereas, fire retardant core material sample was only charred up to small length which showed that fire performance of core material is increased significantly. The fire performance of control and fire retardant core materials is shown in Fig 1.

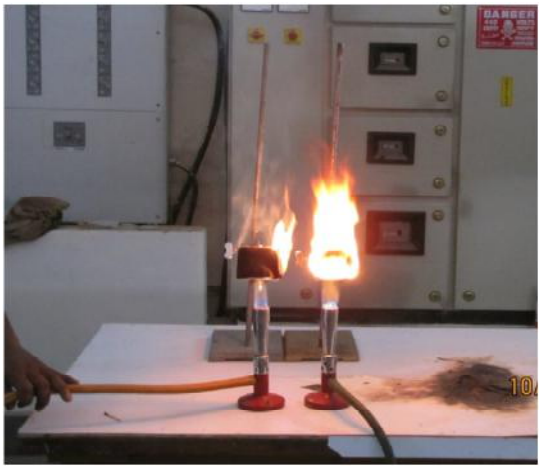


Fig 1: Fire Retardant & Control Core Materials

Thermal Conductivity:

Thermal conductivity of control and fire retardant core materials containing composite panels with a density of 40 and 52 kg/m^3 respectively was measured with two slab guarded hot plate at 30^{0}C as per BIS: 3346. The size of the samples was 300x300x50 mm in the free rising direction. Thermal conductivity depends on the density, average cell size, cell orientation, ratio closed to open cell content and thermal conductivity of fire retardant additives. Thermal conductivity results of composite panels with fire retardant core material are shown in Fig 2. The results showed that there is a decrease in the thermal conductivity of control and fire retardant composite panels from 0.030 to 0.027 W/m-k, a decrease by 0.003 W/m-k. This was due to the high viscosity of the formulation which was increased by the addition of fire retardant additives. It is well known that cell size depends on the viscosity and surface tension of the mixture. The higher viscosity leads to bigger average cell size which increases the thermal conductivity. It is a well known fact that a material or system provides good thermal insulation value with low thermal conductivity.

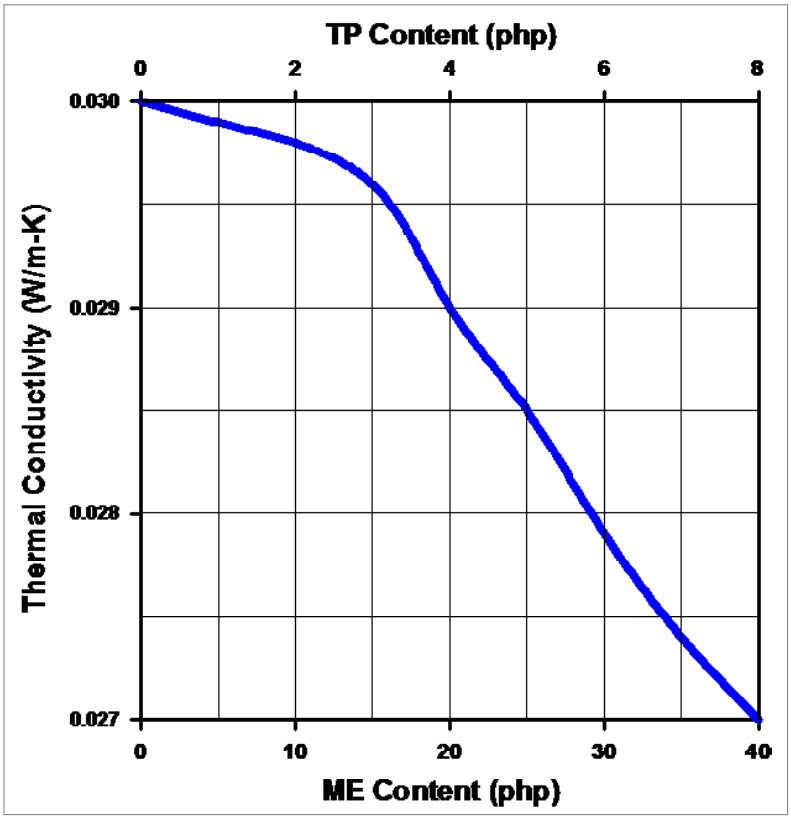


Fig 2: Effect of Fire Retardant Additives on the Thermal Conductivity of Composite Panel

Surface spread of flame test of control and fire retardant core materials containing composite panels was carried out as per BS: 476 parts 7. Specimen of size 900x270x50 mm was hold vertically at right angle to LPG and electrically operated radiant heat panels in the standby position and swings the specimen holder into test position after start timing device. After complete exposure, swing the specimen holder into standby position and remove the tested specimen. After complete exposure, it was observed that control sample start burning after some time and then flame also spread on its surface whereas, core material of fire retardant composite panel did not

burn and only turned into char residue. This char residue acts as insulating blanket and reduces the flame spread rate significantly on the surface of composite panel having fire retardant core material. Fire performance of prepared composite panels was also carried out through horizontal flammability test. The complete fire test set-up is shown in Fig 3. Panels were exposed to 150 mm diameter LPG burner of non-luminous flame. Fire performance was measured by mounting thermocouples in the flaming chamber and on the unexposed surface of the composite panels. It was observed that temperature of control panel was increased very rapidly due to the consumption of core material. However, the temperature on the unexposed surface of panel with fire retardant core material was increased slowly due to the little and slows charring of core material. The fire test results are presented in Fig 4. These results showed that fire performance of prepared composite panels was increased significantly.

Fig 3: Fire Retardant Composite Panel under Fire Test

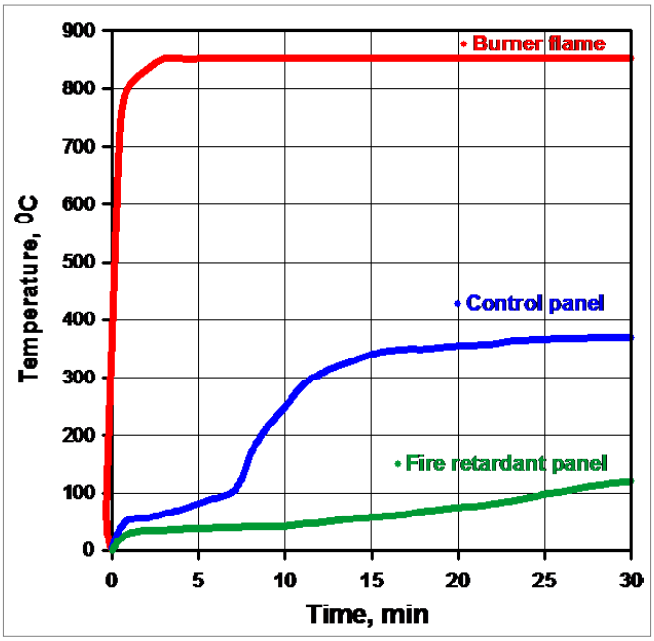


Fig 4: Performance of Fire Retardant & Control Composite Panel during Flame Test

Study of Impact Behaviour of Reinforced Concrete Elements

Achal Kumar Mittal, Mickey Mecon Dalbehera & Team

With the rapid infrastructural development around the world, a greater number of structures are naturally being exposed to various types of impact load during their service life. The response of concrete to dynamic loading is of interest in a variety of civilian and military applications. Understanding the response of concrete to impact or explosive loading is essential for the successful and effective protection of defence structures, rock sheds, designing buildings for debris impact etc.

In continuation to the ongoing study at CSIR-CBRI, Roorkee response of Reinforced Concrete (RC) element subjected to low velocity impact loading has been evaluated numerically using finite element analysis.

An instrumented impact loading test setup for dropping the weights at variable height up to 2.5 meter and recording the impact event (deflection, support reaction and strains vs. time) has been designed. The specially designed support system Fig 1(a) for loading the beam and installing the strain gauge based load cell has been fabricated. The impact loading system with the data logger, load cell, laser displacement sensors with the beam instrumented for performing the drop weight experiment is shown in Fig 1(b).

Fig 1: (a) Support system

Fig 1: (b) Overview of Test Setup

To evaluate the response of RC beam, subjected to low velocity impact loading, simulations are carried out in a FEM software package ABAQUS. The details of the beams and reinforcement detailing are as given in Table 1.The falling of the drop weight of 200 kg from 1.0 m height fall has been simulated. In the analysis, deflection vs. time and reaction forces vs. time of beam obtained from the simulations is compared with that of the experimental results. For simulating the actual behaviour of concrete under low velocity impact loading, Concrete Damaged Plasticity (CDP) model has been used. The Reinforcement Configuration Modelling is shown in Fig 2.

Table 1: Particulars of the RC Beam

Designation of Beams	Compression reinforcement (Acr)			Tension reinforcement (Ast)		
	No. of Rebar	Size (mm)	Area (mm^2)	No. of Rebar	Size (mm)	Area (mm^2) Area (mm^2)
A	2	16 Ø	401.92	2	20 Ø	628.0
Size	2500 X 250 X 150 mm					
Grade of Concrete	M - 60					
Grade of Steel	Fe-500					

In the numerical analysis the CDP has been selected for the analysis because of the following reasons:

I. It provides the capability for modelling concrete and other quasi-brittle materials in all types of structures.

II. It is designed for applications in which concrete is subjected to monotonic, cyclic, and/ or dynamic loading under low confining pressures.

III. It consists of the combination of non-associated multi-hardening plasticity and scalar (isotropic) damaged elasticity to describe the irreversible damage that occurs during the fracturing process.

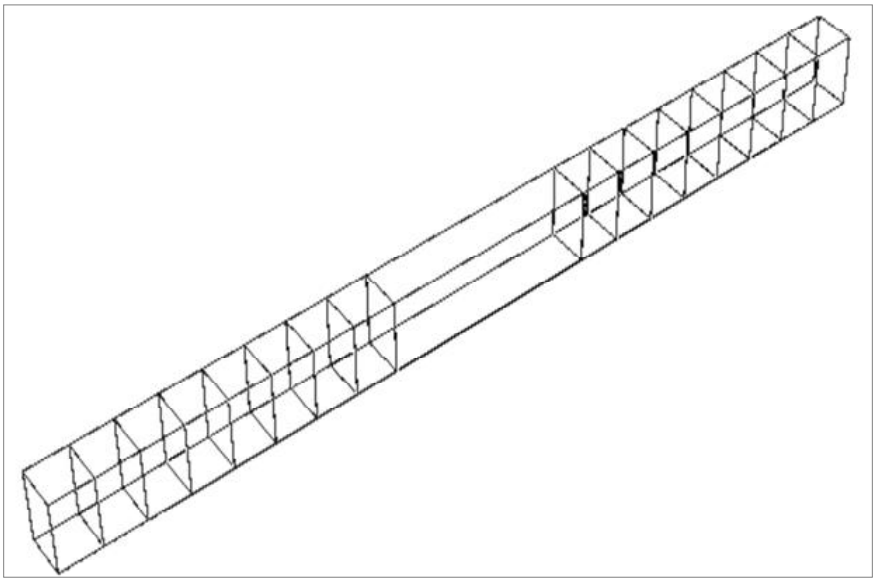


Fig 2: Reinforcement Configuration Modelling

Observations:

I. The peak deflection at the mid span of the beam from simulation is found to be 15.83 mm (Fig 3). The experimental result obtained for the mid span deflection was 11.38 mm. It is observed that there is a difference of 4.45mm in the peak deflection. Even though there is a difference in peak deflection value (Between numerical simulation and Experimental Value), the pattern is of similar nature. One of the possible reasons may be attributed to the lack of true stress vs. strain curve of the concrete. The second reason may be due to higher approximation of impact velocity by not taking friction between Impactor and guiding rods into account.

II. The Reaction Force vs. time curve (Fig 4) from simulation found the peak value to be 118.09kN. For the same case the experimental value obtained was 85.83kN. Even though there is 27% variation in peak reaction force, the pattern of variation obtained is similar to that of experimental values.

III. The cracks in beam under impact are caused by shear stressing and consequent formation of concrete plug (Fig 5). This explains to some degree, the resemblance between the observed crack pattern and the stress pattern in the beam during stress transfer from top to bottom surface.

IV. The excessive stress at the bottom of the beam (Fig 6) after impact is indicative of scabbing due to reflection of compressive stress waves travelling from the impact zone and incident on the bottom surface of the beam.

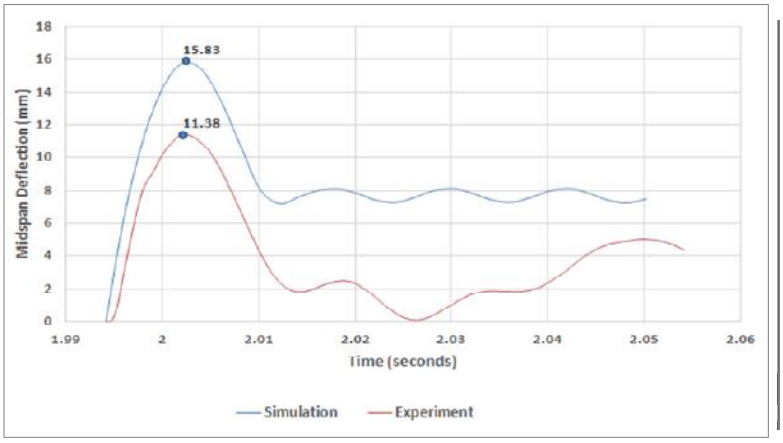


Fig 3: Deflection-Time Curve of Beam for 1m fall of Impactor Mass of 200 Kg

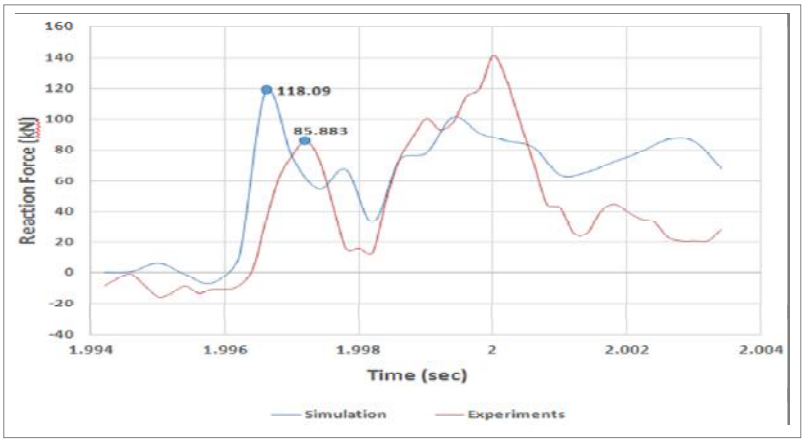


Fig 4: Reaction Force of Beam for 1m fall of Impactor Mass of 200 kg.

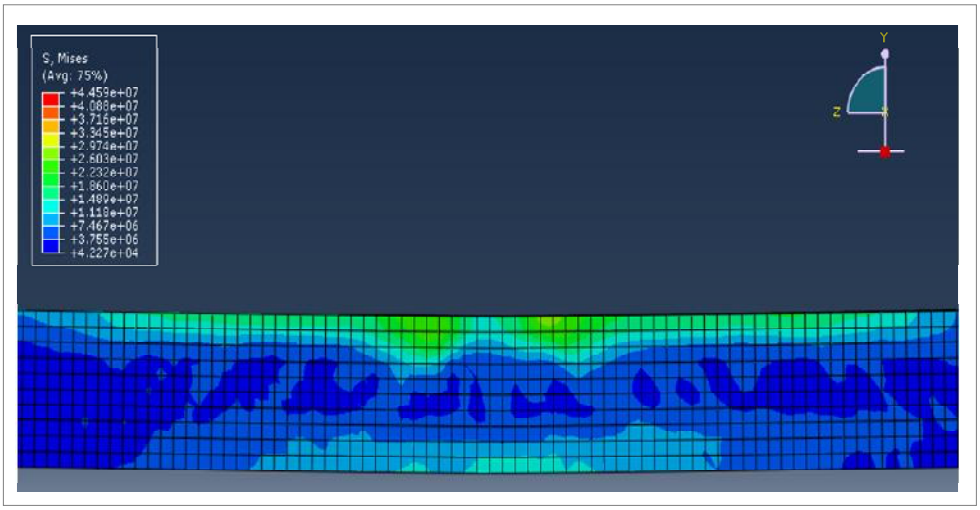


Fig 5: Transfer of Stress from Top to Bottom Region

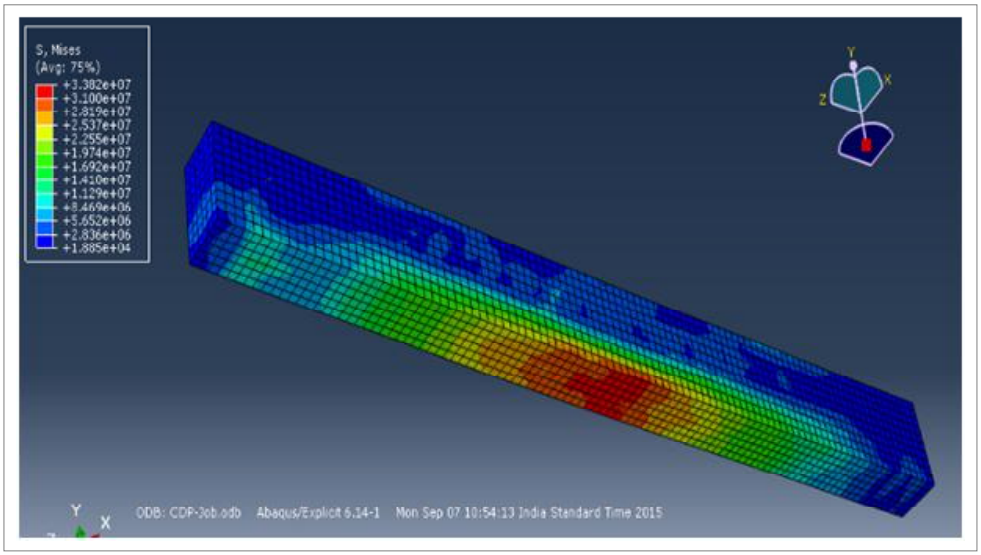


Fig 6: Stress Pattern (Bottom) in Beam just after Impact

Improved Ventilation System for Cleaner Built Environment

Syed Ibrahim Sohel, A.K. Minocha & Jaswinder Singh

Objective:

To design and develop an Improved Ventilation System to reduce inhalable particles in built environment.

Introduction:

This project aims at developing an improved ventilation system to restrict the outdoor inhalable particles from entering the enclosure as well as facilitating the ex-filtration of the indoor particles. To achieve this, experimental data on indoor particle dynamics under the influence of human activities and ventilation will be studied and a model will be developed which will help in designing an improved ventilation system. The research methodology has been submitted earlier (OLP 361).

The environmental air conditioning system was procured and installed at the site along with the dispersion and the re-suspension chamber as can be seen the Fig 1.

Fig 1: Experimental Set-up for Re-Suspension Studies

The set-up was designed to mimic the effect of human walking induced disturbance at a point. The aerodynamic disturbance was simulated with the impingement of six small air jets over the flooring sample. To understand the walking-related airflow motion nearby the floor, experiments were developed in a close environmental chamber using CO_2 vapour released over the floor (Gomes 2004). These experiments provided the range of horizontal air velocity and the visualization of large scale air turbulence resulting from a human walking. The mechanical disturbance was simulated with a system that replicates field collected floor vibration data caused by human walking. Floor vibration acceleration generally falls between 0 and 5% of g (gravitational acceleration) with frequencies ranging from 4 to 20 Hz (Hanagan et al. 2003).

Working of Set-up:

A layer of particles on the flooring sample like tiles, carpets etc. has to be created in a dispersion chamber. The Grimm aerosol generator produces artificial PSL particles of known diameter, specific gravity and density. To ensure the uniform distribution of the particles on the flooring sample, four low speed fans are attached at the base for uniform mixing before the settlement of particles. The settling velocity and settling time was calculated corresponding to a specific particle size.

This floor sample is then placed on the base of re-suspension chamber, which is the disturbed by shaking and air jets from impingements. A 15 sec disturbance can be created based on the floor response and aerodynamic response due to human walking captured in the Fig 2. The response to the floor vibration and aerodynamic effect due to human walking was also presented by Gomes (2004).

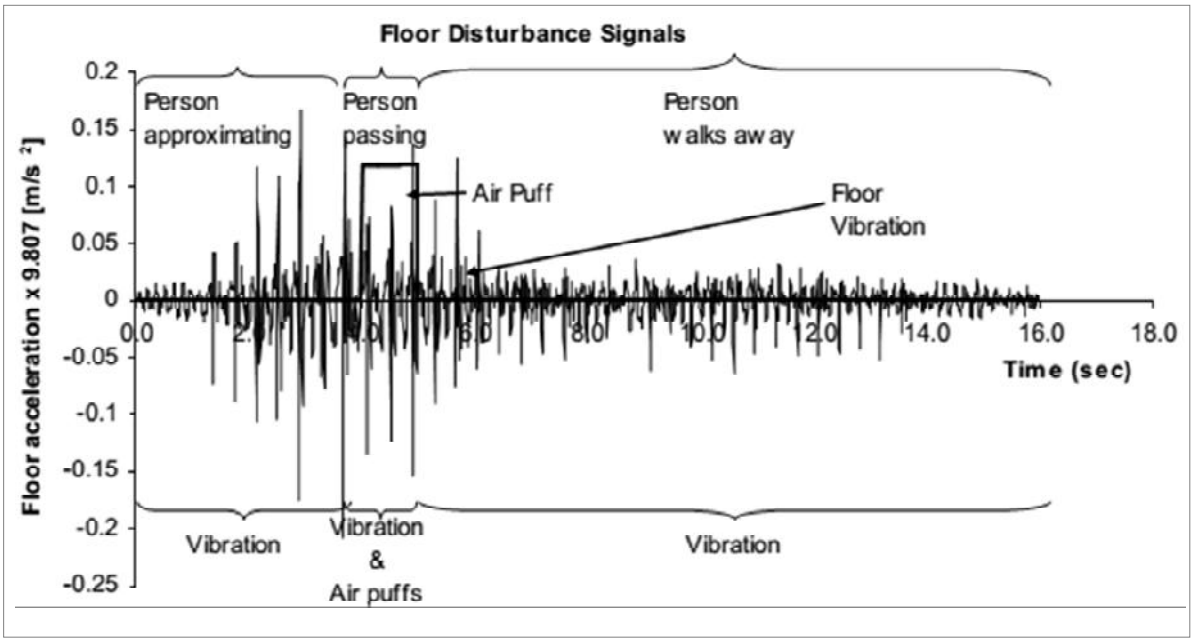


Fig 2: Floor Vibration & Aerodynamic Disturbance Signals

After 15 sec of disturbance, the particles are allowed to settle under simulated microenvironment of known temperature and RH. Some particles coagulate and settle while others remain suspended. These particles are then driven to other end of the re-suspension chamber by air of velocity as low as 1-2 cm/s. These particles are counted with the help of aerosol spectrometer. This fraction of particles is treated as re-suspended fraction and is used in the Eq. 1 to obtain re-suspension rate.

$$r_j(t+\Delta t) = \frac{V}{A_r L_j(t)}\left(\frac{C_{ij}(t+\Delta t) - C_{ij}(t)}{\Delta t} + (a+K_j)C_{ij}(t)\right) \quad \text{eq. (1)}$$

As the installation of the set-up consumed considerable amount of time due to unavoidable reasons, only a few preliminary experiments were conducted. To avoid the complexity in the initial tests, a monolayer deposit of PM2.5 was created on the flooring tile sample. However, further experiments with various combinations of flooring samples, temperature ranges and RH variation is needed to arrive at situation specific re-suspension rates for Indian conditions. These rates give an idea of total retention time and the stratification of PM in the indoor environment, which is critical in designing an improved ventilation system for targeted removal of PM from breathing zone.

ENGINEERING OF DISASTER MITIGATION & HEALTH MONITORING FOR SAFE & SMART BUILT ENVIRONMENT (EDMISSIBLE)

WP-1: Engineering of Landslide Disaster Mitigation.

PI: S. Sarkar & D.P. Kanungo

- Landslide Hazard and Risk Assessment of Chamoli-Joshimath Region, Garhwal Himalaya (CSIR-CBRI),PI: D.P.Kanungo
- Early Warning Instrumentation & Decision Package for a Landslide in Chamoli-Joshimath Region, Garhwal Himalaya (CSIR-CBRI), PI: D.P.Kanungo
- Comprehensive Geo-Investigation and Control Measures of Landslide in Chamoli-Joshimath Region, Garhwal Himalaya (CSIR-CBRI), PI: S. Sarkar

WP-2: Engineering of Earthquake Disaster Mitigation.

PI: Ajay Chourasia & P.K.S. Chauhan

- Sesmic Microzonation of Srinagar, Uttarakhand (CSIR-CBRI), PI: P.K.S. Chahuhan
- Sesmic Behaviour of Piles under Dynamic Lateral Loading (CSIR-CBRI), PI: Parvathi G.
- Sesmic Resistance of Confined Masonary Construction under Different Axial Stress (CSIR-CBRI), PI: Ajay Chourasaia

WP-3: Engineering of Fire Disaster Mitigation.

PI: R.S.Chimote & Suvir Singh

- Development of low Ozone Deplation Potentail Innovation Fire Suppression System
- Development of Innovative Fire Suppression System (CSIR-CBRI), PI: R.S.Chimote

WP-4: Post Disaster Shelter Planning.

PI: S.K. Negi

- Design and Development of Disaster Resistant Intermediate Shelters for Western Himalyan Region (CSIR-CBRI), PI: S. K.Negi

WP-5: Health Monitoring of Buildings Using Wireless Sensor Network.

PI: Ajay Chourasia & Soju Alexander

- Collection & Validation of Data using Developed Sensor, Numerical Modelling, Model Updation and Field Implementation for Building System (CSIR-CBRI), PI: Ajay Chourasia

WP-6: Intelligent Building System for Model Residential Unit.

PI: R.S. Bisht & A.K. Mittal

- Architectural Planning and Design of a Residential Unit for Integrating Intelligent Building Features (CSIR-CBRI), PI: Ashok Kumar.
- Intelligent HVAC & Lighting Controls in Response to Ambient Environmant (CSIR-CBRI), PI: S. J. Alexandar & Team

Glass Façade Cleaning Robotics System (CSIR-CBRI), PI: R. S .Bisht.

WP-1 Engineering of Landslide Disaster Mitigation

S. Sarkar & D.P. Kanungo

The landslide occurrences have been of serious concern to the society due to loss of life, natural resources, infrastructural facilities, etc. and also posing problem for future urban development. Landslides of different types occur very frequently in geo-dynamically active domains in Indian Himalayas. With this in view a project on "Engineering of Landslide Disaster Mitigation" has been undertaken under the 12thFive Year Plan. The objectives of the project are as follows:

- Landslide hazard and risk assessment of Chamoli-Joshimath region.
- Development of a landslide early warning system.
- Comprehensive geo-investigation for design & development of cost effective landslide control measures.

Landslide Hazard & Risk Assessment

D.P. Kanungo & Team

The objective of the study is to prepare large scale landslide hazard and risk maps in Chamoli-Joshimath region of Garhwal Himalaya. The proposed task will focus on large scale landslide hazard and risk mapping in Chamoli-Joshimath region of Garhwal Himalaya.

Various thematic data layers pertaining to the causative parameters for landslides in the Chamoli-Joshimath road corridor of NH-58 along the Alaknanda valley of Garhwal Himalayas have been prepared using high resolution Geo-Eye remote sensing data (0.5m spatial resolution) and field information. The thematic data layers such as slope, slope aspect, geology, drainage and landslide layers have previously been prepared in GIS. The land use land cover map (Fig 1) and the road buffer map are the recent additions to the thematic data base. Once the data base is ready, artificial neural network technique (Fig 2) will be used to determine the importance of different parameters for landslide occurrences in the study area and the weighted thematic data layers will be integrated to spatially classify the study area into different zones of landslide susceptibility. Based on the landslide susceptibility and resource damage potential of the study area, further a landslide risk map will be produced.

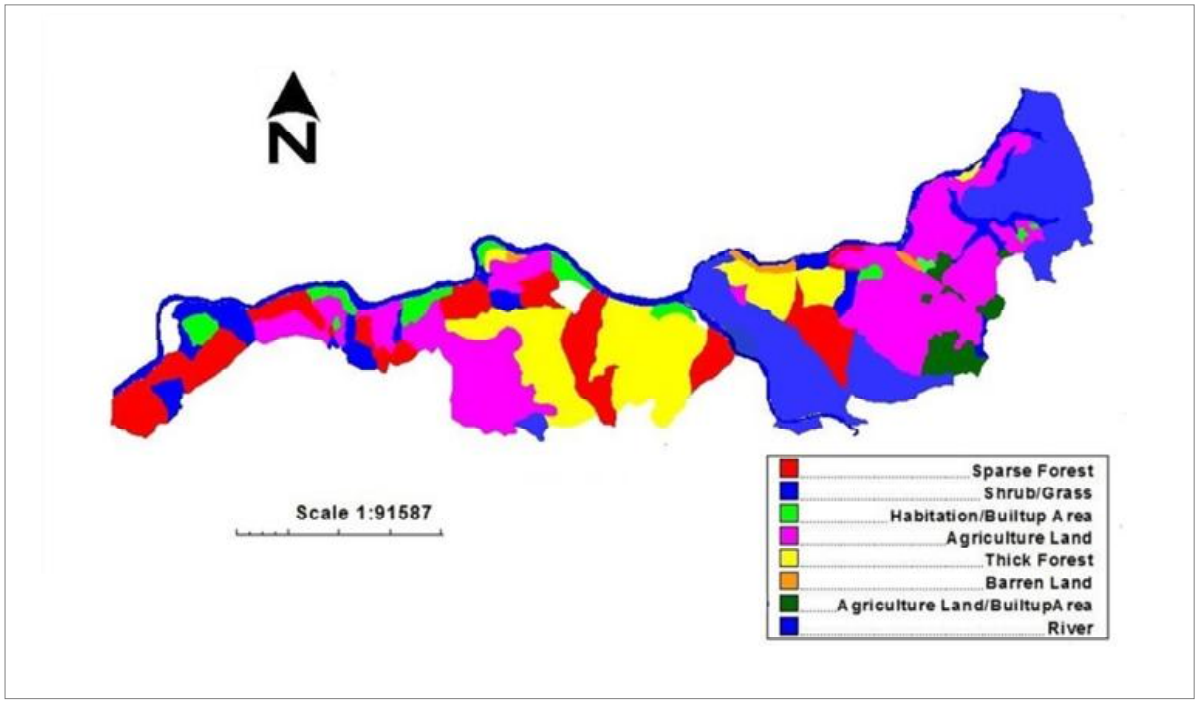


Fig 1: Land Use Land Cover Map of the Study Area

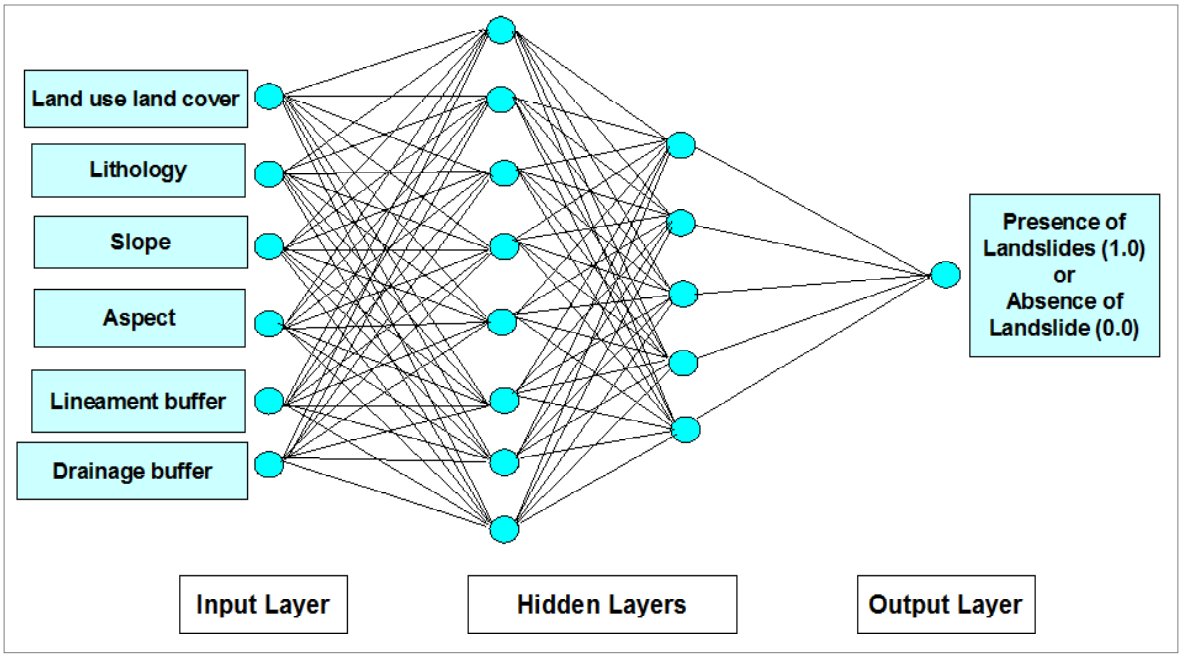


Fig 2: Schematic Diagram of ANN Architecture for Landslide Hazard Assessment

Development of Landslide Early Warning System for a Landslide in Chamoli-Joshimath Region of Garhwal Himalaya

D.P. Kanungo & Team

The objective of this task is to develop a region specific operational Landslide Early Warning System based on multi parameter trigger thresholds. The system will include sensing instruments, real time data transfer system, decision making mechanism & the multi level alarm signal dissemination. The proposed project aims at the development of a landslide early warning system (LEWS) based on multi-parametric real-time monitoring through suitable field instrumentation.

In this direction, a Landslide Observatory with wireless instrumentation for real time monitoring of ground deformation and hydrologic parameters has been established at Pakhi Landslide along the Alaknanda Valley of Garhwal Himalayas, India. This observatory is one of its first kinds in Indian Himalayas for real-time monitoring of an active landslide. The Pakhi Landslide is an active slow moving and retrogressive debris slide, located at a distance of 9 km from Pipalkoti on Chamoli-Badrinath highway (NH-58). The sliding activities of the Pakhi landslide affect the National Highway 58 and disrupt the heavy traffic on this pilgrim route in every monsoon season since more than a decade.

For ground based landslide monitoring, the measurement sensors include in-place inclinometers (IPI) and piezometers installed in bore holes, surface wire-line extensometers across the developed tension cracks and an automatic weather station (AWS) with rain gauge, temperature, humidity, wind velocity and direction measurement sensors. These sensors are wirelessly communicating through nodes to the gateway for real time data acquisition at the landslide observatory. The data is being transferred from the field control station to the central station at CSIR-CBRI, Roorkee through web server. The real time data is being monitored and analyzed to establish landslide warning thresholds based on which an early warning system for landslide will be designed.

The progress in this direction discusses the establishment of a ground based wireless instrumentation and real time monitoring system at Pakhi Landslide and also few inferences drawn on the basis of measured data from different sensors at different locations. The annual cumulative rainfall at the landslide site during 2015 was 1388 mm with the cumulative monsoon period (June to September 2015) rainfall of about 825 mm. Piezometric level variation as observed in borehole no. 2 is shown in Fig 1. From the IPI data at the crown of the landslide beyond the main scarp, it is observed that there is negligible displacement on surface and sub-surface which was as expected being the stable part of the slope. Within the main body of the landslide on the uphill slope, a maximum cumulative displacement of 6.2mm is observed during monsoon period at a depth of 10.5 m representing the interface between debris overburden and soft weathered dolomitic limestone. Further, just above the road level at the minor scarp of the landslide, a maximum cumulative displacement of 6.6 mm is observed during monsoon period at a depth of 3 m within the debris overburden. From the above observations, it can be inferred that the slip surface represents the interface between debris overburden and soft dolomitic limestone and is having a maximum depth of 10.5 m at the main landslide body. Also, it can be deciphered that local slip surfaces exist within the debris overburden with the surface manifestation of minor scarps just above road level. Hence, it can be stated from the ground movement data that the Pakhi landslide is a very slow moving landslide of retrogressive nature (Fig 2).

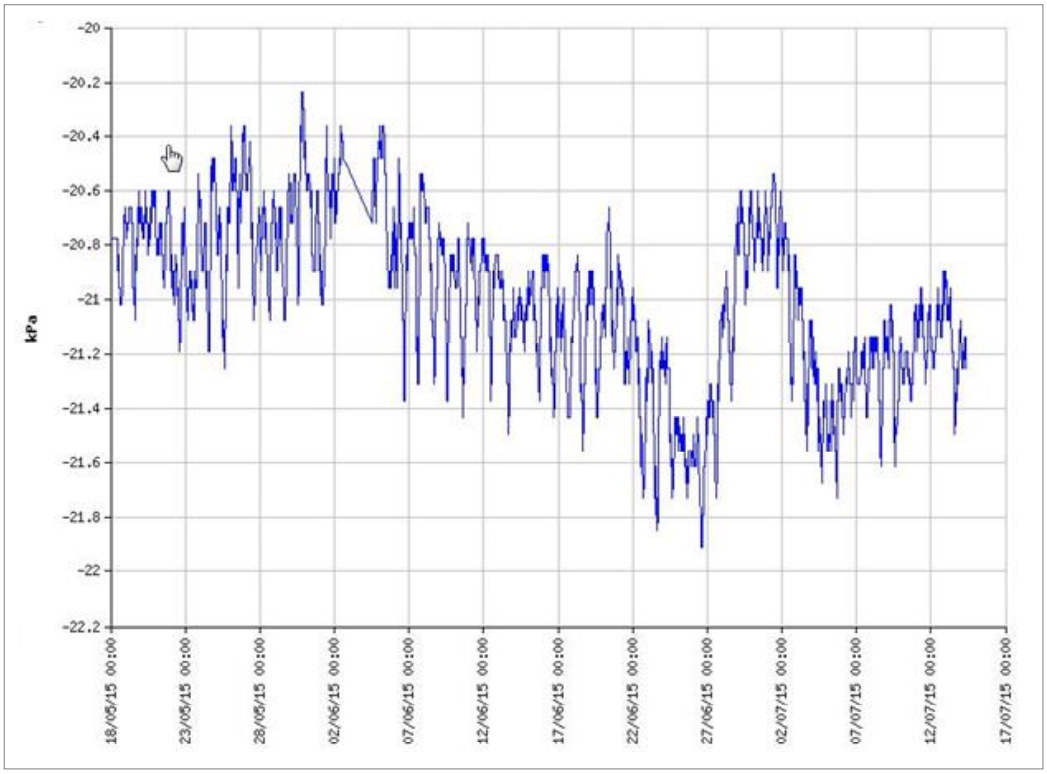
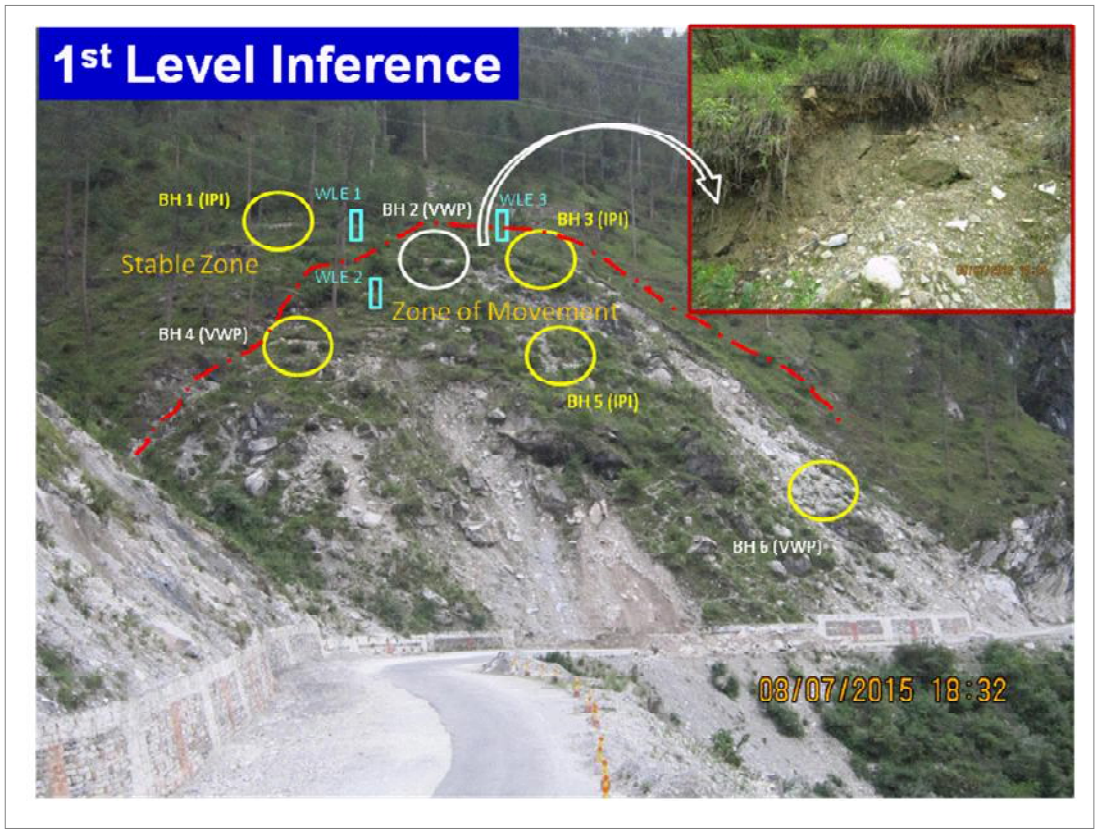


Fig 1: Piezometric Level in Borehole No. 2 at Pakhi Landslide



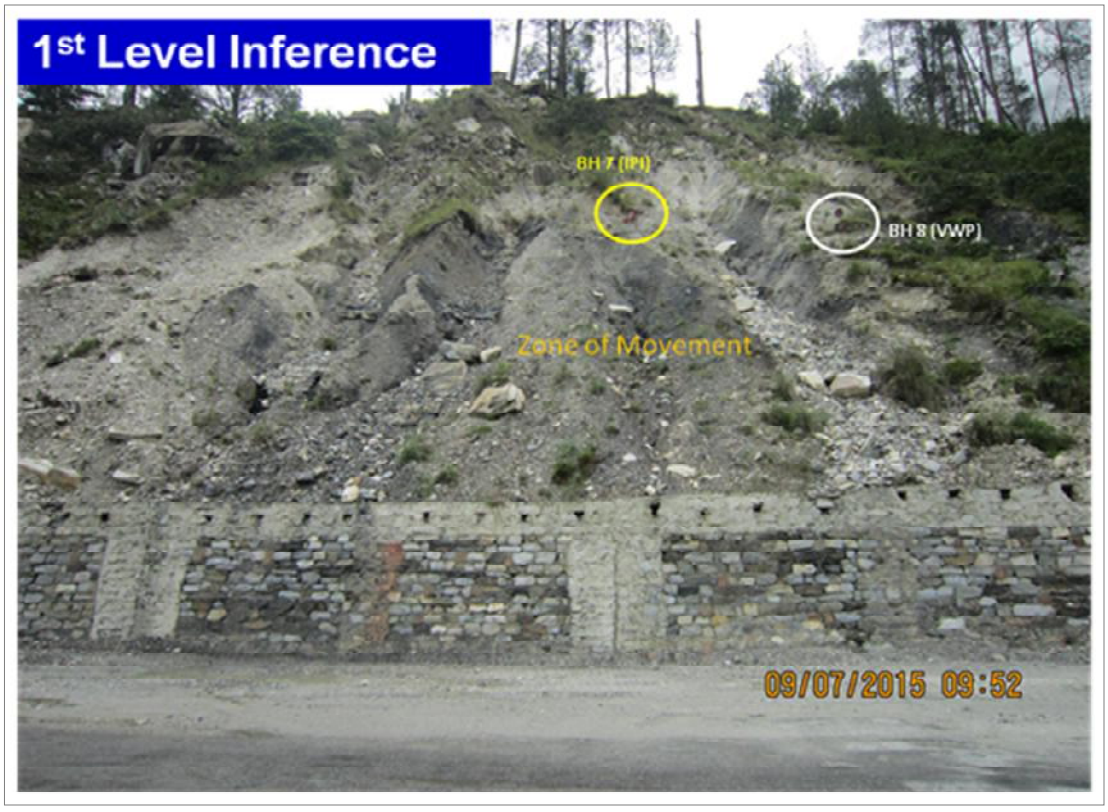


Fig 2: Map showing Movement Zones based on Sensor Measurement Data

Comprehensive Geo-Investigation & Control Measures for a Landslide in Chamoli-Joshimath Region of Garhwal Himalaya

S. Sarkar, Manojit Samanta, Mahesh Sharma & Ajay Dwivedi

Control Measures for Slope Stabilization:

Slope stability analysis was carried out to determine the present stability condition of the slope and the stability it achieves after inclusion of suitable control measures. On the basis of field investigation the following control measures were suggested:

- Gabion wall below the road on downhill slope
- Soil nailing on the uphill slope
- Surface drainage along the seasonal drain

The scheme of proposed measure is shown in the Fig 1.

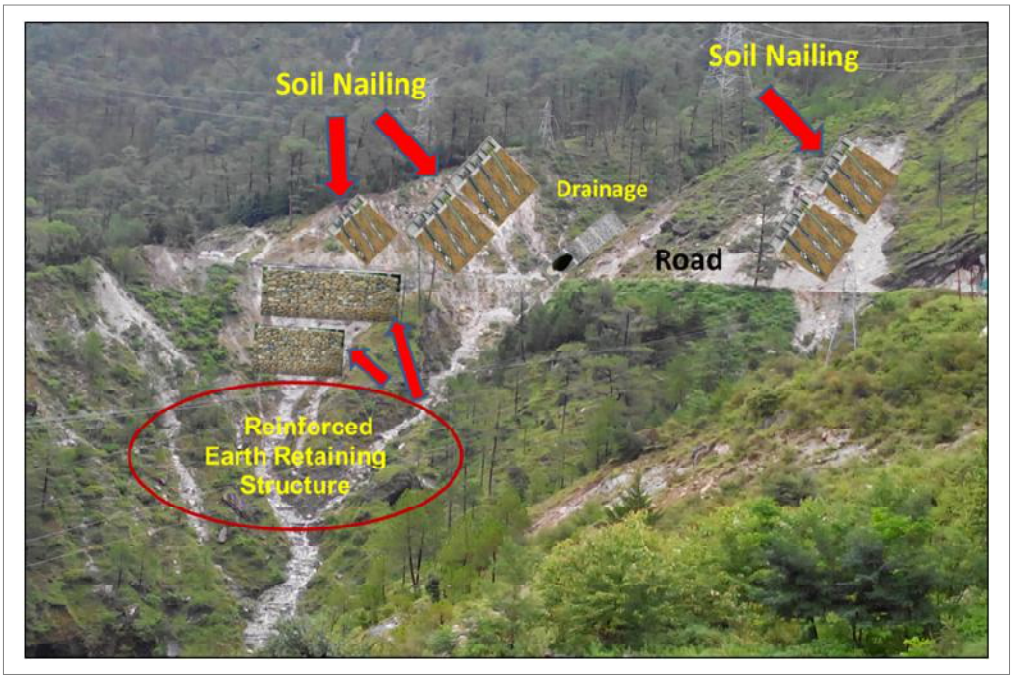


Fig 1: Scheme of Proposed Measure at Landslide Site

Soil Nailing:

It was thought to reinforce the debris material on the uphill slope with soil nailing. For that purpose stability analysis of the slope above the road was carried out with different condition providing nails. Slope stability analysis was carried out for different sections of the slope using Geo-slope. The results indicated that inclusion of nails has increased the factor of safety significantly in both EQ and saturated condition. In continuation with the study of soil nails of different types, a few more experimental studies were carried out in the laboratory. Helical soil nails are being used

in place of conventional soil nails due to ease of installation, rapid loading capability, and high pullout capacity. A series of laboratory pullout tests were conducted to investigate the pullout behaviour of helical soil nail installed in dry dense sand under different overburden pressures (Fig 2). Comparisons have been made between different types of helical soil nails by varying parameters like diameter of helix, number of helix, pitch of helix and surface roughness (Fig 3).

After obtaining encouraging results of helical nails with sand, soil material from the Pakhi landslide, Garhwal Himalaya were brought to the laboratory for carrying out laboratory experiments. A few experiments with v arying nail parameters were carried out by filing the tank with landslide material. It was observed from the results of the experiments that the pull-out capacity of helical soil nails in landslide material has increased significantly as compared to sand. Hence this further validates the application of such helical nails for soil slope stabilization. Experiments with more varied parameters are in progress.

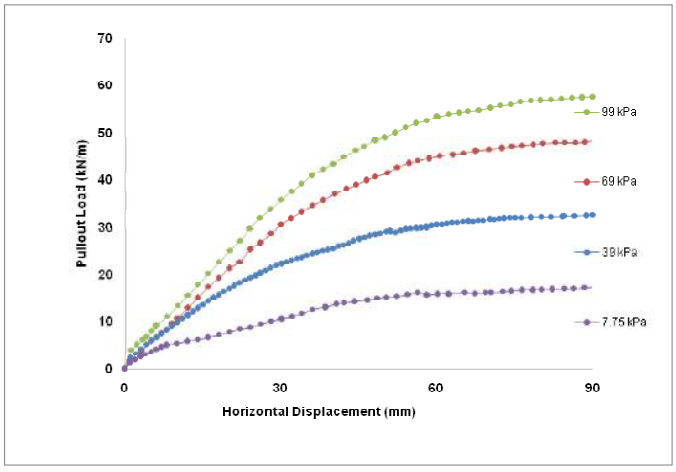


Fig 2: Pullout Displacement Curve for a Typical Helical Soil Nail

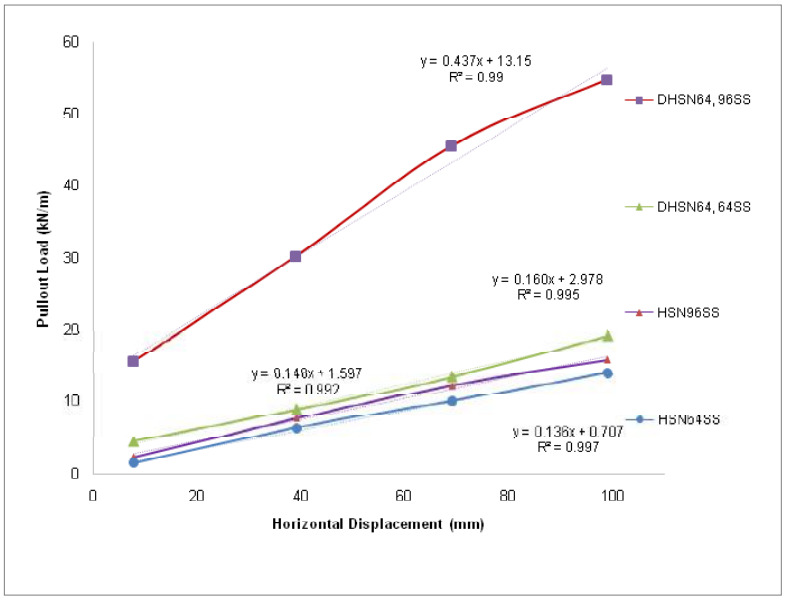


Fig 3: Peak Pullout Capacity Comparisons

WP-2 Engineering of Earthquake Disaster Mitigation

Ajay Chourasia & P.K.S. Chauhan

Seismic Microzonation of Srinagar, Uttarakhand

P.K.S. Chauhan, Abha Mittal & Gayatri Devi

Seismic Microzonation of Srinagar (Uttarakhand) has been initiated in March 2012 under the Engineering of Earthquake Disaster Mitigation (EEDM) in the 12th Five year plan with the following objective, Seismic Microzonation of Srinagar Uttarakhand using geological, geophysical, geotechnical, seismological and liquefaction studies. In the year 2015-2016, the following works were completed.

- Geophysical investigation using Seismic and Electrical methods were carried out at the both banks of the river to delineate the subsurface structure. In total of 11 Seismic Refraction Surveys, 7 Resistivity Imaging profiles were taken. The depth of investigation in these methods depends upon the length of the profile used and the impact of source in the case of Seismic method. The data processing and interpretation has provided the sub-surface information up to the depth of 20m. The sites covered are:\
  - Ramleela Ground, Srinagar
  - Anchal Dairy, Srinagar
  - River bed, Ranihat
  - Left bank Canal,Chauras
  - SSB Ground Srinagar
  - ITI Ground Srinagar
  - Horticulture Ground Srinagar
  - Chauras Inter College Srinagar
  - Court Compound Kirti Nagar
  - GGIC, Srinagar
  - HNB Garhwal University, Chauras

The results of survey at Ramleela Ground and Anchal Dairy are shown in Fig 1(a) & Fig 1(b).

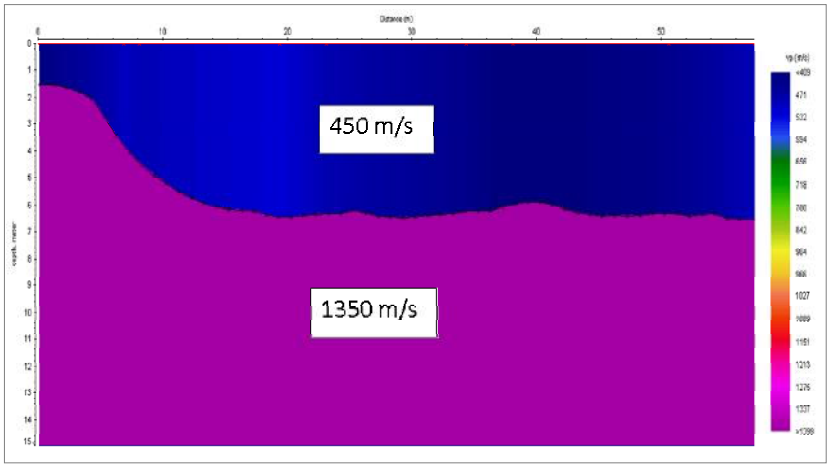


Fig 1: (a) P-wave Velocity Variation at Ramleela Ground, Srinagar using Refraction Method

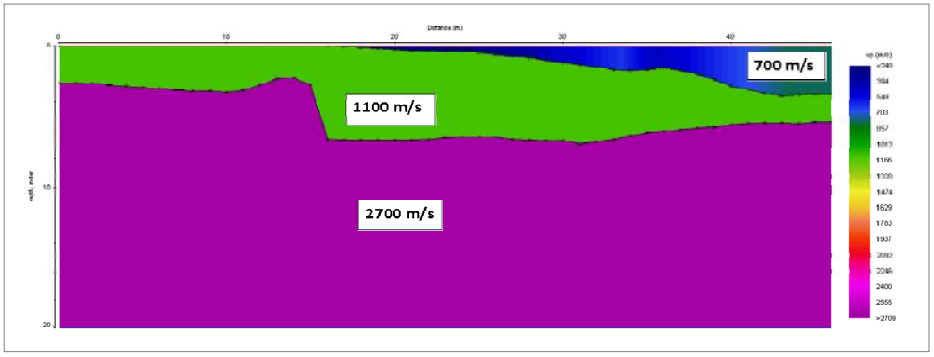


Fig 1: (b) P-wave Velocity Variation at Anchal Dairy, Srinagar using Refraction Method

- Nepal Earthquakes (April 25, 2015, April 26, 2015 and May 12, 2015) have been successfully recorded at our SMA network at Srinagar (Fig 2, Fig 3 & Fig 4). The accelerograms recorded for these events are shown below.

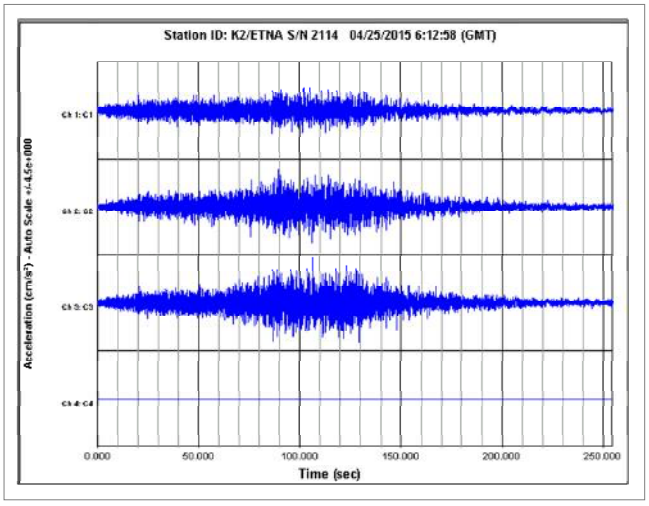


Fig 2: Main Shock 25/04/2015 GGIC, Srinagar (Max PGA: 4.086 Cm/sec^2)

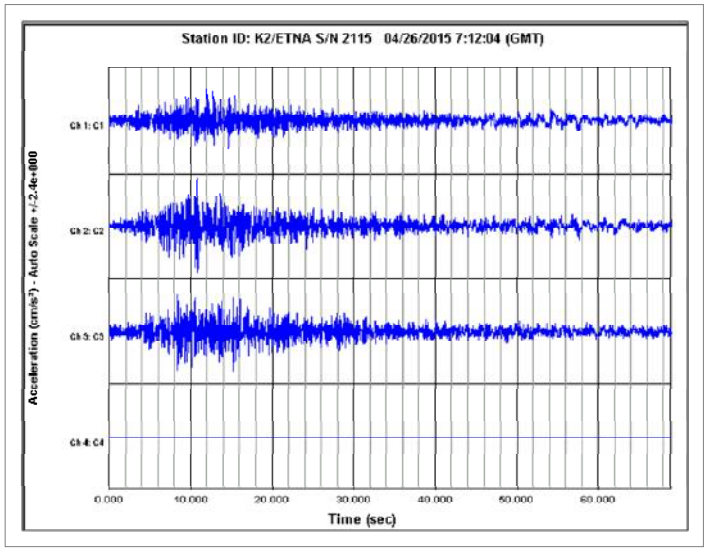


Fig 3: Main Shock 26/04/2015 HAPRC Srinagar (Max PGA: 2.184 Cm/sec^2)

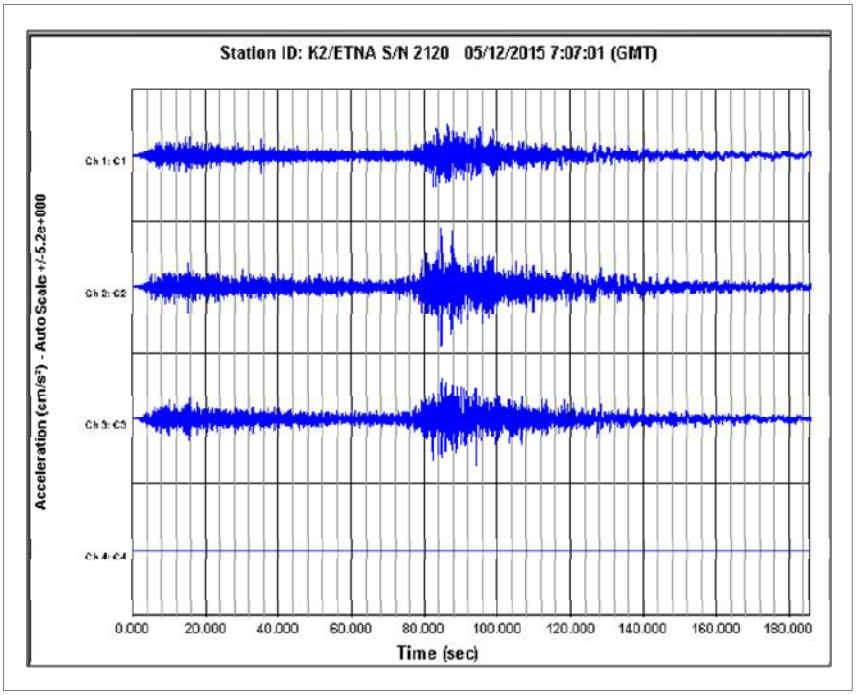


Fig 4: Main Shock 12/05/2015 at Tehsil, Srinagar (Max PGA: 4.698 Cm/sec²)

- Natural frequency contour map of Srinagar, based on micro tremor data analysis, has been generated as shown below in Fig 5. The map will be further updated by incorporating more data.

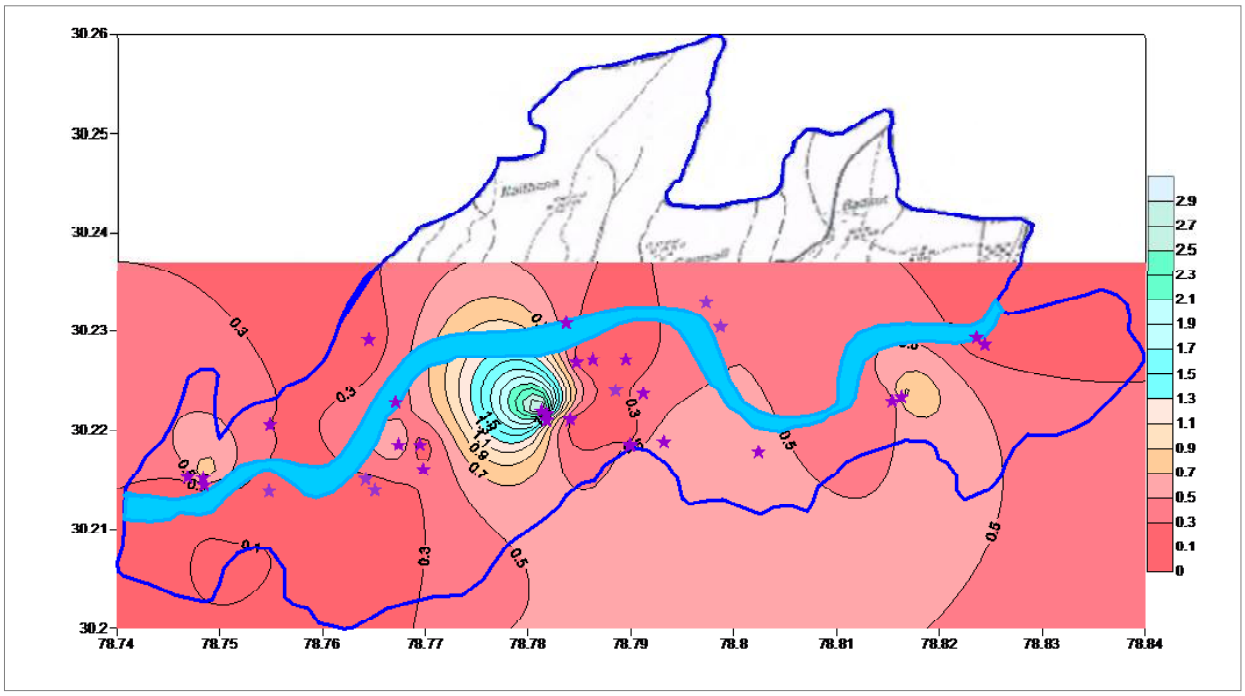


Fig 5: Natural Frequency Contour Map of Srinagar

Seismic Behaviour of Piles under Dynamic Lateral Loading in Layered Sandy Soil

Piyush Mohanty, Manojit Samanta, Dalip Kumar & Zamir Ahmad

Objectives:

- To investigate the seismic behavior of piles subjected to dynamic lateral loading through numerical analysis and experimental model testing.
- To investigate the influence of various soil and pile parameters on the seismic behavior of piles. The influence of liquefiable soil layer on the behavior of piles will also be studied.
- Development of a methodology for seismic design features of piles in layered sandy soils.

Progress:

1. The Uni-axial Shake Table of make BISS has been procured and a dynamic soil test facility with adequately designed strong floor has been created to carry out tests to simulate earthquake conditions in the soil as shown in Fig 1.
2. Experimental model test design is completed. This includes the design of the test tank and the test piles as shown in Fig 2(a) & Fig 2(b).
3. Laboratory model test is being done on 1.4mx1.0mx1.0m test tank for dynamic analysis. Aluminum model piles of 25mm diameter are being used as model piles. The sand from Solani River is being used to carry out the model tests.
4. Proper care was taken to nullify the boundary effects by placing PU foam and the same was verified by placing the accelerometers at different positions near the boundary to check the boundary condition problem. Correspondingly, satisfactory results are being obtained.

Fig 2: (a) Model Test Tank with the Sand Specimen

Fig 2: (b) Use of Foam to Nullify Boundary Effects

5. Pile groups in loose and dense sandy soils, subjected to combined axial and lateral loading has been numerically modeled with the help of PLAXIS3D FEM software. The numerical model has been validated with a number of published works. The parametric studies are also being carried out to study the influence of lateral loading on pile foundation in a seismic condition. The soil has been modeled using linear elastic perfect plastic Mohr-Coulomb model. This model involves five input parameters, i.e. Young's modulus E and Poisson's ratio nu for soil elasticity; friction angle (Ö), cohesion(c) and dilatancy angle (Ø) for soil plasticity.

6. Literature review of the preset work is carried out continuously to keep up the knowledge base of the project.

Results and Discussions:

1. The pile group carrying lateral load was numerically modeled in PLAXIS 3D. The validation of the 3x3 pile group numerical model was carried out with the published results of Comodromos et al. (2009), Ercan et al. (2010), and Turan et al. (2015) as shown in Fig 3(a) & Fig 3(b). The soil is modeled using elastic perfectly plastic Mohr-Coulomb model. The pile is modelled as beam element with the properties of concrete as described in the published literatures.

2. To model the pile behavior in case of earthquakes, the validation of the numerical model, built using PLAXIS3D Dynamic was carried out with the published work of Jesper et al., 2010. The lateral load on the pile foundation of a LPG Storage Tank in case of

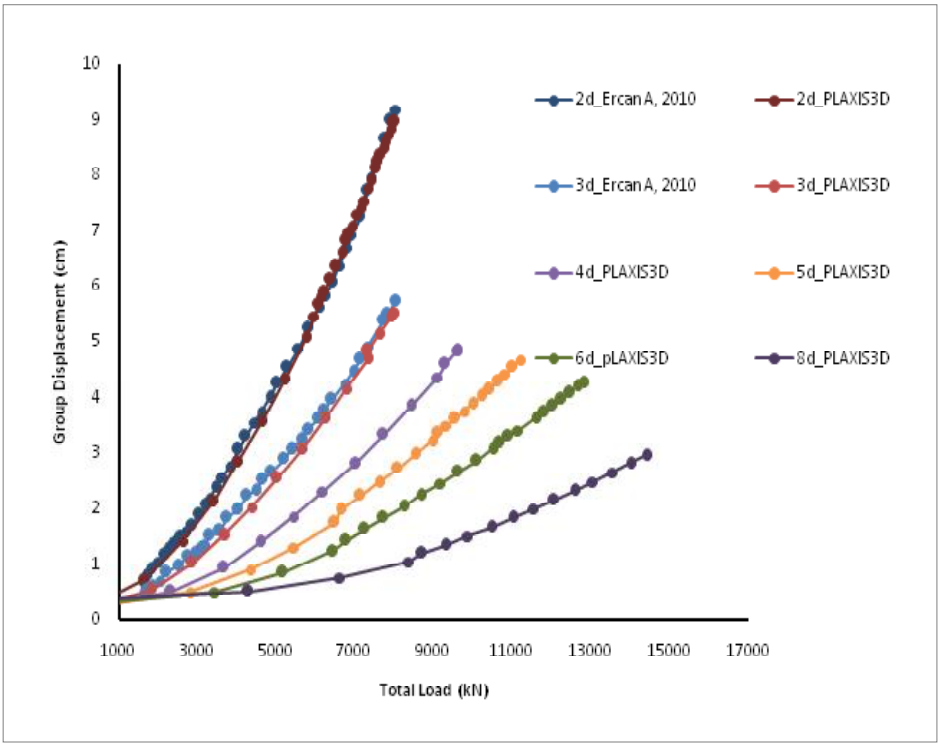


Fig 3: (a) Close Matching of the Pile Group Displacement as per Ercan et al. (2010)

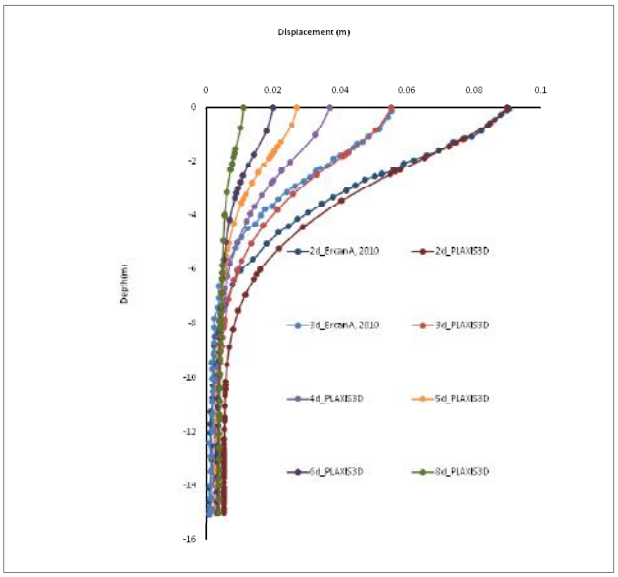


Fig 3: (b) Close Matching of the Pile Head Displacement as per Ercan et al. (2010)

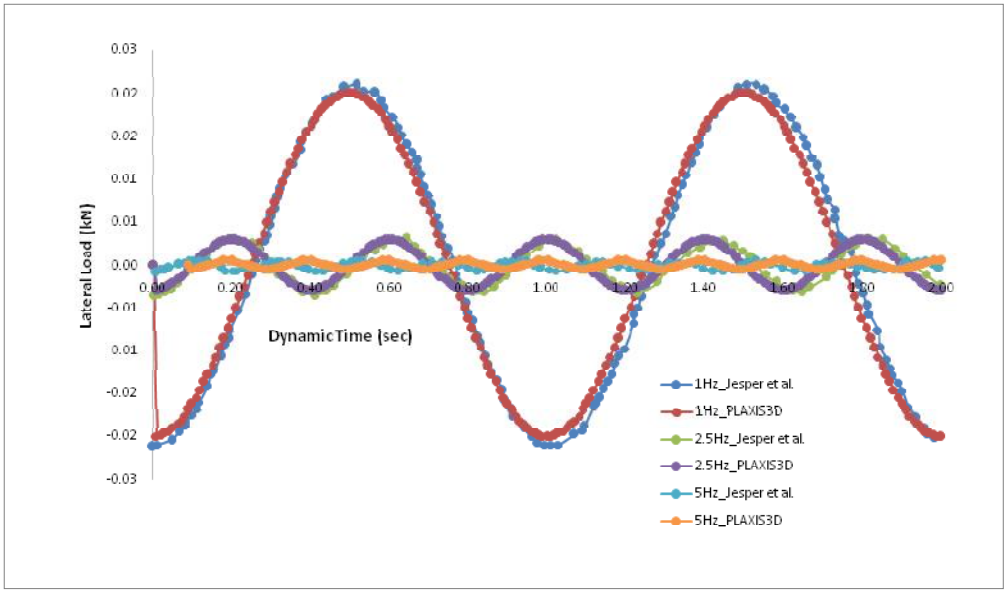


Fig 4: Validation of PLAXIS3D Dynamic with the Results of Jesper et al. (2010)

an earthquake was matched with the results of PLAXIS3D Dynamic as shown in Fig 4.

3. Parametric study is being carried out for 3x3 groups of piles. The pile cap is properly designed according to BS 8110 Part 1:3.11.4.1(5). The pile cap dimension is chosen as 2300x2300x900 mm and the pile diameter and the length are taken as 0.5m and 10m respectively.

4. From the analysis of results, it has been observed that due to the shadowing effect, the leading pile row carries 80% of the load as compared to the load it would have carried as a single pile. Middle row carries 30% of the load and the trailing pile row carries the 50% of the load. So, the pile group behavior can be explained through p-multiplier approach.

Seismic Resistance of Confined Masonry Constructions under Different Axial Stress

Ajay Chaurasia

Among 301 million existing building stock in India (Census 2011), approximately 85% buildings are masonry buildings, mostly unreinforced masonry. Brick Masonry is always preferred because of their low cost and eases of construction. The safety of these buildings from the wrath of earthquakes is a subject of highest priority due to the fact that in the moderate shaking it suffers extensive damage and loss of lives. In order to minimize such damage from future shaking, it would be pertinent to upgrade the earthquake resistance of such existing masonry construction or damaged masonry building by innovative and low cost interventions.

In the present research program it was envisaged to retrofit damaged full-scale confined masonry building using innovative and cost-effective material. To explore the possibility various alternative options viz. Welded Wire Mesh (WWM), Chicken Mesh (CM), Nylon Mesh (NM), Industrial Geo-grid (IG), Polypropylene band (PP) and Plastic Cement Bag (PCB) were evaluated for retrofitting of masonry prisms and wallets, at the first instance. Subsequently, the best option shall be implemented to retrofit damaged confined masonry building on a full-scale.

First phase of the programme deals with study of basic parameters like strength, stress-strain relationship and failure mode of primary units of brick masonry viz. brick and mortar. Different grades of mortar i.e. 1:6 and 1:8 (cement: sand) were tested, to obtain the best possible mix for the construction of prisms and wallets. Tests were performed on the solid clay burnt bricks (9 samples), 9 specimens of cubes and cylinder of mortar of different grades were tested. 24 masonry prisms (size: 410x115mm) and wallets (670x670x230mm) were cast in 1:6 cement: sand mortar (10mm thick); each set comprising three specimens, strengthened by jacketing using six different materials, duly embedded in 15mm thick, 1:4 cement: sand plaster, keeping one set as a control specimen. The prisms were tested under uni-axial compression, in accordance with ASTM C1314 while wallets were tested as per ASTM E519 to study the strengths, stress-strain relationship, and failure pattern. The average compressive strength of brick units along thickness was obtained as 13.137MPa with a standard deviation of 2.09MPa and coefficient of variation of 15.63. Nearly linear stress-strain relationship of bricks was noticed up to 85% of maximum compressive strength with brittle mode of failure. The Young's modulus and Poisson's ratio of bricks was determined as 1300MPa and 0.1 respectively. The compressive strength of 1:6 cement: sand mortar was obtained as 2.97MPa.

The behavior of masonry prism, plastered with 15mm thick 1:4 cement: sand mortar was studied when loaded normal to bed joint, as control specimen. The compressive strength of un-plastered masonry prism was obtained as 3.05MPa, whereas for the control specimen was obtained as 3.22MPa, showing an increase by 5.57% due to plaster. The comparison of mechanical properties, cost for control vis-a-vis strengthened masonry prisms/wallets along with failure mode is presented in Table 1. The values obtained in the study demonstrates substantial increase in the compressive strength of masonry strengthened using welded wire mesh (6.48MPa), plastic cement bag mesh(6.09MPa) and geo-grid mesh (6.03Mpa). Fig 1 shows comparison of average stress-strain relationship for the tested masonry specimens. The stress- strain behavior of strengthened masonry prisms was non-linear in all the cases except for masonry prism strengthened using nylon mesh. In contrast, the cost analysis of materials used for strengthening of masonry, as presented in Table 1 shows considerable cost reduction for specimen strengthened using plastic cement bag mesh.

The present research programme shows that strengthening of masonry can be achieved using mesh type of material. Among the different material tested for strengthening, welded wire mesh, geo-grid mesh, PP band mesh and Plastic cement bag mesh performed effectively, with enhancement of compressive and shear strengths by 200%. However, the analysis of material cost indicates that plastic cement bag mesh amounts to Rs.62/- per sqm, in contrast to welded wire mesh (Rs.141/sqm) and geo-grid mesh (Rs.414/- /sqm). Thus, using plastic cement bag mesh for masonry strengthening can be implemented as it has features like – low cost, non-corrodible, adequate grip, high flexibility, low thickness and re-use of waste material.

Table 1: Properties of Strengthened Masonry using Different Materials

Masonry Test specimen	Compressive Strength, MPa	% increase in Compressive Strength	Modulus of Elasticity, MPa, $E_{nu}=456f_m$	Experimental Modulus of Elasticity, MPa,	Material Cost Rs./ m^2	Failure Mode
Plastered Control Specimen	3.20	100.0	1460	1478	-	Crushing
Strengthened using Welded Wire Mesh	6.48	202.0	2954	3058	141	Flexure
Strengthened using Chicken Mesh	5.29	165.3	2412	2560	95	Flexure
Strengthened using Nylon Mesh	4.35	132.8	1938	2140	86	Shear
Strengthened using Geo-grid Mesh	6.03	188.4	2749	2725	414	Flexure
Strengthened using PP Band Mesh	5.91	184.0	2694	2712	180	Shear
Strengthened using Plastic Bag Mesh	6.09	190.3	2833	2879	62	Flexure

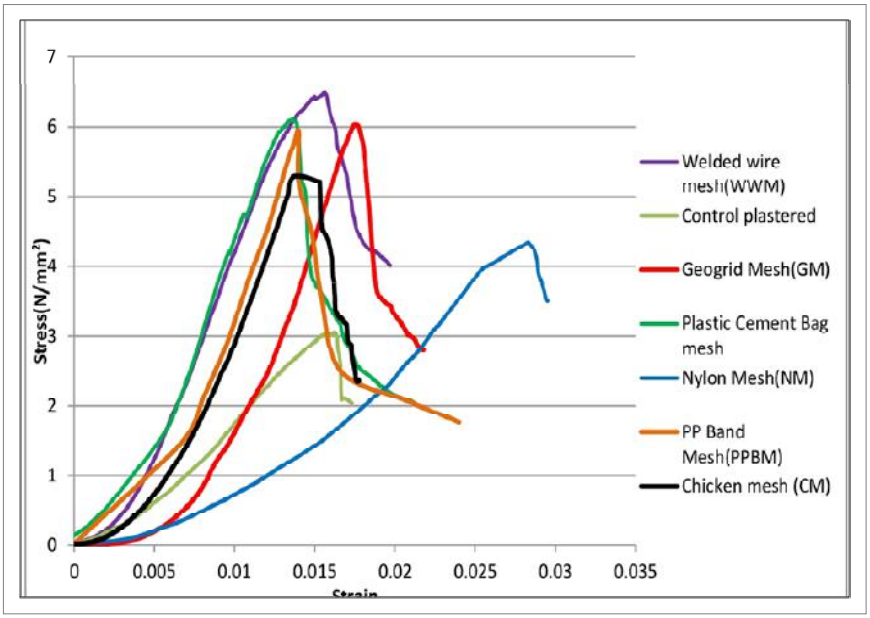


Fig 1: Stress-Strain Relationship of Masonry Strengthened with Different Mesh Types Materials

WP-3 Engineering of Fire Disaster Mitigation.

R.S. Chimote & Suvir Singh

Development of Low Ozone Depletion Potential (0.01-0.5) Innovative Fire Suppression System

R. S. Chimote

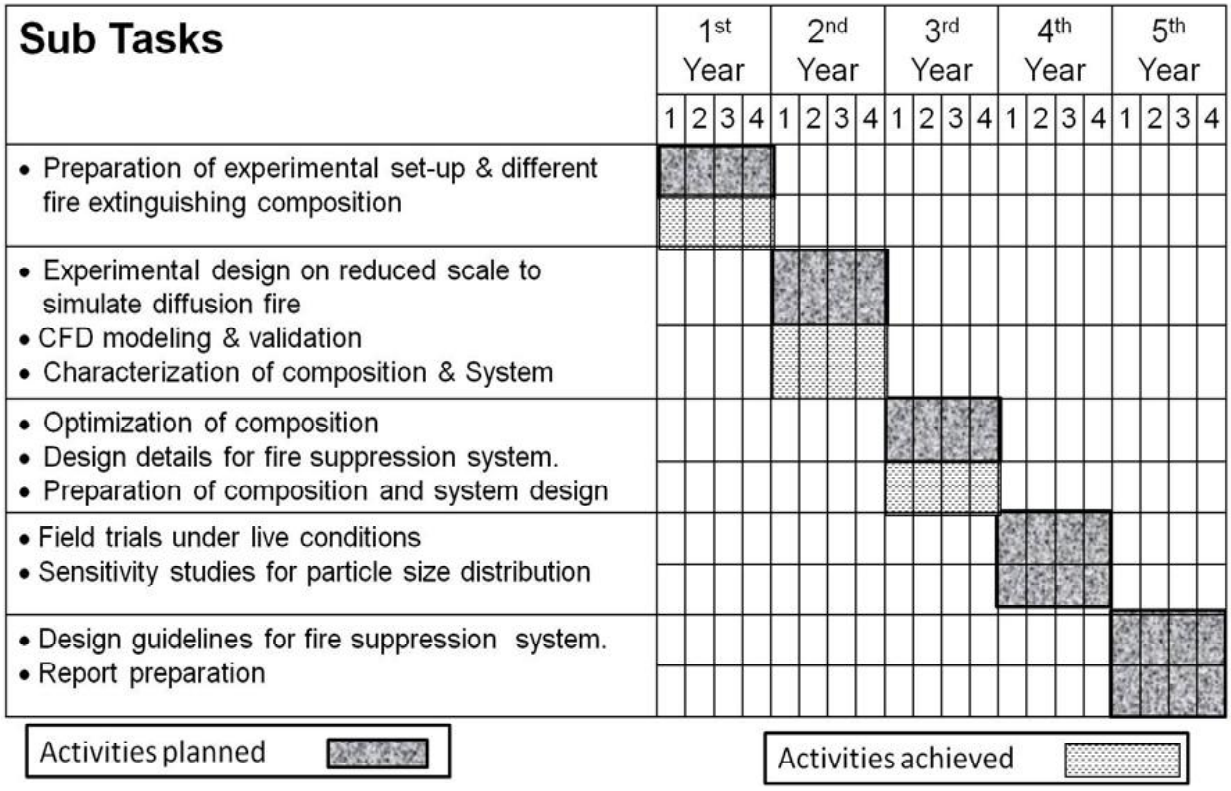
Project Objectives/Deliverables:

- Development of water-mist based fire extinguisher
- Development of evaluation facilities for fire extinguishing system

Yearly Objectives & Deliverables of the Project during April 2015 to March 2016:

- Field Trials under live fire conditions

Schedule of Activities (2012-2017):



- **Revalidation with Field Trial of Novel Water-Mist and/or Low ODP Extinguishant Fire Suppression System:** The field trial experiments with novel water-mist and/or low ODP extinguishant fire suppression system based on water-mist technology has been carried out on a working space of 3mLx2m(w)x2.75m(H) has been carried out as depicted in the following Fig 1.

Fig 1: Revalidation with Field Trial of Novel Water-Mist and/or Low ODP Extinguishant Fire Suppression System based on Water-Mist Technology has been carried out on a Working Space of 3m(L)x2m(W)x2.75m(H)

- **Field Trials of Class 21B Fires on Flammable Liquid Fires:** The field trial experiments were carried out as depicted in the following Fig 2 for fire extinguishing performance evaluation of the 9 litre capacity Water-Mist Fire Extinguisher with fire suppression times of 25-30s with 100% fire suppression efficiency with 80-90% discharge.

Fig 2: Field Trial of Class 21B Fires on Flammable Liquid Fires for Fire Extinguishing Performance Evaluation of the 9 litre Capacity Water-Mist Fire Extinguisher

- **New Experimental Facility for Controlled Experiments have been created for Class A/Class B Fires for Full-Size Standard Compartmental Fire Suppression R&D Studies on Any Type of Field Trial-Fires:** An experimental facility of 3mx3mx4m size for controlled experiments have been created for Class A/Class B fires for full-size standard compartmental fire suppression R&D studies on any type of field trial-fires based on validated results for Class A/Class B fires with 95-100% fire suppression efficiency in 10 to 15 s on 1000cm^2 fires, as shown in Fig 3.

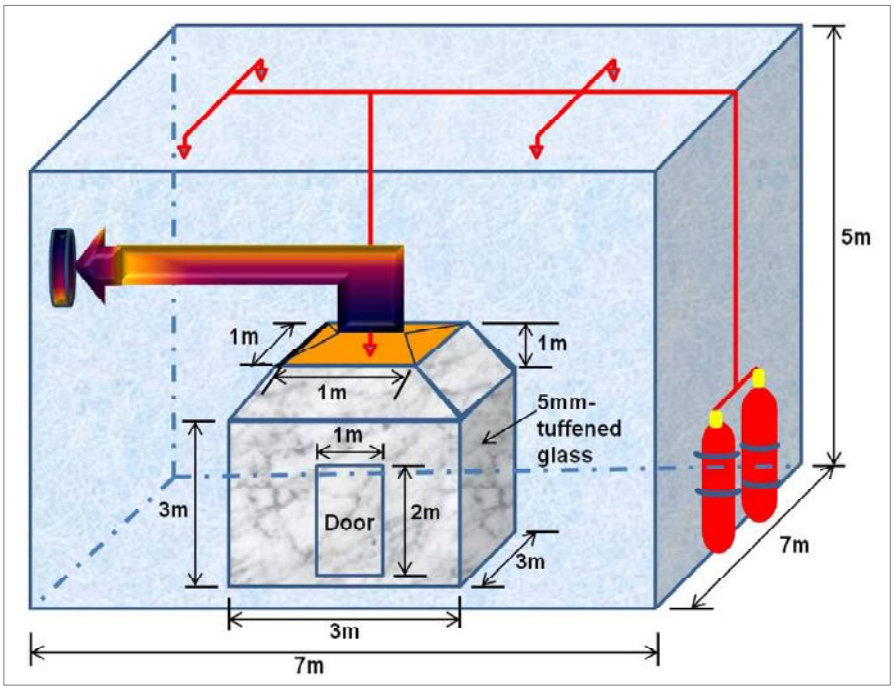


Fig 3: An Experimental Facility of 3mx3mx3m size for Controlled Live Field Trial Fire Suppression Experiments

Fire Performance Evaluation of Structural Elements & Rehabilitation

Suvir Singh

Introduction

The performance of reinforced concrete (RC) beams under simultaneous fire and structure loading conditions is carried out. Four RC beams were tested under different configurations. The test variables included two control beam and two under fire conditions.

The test includes a series of four experiments on normal and high strength concrete beams. To study the flexural behavior of RC beams, two reference specimens of two different grades namely M30 and M60 were tested under two point loadings. In the tests observations were related to first cracking load, ultimate load, deflections and fire resistance were monitored.

Data from test is utilized to compute performance of normal and high strength concrete beams. Measured temperature and deflection were compared as a function of fire exposure time. Results from the test infer that concrete beams made of normal strength concrete possess higher fire resistance as compared to high strength concrete beams.

Design & Fabrication of Beams:

Four reinforced concrete beams, two of normal strength and two of high strength concrete was fabricated for carrying out experimental studies. The material used for the fabrication of beams comprises 43-Grade ordinary Portland cement conforming to IS 8112:1989, fine aggregate of Zone II grading locally available river sand and coarse aggregate obtained through crushed sand stone rock. The coarse aggregate of size 20 mm and 10 mm down was used in normal strength concrete where as in high strength concrete 10 mm down aggregate was used.

For compression and tension reinforcement in beam specimens, 12 mm steel bars of yield strength 500MPa and for stirrups 8 mm mild steel bars were used (Fig 1). Water used for the purpose of casting and curing of specimen was tap water which was free from injurious amount of deleterious material as per IS 456 specification. The super plasticizer of third generation carboxylic ether based Glenium-51 made by BSAF which confirm to IS: 9130-1999 was used. The colour of super plasticizer was dark brown and specific gravity was 1.18.

For measuring the temperature profile at different locations in the concrete and on reinforcing bars during fire exposure, thermocouples were fixed at different location as shown in the Fig 2. The type K chromal-alumal, stainless steel sheathed thermocouples were used.

Experimental Works:

a) Strength Tests on Unexposed Concrete Beams:

To study the flexural behavior of NSC and HSC beams, beams were tested in two points loading as shown in the Fig 1. The observations were made for the first cracking load, ultimate load, and load at permissible deflections.

b) Fire Tests on Beams:

The fire resistance tests on NSC and HSC beams were carried out at CSIR-CBRI using floor furnace. The furnace has long flame burners and uses kerosene oil as fuel. The furnace chamber was equipped with five thermocouples to monitor the furnace temperature during fire exposure.

The experimental setup as shown in Fig 3 accommodates one beam at a time. During fire exposure the beam specimen was placed on the floor furnace in a manner that the three faces of the beam were exposed to standard heating conditions. The beams were of 2.55 m span and 2.40 m of the beam length was exposed to fire.

All the beams were tested under two point loads applied at 0.8 m from the end supports. For all beams a constant load of 15kN was applied at each point in two points loading under simply supported end conditions by using a mechanical jack.

The load was applied 30 minute before the fire exposure and was maintained until a condition was reached at which no further deflection of the beam was measured. This was selected as the initial condition for the deflection of the beam. To find out the fire response of NSC and HSC beams, the beams were exposed to ISO 834 standard fire exposure curve as shown in Fig 4. The load was maintained constant throughout the fire exposure. The beams were exposed to standard heating conditions till it failed with respect to deflection criteria i.e. when the deflection of beams reached to a value of 120 mm as per L/20 failure criteria.

Test Results:

a) Structural Response of Unexposed Beams:

The load deflection curves for the unexposed normal strength and high strength concrete beams are plotted in Fig 5 and Fig 6. The first cracking load for the NSC beam was found out to be as 27kN. The load at permissible deflection i.e. 9.6 mm (L/250) according to IS 456:2000 for NSC beam was 78kN and ultimate load was 90kN. The HSC beam shows the similar trend as found in the NSC beams with minor differences. The first cracking load for HSC beam was found to be 45.5kN. However the loads at permissible deflection were found to be 126.9kN and the load at failure was 147kN.

The NSC beam failed in flexure and the cracks developed at ultimate loads for beams were found to be purely flexural, as shown in Fig 7. In regard of the cracks developed in the HSC beams showed clear and visible flexural cracks which appeared at the soffit and then propagate to the top of the beam, as shown in Fig 8.

b) Thermal Response of Fire Exposed Beams:

I. Visual Observation:

The visual observations of fire damaged NSC and HSC beams shows that the surface of concrete turned to buff for both the beams as shown in the Fig 9 and Fig 10, which indicates that the maximum temperature at surface of beams was in the range of 900-1000^{0}C. Cracks at all the three exposed faces of the beams were observed after fire exposure. Cracks in NSC beam were evenly spaced flexural cracks propagating from bottom to top surface. Width of cracks is also same for NSC beam. Cracks in HSC beam are also flexural but not evenly spaced and also have varying widths. Cracks in HSC beam are wider in comparison to NSC beam.

II. Temperature Distribution:

The temperature attained at steel and concrete is critical for the assessment of the loss in strength of steel and concrete after fire exposure. The temperature distribution at different locations in NSC and HSC beams was recorded during the standard fire exposure.

- **Reinforcement Temperature:**

The time-temperature curve for the reinforcing bars in NSC beam is plotted in Fig 11. It is clear from the Fig 11 that there no significant difference in the temperature on the reinforcement at T1 and T2 up to first ten minutes of fire exposure. After 30 minutes of fire exposure the temperature was about 140 °C at each location. However with further increase in duration of fire exposure the temperature difference between locations T1 and T2 was higher. It continued during the heating period of 130 minute when the furnace temperature was 1030^{0}C. The maximum temperature attained at locations T1 and T2 after standard fire exposure of 130 minutes was 620^{0}C and 585^{0}C respectively.

The temperature variation with time at rebar location T1 and T2 in HSC beam is plotted in the Fig 12. The temperature at location T1 was observed to be higher as compared to T2 just

after the standard fire exposure increases. The difference between the temperatures at two locations kept increasing with fire exposure, the maximum temperature of 570 °C and 509 °C was attained after 100 minutes of standard fire exposure at T1 and T2 respectively

• **Concrete Temperature:**

During the fire exposure in NSC beam temperature plateau was observed at around 100 °C at T3 after 20 minutes of fire exposure as shown in Fig 13. This temperature plateau can be attributed to the evaporation of water in concrete which significantly consumed the latent heat for vaporization. Further at location T4 temperature plateau was observed at 100 °C after 30 minutes of start of fire exposure.

Fig 13 signifies that the measured temperature in concrete decreased with the increasing distance from the soffit owing to the inherent thermal property of low thermal conductivity and high thermal capacity of normal strength concrete which slowed down the heat penetration to the concrete inner layers. The temperature at T3 and T4 locations were 555 and 479 °C in NSC beam after 130 minutes of fire exposure.

The concrete temperature in the HSC beam was observed as shown in the Fig 14. With the increase in time, the temperature difference between locations T3 to T4 increased.

c) Structural Response:

The measured mid-span deflections for the two tested beams (NSC and HSC) are shown in Fig 15 as a function of fire exposure time. It can be seen that for both the beams the mid-span deflection gradually increases with time at early stages of fire exposure as a result of the deterioration of strength and stiffness properties of concrete and reinforcing steel with temperature. The deflections for both beams were similar at the beginning of the fire test. The initial deformation of the beams results mainly from thermal gradients developed within the beams cross section and also due to the applied loading. These beams experienced very high temperature in concrete and steel prior to failure resulting in high stress levels.

The effect of concrete strength on the fire response of RC beams can be studied by comparing the time-deflection curves of beams NSC-F and HSC-F as shown in Fig 15. It can be seen that after 30 minutes of fire exposure the mid-span deflection of HSC beam is higher than the NSC beam throughout the range of standard fire exposure. The higher deflection in HSC beam resulted from the higher rebar temperature also due to the faster degradation of strength and stiffness of HSC at elevated temperatures. The larger deflection led to early failure of the HSC beam resulting in lower fire resistance. The failure in HSC beam was of more brittle nature as compared to that of NSC beam.

The lack of spalling in HSC beam can be attributed to the cracking in the tension zone of the beam due to the applied loading. Cracking enhances permeability and facilitates the escape of steam and thus reduces the build-up of pore pressure under fire conditions.

Comparative Performance:

a) Comparison of Temperature Distribution in NSC & HSC Beam:

The data presented in the Fig 16 shows the comparison of temperature variation on reinforcement in NSC and HSC beam at location T1. Just after start of fire exposure the temperature at location T1 on reinforcement increased in both the beams. It was higher in HSC beams as compared to NSC beams after 30 minutes of fire exposure. This can be attributed to the fact that at this location the damage in the HSC concrete is more and hence the heat penetration is more as compared to NSC.

The temperature at location T2 increases in both, NSC and HSC beams during the standard fire heating during first 30 minutes of fire exposure as shown in the Fig 17. NSC

The temperature measured in the core of concrete in HSC beam was higher than NSC

beam at location T3 as shown in Fig 18. The temperature kept on increasing and in a range of 100-150°C for both beams a peak in temperature was observed in both type of concretes owing to vapour generation and movement. Further with increase in temperature, accumulation of pore water and temperature in NSC beams increases however the temperature in NSC beams was lower as compared to HSC beams.

From the Fig 19, it had been observed that the temperature in HSC and NSC beam was same up to 30 minutes of fire exposure at T4 location. However with further increase in time around 40 minutes, the temperature in NSC beam at this location was observed higher than HSC beams. This can be explained on the basis of generation of pore water pressure and increased temperature of pore water vapours inside the NSC beams. Further with escape of vapours from the cracks formed on the top surface of beams the temperature again decreases and the temperature of both beams became same till end of fire exposure duration.

b) Fire Resistance:

The time to reach failure is defined as the fire resistance for the beam and failure is said to occur when any one of the following reached i.e. a deflection of L/20 or rate of deflection of beam reaches to its limit $L^2/9000d$ only after the deflection of L/30. Both beams, exposed to ISO 834 standard fire, attained failure with respect to rate of deflection.

The HSC beam failed in 76 minutes with respect to rate of deflection however a deflection of 120mm reached after about 104 minutes. At the time of failure i.e. 76 min the maximum temperature on the corner reinforcing bar was about 456^{0}C and on the bar at the centre of beam was 393^{0}C. However at a deflection of 120mm these temperatures were 574^{0}C and 509^{0}C respectively.

While in case of NSC beam, it failed in 114 minutes with respect to rate of deflection and after about 125 minutes of standard fire exposure a deflection of 120mm was achieved. At the time of failure the temperature on the corner bar was 556^{0}C and on the bar at the centre it was 526^{0}C. While when a deflection of 120 mm was achieved after 125 minutes these temperatures were 600^{0}C and 566^{0}C respectively.

The effect of concrete strength on the fire resistance of RC beams can be illustrated by comparing the fire resistance of HSC and NSC beams. The fire resistance of HSC beam was 76 minutes. It was found to be lower than that of NSC beam for which it was 114 minutes. This can be mainly attributed to the faster degradation of strength properties of HSC.

Conclusions:

In present study, fire performance of reinforced concrete (RC) beams exposed to standard fire exposure has been studied through experimental work. Deflection at mid-span of beams during fire exposure was measured using Linear Variable Displacement Transducers (LVDTs) installed at different locations. Temperatures at different locations in concrete beams were also measured.

The load deflection studies were carried out for normal strength (NSC) and high strength (HSC) concrete beams without fire exposure. The observations were made for first cracking load, ultimate load and strains in beams. The following observations were made:

i. The first cracking load for NSC was found to be 27kN and for HSC beam it was found to be at 35kN and 45.5kN.

ii. An ultimate load of 90kN was observed for the NSC beam and for HSC beams it was 147kN.

The normal and high strength concrete beams were exposed to standard heating conditions. During the entire period of fire exposure temperatures were measured at reinforcement and at different depths in concrete core:

i. The temperatures at all locations in the high strength concrete (HSC) beam are higher as

compared to normal strength concrete (NSC) beam during entire period of standard fire exposure.

ii. The retention range of the normal strength concrete beam at around 100°C is longer than for high strength concrete beam at all the locations. This may be due to the fact that NSC beam suffered less damage/cracks as compared to HSC beam.

iii. The temperature at corner reinforcement for NSC and HSC beams was 556°C and 456°C respectively at the time of failure. While at mid bar it was 526°C and 393°C for NSC and HSC beam respectively.

iv. When a deflection of 120mm i.e. L/20 is achieved the temperature at corner reinforcement for NSC and HSC beams was 600°C and 574°C respectively, while at mid bar it was 566°C and 509°C for NSC and HSC beam respectively.

v. At the end of fire exposure it was observed that the cracking in the tensile Zone was more for HSC beam. Cracking of concrete in the tensile zone has significant effect on the ultimate temperature on reinforcement in beams.

vi. Fire resistance rating for NSC and HSC simply supported beam under two point loading of 15kN each was determined experimentally and it was found to be 114 minutes and 76 minutes respectively. Thus the strength of concrete has an influence on the fire resistance of RC beams.

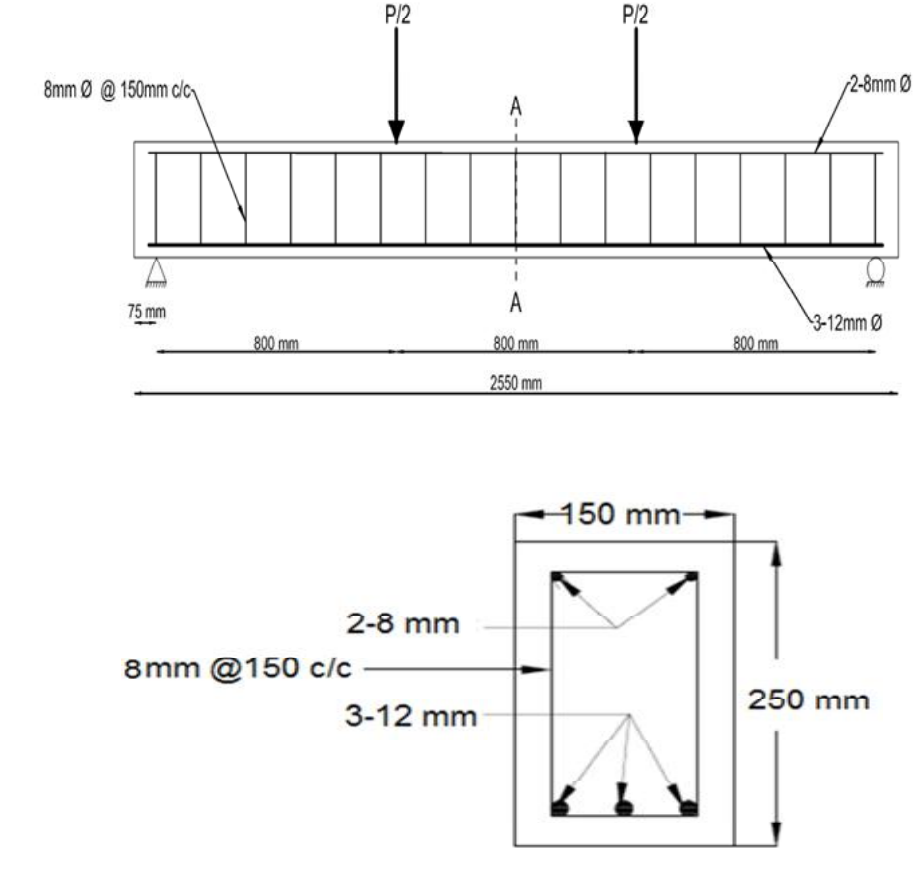


Fig 1: Details of Beam Reinforcement

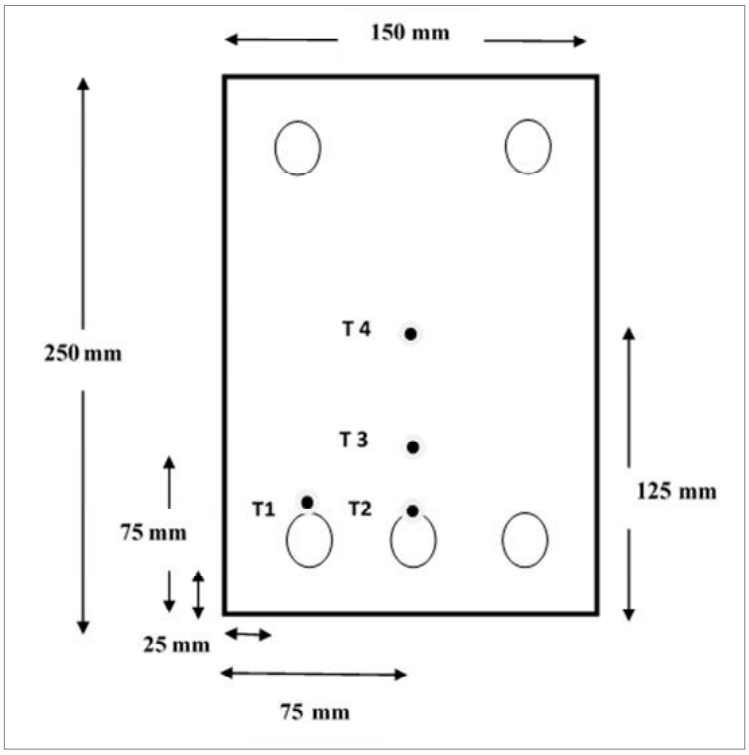


Fig 2: Position of Thermocouples Installed in the Beam Specimen

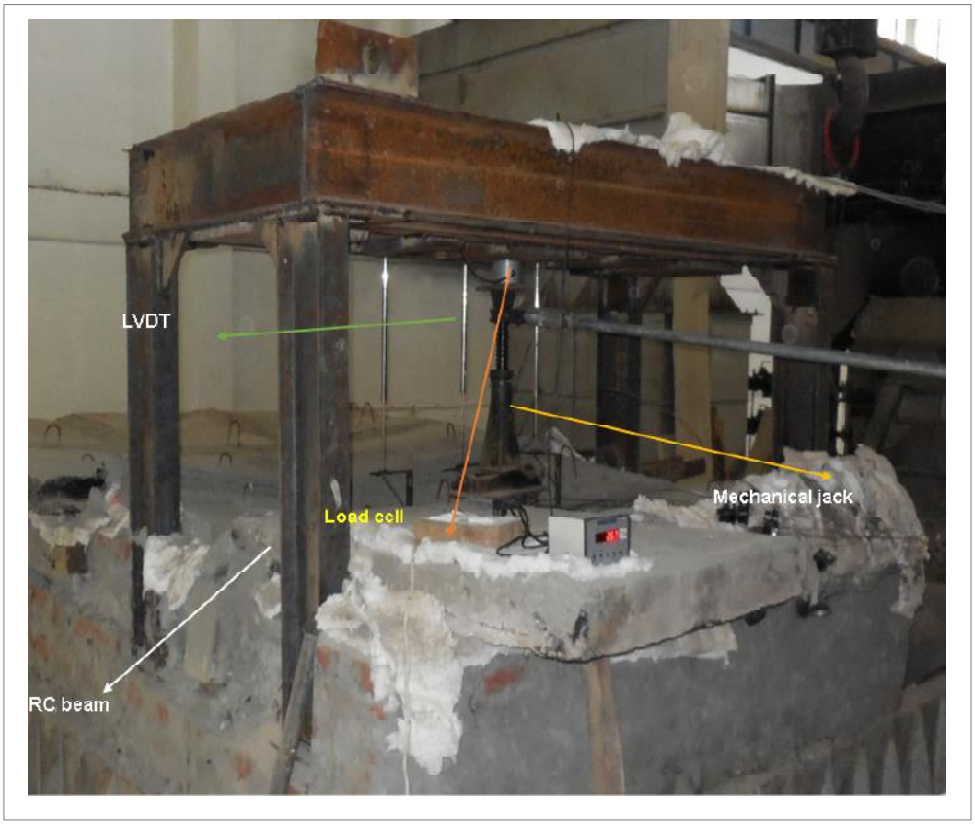


Fig 3: View of Test Set-up

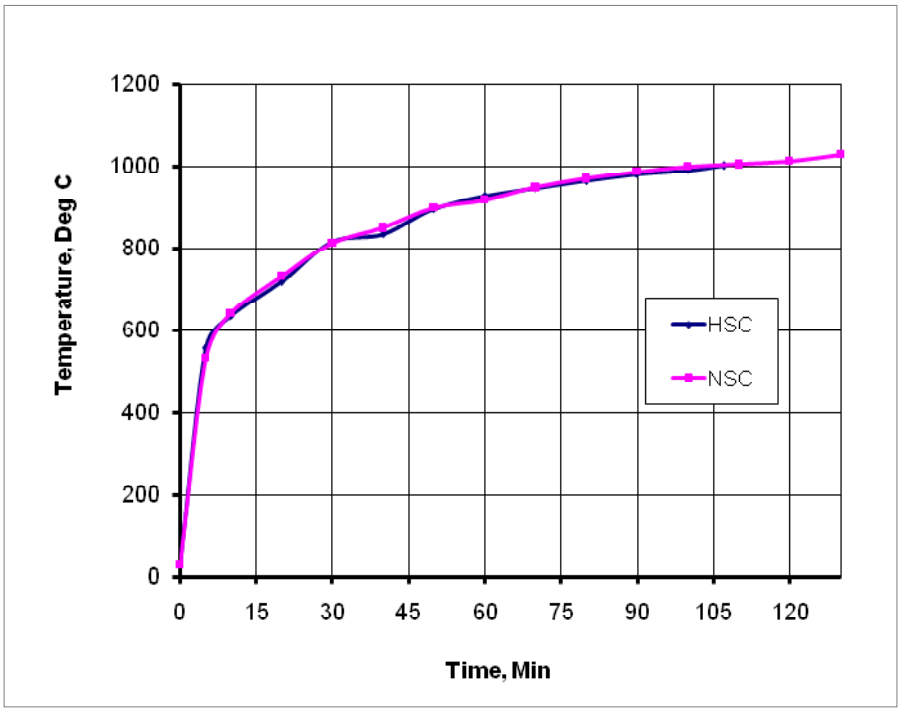


Fig 4: Furnace & Standard Fire ISO 834

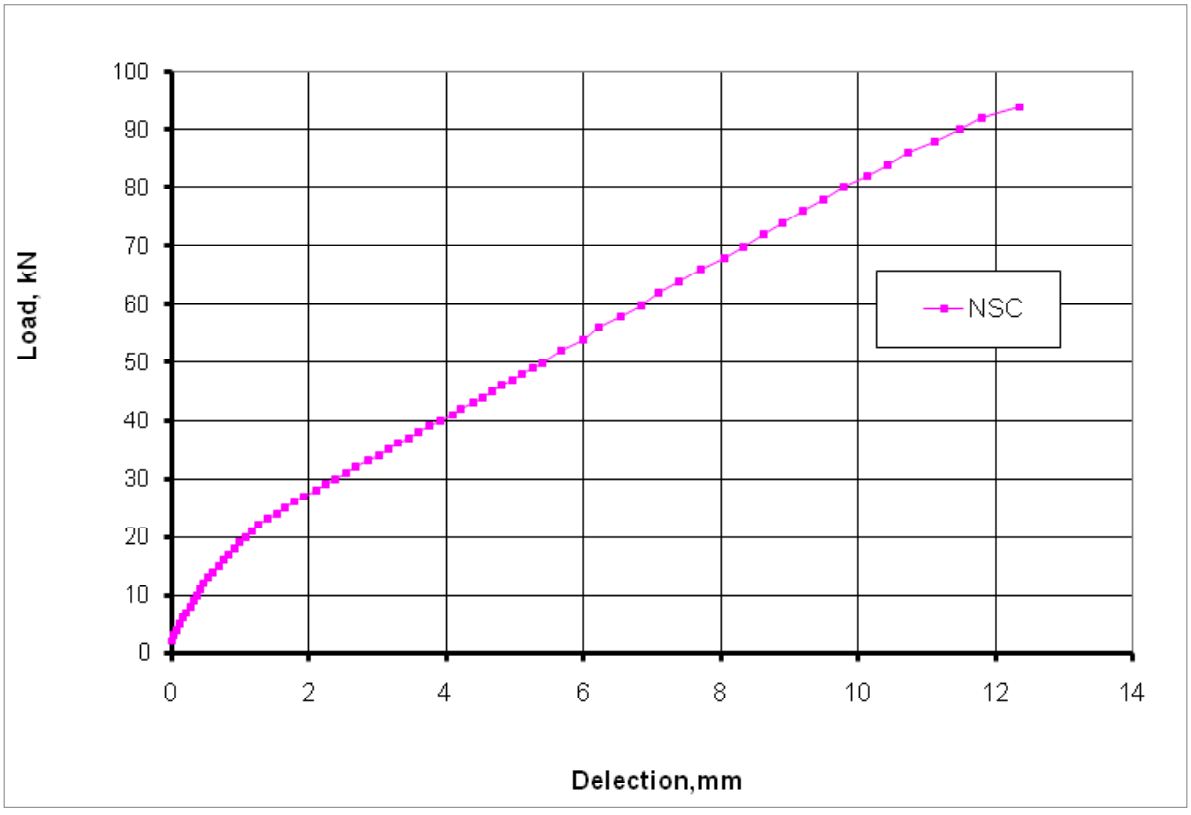


Fig 5: Load Deflection Curves of NSC Beam

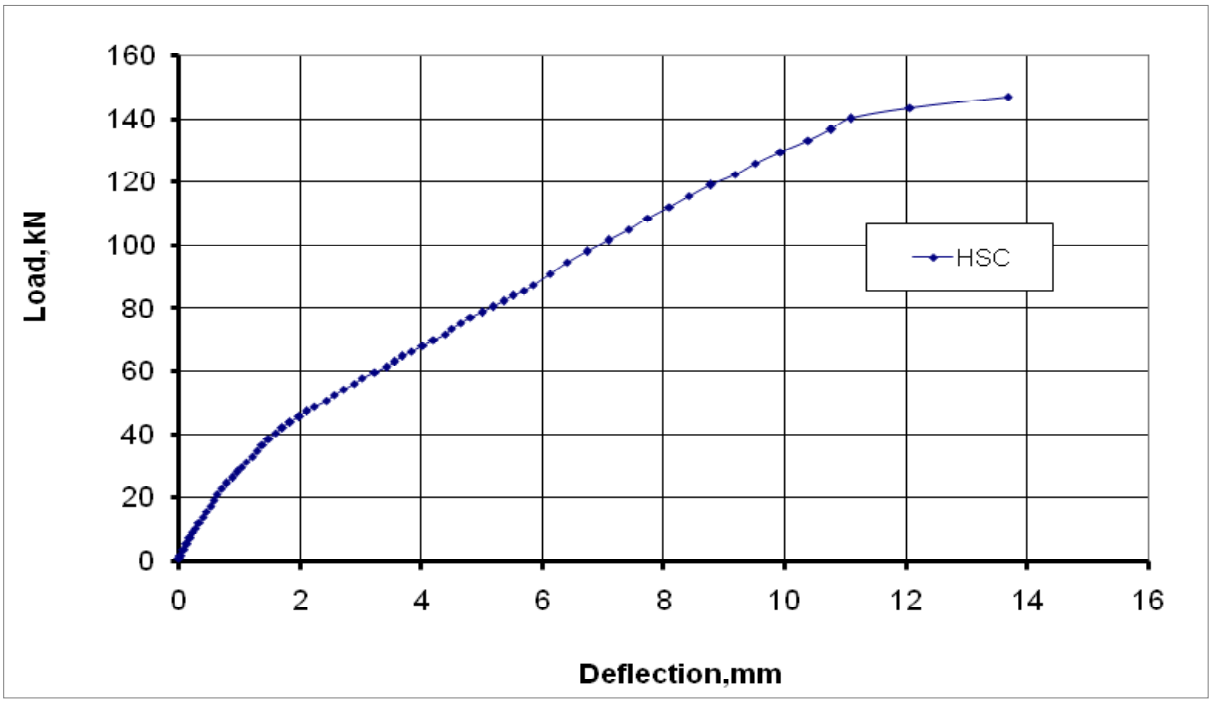


Fig 6: Load Deflection Curves of HSC Beam

Fig 7: Cracks in NSC-1 Beam

Fig 8: Cracks in HSC-1 Beam

Fig 9: Bottom View of NSC Beam NSC

Fig 10: Bottom View of HSC Beam

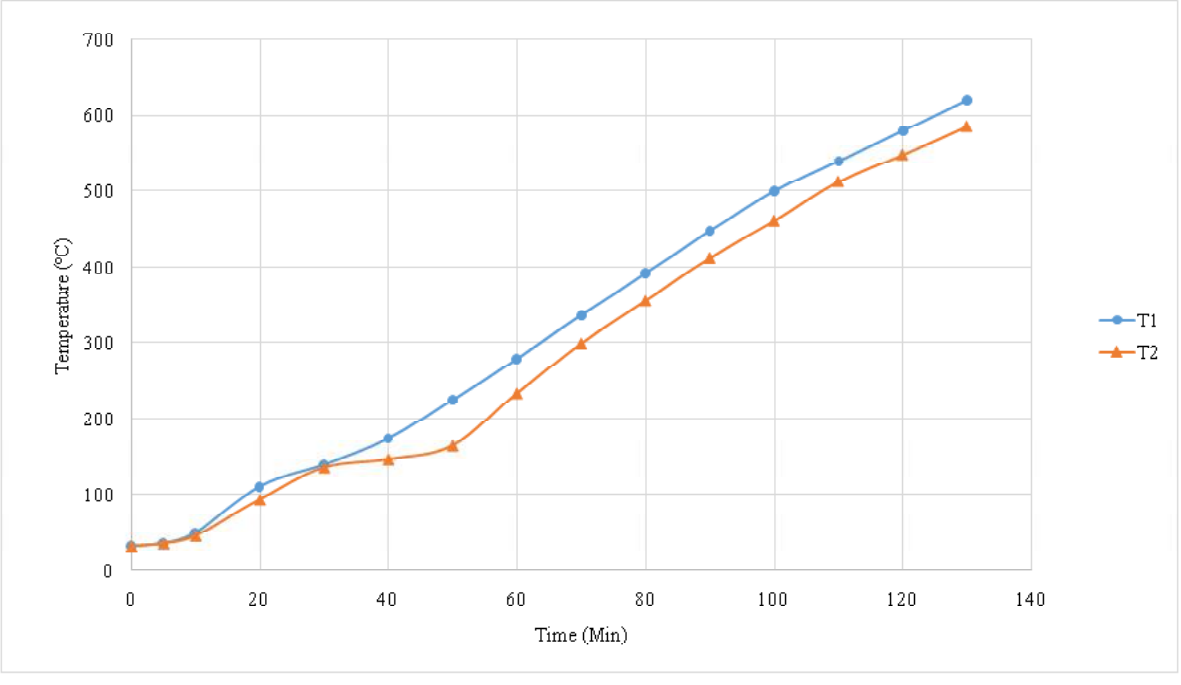


Fig 11: Temperature Profile in Rebar of Beam NSC

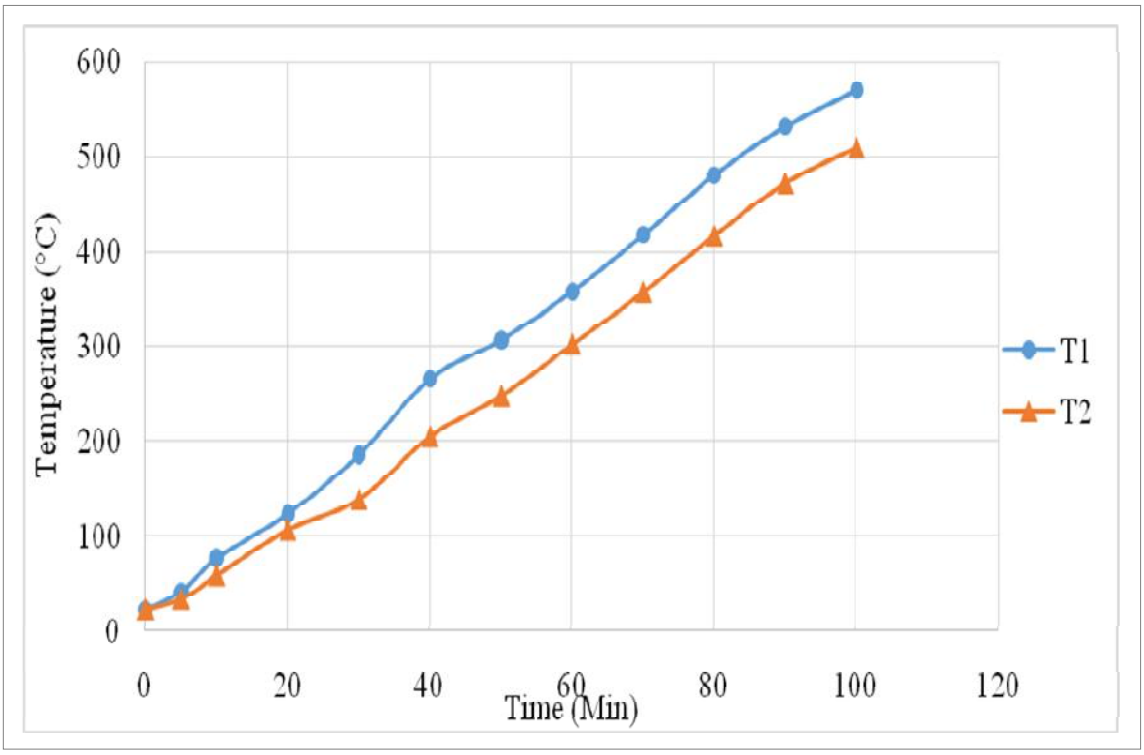


Fig 12: Temperature Profile in Rebar of Beam HSC

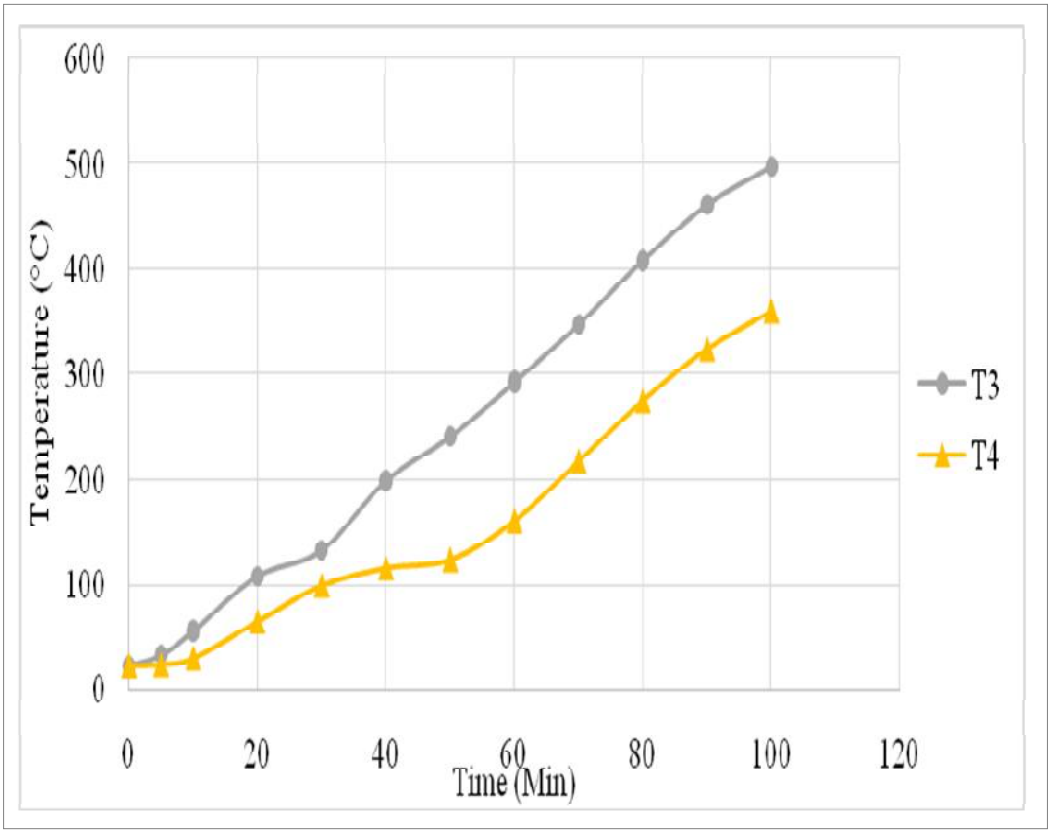


Fig 13: Temperature Profile in NSC Beam

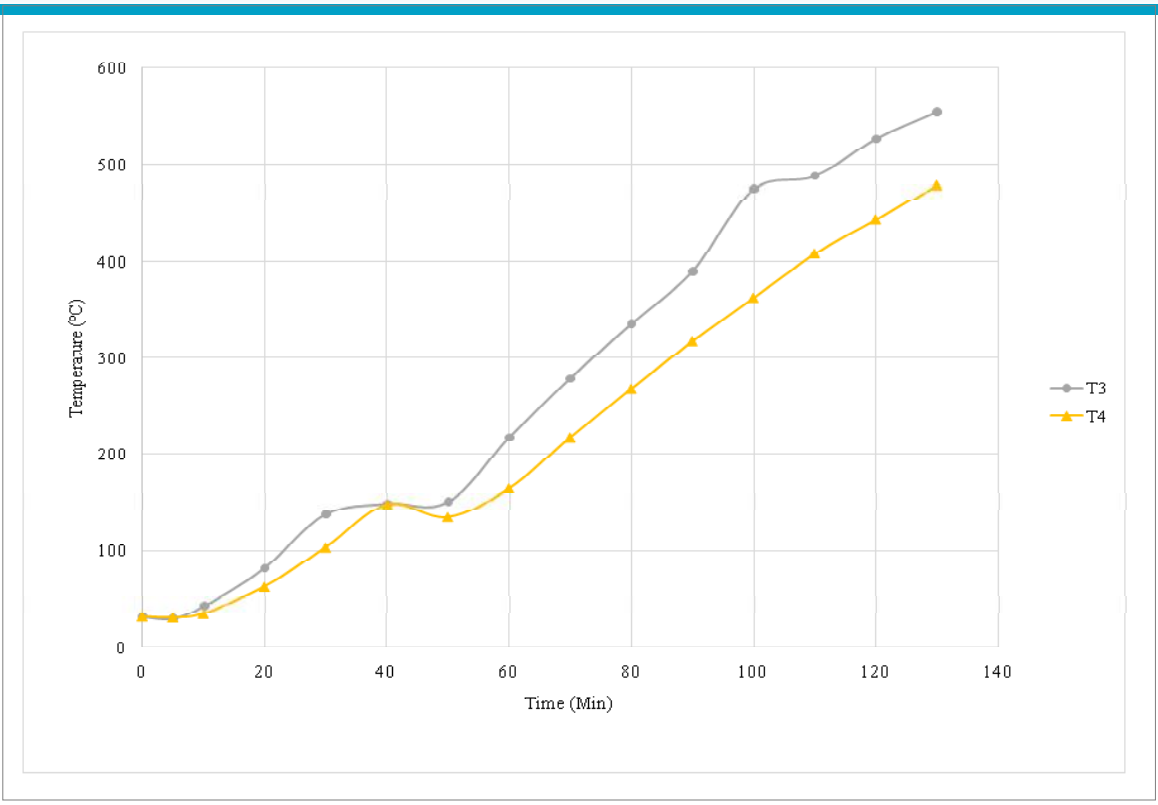


Fig 14: Temperature Profile in HSC Beam

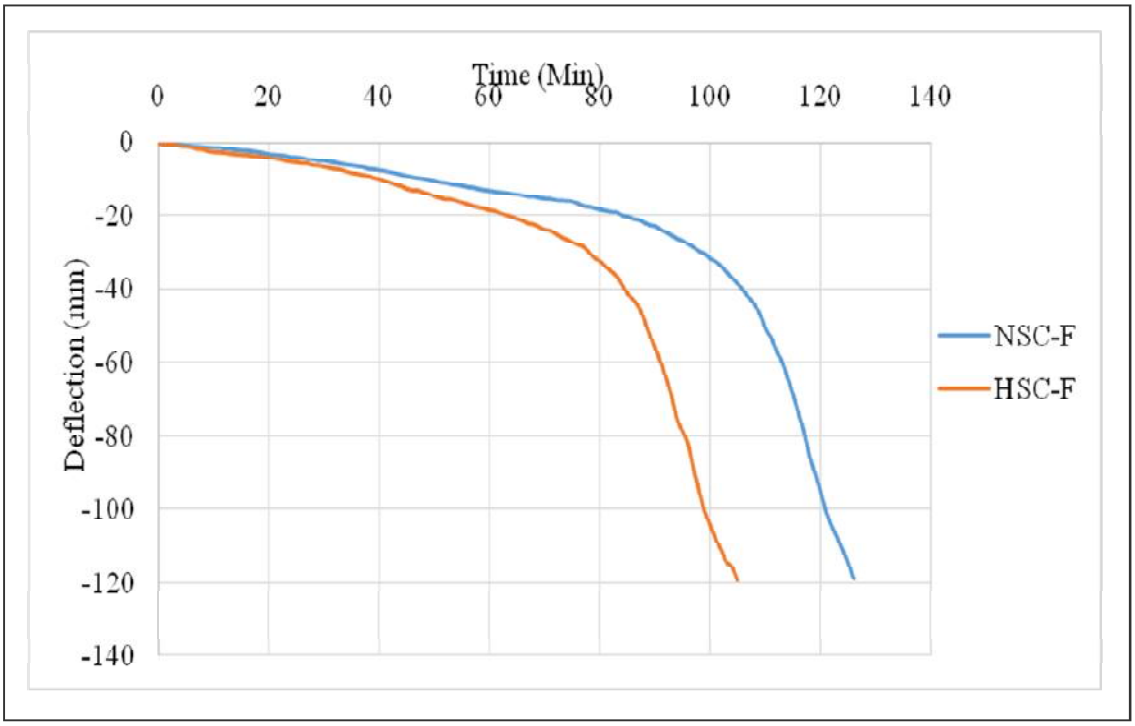


Fig 15: Time-Deflection Curve of HSC-F & NSC-F Beams

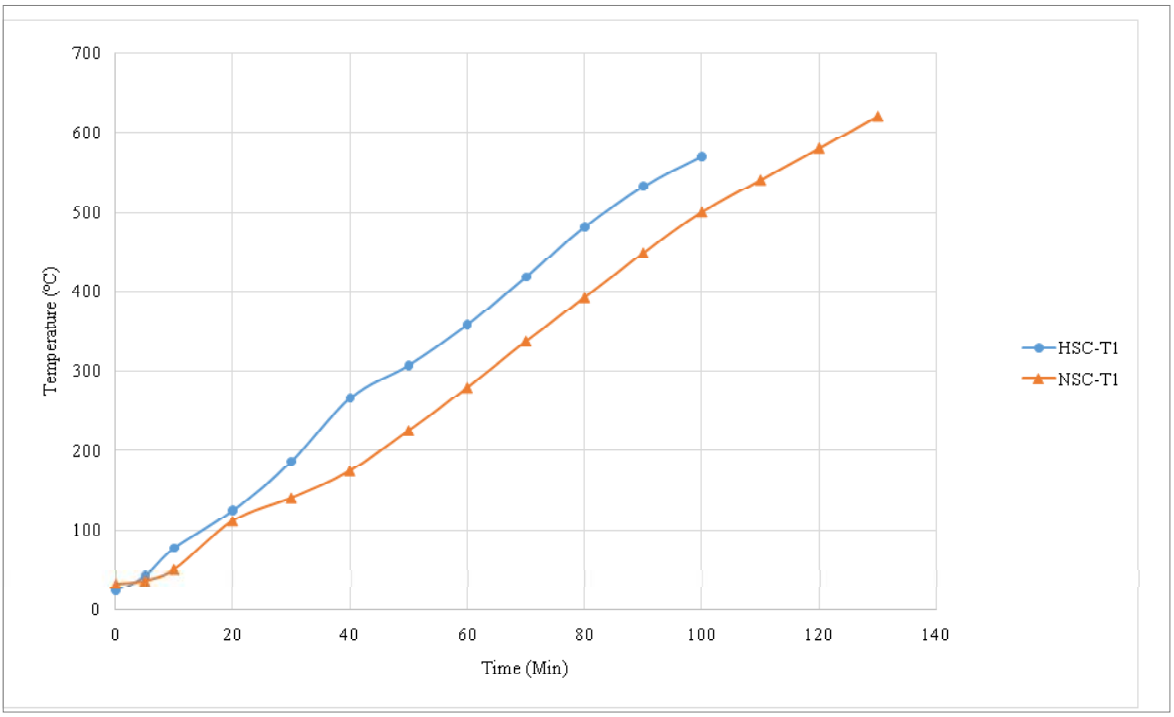


Fig 16: Comparison of Temperature in HSC & NSC Beams at Location T1

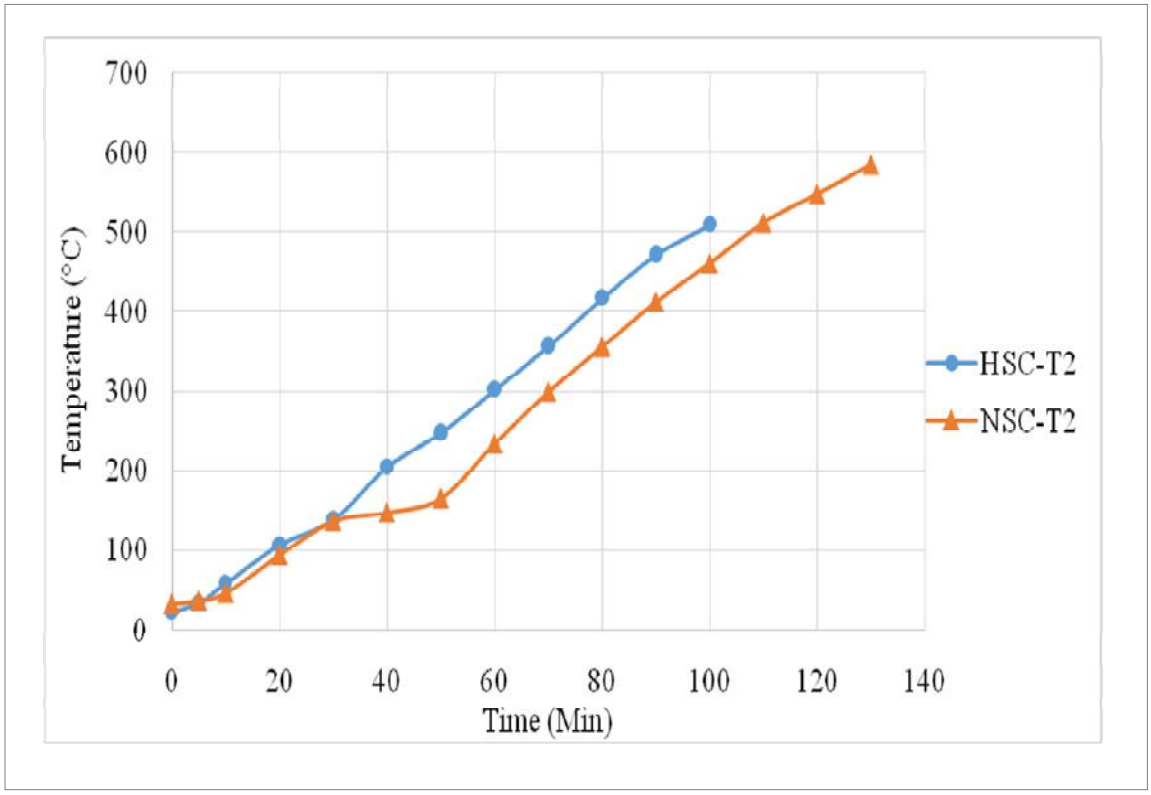


Fig 17: Comparison of Temperature in HSC & NSC Beams at Location T2

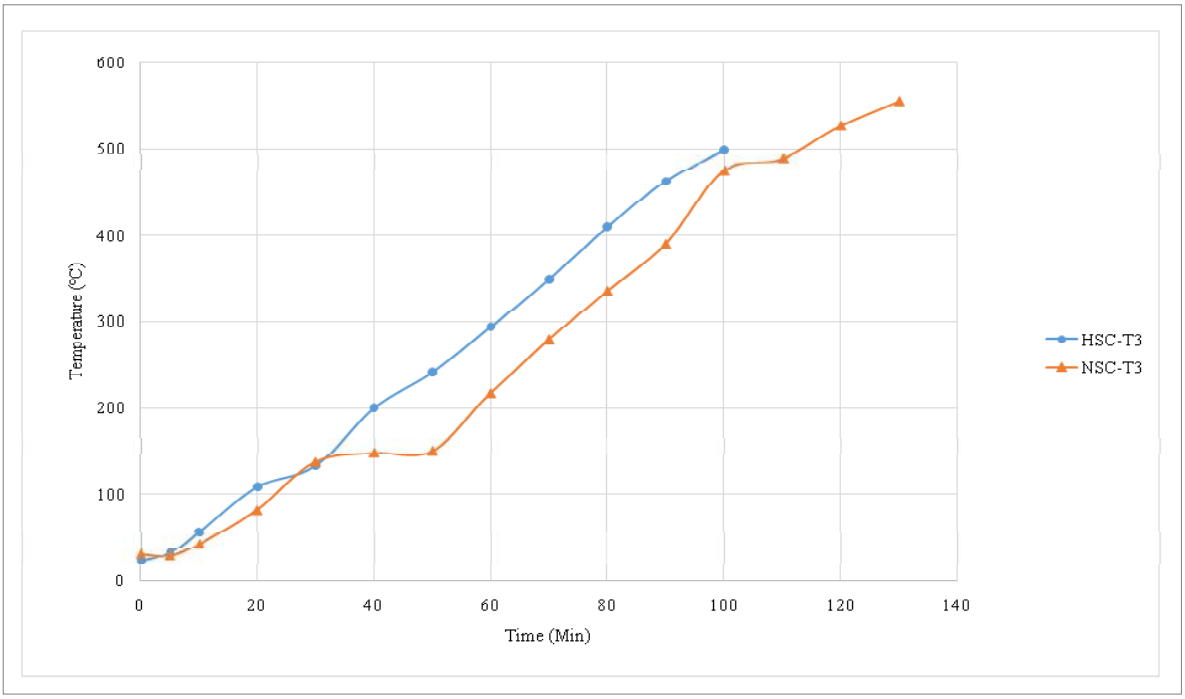


Fig 18: Comparison of Temperatures in HSC & NSC Beams at Location T3

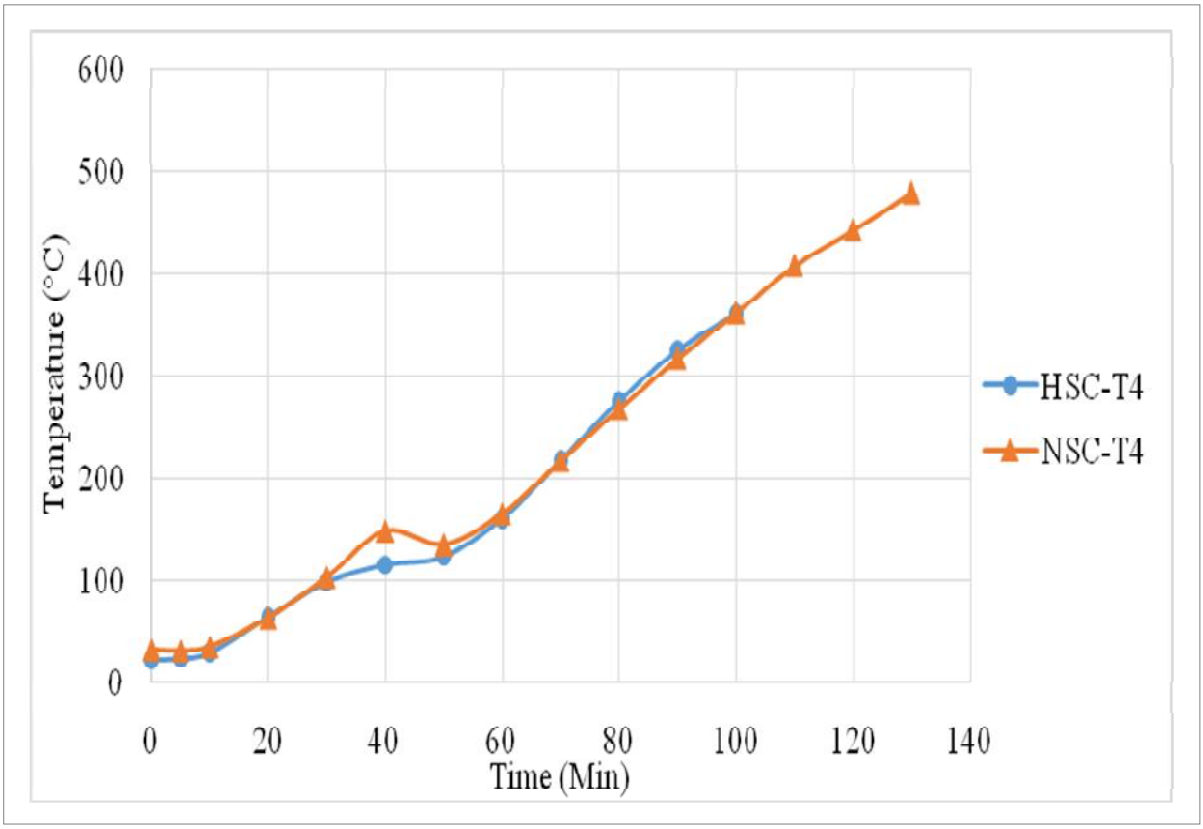


Fig 19: Comparison of Temperatures in HSC & NSC Beams at Location T4

WP-4 Post Disaster Shelter Planning

S. K. Negi

Post Disaster Shelter Planning for Rural Areas in Western Himalayan Region

S. K. Negi

Objective:

To develop a technology package for Disaster Resistant Transit Shelters for Western Himalayan Region.

Envisaged Deliverables:

- Prototype Development and its validation of Transit Shelters.
- Field Demonstration of Prototype designs of Transit Shelters.
- Detailed Project Report.

Design:

These hazards can be minimized by using modern scientific and technological advancements. During all these disasters millions of people, became homeless for months together and spent days in some high land or other places in a very adverse situations. These situations further causes post disaster diseases. It is of therefore immense importance to design and develop 'Transit Shelter' which can be readily usable during the disasters without hampering the social streamlines and provide better environment to the disaster victims.

As the frequency of natural disasters is rising every year & so challenges are rising every day. For any particular disaster affected site every single day is a potential fight against nature for the victims. So the foremost objective of the reconstruction process should be the provision of optimum living comfort to the people & eventually the shelter become the physical product of the reconstruction process.

One prototype design options of Foldable Portal frame (Aluminum) shelter of the portal frame for a family of five to six members is developed. The size of one portal frame is 2100mm and four such frame are joined together to form a frame which can be folded from the joints. Three foldable frames are used in one shelter to form the skeleton of the shelter. The use of aluminum in the frame makes it light weight as well as durable.

Detail of the prototype Foldable Portal Frame shelter:

- The shape & geometry i.e. detail working drawing of mechanical & architectural as per the fabricators requirement.
- Cladding – Pre-coated corrugated aluminium sheet for roofing/walling.
- Weight of structural system = 80 - 90 kg. Approx.
- Weight of one portal frame = 16 –18 kg. Approx.
- Floor Area = 16 - 23 sq. m.

At present works are going on assembly, knock down and packaging of the Prototype designs of Transit Shelters, so that its transportation and assembly becomes easy at the remote and adverse situations.

WP-5 Health Monitoring of Buildings using Wireless Sensor Network

Ajay Chourasia

Implementation of Health Monitoring Approach using Wireless Sensor Network, Numerical Analysis & Model Updating on Real-Life Building

Ajay Chourasia & S.K. Panigrahi

Masonry in-filled RC buildings even designed to sustain lateral loading often undergo unanticipated failure during the seismic event. The major cause of the unexpected failure pattern is the unavailability of proper health monitoring measures. The conventional techniques such as visual inspection and non destructive tests require huge time and effort. Also this requires the vicinity and accessibility of damage is known at priori. This calls for an urgent need to facilitate real time structural assessment for early detection and diagnosis of cracks. This enhances serviceability and integrity of the structures resulting in reduced life cycle cost. Structural Health Monitoring (SHM) identifies damage by virtue of changes in the overall vibration response of the buildings. The change in modal parameters (natural frequency, mode shapes and modal damping coefficient) gives an indication of the possible damage.

The study presents the brief review on the state of the art signal processing techniques used in health monitoring of structures and proposes numerical algorithms to identify structural damages. The effect of variation in physical properties such as stiffness and mass on the structural response is also highlighted. Further, this research emphasizes on macro-model concepts of equivalent diagonal strut to consider the contribution of masonry infill as a structural element. The work simulates the behaviour of 6- storey scaled down RCC model with and without infill in SAP2000 v14 and compares it with experimentally obtained values. Comparative study of the seismic performance of masonry in-filled RC building with bare frame building is performed as per ATC-40. The structural behaviour of the intact and damaged masonry in-filled RC prototype model is investigated using two damage identification algorithms viz. Curvature Damage Factor (CDF) and wavelet based approach.

The dynamic properties of 1:3 scaled RC model is studied (Fig 1), for bare frame and with masonry infill along short direction panels at first floor level. The vibration response is recorded using wireless accelerometers and wired velocity sensors in real time under all three states namely, ambient, free and forced state. The external excitation has been provided with Long Stroke Shaker (LSS). The stiffness of the prototype model has been varied with the introduction of masonry infill in the second storey along the shorter span of the building. Progressive damage is induced in masonry infill to investigate the changes in dynamic response as a result of change in physical properties of the structure (Table 1). The recorded time histories are processed for Frequency Response Spectra (FRS) with Fast Fourier Transform (FFT) and mode shapes are obtained.

The behaviour of masonry in-filled RC frame building is simulated using macro-modelling approach in nonlinear analysis software SAP2000 V14. Infill panels are modelled as a single strut element with axial hinges. The effect of infill on dynamic

characteristics, yield patterns and seismic performance is studied with the help of nonlinear static analysis.

Further, the identification of damage in masonry infill using the CDF algorithm and the results i.e. curvature mode shape and CDF, for the different cases is presented in Fig 2 & Fig 3 respectively, while processing of the data using wavelet transform was performed using complex Gaussian and complex Frequency B-spline wavelets. Wavelet coefficient modulus obtained is maximum for the sensor close to the location of stiffness or mass variation. The results thus obtained are shown in Fig 4.

The study demonstrates that the wavelet based approach is more robust as compared to traditional CDF approach in detecting the change in mass or stiffness. Also the CDF approach requires knowledge of modal characteristics of structure in undamaged state which is not always available. Wavelet based approach is an output response based approach only and hence do not require any baseline data. Frequency B-spline wavelets proved to be more effective in detecting the highfrequency component added to signal due to abrupt variation of physical properties of structure. Also wavelet coefficient modulus was observed to increase with increase in damage.

The simulation results confirm that the inclusion of infill in the intact state increases the strength capacity, stiffness and reduces the drift demand. The damage in infill panels decreases in the stiffness of the structure. The pushover analysis results shows that hinges occur firstly in infill and then in beams and columns.

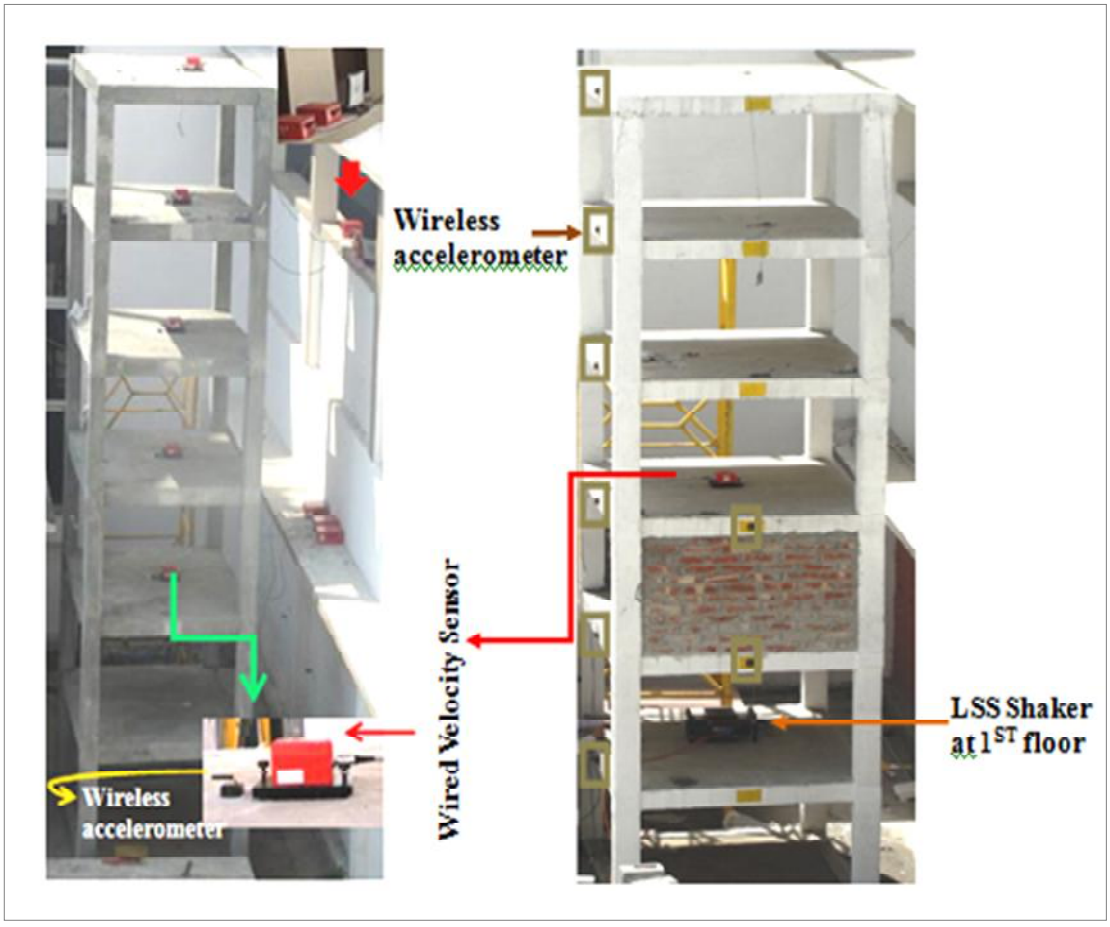
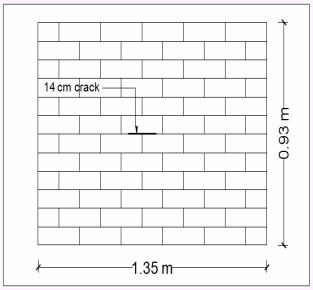
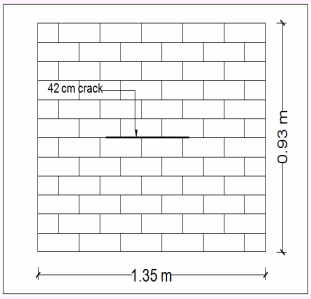
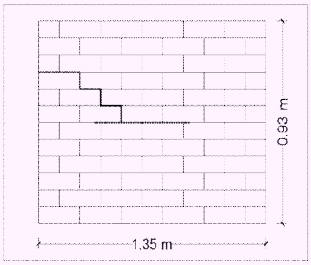
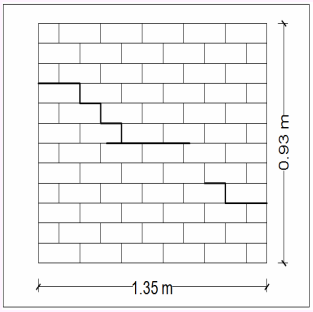
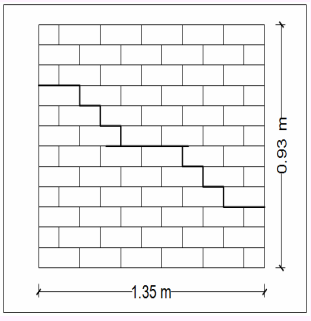


Fig 1: Health Monitoring of RC Model Building, with & without Masonry In-fill at Third Floor Level

Table 1: Progressive Damage Induced in Masonry In-fill of RC Model

Cases	Damage Description	Pictorial View
Damage Case 1	140mm long crack at near centre of the infill wall induced as the first stage of damage to observe the change in parameters	
Damage Case 2	140mm long crack at near centre of the infill wall induced as the first stage of damage further extended to the length of 420mm horizontally to observe the change in parameters	
Damage Case 3	420mm long crack at near centre of the infill wall further extended in steps left side upward till end of wall to observe the change in parameters in near real life scenario. The profile of crack/ damage is depicted in the picture here.	
Damage Case 4	420mcm long crack at near centre of the infill wall extended in steps left side upward till end of wall was supplemented with diagonal mirror like crack starting from right end of wall to observe the change in parameters in near real life scenario. The profile of crack/ damage is depicted in the picture here.	
Damage Case 5	420mm long crack at near centre of the infill wall extended in steps left side upward till end of wall and supplemented with diagonal mirror like crack starting from right end of wall extended till centre crack to observe the change in parameters in near real life scenario. The profile of crack/ damage is depicted in the picture here.	

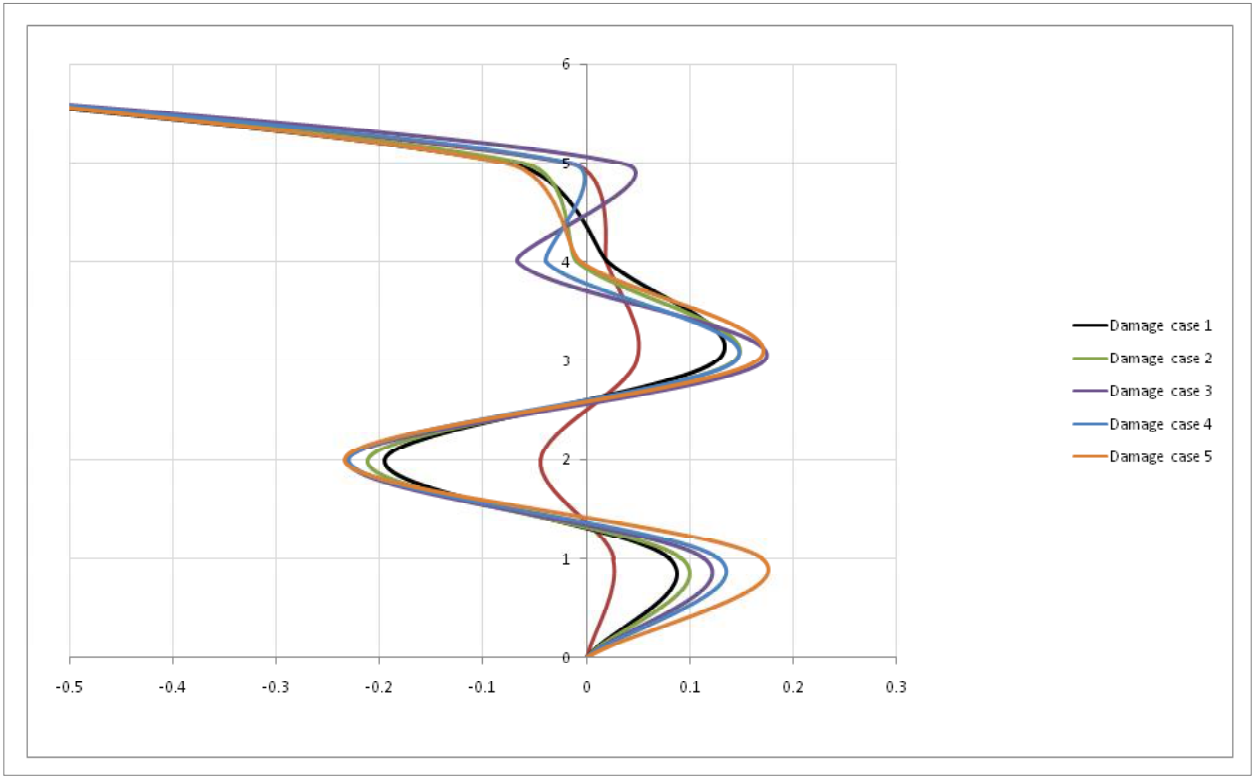


Fig 2: Comparison between Changes in Curvature of Mode Shapes of Masonry In-filled RC Building in Different Extent of Damage

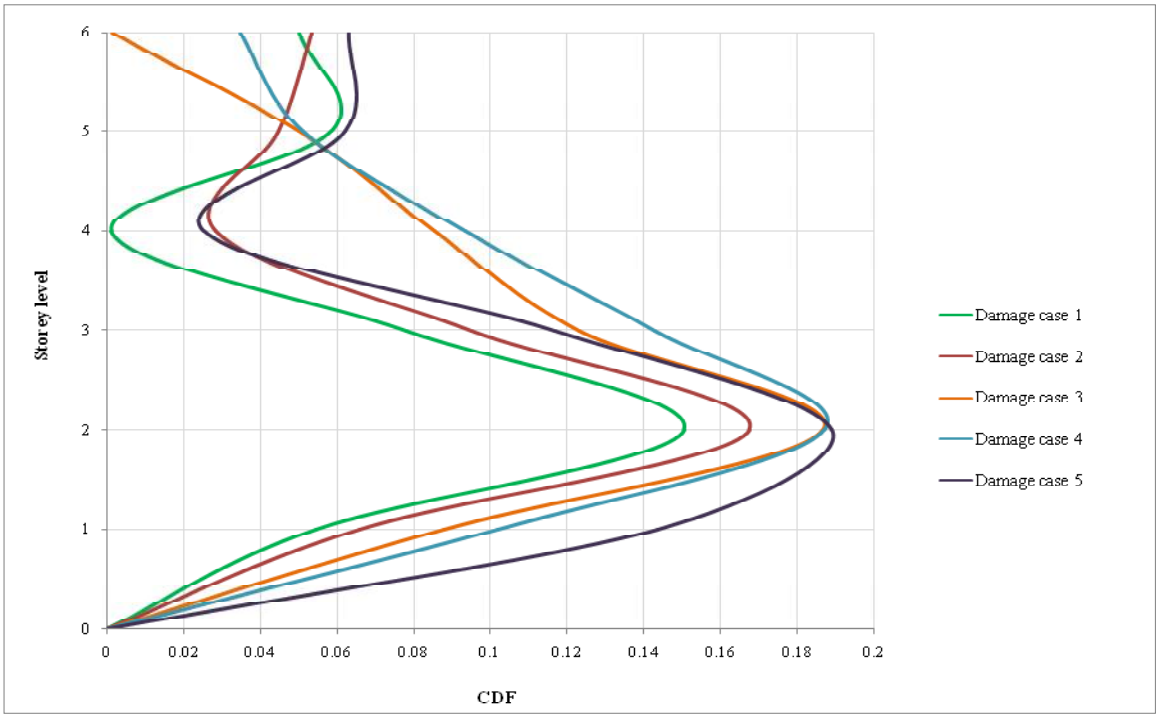
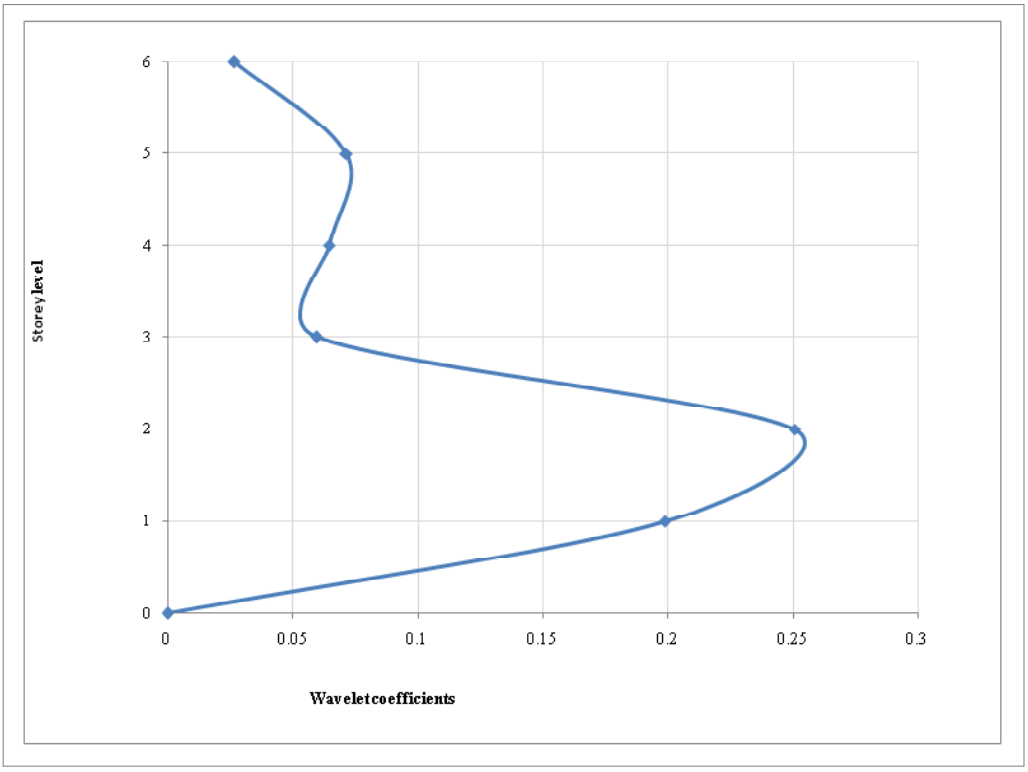


Fig 3: CDF Value of Masonry In-filled RC Frame in Different Extent of Damages



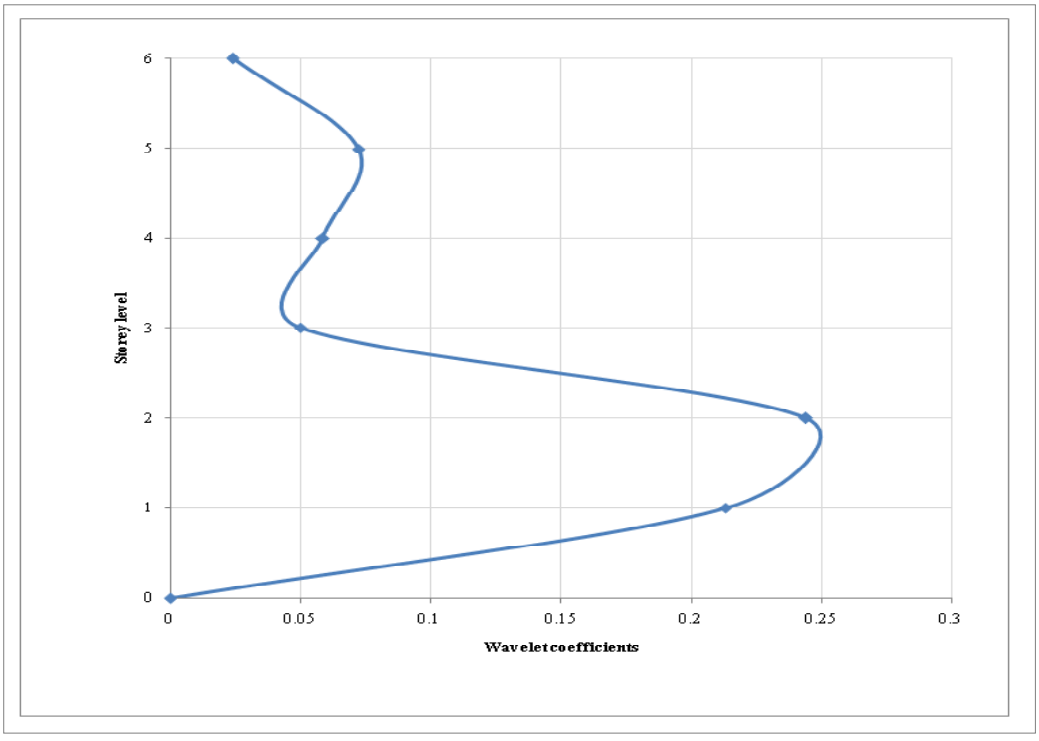


Fig 4: Wavelet Coefficient for RC Model: Damage Case-5

WP-6 Intelligent Building System for Model Residential Unit

R.S. Bisht & A.K. Mittal

Architectural Planning & Design of a Residential Unit Integrating Intelligent Building Features

Ashok Kumar & Team

The objective of the task is to develop a cost-effective and energy efficient intelligent residential unit. During the period, the following activities have been completed:

- Case study of an existing building Indira Paryavaran Bhawan located in New Delhi to identify the smart and energy efficient features.
- Drawings good for construction with electrical and intelligent features have been prepared and sent to estate department (Fig 1).
- The Brand / Make of the Intelligent Features has been finalized.
- Estimation for civil and electrical work along with tender documents has been completed.

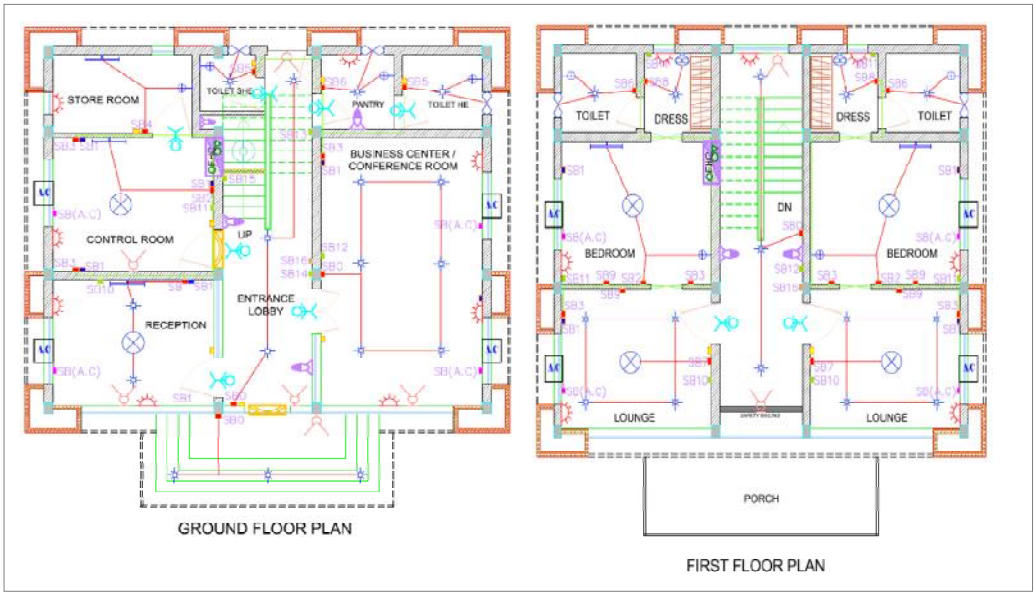


Fig 1: Ground & First Floor Plans of the Proposed Intelligent Building

All the activities related to construction have been completed including Notice Inviting Tender (NIT) and the construction is going to start shortly.

Intelligent HVAC & Lighting Controls in Response to Ambient Environment

S.J. Alexander, R.S. Bisht, Nagesh B Balam & Jogender Kumar

Objective:

To identify, develop and integrate the intelligent features into a model house making it a fully automated residential unit which is occupant friendly, safe, secure, eco-friendly as well as energy efficient.

Progress:

Performance Testing Various Occupancy Motion Sensors (PIR, Microwave & Ultrasonic):

The main objective of using occupancy sensor inside the building is to make it more energy efficient. Occupancy Sensors detect the presence of person occupying a room. Lights will be switched ON only when the space is occupied by any person otherwise lights will be automatically switched OFF.

Various occupancy sensors having different operating technology has been mounted on wall and ceiling for the testing purpose. Also, a test load has been made for testing the performance as shown in the following Fig 1.

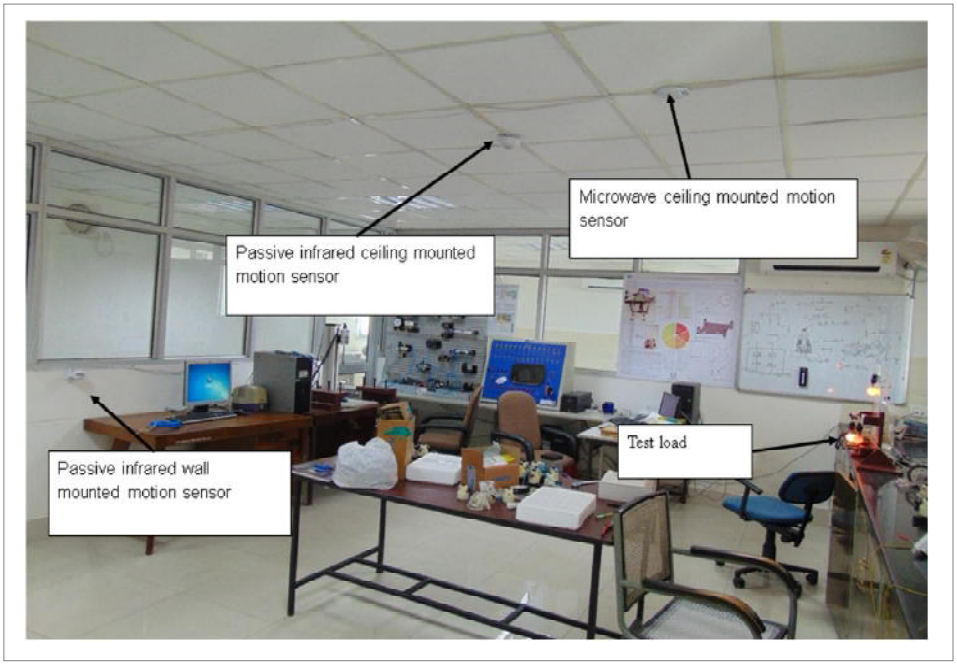


Fig1: Location of Occupancy Sensors along with Test Load

Test load has been connected with each sensor (PIR, Microwave and PIR + Microwave) for ensuring their false operation i.e. off condition inspite of the movement in the detecting area. We had tested the Numbers of unexpected (actuated to OFF while having movement in the detecting zone) and expected (actuated to OFF when no movement) actuations for different time settings and the result for each sensor has been shown below in Fig 2.

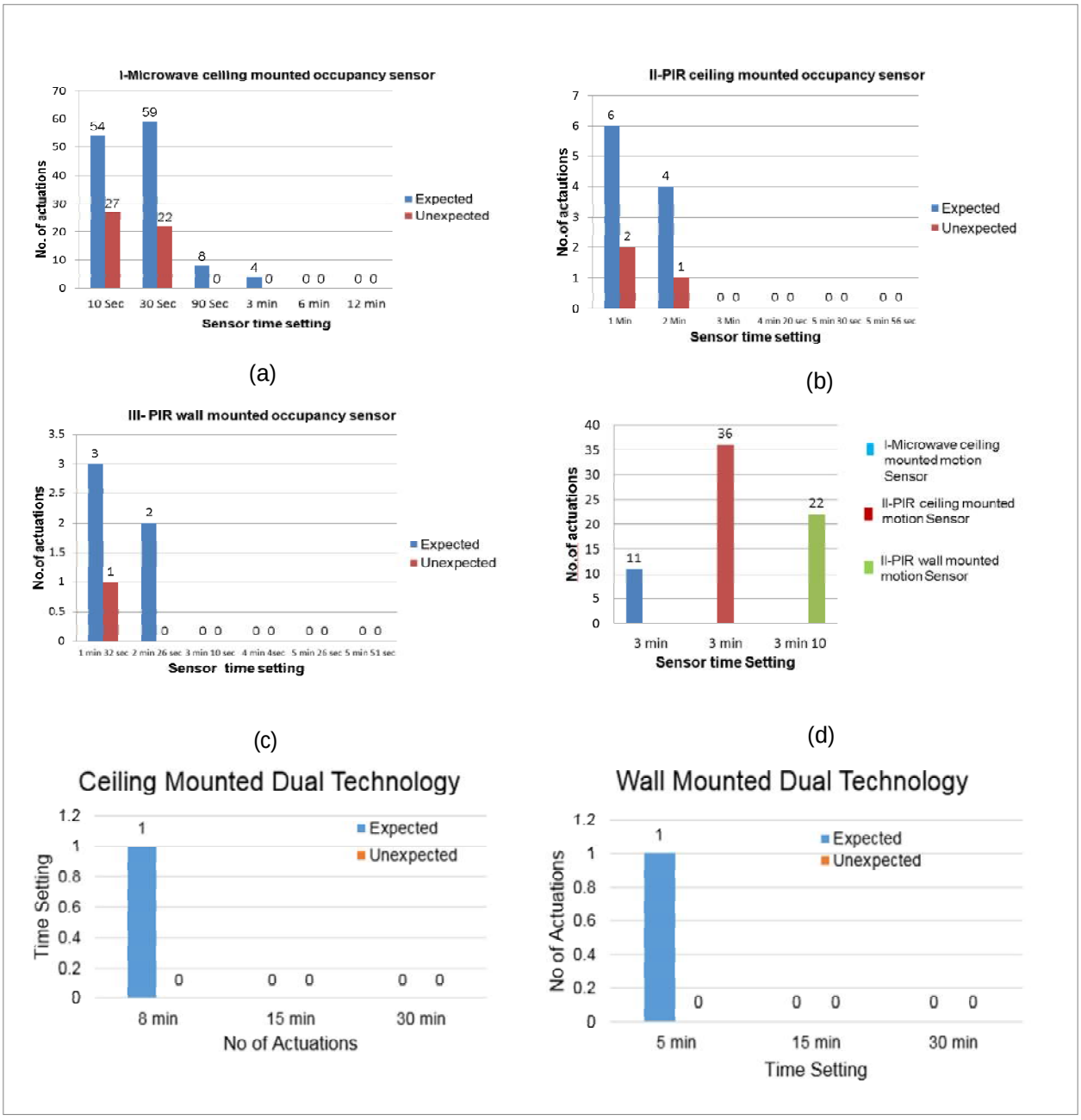


Fig 2: Sensor Time Setting vs. No. of Actuations for Various Occupancy Sensors

For an occupancy sensor there should not be any OFF operation while having movement in its zone with minimum time setting i.e. no. of unexpected actuations should be a minimum or zero with minimum time setting. Now, we concluded that the numbers of unexpected actuations are a minimum for the dual technology sensor. So we decided that this sensor (dual technology ceiling mounted) would work best in the area where the movement is not so frequent like in office and bed room. For corridor or the area of more movement we would use wall mounted PIR technology sensor with minimum time setting.

Glass Facade Cleaning Robot

Achal Mittal, R.S. Bisht, S.J. Alexander, Nagesh B. Balam, Sudhakar Jain & Jogender Kumar

Uniform Dirt Distribution & Dirt Detection Test for Sensor Development:

Experiments have been carried out to devise a methodology for detecting dirt using IR Photo diode (PD) and LED, to be incorporated within the cleaning mechanism of glass façade cleaning robot.

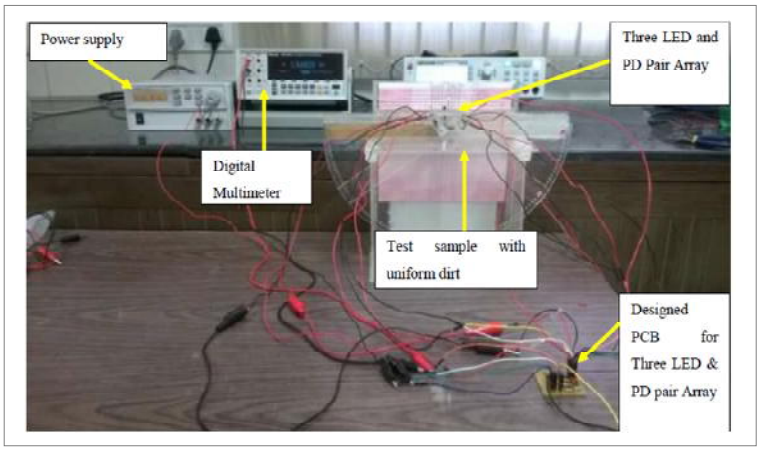
Uniform Dirt Distribution Test:

Experimental set-up using trapezoidal chamber with four small exhaust type fans powered by DC supply for dust circulation has been developed for the uniform dirt distribution over the glass samples. Fig 1 shows uniformly distributed dirt samples (glass) in ascending order for testing of dirt sensor made of three pairs of IR PD and LED.

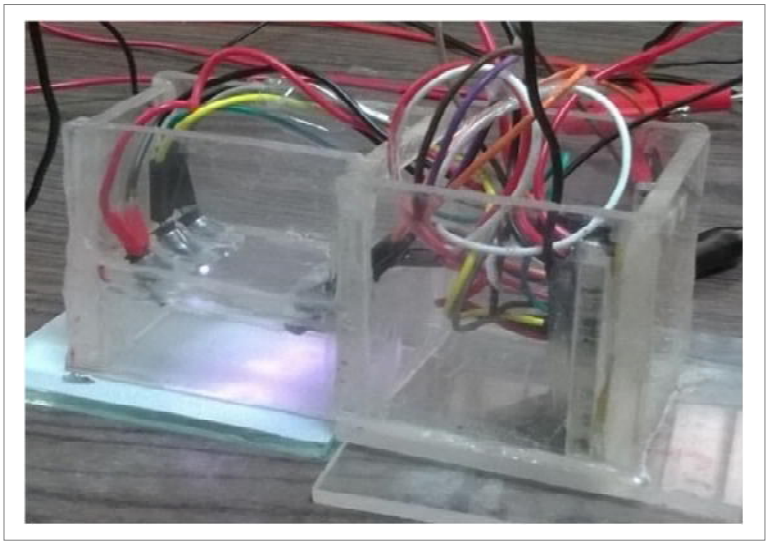
Fig 1: Uniformly Distributed Dirt Samples (Glass) in Ascending Order for Testing of Sensor

Dirt Detection Test for Three Pairs of IR PD & LED:

Experimental set-up as shown in Fig 2 shows provision for mounting three pairs of IR LED and PD placed over the dirt sample (size 6X6 cm^2).It is also possible to vary the parameters (H, d and è) used to design the dirt detection sensor. Where, H is height for both IR LED and PD from the glass sample, d is the gap and è is the angle between IR LED and PD, respectively. For LED (viewing angle = 26°) and photo diode (acceptance angle = 34°) pair, the optimal position is (15 mm, 21 mm, 35°) evaluated experimentally as interpreted in the Fig 3. The electronic circuit connection for three pairs of IR PD and LED used in the experiments is shown in Fig 4.



(a)



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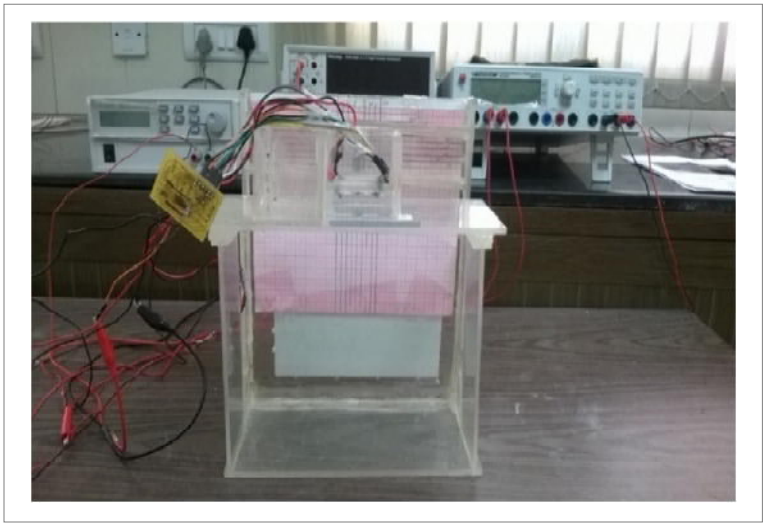


(c)

Fig 2: Test Set-up for (a) configuring the Three Pair of IR LED & PD Array; (b) Dirt Detection Testing of Sensor (c) Dirt Detection Sensor Unit

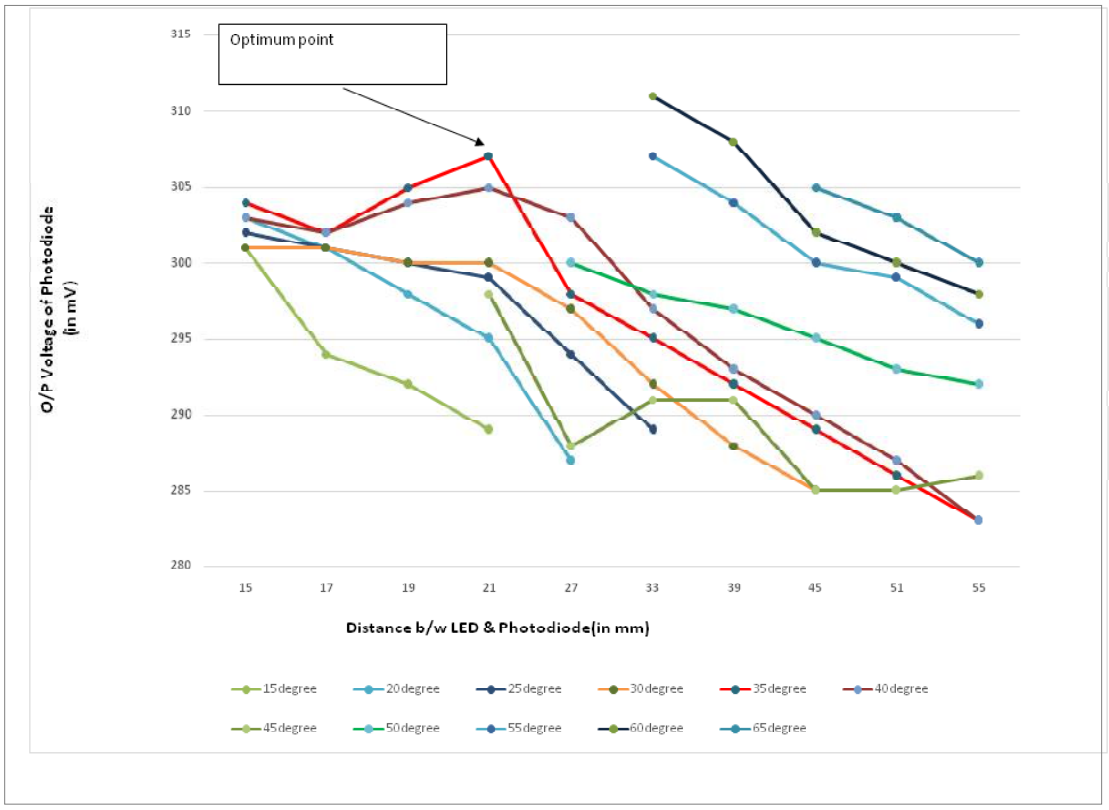


Fig 3: Experiments for Optimal Position of Photo Diode & LED with respect to Glass Samples (Single Pair of IR PD & LED)

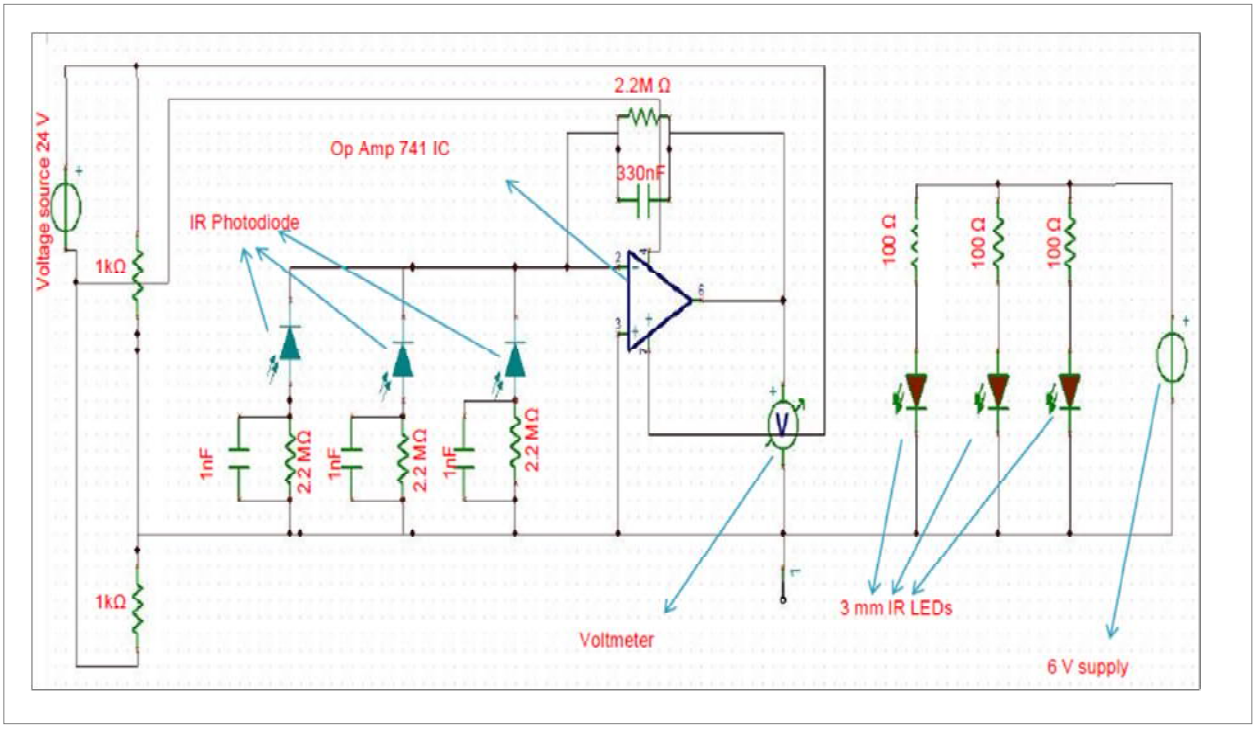


Fig 4: Circuit Connections for Three Pair of IR PD & LED using Single Power Supply

Laboratory testing of dirt detection by photo diode sensor was carried out by comparing its output voltage for ten different dirt glass slabs with varying dirt level. The test results have been evaluated in Table 1 and the variation of output voltage of Photo diode with respect to mass of dirt is shown in Fig 5. As dirt increases, output voltage decreases and stabilizes (1392 mV) after a particular amount of dirt (approximately 27 mg).

Table 1: Experimental Results

Sample	0	1	2	3	4	5	6	7	8	9
Voltage(mV)	1451	1431	1425	1418	1412	1400	1394	1392	1392	1392

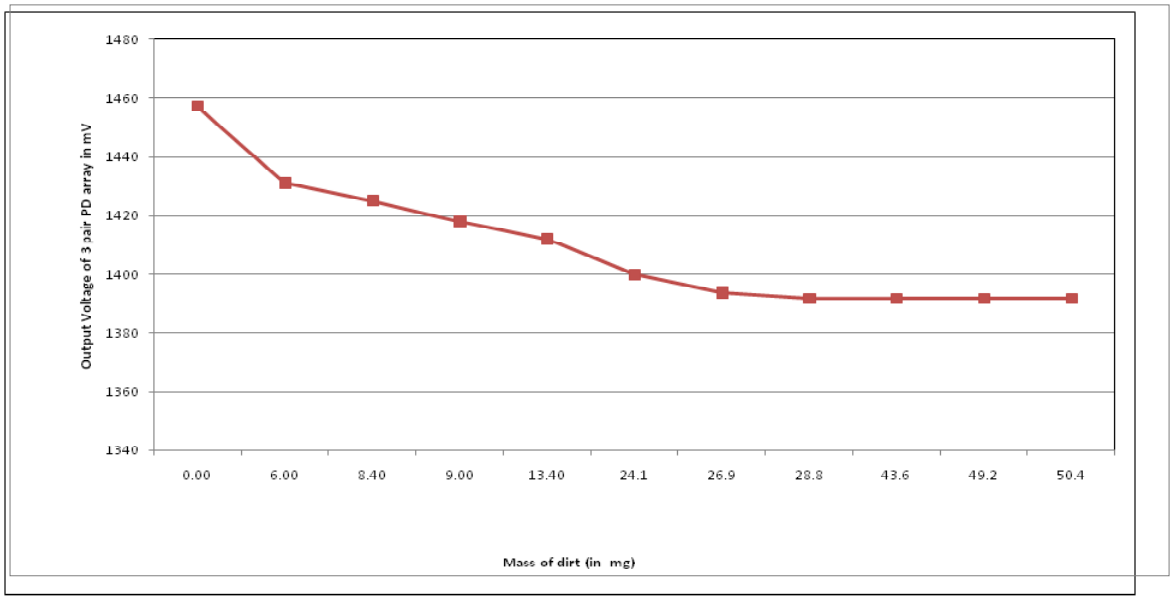


Fig 5: Test Results of 3 Pair IR PD & LED Sensor for Different Dirt Samples

Testing of Path Planning of Robot for Cleaning within a Specified Area:

A four wheeled mobile robot with three degrees of freedom (DOF) has been designed and fabricated for path planning purpose. The locomotion control of the robot using differential drive mechanism has been implemented. The robot can perform various motions such as forward, backward, spin and turn using these control strategies. The robot has length 337 mm and width 360 mm with a ground clearance of 20 mm. The wheels have a diameter of 105 mm and width 25 mm. Two front wheels are connected with individual DC geared motor, and the two rear wheels are ideal for free rotation provided by pillow block bearing support system with the robot frame. The robot traces its path on the floor using a sketch pen arrangement on the four corners, allowing verification of the coverage area experimentally.

The robot is to be tested for various planned paths such as spiral pattern, Line-sweep, their combination and spatial cell diffusion as given in Fig 6. For efficient coverage, the repetition has to be minimized. Coverage efficiency was calculated theoretically for various planned paths such as spiral pattern, line-sweep, their combination and spatial cell diffusion using the relation (Covered area- Repeated area)/Total area. In this calculation

repetition/overlap is not considered from Table 2. It was observed that maximum coverage was achieved in the case of combination path, however, at an expense of repeated coverage.

Simulation in MATLAB has been performed for feedback trajectory following case as shown in Fig 7. Our future attempt shall be implementation of trajectory following feedback controller for path planning with better coverage efficiency in comparison to the tested paths.

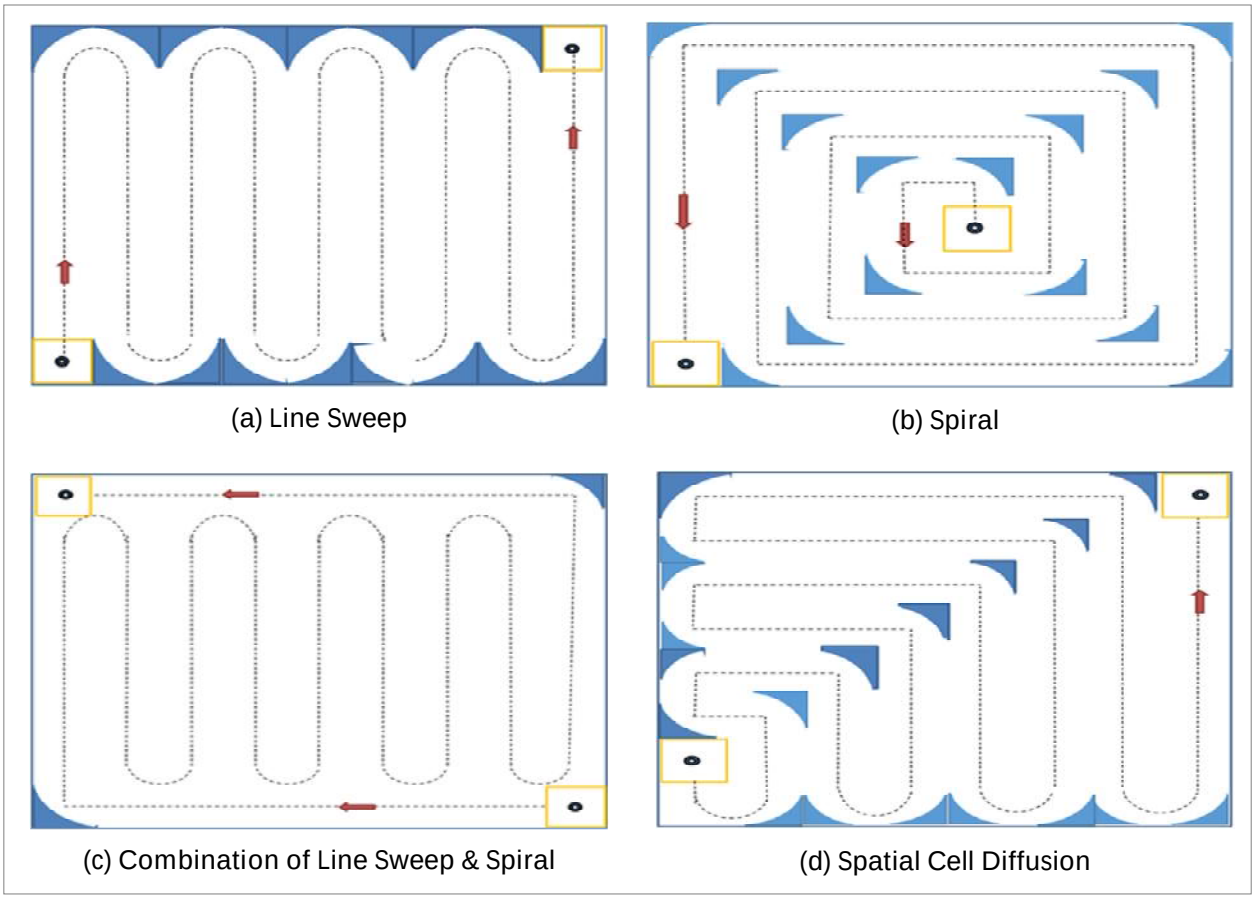
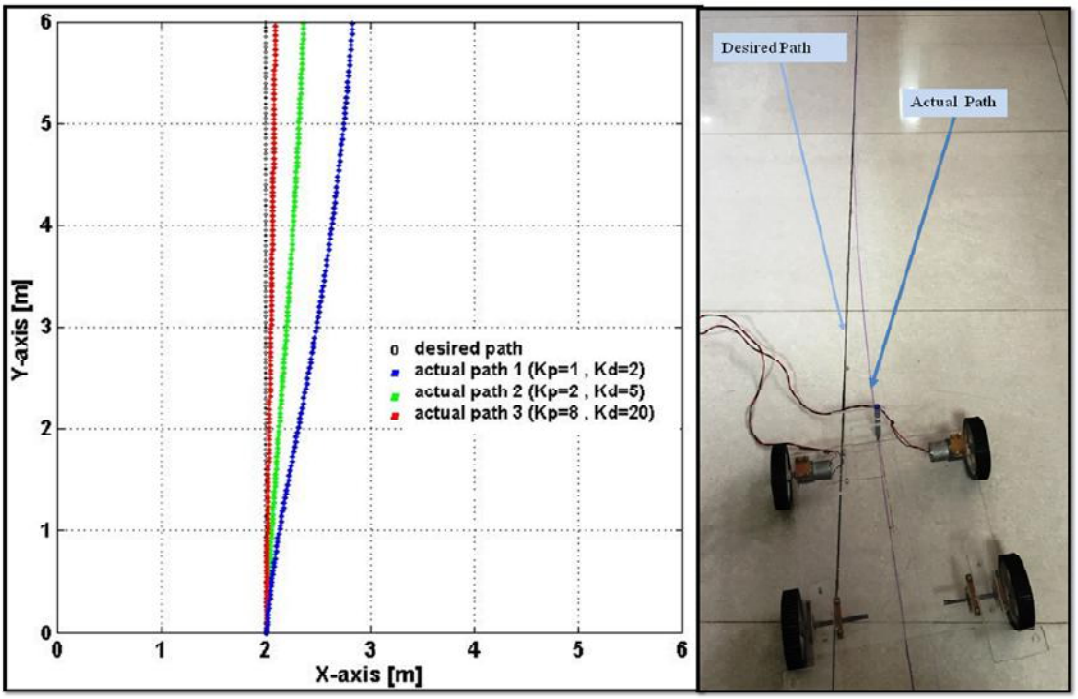


Fig 6: Covered & Uncovered areas by wheeled Mobile Robot for Various planned Path

Table 2: Coverage Efficiency for Various planned Path (Assumption: Overlap Area is not considered for the Calculation)

Pattern	Line-Sweep	Spiral	Combination of Line Sweep & Spiral	Spatial Cell Diffusion
Total area (m^2)	9	9	9	9
Covered area (m^2)	8.4828	8.6106	8.9444	8.4762
Uncovered area (m^2)	0.4171	0.3893	0.0556	0.5238
Coverage efficiency (%)	95.63	95.67	99.38	94.18



(a) (b)

Fig 7: Trajectory following Feedback Response Simulation & Experiment of wheeled Mobile Robot; (a) Simulation; (b) Test Results

Network Projects

CSIR- CBRI AS A PARTICIPATING LABORATORY

Removal of Heavy Metals from Waste Water using Fly Ash & Secured Disposal of the ludge.

PI: S. Maiti

[CSIR-NEERI, "Clean Water: Sustainable Options"]

Estimation of Crustal Deformation of Garhwal Himalaya.

PI: S. Sarkar

[CSIR-4PI, Advance Research in Engineering & Earth Sciences (ARiEES): Data Intensive Modelling & Crowd Sourcing Approach]

Energy Efficient Seed Storage Structures.

PI: Nagesh B. Balam

[CSIR-CSIO, Advanced Instrumentation Solutions for Health Care and Agro – based Applications - ASHA]

Robotic Technology for Periodic Inspections of Civil Infrastuctures

PI: Ravindra S. Bisht

[CSIR-CMERI, Micro Machines and Robotics]

Removal of Heavy Metals from Waste Water using Fly Ash & its Subsequent Use in the Production of Value Added Building Components

S. Maiti & A.K. Minocha

Coordinating Lab: CSIR-NEERI

Participating Lab: CSIR-CBRI

Objective:

Main objectives are

- Design and construction of a packed bed reactor for removal of heavy metals from waste water by using fly ash and optimization of process variables.
- Use of the altered sludge for production of building component.

An integrated adsorption-solidification/stabilization process was developed for fixing and immobilizing the metal loaded fly ash. The mortar was casted according to IS 4031 (part 6) 1988 in a 70.60 mm specimen cube mould. Ordinary Portland cement was used as the fixation agent. Cement is replaced by metal laden fly ash up-to 30%. Fig 1 is the flowchart of the procedures for cement fixation experiments.

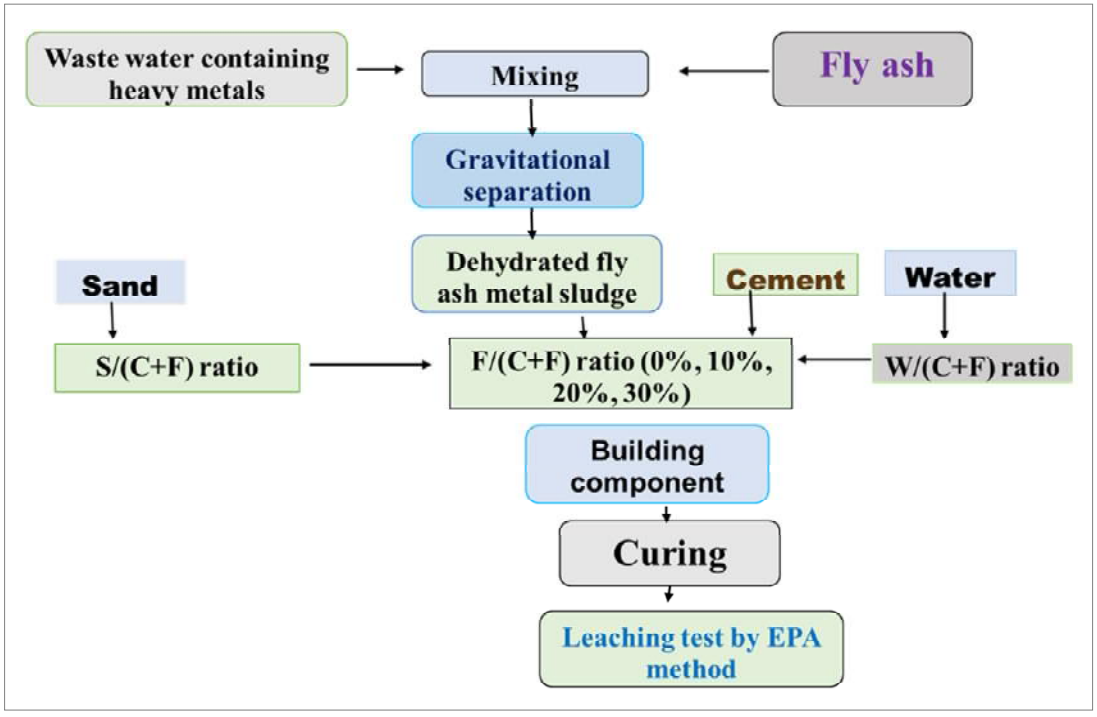


Fig 1: An Integrated Adsorption-Solidification/Stabilization Process for Fixing & Immobilizing the Metal Ion

The setting times of OPC with and without zinc was measured and presented in the Table 1. It is apparent that zinc retards the setting process of cement. The change in final setting time is very much dependent on the initial zinc concentration. The control cement reached final setting in 6 h.

Table 1: The Final Setting Times of OPC with & without Zinc Laden Fly Ash

S.N.	Description	Setting Time	S.N.	Description	Setting Time
1	Control	6 hours	11	Cement + 5%FA+ 10000ppm Zn	7 hours 20 min
2	Cement + 5%FA	6 hours 27 min	12	Cement + 10%FA+ 2000ppm Zn	7 hours 6 min
3	Cement + 10%FA	7 hours 37 min	13	Cement + 10%FA+ 5000ppm Zn	7 hours 20 min
4	Cement + 15%FA	7 hours 45 min	14	Cement + 10%FA+ 10000ppm Zn	7 hours 40 min
5	Cement + 20%FA	7 hours 58 min	15	Cement + 15%FA+ 2000ppm Zn	7 Hour 15 min
6	Cement + 2000ppm Zn	7 hours 10 min	16	Cement + 5%FA+ 5000ppm Zn	7 hours 30min
7	Cement + 5000ppm Zn	7 hours 30 min	17	Cement + 15%FA+ 10000ppm Zn	7 hours 50 min
8	Cement+10000ppm Zn	7 hours 45 min	18	Cement+20%FA+ 2000ppm Zn	7 hours 35 min
9	Cement + 5%FA +2000ppm Zn	7 hours 3 min	19	Cement+20%FA+ 5000ppm Zn	7 hours 45 min
10	Cement+5%FA+ 5000ppm Zn	7 hours 5 min	20	Cement+20%FA+ 10000ppm Zn	8 hours 2 min

This retarding behaviour can be explained with the help of gel model. According to the gel model, when C_3S is in contact with water, a membrane of C–S–H gel is formed on the surface of C_3S grains, which permits the inward flow of water molecules and the outward migration of mainly Ca^{2+} and silicate ions due to the difference of osmotic potential on both sides of the membrane. The membrane ruptures periodically and re-forms by extruding concentrated silicate solution. As a result, an excess of Portlandite will accumulate on the fluid side of the membrane. The retarding effect is due to the formation of insoluble gelatinous hydroxyl compounds of metals in an alkaline medium. This compound prevent the flow of water as result of this setting time decreases with increasing concentration of metal ion.

Fig 2 demonstrates the compressive strength of mortar as a function of percentage of zinc loaded fly ash in cement respectively. It is clear from these figures that compressive strength of the stabilized product decreases slightly with increasing the metal content in the cement.

When zinc salt added to the Portland cement and fly ash, zinc ions precipitated as hydroxides and dispersed in the matrix of C-S-H which is responsible for compressive strength. These zinc ions trapped in the C-S-H pores during solidification and retard the hydration process. Thus, compressive strength decreases on increasing the amount of zinc salt in cement mixture.

SEM and EDX micrographs of the 28 days cement paste and metal laden cement paste were presented in the Fig 3 & 4 respectively**.** SEM micrograph of a cement mortar cured for 28 days, the platelet-like crystalline phases are observed. As indicated by EDX analysis this crystalline phase appears to be the CSH or calciumaluminate-hydrates.

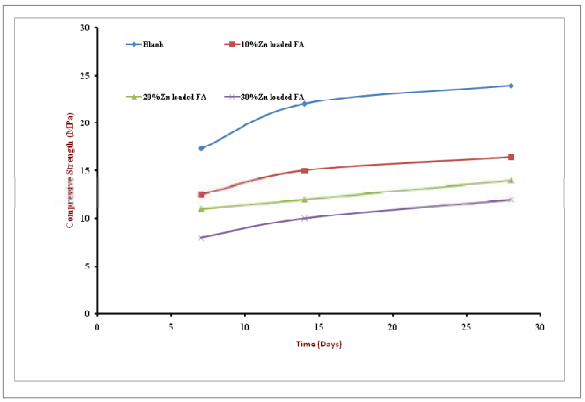


Fig 2: Compressive Strengths of Mortar as Function of Percent Zn-Laden Fly Ash in Cement

The micrograph of cadmium loaded matrix reveals that needle-like crystals covered the surface of the spherical particles. These needle-like crystals are believed to be ettringite ($3CaO\text{-}Al_20_3\text{-}3CaSO_4\text{-}31H_20$) or other amorphous matrix forms, which are the hydration products of cement. The ettringite, due to its needle-like structure, does not contribute greatly to the strength of mortar at early stage.

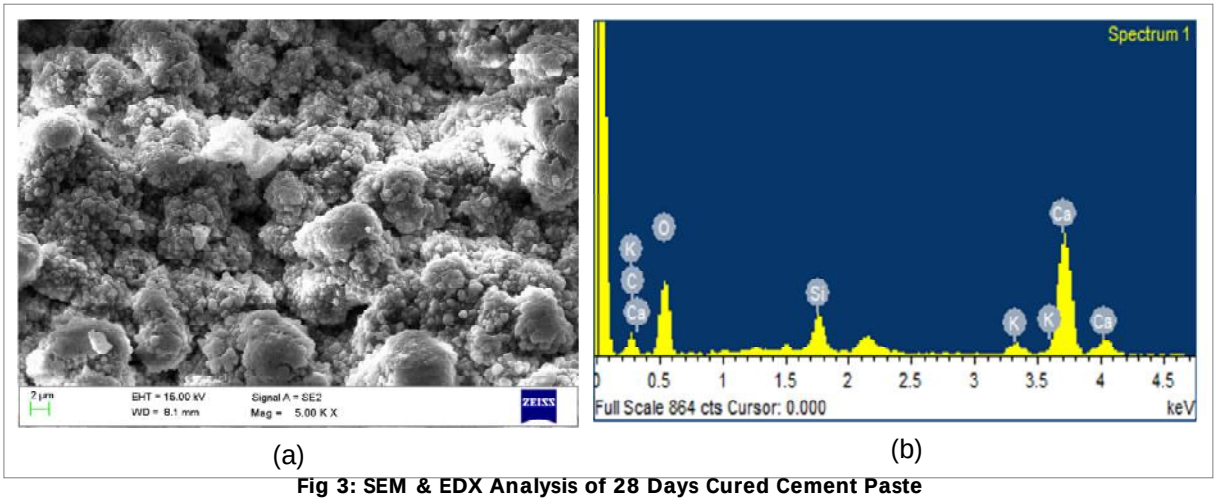


Fig 3: SEM & EDX Analysis of 28 Days Cured Cement Paste

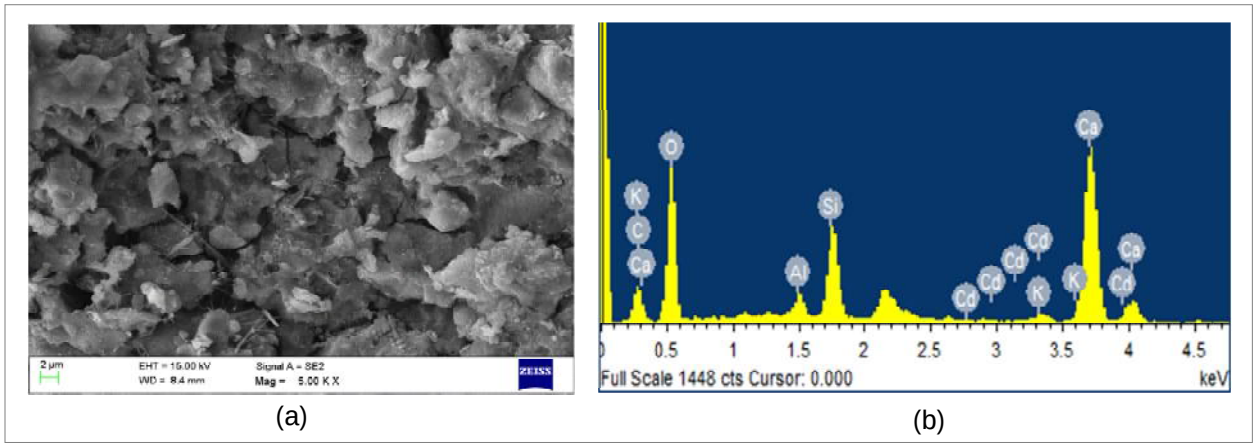


Fig 4: SEM & EDX Analysis of 28 Days Cured Metal Laden Cement Paste

Setting time, Compressive strength and micrograph analysis results suggest that metal-laden fly ash can be considered for use in secondary construction materials.

Estimation of Crustal Deformation of Garhwal Himalaya

S. Sarkar, D.P. Kanungo, P.K.S. Chauhan, Anil Malheta & Neelu Sharma

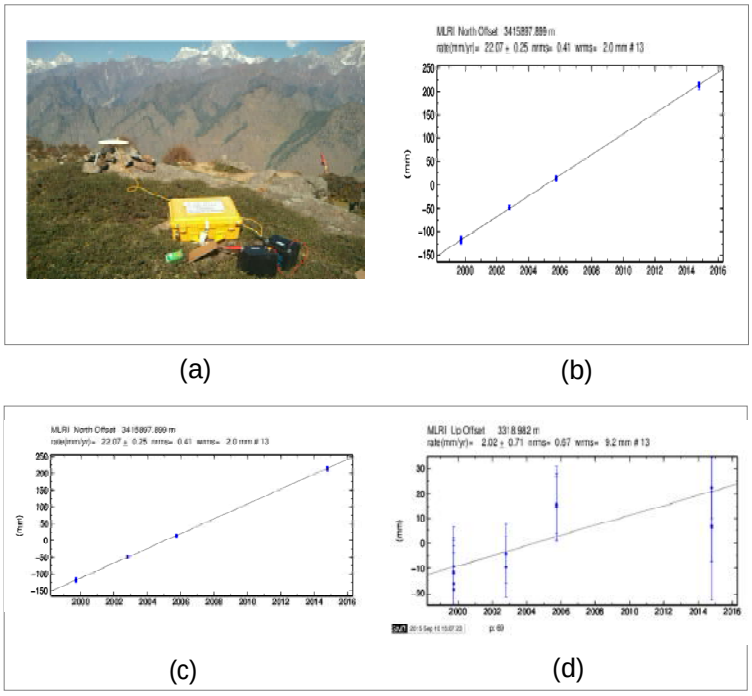
Coordinating Lab: CSIR-4PI

Participating Lab: CSIR-CBRI

This project is one of the Tasks of the Work Package on "Data Intensive Research for Earthquake Hazard Assessment by Modelling the Solid-earth (DREAMS)" co-ordinated by CSIR-Four Paradigm Institute, Bangalore. The main objective of the project is the estimation of the ongoing tectonic deformation of Garhwal Himalayas by establishing a real time GNSS network.

The GPS data are being collected at permanent GPS station at CBRI Roorkee continuously and in campaign mode at several locations in Garhwal Himalayas such as Pipalkoti, Auli, Malari, Tungnath, Sukki, Chamba and Lansdown. The data are being analysed with CSIR-4PI for estimating the crustal deformation by determining the extension as well as subtraction of the selected segments in Garhwal Himalaya.

The Time series in NEU are analysed for all the six locations located in lesser and Higher Himalayas.The GPS data so far collected and analysed are integrated with the earlier data collected by CSIR-4PI since 1995 to determine the long term deformation rates (1995-2014) per year in this region. The analysis has shown that the location AULI, CHAMBA and LANSDOWN show almost the same velocity and deformation to the order of 5 to 10mm (Fig 1) as indicated between AULI, CHAMBA, LANSDOWN (~ 33-34 mm/yr in N and E) and MALARI (22 mm/yr N and 29 mm/yr E) (Fig 2), SUKI (24 & 29 mm/yr in N and E) and TUNGNATH (27 & 29 mm/yr in N and E). AULI-TUGN baseline indicates an extension of 8 mm/yr and the rest of the baselines indicate shortening of 5 to 10 mm/yr.

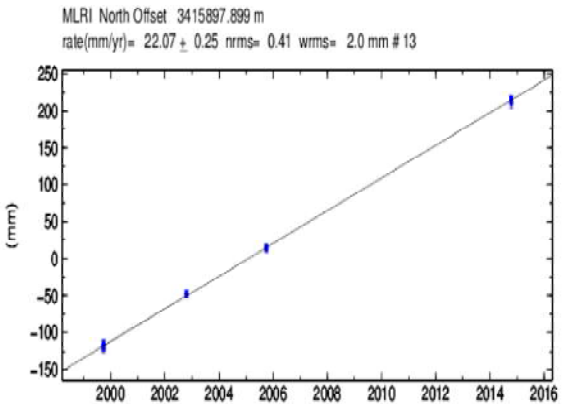


(a) (b)

(c) (d)

Fig 1: Time Series Data of Auli Station

(a)



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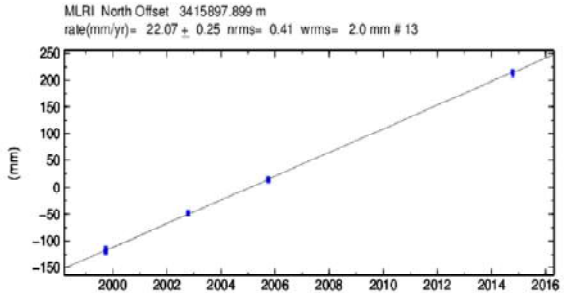
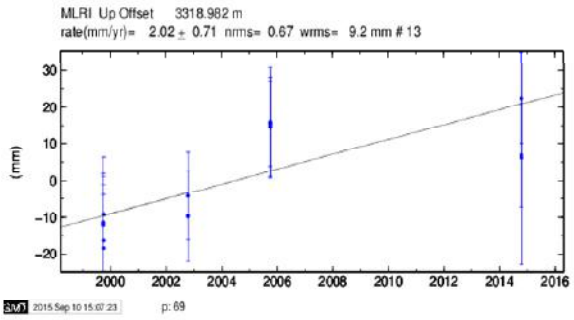


(c)



(d)

Fig 2: Time Series Data of Malari Station

The data of CBRI station collected till now will be analysed to give the velocity of the CBRI GPS station. Repeat GPS measurements of Garhwal GPS network have been collected recently (Fig 3) which are being analysed. The results of the analysis will be combined with the results obtained so far to partition the long term stress build up and strain accumulation in this region.

Fig 3: Pictures of GPS data collection by CBRI & 4PI Team at Auli & Malari station in March-April 2016

Energy Efficient Seed Storage Structures

Nagesh B. Balam, A. Aravind Kumar & Somya Srivastava

Coordinating Lab: CSIR-CSIO

Participating Lab: CSIR-CBRI

Objective:

I. Optimum temperature, humidity and ventilation rate control inside seed storage structures

II. To reduce the operational energy by making the seed storage structures more energy efficient.

Deliverables:

1. Heat and humidity insulated light weight Composite Panels for seed storage structure.
2. Guidelines for maintaining Controlled environment (Temperature, Humidity and air-changes) in seed storage structures

Progress:

Numerical simulation studies are carried out for improvement of energy efficiency in a room by with different thermal insulating materials using computational fluid dynamics (CFD). The study considered various building insulating materials (BIM's) such as: (a) Expanded Polystyrene (EPS) (b) Fibres Glass (Resin bonded (RB)-Glass wool) (c) Polyurethane Foam (PUF) and (d) Cement Plaster (CP) along with composite bricklayer combination. A multi-physical 3D model room of size 2.6 m × 2.6 m × 2.6 m is created to analyze the performance of different insulating materials using CFD simulations (Fig 1). Physical properties of these insulating materials are described in Table 1. The experimental data of 24 hr temperature cycle of the ambient air is used for the analysis of performance of thermal comfort inside the room with the incorporation of different thickness of the insulating materials. The thickness of insulation 0.03, 0.1, 0.2 and 0.3 m is applied on interior side of walls and roof of the building. The temperature profile of this room without using any insulating material is shown in Fig 2.

Fig 1: Ecperimental Room

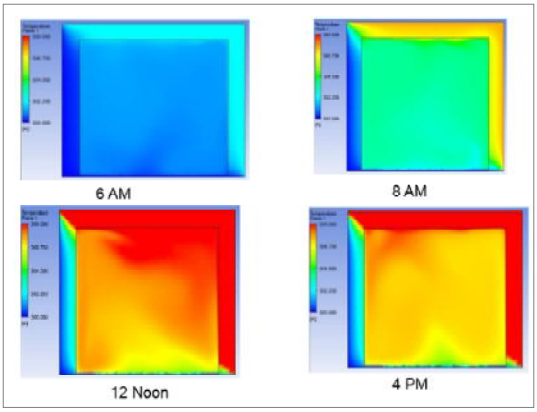


Fig 2: Temperature Profile of Room without using any Insulating Material

Table 1: Insulation Material Properties

Material	Density (kg/m³)	Specific Heat Capacity J/(Kg·K)	Thermal conductivity W/(m·K)
Air	1.1850	1004.4	0.0261
Brick	1600.0	880.00	0.6400
Expanded Polystyrene (EP)	24.000	1340.0	0.0350
Fibre Glass ((RB-Glass wool)	16.000	1000.0	0.0400
Polyurethane Foam (PUF)	32.000	820.00	0.0270
Cement Plaster	1762.0	840.00	0.7210

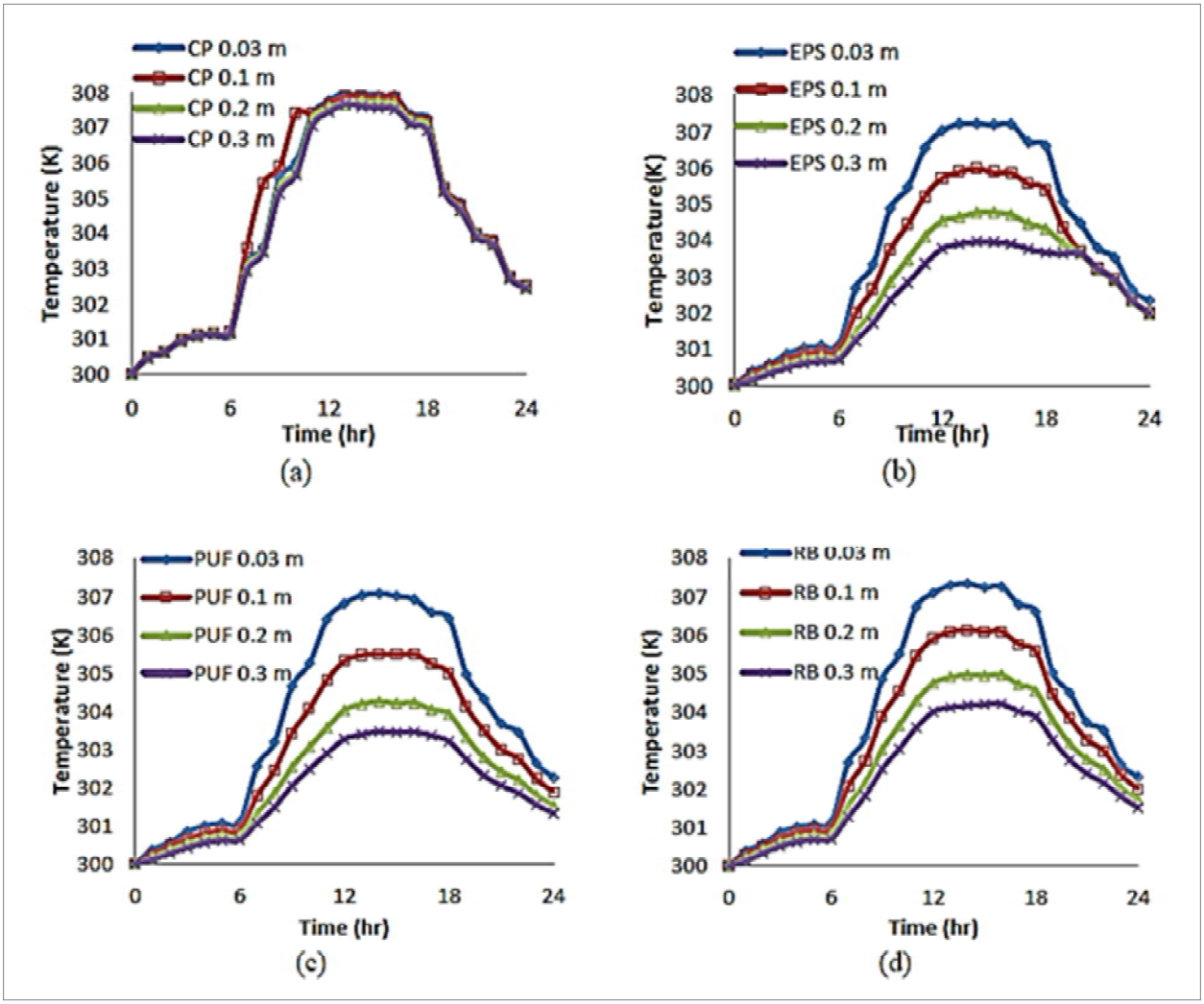


Fig 3: Comparison of Temperature inside the Room for the Insulating Materials of (a) Cement Plaster (CP) (b) Expanded Polystyrene (EPS) (c) Polyurethane Foam (PUF) & (d) Fibre Glass (Resin bonded (RB)-Glass wool) with Different Thicknesses of 0.03, 0.1, 0.2 & 0.3 m.

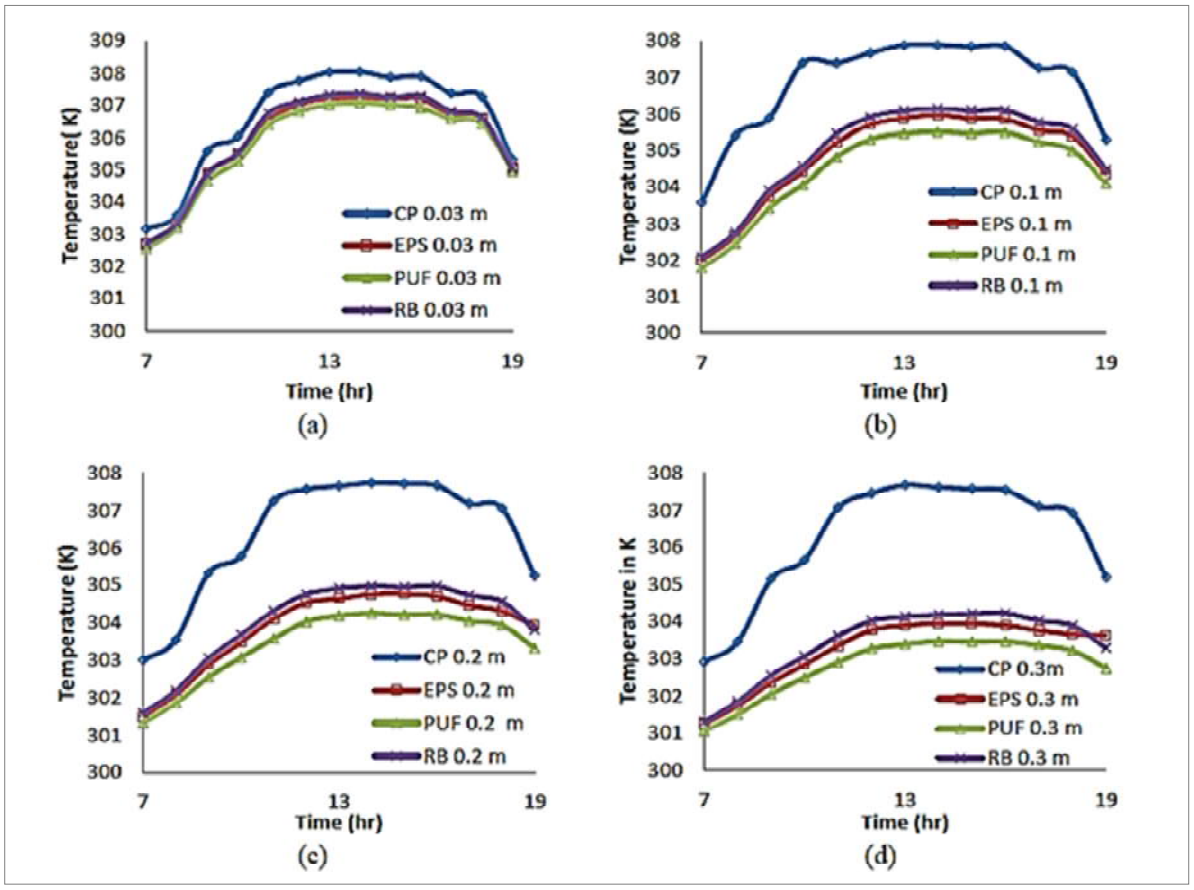


Fig 4: Comparison of inside Room Temperature Cycle from 7 am to 7 pm for the Insulating Materials of (a) Cement Plaster(CP) (b) Expanded Polystyrene (EPS) (c) Polyurethane Foam (PUF) & (d) Fibre Glass (Resin bonded (RB)-Glass wool) with different thicknesses of 0.03, 0.1, 0.2 & 0.3 m.

So from the results of comparison shown in Fig 3 & Fig 4, it is to conclude that the Polyurethane Foam (PUF) is more preferable than the other three materials. The optimum thickness of the insulation is found to be 0.2 m based on the indoor thermal temperature study. Even though the temperature is decreasing with insulation thickness but at the same time the cost will increase. The maximum temperature difference observed to be 15° C under insulated condition when outside temperature is 44° C and predicted inside the room temperature as 29° C at 2pm. In the case of non-insulated condition an 8° C temperature difference is observed at the same time.

Robotic Technology for Periodic Inspection of Civil Structures

R.S. Bisht, S.K. Panigrahi, S.J. Alexander, Jogender Kumar & Sudhakar Jain

Coordinating Lab: CSIR-CMERI

Participating Lab: CSIR-CBRI

Objective:

- To design and develop a service robot with manipulator for precise inspection of desired surface of the civil structure.
- The precise inspection will be carried out by vision and NDT sensors mounted on the service robot

Progress Highlights/ Significant Achievements:

1. Design and drawings for the fabrication of a service robot with manipulator have been completed.

2. A manipulator arm with 4 degrees of freedom (DOF) has been designed and fabricated, which will be integrated into service robot platform for carrying out inspection task. Fig 1(a) and Fig 1(b) shows both the assembly design and motion control testing set-up of 4-DOF fabricated robot manipulator arm.

3. Experiments for measuring axial force generated by flat suction cup which is to be used in the holding mechanism of the robot have been performed. The axial force generated by the flat suction cup is due to negative pressure created using vacuum supply units. Experimental set-up using Motorized test

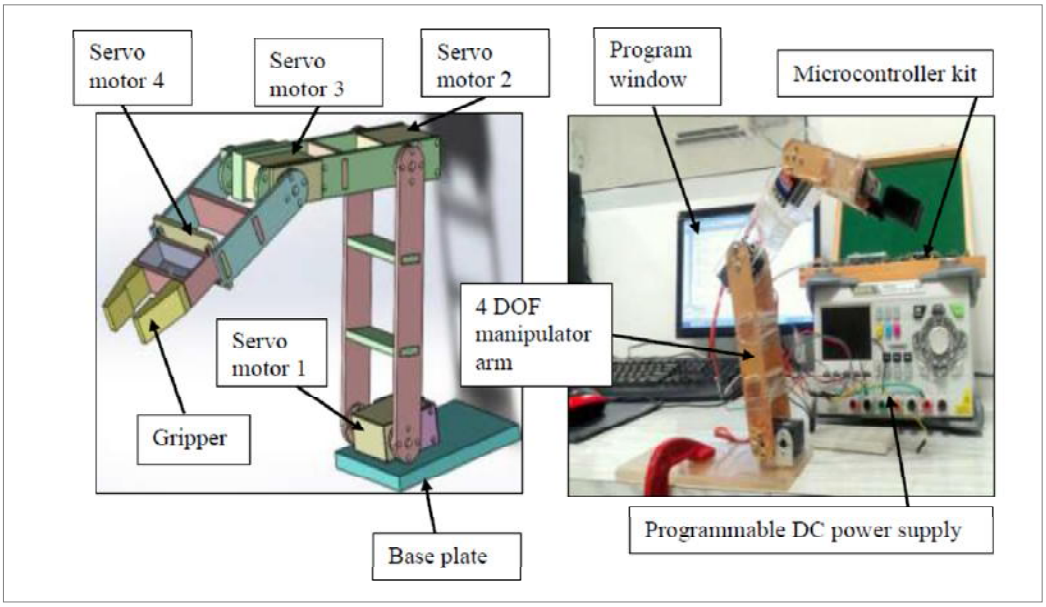


Fig 1: (a) Assembly Design of 4 DOF Manipulator Arm (b) Motion Testing using Microcontroller of 4 DOF Manipulator Arm

stand with Force gauge was used to measure the axial force generated along the normal axis of the flat suction cup. Detail of overall experimental set-up design for vacuum gripper force generation testing is shown in Fig 2.As seen from the Fig 3 and Fig 4 generated force from the test results by the flat suction cup is increasing as we increasing different vacuum levels ranging from 100 to 600 mbar. For different levels of vacuums in the flat s uction cup holding mechanism, the generated forces are 24.6, 43.8, 64.6, 83.2, 103.6 and 121.0 N, respectively.

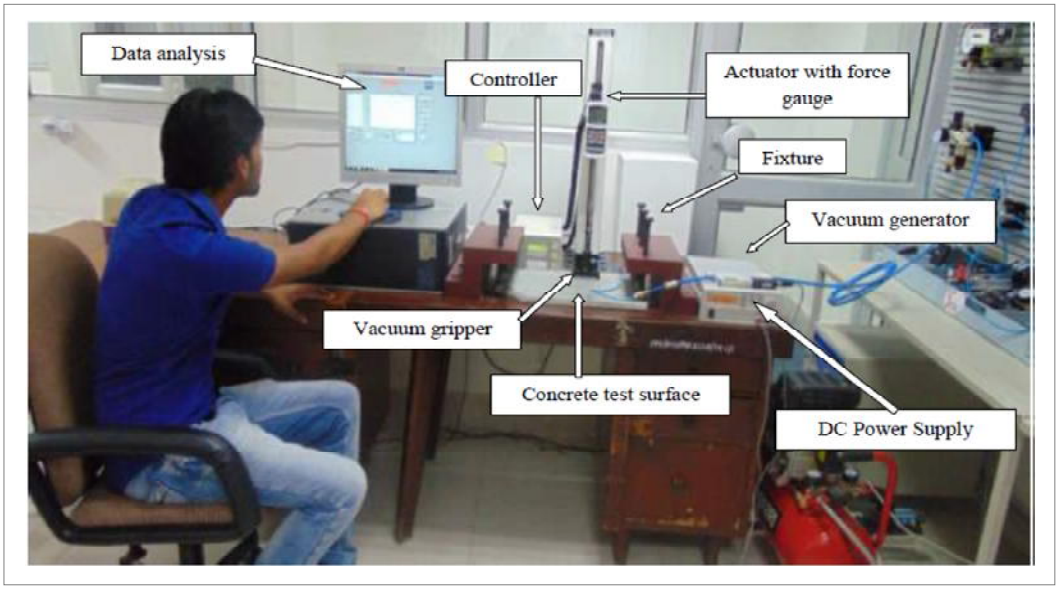


Fig 2: Overall Experimental Set-up for Flat Suction holding Mechanism Testing

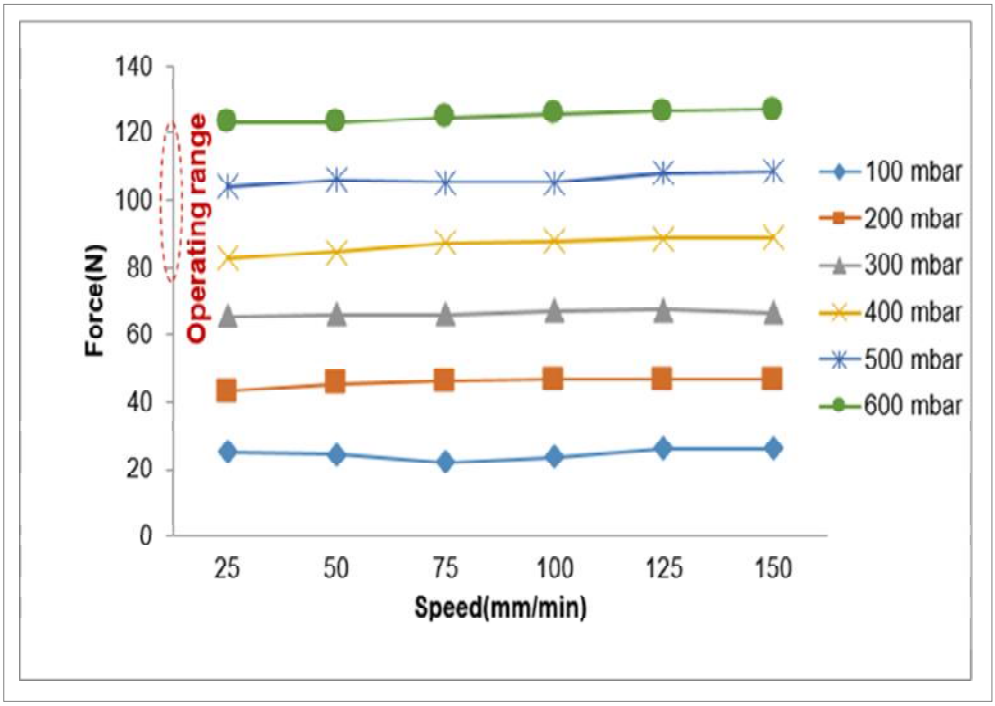


Fig 3: Pneumatic Force Characteristics under Different Vacuum Level and Actuator (for Smooth concrete surface)

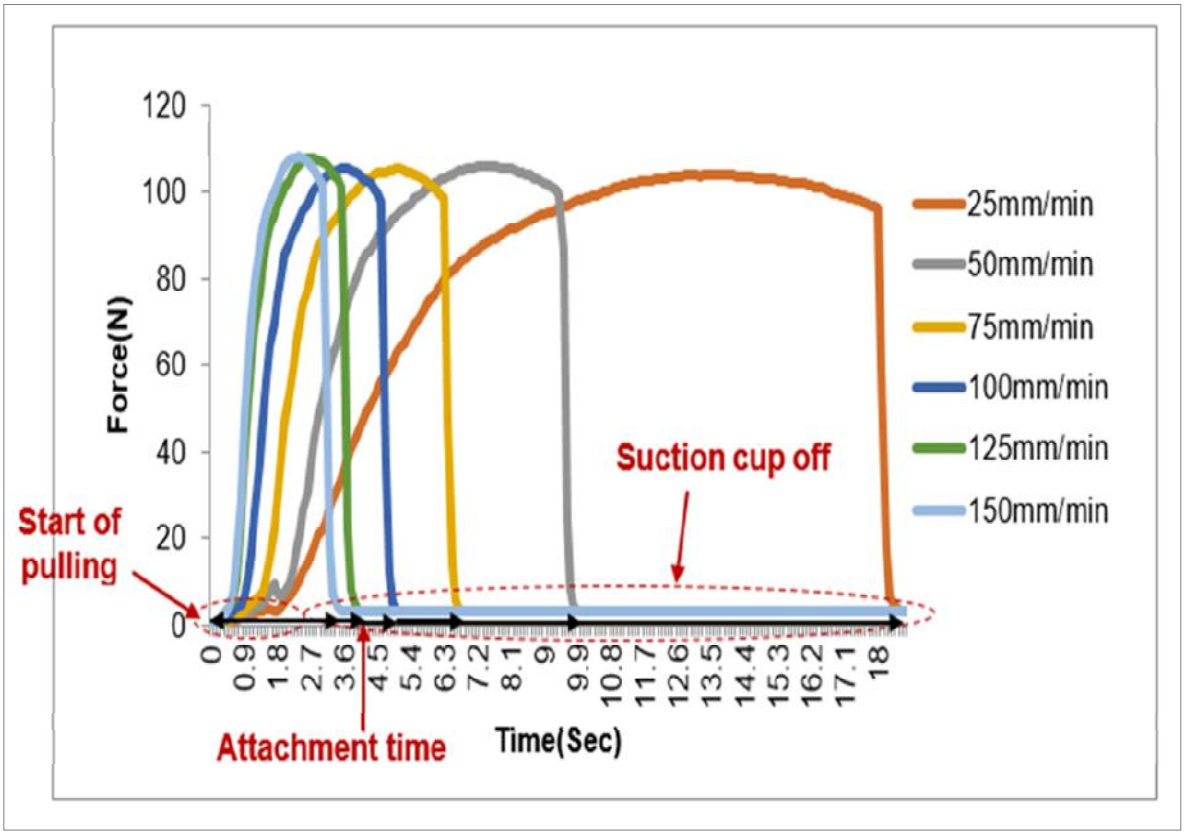


Fig 4: Pneumatic Force Characteristics under Different Pulling Speed of Actuator (500 mbar Vaccum Pressure, Smooth concrete surface)

Development of Technology for Making Flooring & Wall Tiles using Kota Stone Waste

Rajni Lakhani & Team

Kota and Jhalawar Districts of Rajasthan is abound with about 100 million tonnes of split able type of decorative grade flooring limestone. Its deposits are also found in Ajmer, Swai-Madhopur, Rajsamand, Udaipur, Banswara but major deposits are found in Kota district and hence the name Kota stone. The year wise production of Kota stone is almost continuously increasing.

During different operations on stones like quarrying, sawing, cutting etc. the stone waste is generated in abundance. In general there are two types of waste namely quarry/cutting/sawing waste from in-situ stone sites and polishing waste from construction sites. Every year about 2.50 to 3 Million Ton of stone polish is discharged into local convenient places which poses major environmental and ecological problems besides occupying a large area of land for their storage or disposal. Looking to such huge quantity of wastes as minerals or resources, there is tremendous scope for setting up secondary industries for recycling and using such solid wastes in construction materials.

A research project was undertaken by CSIR-CBRI, Roorkee for developing flooring and wall tiles using Kota stone cutting & slurry wastes under the aegis of Department of Science & Technology, New Delhi.

The project has turned out to be successful in producing value added products by studying the engineering properties of Kota stone waste and utilization of this waste to develop flooring tiles and light weight blocks as an infill material for walls as per the standard specifications.

A pilot plant for tiles has also been installed with the funding provided by Rajasthan State Pollution Control Board, Jaipur. This study will not only help to utilize the Kota stone waste but will generate employment opportunities for the masses as well.

Progress

The engineering properties of Kota stone waste has been studied and utilization of this waste as replacement of fine and coarse aggregates of size ≤ 4.75 mm (F.M. 2.5) has been done to develop flooring tiles meeting the specifications of IS: 1237 and light weight foamed concrete blocks with targeted density of 800 and 1000 kg/m^3 as per IS: 2185 (iv) code that can be classified for non-structural applications.

Flooring Tiles:

a) Targeted Specifications:

The targeted specifications of the flooring tiles as per IS: 1237-2012 are given in Table 1.

Table 1: Specifications as per IS: 1237-2012

S. No.	Physical Requirements	General Purpose Tiles	Heavy Duty Tiles
1	Resistance to Wear, Average Wear, Max. wear on individual specimens	3.5mm	2.5mm
2	Flatness of the Tile Surface, Max.	1mm	1mm
3	Perpendicularity, Max.	2%	2%
4	Straightness, Max.	1%	1%
5	Water Absorption, Max.	10%	10%
6	Wet Transverse Strength, Min.	3N/mm^2	5N/mm^2

b) Manufacturing Process:

An attempt has been made for utilizing Kota stone waste for the preparation of flooring tiles; waste being used as an additive and as a replacement of fine aggregate. After a number of trials, the mix proportions have been optimized by replacing fine aggregate by Kota stone waste by different amounts as per the mix design and using a fixed amount of cement.

In the mixing process of samples, cement, sand and Kota stone waste powder (KSWP) are placed in a mortar mixer and mixed for 1 min. It is observed that KSWP is uniformly scattered within the mixes and water is sprayed uniformly. The different mix proportions containing 0%, 25%, 50%, 75% and 100 % KSWP have been used as fine aggregate for casting tiles under vibration as well as compaction at optimized pressure.

c) Experimental Results:

Different physico-mechanical properties such as Water absorption, Flexural strength, Wear Resistance of samples have been determined. On the basis of the values obtained the mix proportion has been optimized for both grades of tiles i.e. (i) General purpose tiles and (ii) Heavy duty flooring tiles (Fig 1 & Table 2).

Table 2: Properties of Optimized Mix Proportion

Name of Tests	Market Tiles	Optimized Mix Proportions	
		General Purpose Tiles	Heavy Duty Tiles
Resistance to Wear	0.5mm	0.11mm	0.11mm
Flatness of the Tile Surface	1mm	0.44mm	0.44mm
Perpendicularity	0.34%	0.37%	0.37%
Straightness	0.33%	0.44%	0.44%
Water Absorption	6.50%	8.76%	8.68%
Wet Transverse Strength	2.52 N/mm^2	5.56 N/mm^2	7.39 N/mm^2

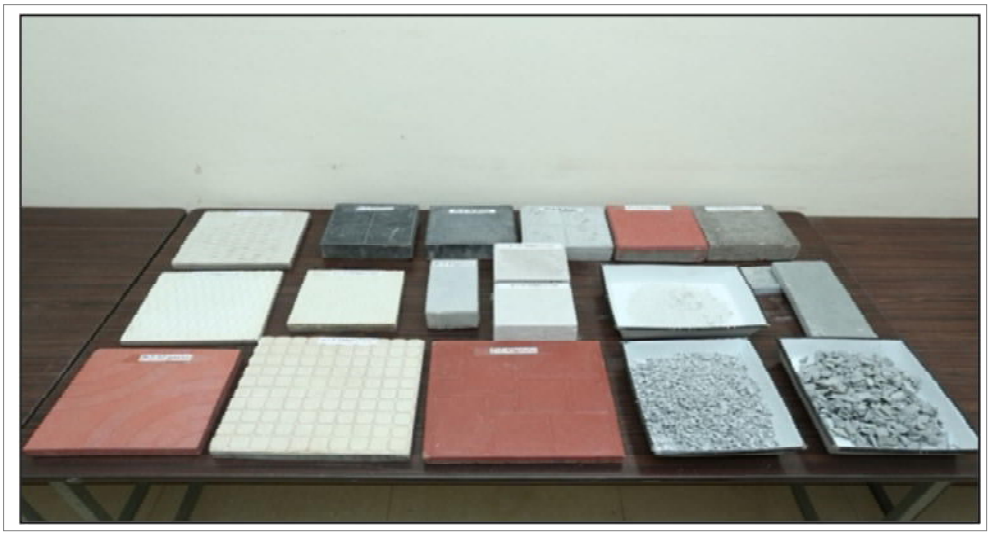


Fig 1: Developed Tiles from Kota Stone Waste

d) Applications

These are general purpose tiles suitable for floors of residential, commercial and industrial buildings.

e) Creation of Pilot Plant Facility for Tiles

A pilot plant has been installed and commissioned for the production of flooring and wall tiles at CSIR-CBRI, Roorkee. The capacity of the pan mixer is 150 litre approx. 500 tiles of size 300x300cm can be prepared in one shift of 8 hrs. The prepared tiles approx. 250 in number has been laid in a demo room in CSIR-CBRI, Roorkee Fig. 2. The cutting of tiles can be done as shown in Fig. 3. The cost of one tile of size 300cm. x 300cm. is 30-35 % less as compared to market tile (buying price).

Fig 2: Laying of Tiles in Demo Room

Fig 3: Showing Cutting of Tiles

Cellular Foamed Concrete (CFC) Blocks:

a) Targeted Specification:

Light weight blocks have been manufactured using Kota stone slurry waste (KSSLW) and foam to produce cellular foam concrete. Different mix designs have been obtained by varying amount of waste, w/c ratio, weight of foam etc.

Prior to making CFC blocks of density 800 and 1000 kg/m^3, targeted specifications were fixed as per IS: 2185 (IV)-2008[38].

b) Mix Design Detail:

To make foamed concrete, cement and sand ratio was kept at 1:1.35 as per ACI: 523.3R-93 and British Cement Association (1994). As per desired mix design, weight of foam was calculated. The mixtures with foam were prepared using suitable w/c ratio until acceptable workability was achieved. The proportions used in the cellular foamed concrete mix composition for 1-100% replacement of natural sand.

c) Manufacturing Process:

The dry materials, i.e., cement, Solani sand and fillers (KSSLW) were mixed together in the mixer for five minutes. The total quantity of water was then added and mixed with the dry materials for approximately five minutes until a homogeneous base mix was obtained. The preformed foam, which is made by blending the foam concentrate, water and compressed air in predetermined proportions in a foam generator, were added to the mix immediately in the mixer. The mixture was mixed for at least four minutes until all the foam was uniformly distributed and incorporated within the mix as noticeable during mixing. After an additional mixing to get uniform consistency, the slurry form of cellular foamed concrete of desired wet unit weight was ready to be poured into moulds. No compaction was done to prevent the collapse of the preformed foam. After 14 hrs, the specimens were de-molded and moist cured by wrapping with hessian clothes and stored at the room temperature until testing.

d) Experimental Strength of Cellular Foamed Concrete

The compressive strength of foamed concrete mixtures with different KSSLW contents and moist densities has been determined. From the data, it is clear that in case of foamed concrete, compressive strength depends on the density and in case of foamed concrete of density 1000 and 800 kg/m^3, 28 days oven dry density varies from 990-1251 kg/m^3 and 667-968 kg/m^3 respectively. Thus a variation of strength with density has been noted. A term performance factor has been defined as the ratio of compressive strength and dry density instead of only the compressive strength at 28 days. Similar phenomena were observed as regards to flexural and tensile strengths.

The graphical representation of performance factors of all the three mechanical strengths i.e.

compressive (PFc), flexural (PFf) and tensile (Pft) for both density (1000 and 800 kg/m^3) are given in Figs. 4 and 5. The maximum performance factor has been shown for all the three strength at 28 days, at different w/c ratios.

From the trend of performance factors for compressive, flexural and tensile strength, it is clear that if any mix proportion has maximum $PF_{c.28}$, it is not necessary that it will also have maximum $PF_{f'28}$ and $PF_{t'28}$ values.

e) Thermal Properties of Developed CFC-Blocks

Thermal conductivity is the property of a material that relates to its ability to conduct heat. IS 3346:1980 specifies the test procedure for laboratory measurement of the steady state heat

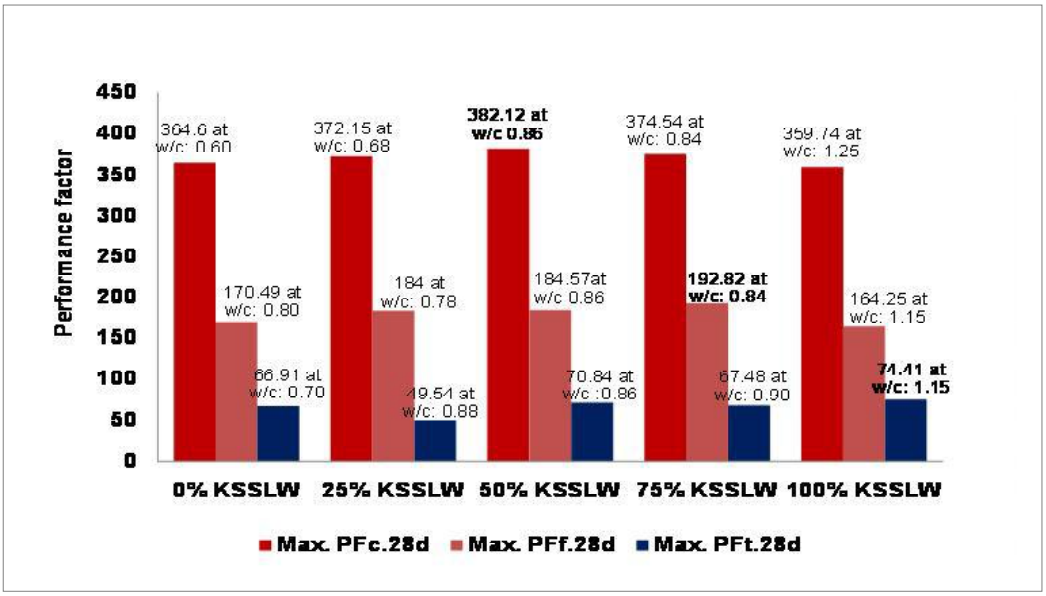


Fig. 4: Performance Factor v/s % Replacement of Sand by Kota Stone Slurry Waste (KSSLW) for targeted Design Density of 1000 kg/m^3

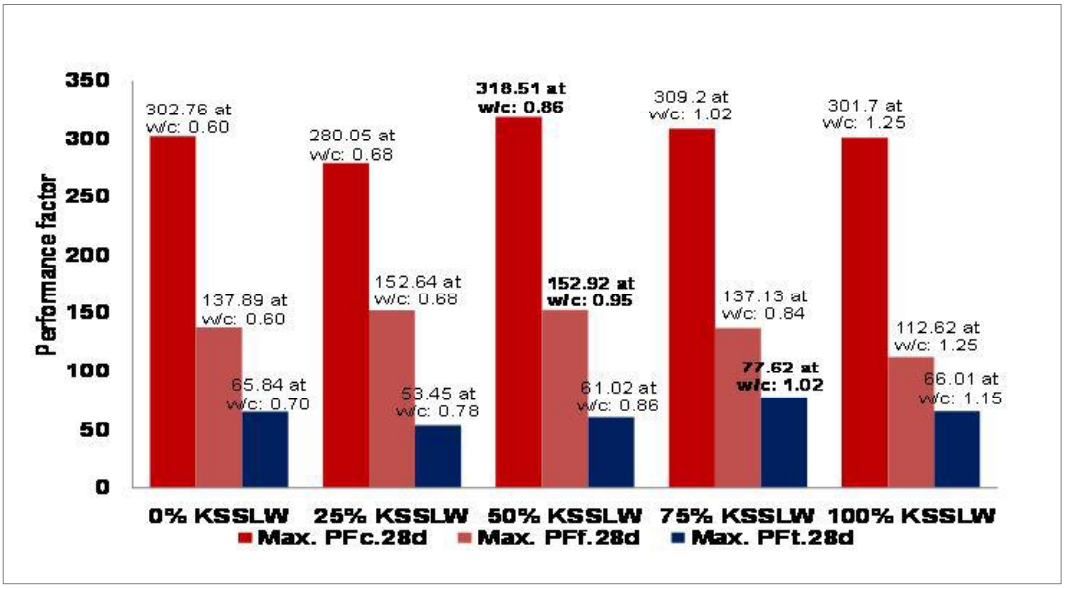


Fig. 5: Performance Factor v/s % Replacement of Sand by Kota Stone Slurry Waste (KSSLW) for targeted Design Density of 800 kg/m^3

flux through flat, homogenous specimens with their specimens in contact with solid, parallel boundaries held at constant temperature using the guarded hot plates.

The results showed that the thermal conductivity of all CFC samples is positively proportionate with the density. For instance, the thermal conductivity for CFC reduced from 0.331 to 0.297 W/m.K for corresponding densities of 1000 and 800 kg/m^3, respectively which was less than that is specified in IS 2185(iv):2008. This happened due to formation and size of pore that consist inside CFC. The thermal conductivity gave better result as the density decreased. This was due to different formations and size of pores on the microstructure formation of CFC.

Thermal insulation provided by CFC is up to 4-5 times superior than concrete having conductivity 1.44 W/m.k. This provides better thermal insulation and thereby reduces air-conditioning and heating costs over the lifecycle of a building. Also, thermal conductivity of CFC sample was less than that of brick i.e. 0.72 W/m.k. Therefore bricks can be easily replaced by CFC-block of lower density as an infill material.

The properties of developed CFC blocks (Fig. 6) are given in table 3.

Table 3: The Properties of Developed CFC Blocks

Properties	Values			
	Density 800 kg/m^3	As per IS:2185 (IV)-2008.	Density 1000 kg/m^3	As per IS:2185 (IV)-2008.
Compressive Strength, MPa	2.61	2.50	3.83	3.50
Thermal Conductivity, W/m.K	0.297	0.32	0.331	0.36
Drying Shrinkage, %	0.079	0.08	0.071	0.08
Performance Factor (Compressive Strength) at 28d	318.51	312.50	382.12	350.00

Fig 6: CFC Blocks

Optimization of Water Sprays & Location of Sprinkler in an Enclosure Fire

A. Aravind Kumar & Rajiv Kumar

Introduction:

Compartment fires have the potential to cause major loss to life and property. The importance of understanding the fire behaviour involved in movement of heat and smoke with a burning structure is essential to carry out the design of fire protection in the buildings. In practice, automatic sprinkler system and fixed water spray system are used as fire services installations. With the advancements in technology there are so many fire sprinkler nozzles provided in the market which can able to generate the smaller droplets of water under high pressures. Since the nozzle will operates under relatively high injection pressure to yield fine droplets of water, however, it requires more elaborate efforts in designing the sprinkler nozzle and the water supply system. As a matter of fact, the performance of water sprinkler systems are significantly affected by a number of factors such as droplet size, water flow-rate, spray angle, properties of fire source and ventilation conditions.

Objective of the Project:

To achieve the early suppression of fire by optimizing the sprinkle spray characteristics such as particle diameter, mass flow rate and location of the sprinkler in an enclosure fire.

Scope of the Work:

The scope of the work is carried out for the early suppression of fire in an enclosure using sprinkler protection system. The methodology of the work has been carried out in three parts:

- Compartment Fire behavior using HRR/ Combustion modeling.
- Fire and sprinkler water spray interaction studies and comparison.
- Optimization studies.

Methodology for Compartment Fire behaviour using HRR/Combustion modelling:

The fire behaviour studies in a compartment are performed using CBRI experimental data as well as data from the literature (Steckler et al.). The simulations studies performed in two configurations with and without sprinkler operation in the enclosure fire using CBRI experimental data of benzene as a fire source. CBRI has conducted experiments on compartment fires in a single compartment of size, 2.5m×2.0m in plan, and 1.5m in height. A centrally placed single door opening of size 1.2m wide and 1m high was provided at west wall. The walls were made of clay bricks and cement sand mortar, 0.125m thick. The interior wall and the ceiling surfaces are plastered with 0.013m thick cement-sand mortar of 1:4 ratios. The compartment was provided with instruments to measure the following variables: (i) fuel burning rate, (ii) hot layer temperature, and (iii) outgoing gas temperature. A weight loss measuring platform is located at a height of 0.05m above the floor. The fuel used is benzene which is burned in square metal tray. The size of 0.25m×0.25m has been used for carrying out experiments. Hot layer temperatures were measured at 9 locations by thermocouples at 0.045m below ceiling. The thermocouples have been marked as T1, T2, T3, T4, T5, T6, T7, T8 and T9. Specially designed K-type thermocouples were used to measure temperatures as shown in Fig1.

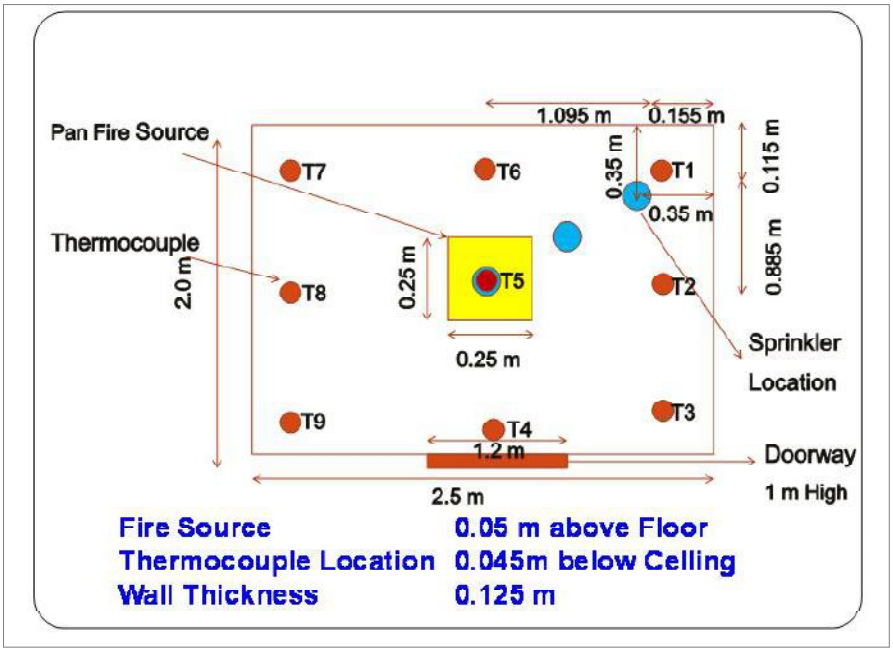


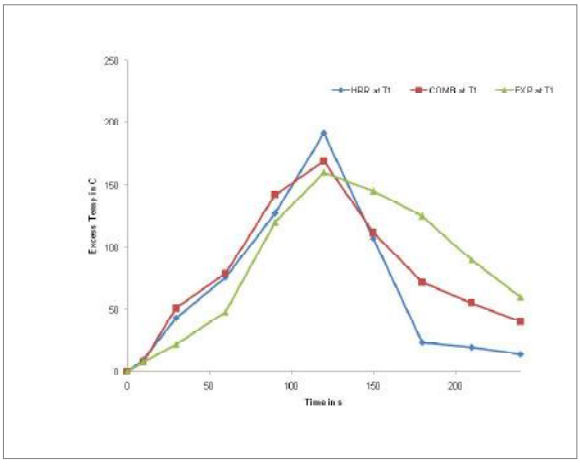
Fig 1: Top View of Thermocouple & Sprinkler Arrangement

Results without sprinkler operation:

The predicted results of simulation for ceiling temperatures at different locations in the experiment are compared with the CBRI experimental data as shown in Fig 2(a) & Fig 2(b).

The Results with Sprinkler Operation

With the standard sprinkle nozzle (P13B) data of water spray volume mean particle diameter 1450 μm, the Numerical simulation studies has been carried out in the enclosure fire of benzene. The predicted ceiling temperatures are compared with the CBRI experimental data as shown in figure a-d at the thermocouple locations of T2 & T5 temperature of thermocouples with respect to time. The studies are extended by varying the droplet diameters 393, 1450, 1251, 1197, 1167, 1117, 895, 744, 696 and 439μm to find the optimum range of water particle diameter of sprinkler water spray. The predicted average ceiling temperatures are compared with the CBRI experimental data as shown in Fig 3(a) & Fig 3(b) with respect to time.



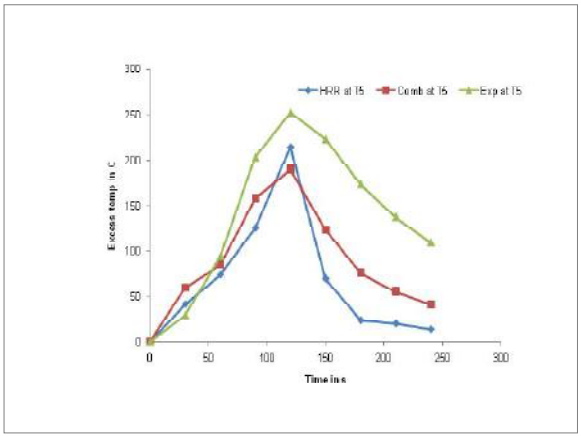


Fig 2: Temperature vs. Time Curve at Locations of T1 & T5.

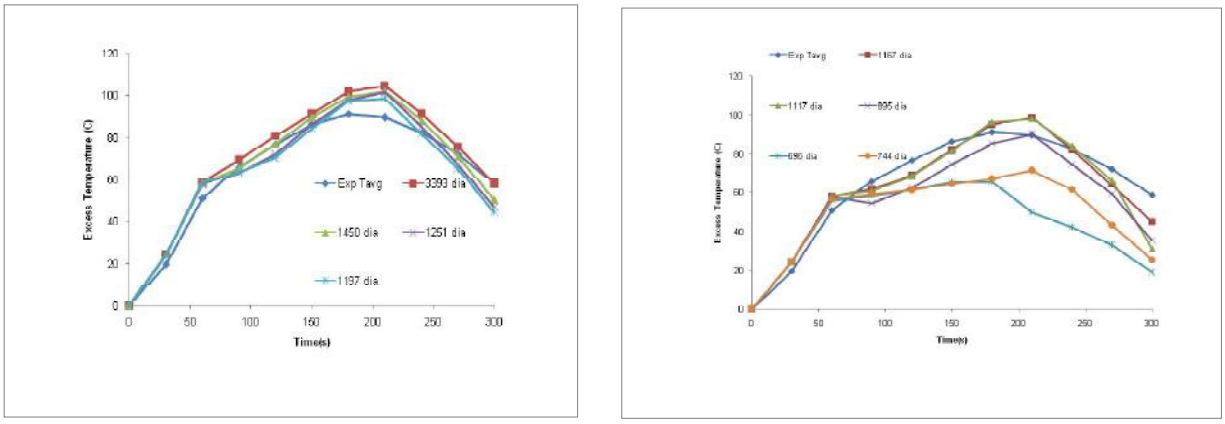


Fig 3: Sensitivity Analysis of the Results for Different Droplet Diameters 3393, 1450, 1251, 1197, 1167, 1117, 895, 744 & 696 μm.

Conclusion/Remark/ Discussion:

- Smaller the water particle diameter the fire suppression time is reducing with sprinkler covered area also.
- The water droplet diameters above 895 μm are suppressing the fire by gradual cooling and sudden impingement (striking the fire source surface) effect.
- The droplet diameter less than 895 μm are suppressing the fire with the rapid evaporation rate as well as sudden impingement effect of the particles.
- The fire suppression time is less when the location of sprinkler is above the fire source compared to other locations.
- The optimum volumetric flow rate of water is found to be 60 lpm for the droplet diameter range of 895-696 μm and it can be reduced to 40 lpm if sprinkler nozzle particle diameter range can be 439 to 696 μm.

Study of Residential Schools in Composite Climate for Energy Conservation

Neeta Mittal

Objective:

The aim of the study is to evolve a methodology & frame work for energy efficient schools which will enhance the thermal comfort in composite climate and utilize the renewable solar energy in schools.

Thermal comfort study has been done in residential schools. Climatic parameters such as Air velocity, mean radiant temperature, air temperature and humidity are measured for assessment of comfort in summer and winter season in composite climate. Also, studied the designs of schools to evaluate thermal comfort in school classrooms and dormitory in the campus and identified the architectural and various physical aspects for comfort. Residential schools Jawahar Navodaya Vidyalaya selected for the study are located in village Motuka in Faridabad district, Baghra district Muzaffarnagar, and in Chandigarh for data collection. Thermal comfort study has been done in schools dormitories and in dining hall and in residences. All the collected data analyzed for comfort conditions in critical summer season. Improvements in design are suggested for thermal comfort conditions. It has been observed if the passive design techniques and fundamentals are adopted energy can be saved and comfort conditions can be achieved. To improve indoor thermal comfort conditions in schools and dormitories guide lines are formulated and report is prepared.

Group Effect of Piles in Loose Sandy Soil in Earthquake Induced Lateral Spreading

Piyush Mohanty

I. Development of methodology to determine lateral load distribution in pile group in case of earthquake induced lateral spreading.

II. It can be used to design methods to countermeasure the detrimental effect of liquefaction on central piles by putting surrounding piles

Deliverables of the Project:

Develop the design methodology to countermeasure the detrimental effect of liquefaction on central piles by putting surrounding piles.

Progress of the Project from April 2015 to March 2016:

A uni-axial shaking table of payload capacity of 2 ton was used in the present study. Sand beds were prepared in a perspex box of dimension of 1.4 m x 1.0 m x 1.0 m. Height of the sand bed was kept as 500 mm in all the tests. As rigid Perspex box was used for the tests, the initial concern was to minimise the boundary effect imposed by the rigid boundary. Hence, 50 mm thick PU foam was used at the boundary after taking into account the following mechanism.

Experimental Study for Boundary Effect:

After determination of type and thickness of foam, tests were carried out to check the boundary effect after the addition of foam near the end walls. The test setup for this is shown in Fig 1.

Experimental Study:

Tests were carried out with and without the foam to compare the response of sand near the boundaries. For this, four MEMS accelerometers, provided by BiSS Bengaluru were used. The accelerometers can measure up to 2g, with an operating frequency of 100 Hz. Accelerometer 1 was attached to the table to measure the input table acceleration. Accelerometers 2, 3 and 4 were attached to a perspex glass plate of dimensions 70 mm x 40 mm x 5 mm and placed inside the sand. Sand paper was pasted below the plate in order to prevent slippage between the plate and soil. The data was recorded using the inbuilt data acquisition system of the shake table.

Fig 1: Test Setup for Boundary Effect Study

Experimental Procedure:

To carry out the tests, initially the base of the tank was made rough by pasting sand paper over it. After that calculated amount of sand was filled inside the tank in layers, it was vibrated at high frequency using the shake table in order to compact it. A few trial tests were conducted at first and it was found out that upon vibration, the sand got

compacted to a relative density of 90%. No change in relative density was observed for further vibrations. The density was calculated by measuring the weight of sand inside samplers placed at different heights at the time of filling up of tank. For placing the accelerometer at a particular depth, the sand required up-to that layer was filled and then the tank was vibrated. The surface was then made plain with the help of a wooden spatula (specially prepared for this purpose). The accelerometers were kept at desired positions. Later, different tests were carried out using sinusoidal motion as input with different acceleration amplitude 0.2g, 0.4g and 0.6g at frequencies 2, 3, 4, 5 and 6 Hz.

To check the efficacy of foam for restraining boundary effect, PU foam was placed at the ends and fixed to the wall using the cello tape. Thereafter the tank was filled with the sand using aforementioned procedure. The accelerometers were fixed at locations as shown in Fig 2 while filling the sand and the tests were carried out at similar acceleration amplitude and frequencies.

Result & Discussion:

The results of the tests carried out to study the boundary affects are shown below. For studying the boundary effects, the amplification of the base motion by soil at different locations was taken. The basic criterion for studying boundary effects is that the horizontal displacement at a particular layer/ depth of soil must be same at all places. The displacement can be obtained by integrating the acceleration data obtained from the accelerometers. But due to some noise in the acceleration data, it was difficult to estimate the displacement. Therefore the ratio of accelerometer output data to the input data was studied. The peak from each cycle of the acceleration time history of all 4 accelerometers was taken and its average was calculated. This average value was used to calculate the acceleration ratio. This acceleration ratio, which can also be termed as amplification, was plotted against input frequency for further study.

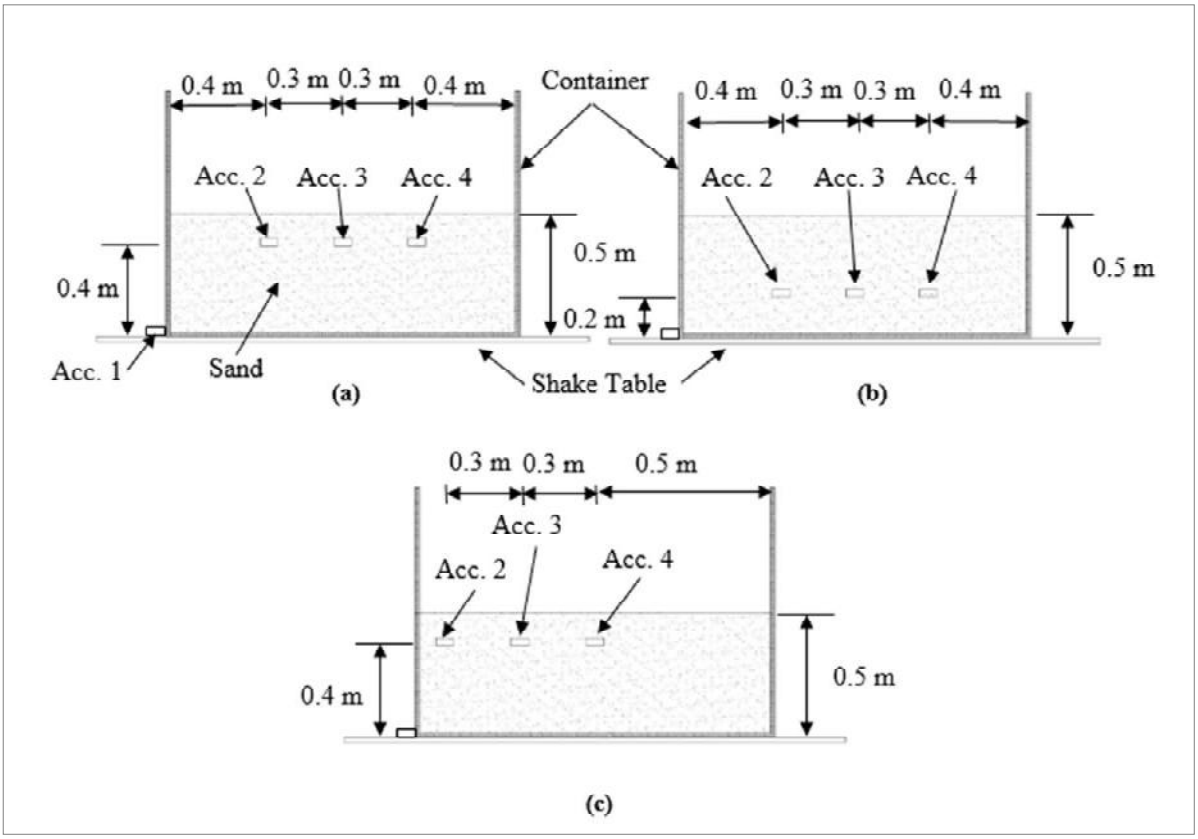


Fig 2: Schematic of Test Setup for Study of Boundary Effects without placing PU Foam

At 40 cm Height from Bottom:

The Fig 3 shows the variation of amplification of acceleration at different points within the same level from bottom, with and without use of foam. The setup for this is shown in Fig 2 (a) & Fig 2 (c). It can be observed that without addition of foam, slight difference exists in the amplification value at different locations. But after addition of foam, this difference is reduced. The amplification near both boundaries is almost same.

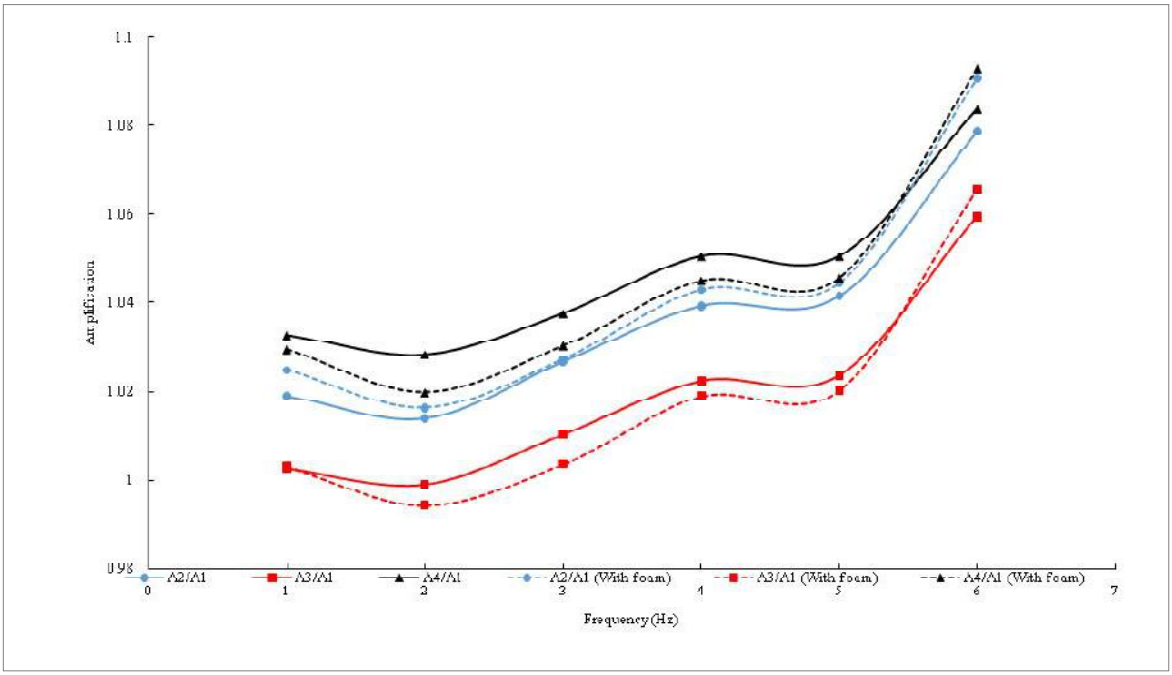


Fig 3: Variation of Amplification with Frequency for 0.2g at 40 cm Height from Bottom, with & without Foam

At 20 cm Height from Bottom:

Fig 4 shows the variation of amplification of acceleration at different points within the same level with and without use of foam. The setup for this is shown in Fig 2 (b). It can be observed that there is not much change in the amplification after addition of foam. The amplification is also very small, thus significant effect is not observed for this case.

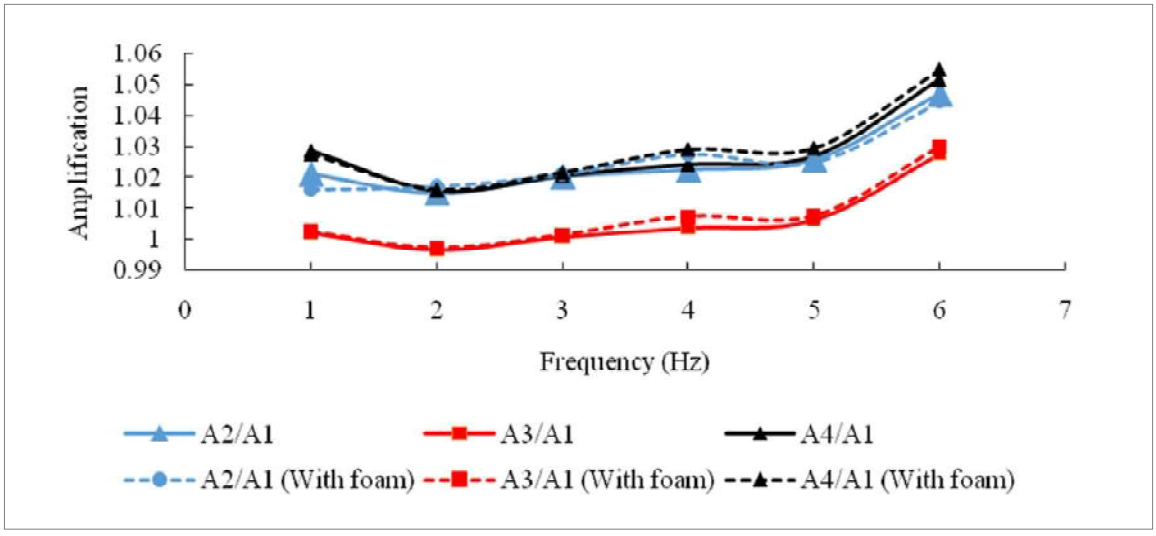


Fig 4: Variation of Amplification with Frequency for 0.2g at 20 cm Height from Bottom, with & without Foam

It can be observed that the transmitted acceleration is almost similar. Thus there is only a slight variation in the transmitted acceleration for a particular depth. So the foam is able to reduce the boundary effects for the tested range of acceleration and frequency.

Experimental Procedure for Liquefaction:

A saturated sand bed of uniform density was prepared inside the Perspex box using a wet pluviation method. The relative density of the sand was kept uniform as 43% in all the tests. Amount of water required to saturate the sand bed was calculated and ûlled in the perspex box. Dry sand with known natural moisture content was poured uniformly into the water through a funnel and solid cone arrangement. A miniature accelerometer was kept at exactly mid-depth along the central line of the sand bed by a cable and thread arrangement to give free movement. The weight of this accelerometer is less than 5 g, and hence the interference of the sensor with the movement of the soil during dynamic testing is minimal. A manual piezometer was also used during the test. Photograph of the test set-up is shown in Fig 5.

Fig 5: Test Setup for Liquefaction of Sand

Three different series of shaking table tests were carried out in this study. In the first series, the saturated sand bed was subjected to dynamic horizontal shaking at a frequency of 1 Hz, varying the base acceleration as 0.1g, 0.12 g, 0.13 g, 0.14 g, and 0.15 g. The objective of this series is to obtain the ground motion parameters to initiate liquefaction in the sand bed. In the second series of tests, the effect of overburden pressure on the liquefaction response of saturated sand bed was studied. For this purpose, a dry sand layer of varying thickness was placed over the prepared saturated sand bed in the shaking table in different tests, keeping the total height of the sand bed as 500 mm.

Results & Discussions:

Initiation of liquefaction is identified in terms of complete loss of effective stress when the pore water pressure ratio (ratio of excess pore water pressure to the initial effective overburden stress) becomes one. The first series of tests in this study are designed to find out the base acceleration required to initiate liquefaction in the saturated sand bed at a shaking frequency of 1 Hz. In the first test in this series, S1A10, with acceleration amplitude of 0.1 g, the sand bed was not liquefied even after 100 load cycles. The acceleration was gradually increased in subsequent tests to 0.12 g, 0.13 g, 0.14 g, and 0.15 g respectively. It was clearly observed that the response of sand is substantially affected by the small variations in acceleration amplitude. However, no flow liquefaction was observed for tests S1A12, S1A13, and S1A14 up to 50 load cycles as shown in Fig 6.

Liquefaction was observed in S1A15 within six load cycles, when the acceleration amplitude was 0.15 g.

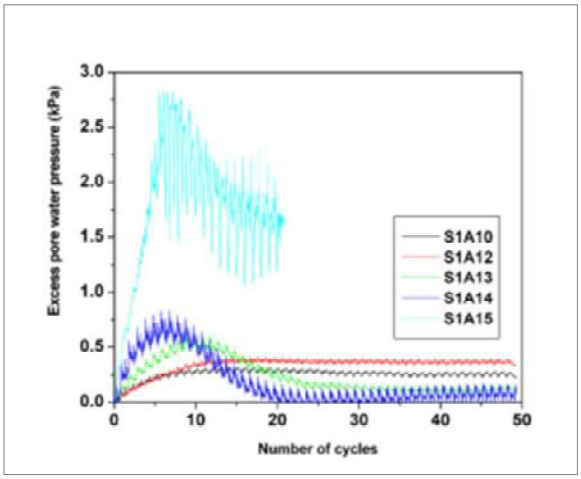


Fig 6: Variation of Excess Pore Water Pressure Measured During Test

Flow liquefaction with complete loss of shear strength was visually observed in the sand bed at 0.15 g acceleration and 1 Hz frequency. Formation of small sand boils, which represent the gushing out of pore water pressure from the sand layer underneath, was observed in the test. Fig 6 shows the sand bed liquefied in the test with base acceleration of 0.15 g and also a close view of the sand boil developed during the test. For all the acceleration amplitudes less than 0.15 g, there was limited liquefaction, exhibited by increase in pore pressure ratio and decrease in effective stress.

Variation of pore water pressure and effective stress with number of cycles for the tests in this series is plotted in Fig 6. The figure clearly shows that pore water pressure reached its peak to equal the total stress only for the test S1A15 when the acceleration amplitude was 0.15 g. For all tests below this acceleration amplitude, pore pressure increased and effective stress reduced with the increase in acceleration amplitude but complete liquefaction did not occur.

I. Numerical Study:

The numerical study was carried with the help of FE package PLAXIS3D. Firstly, the validation of the numerical model built on this platform was carried out with the published results.

The numerical modelling of an embankment founded on loose liquefiable sand was carried out with the help of PLAXIS 3D FE software. Acceleration base-input excitation of the El Centro earthquake is applied to the model monitoring the displacements, liquefaction potential and EPP. Initially, the numerical model of PLAXIS 3D was validated with the published work of a centrifuge study by Adalier et al., 1996. Centrifuge modelling has been considered among the best experimental methods for modelling and observing soil-liquefaction phenomena. It creates stress conditions in the model that closely simulate those in the full-scale prototype. The correctness and accuracy of the proposed numerical modelling in PLAXIS 3D is validated by comparing the numerical results with the centrifuge study results conducted at the RPI centrifuge facility (Adalier 1996). Dynamic stability of a 4.5-m clayey sand embankment (Fig 1) supported on 6m of medium-saturated sand tested in a 75-g centrifugal acceleration field (the models were 20m in thickness) has been used for the validation of proposed model developed in PLAXIS 3D. The embankment was built at 1:1 slope, composed of a Kaolin clay and Nevada sand mixtures (1:4 weight ratios) with a mass density of 1:9 t/m3 and water content of 14%.

Nevada fine sand (Arulmoli et al. 1992) was used as the liquefiable foundation soil (DR = 40%). The foundation layer was saturated with a pore fluid at a prototype permeability coefficient of 5:5 × 10"4 m/ s, within the range of medium sands (Lambe and Whitman 1969).

Constitutive Relation:

A modified non-associative plastic-potential function based on the Drucker–Prager criterion is used to the maintain co-axiality of stress strain in the deviator plane for a stress path initiated from the isotropic line. The soil-densification rule is also added to predict more realistic EPPs in cyclic loading. This rule allows for the increase of pore water pressures with decreasing rates during shearing, as shown in the experimental studies. The main characteristics of the model are presented in the following sections.

Yield Function:

In the present analysis, two yield surfaces are used, namely, primary and secondary. The primary surface is based on isotropic hardening and becomes active when the mobilized friction angle is equal to the maximum mobilized friction angle that the soil has ever reached. Here, the current stress ratio is the highest stress ratio in the loading history. A simplified kinetic-hardening rule is used for the secondary yield surface. It becomes active when the mobilized friction angle is less than the maximum mobilized friction angle. Here, the current stress ratio is lower than the maximum stress ratio in the loading history. This distinction between yield surfaces is made to be able to have the densification rule in secondary yield surfaces. A stress state is considered on the isotropic axis, and both yield surfaces are in the same position. From the isotropic stress state, both primary and secondary yield surfaces expand according to the same hardening rule. When soil is unloaded, the secondary yield surface shrinks, and soil acts in an elastic behaviour. On reloading, the secondary yield surface becomes active, and behaviour becomes elasto-plastic. When the mobilized friction angle reaches the maximum mobilized friction angle, the primary yield surface becomes active again, and behaviour becomes softer. The Mohr– Coulomb yield formulation is used to define both yield surfaces.

Validation:

Centrifuge modelling has been considered among the best experimental methods for modelling and observing soil-liquefaction phenomena. It creates stress conditions in the model that closely simulate those in the full-scale prototype. The correctness and accuracy of the proposed numerical modelling in PLAXIS 3D is validated by comparing the numerical results with the centrifuge study results conducted at the RPI centrifuge facility (Adalier 1996). Dynamic stability of a 4.5-m clayey sand embankment (Fig 7) supported on 6m of medium-saturated sand tested in a 75-g centrifugal acceleration field (the models were 20m in thickness) has been used for the validation of proposed model developed in PLAXIS 3D. The embankment was built at 1:1 slope, composed of Kaolin clay and Nevada sand mixtures (1:4 weight ratios) with a mass density of 1:9 t/m3 and water content of 14%. Nevada fine sand (Arulmoli et al. 1992) was used as the liquefiable foundation soil (DR = 40%). The foundation layer was saturated with a pore fluid at a prototype permeability coefficient of 5:5 × 10"4 m/ s, within the range of medium sands (Lambe and Whitman 1969).

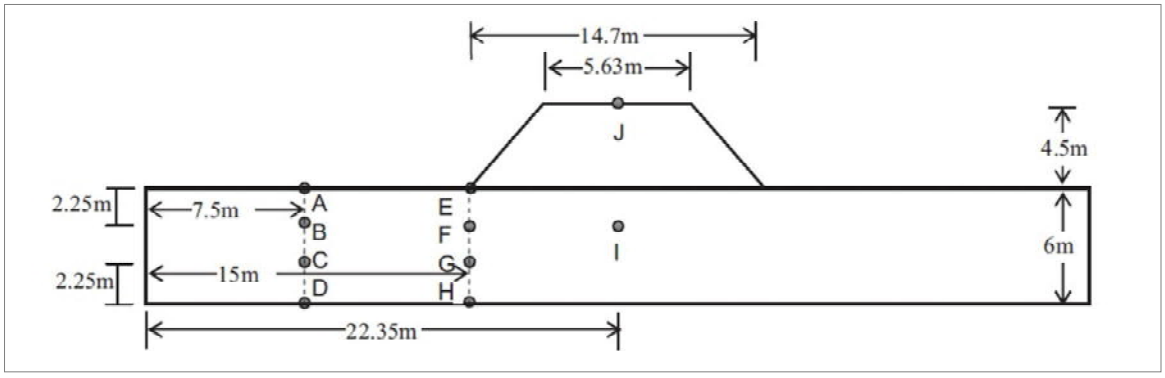


Fig 7: Layout of the Embankment & the Instrumentation used for Validation

The input motion is comprised of 10 cycles of 0:18 g at 1.6-Hz prototype scale. The measured and predicted displacement, acceleration, and excess pore water-pressure time histories at different locations are shown in Fig 8(a), Fig 8(b) & Fig 8(c) respectively. Fig 8 shows that the predicted displacements are in good agreement with the measured values. At Location E, the maximum vertical displacements are 1.03 and 1.24 cm for the experimental and numerical study, respectively, whereas these values are 20.6 and 19.9 cm at Location J. A close agreement is observed between

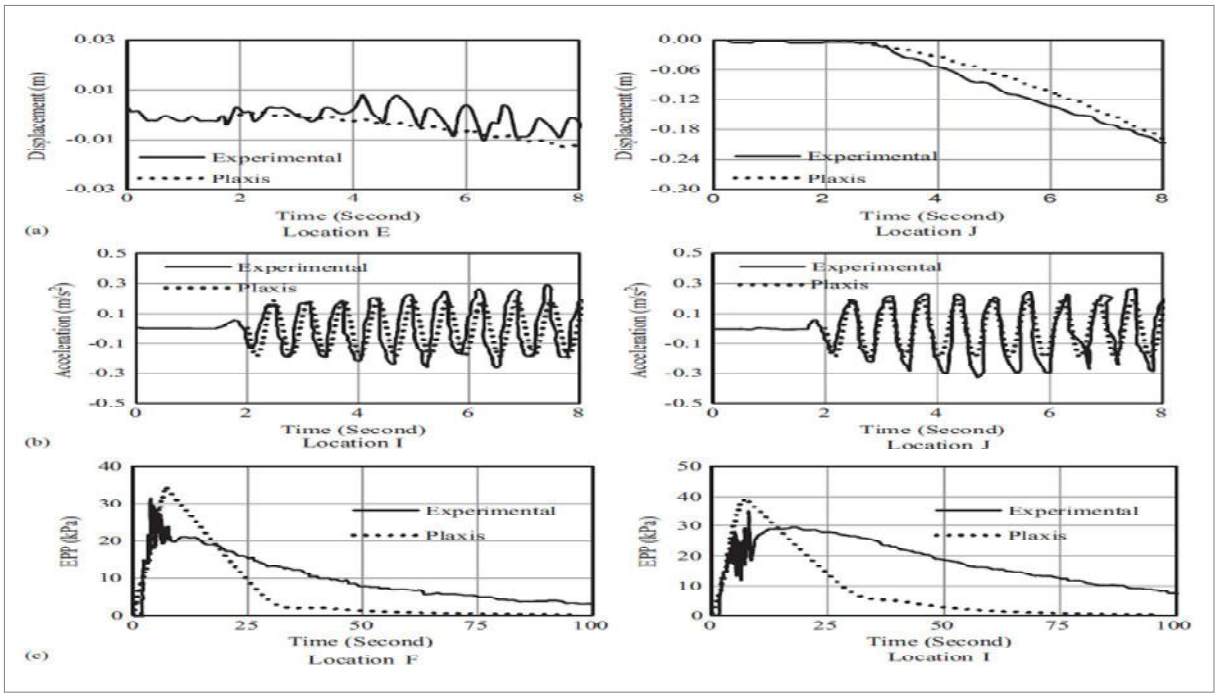


Fig 8: Measured Displacements, Acceleration & Excess Pore Water Pressure

numerical and experimental results. Similar comparison of acceleration at Locations I and J is presented in Fig 8(b). It is observed that predicted values of accelerations are slightly lower than the experimental values. It is revealed from Fig 8(c) that the predicted values of EPP are in good agreement with the measured values in the centrifuge experiment. The maximum values of EPP at Location F are 33.33 and 30.07kPa for the experimental and numerical models, respectively, whereas corresponding values at Location I are 34.84 and 37.8kPa, respectively. At Location F, the excess pore water pressure has reached the initial vertical effective stress corresponding to 100% pore-pressure rise at the time of 7 s, indicating initial liquefaction. The results show fairly good agreement with those presented by Adalier (1996), with little deviation. It appears that post-liquefaction dissipation of EPP is faster in the numerical analysis as compared with actual observation. Numerical analysis is based on constant value for permeability throughout the analysis, whereas in the actual case, the permeability after liquefaction will be different than the original depending on densification (reduction in permeability) or dilation (increase in permeability) behaviour. The comparison demonstrates that the current model can approximately simulate the real behaviour of liquefaction.

Numerical Parametric Analysis:

In the dynamic analysis of piles, moving soil interacts with the pile and in the vicinity of the pile; soil displacement is different from the displacement of the soil if there were no piles. Therefore, in the pile analysis, it is assumed that the displacement of the soil away from the pile can be represented by the displacements obtained from the free field ground response analysis. Soil–pile interaction is modelled using the analysis method for a dynamically loaded beam on a nonlinear Winkler foundation, where the pile is modelled as a beam and the lateral pressure acting on the pile is modelled using a spring-dashpot model with a plastic slider to limit the ultimate lateral pressure at the pile–soil interface as shown in Fig 9. In this model, displacement of the soil adjacent to the pile wall is represented by the displacement of the plastic slider, which is different from the displacement of the soil away from the pile.

Pile Group Behaviour:

The behaviour of an isolated single pile under lateral spreading is manly governed by the stiffness

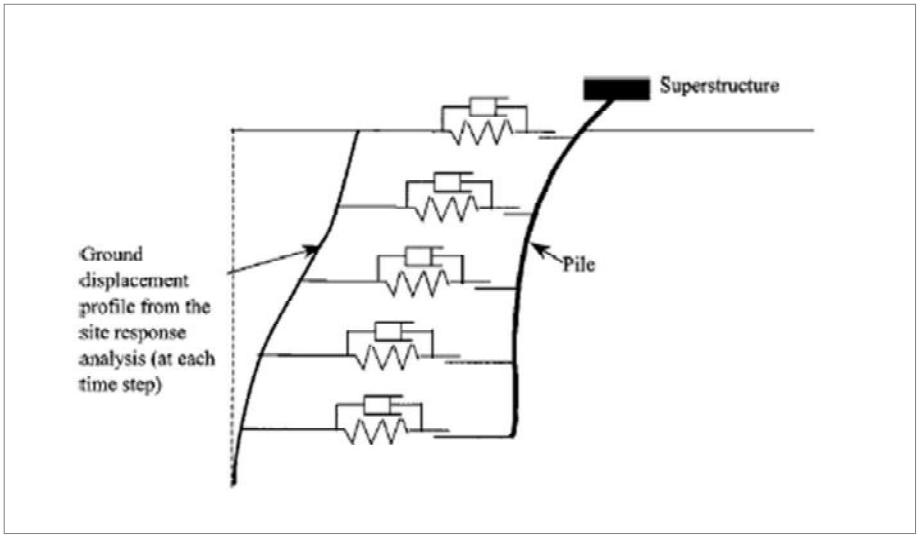


Fig 9: Beam on Winkler Foundation Model for Pile Analysis

of the pile, the stiffness of the soil along the length of the pile and the permanent ground displacement. In contrast, in the field, piles are often arranged in groups and behaviour of a pile group may differ substantially from that of a single pile. It is known that, for closely spaced piles, less than 5 pile diameters, the interaction of one pile with the others in the pile group cannot be neglected and the pile-soil-pile interaction should be taken into consideration. Most of the present information about pile group behaviour is based on the pile-soil-pile interaction in medium to dense sand, clay and other type of soil conditions which is substantially different from pile group effects in liquefiable and spreading ground.

To evaluate the performance of the pile group undergoing lateral spreading of liquefied ground, the lateral force per pile row, which is estimated as the sum of the lateral force acting on each pile in the pile row, is employed. Fig 10(a) & Fig 10(b) present the lateral force per pile row divided by the total lateral force acting on the pile group in the cases of 5D and 2.5D pile spacing.

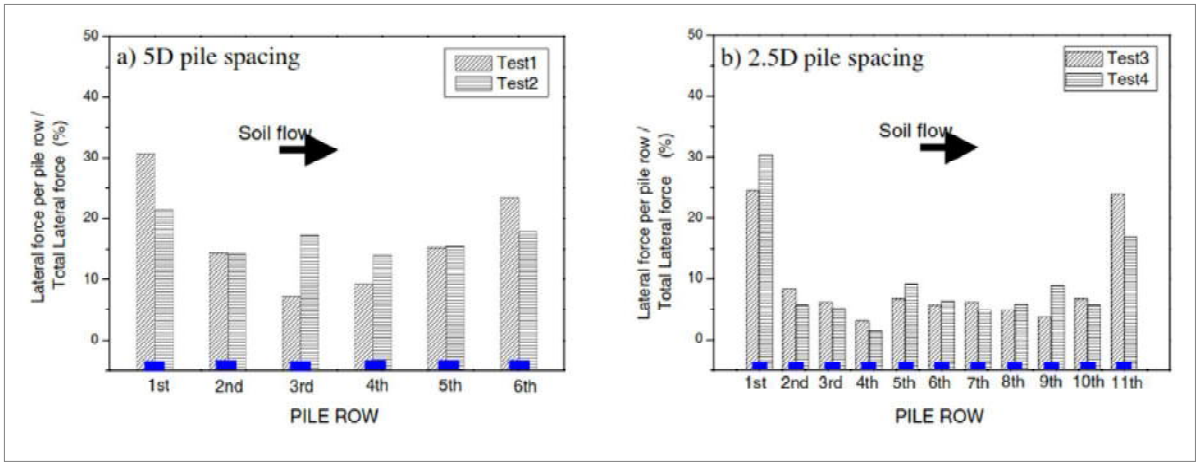


Fig 10: Distribution of Lateral across Different Pile Rows in a Pile Group

Study on Carbonation of RC Structures

Mickey M. Dalbehera & Achal Kumar Mittal

Carbonation is a major cause of reinforced concrete structures deterioration leading to expensive maintenance cost. The corrosion of steel bars due to carbonation affects the durability of reinforced concrete, thereby decreasing the long term performance and safety of the structures. The rate at which carbonation in concrete takes place is mainly dependent on the moisture content and relative humidity in the vicinity of the concrete structure. Carbonation is also greatly influenced by the CO_2 concentration in the air, type of cement, w/c ratio of the concrete mix. Even though the results from accelerated carbonation tests have been used in the past to predict long term carbonation depths, there is in general no agreement on how to extrapolate from accelerated testing conditions in laboratory to real conditions in the field. This is because carbonation in itself is a complex phenomenon. Microstructure of the carbonated concrete formed in the accelerated conditions may not be same as under natural conditions. Mass transport properties as well as CO2 concentrations of accelerated testing and natural conditions differ from that of laboratory specimens and structural elements on filed. Variances in mass transport property of concrete arise from different placing; compacting, curing conditions; relative humidity and dry- wet cycles.

Objective of the Project:

To study the effect of cyclic humidity on M20, M30, M40 grade of concrete subjected to carbonation.

Observations:

1. Moisture movement in structural concrete during the course of service plays a critical role in the initiation and propagation of rebar corrosion in reinforced concrete (RC) elements. The provision of an adequate cover depth is thus essential to restrain the ingress of moisture up to the layer of embedded steel, mitigating thereby the evolution of the corrosion process. The sequence of event in the experimental testing is as shown in Fig 1.

Fig 1: The Sequence of Event in the Experimental Testing

2. It has been observed that Water–cement ratio has an inverse effect on the carbonation resistance of the concrete. An increase in water-cement ratio (w/c) causes higher porosity, which leads to a coarser pore structure of the concrete. Higher values for w/c reduce the carbonation resistance in an exponential manner. This effect is more pronounced for concretes that have low potential resistance due to the binder type (e.g. slag cements).

3. An increase in cement content increases the binding capacity which improves the carbonation resistance. On the other hand, an increase in cement content will also increase the amount of permeable cement paste, leading to a higher effective diffusion coefficient and thus reduced carbonation resistance.

4. A numerical study in MATLAB is made to map the moisture movement inside the concrete when subjected to different moisture content. The moisture profiling in the concrete (drying phase) has been shown in Fig 2.

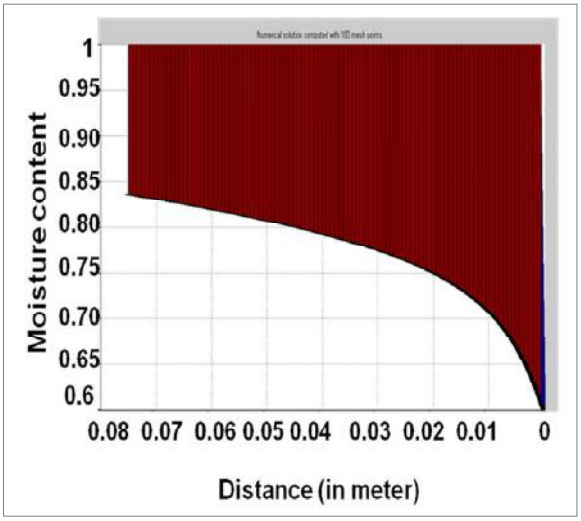


Fig 2: Moisture Profiling in Concrete in Drying Phase

Conclusions:

The carbonation of concrete was studied using an accelerated approach with 5% CO_2 by volume and various RHs at a constant ambient temperature of 25°C. The results showed that the carbonation of concrete is influenced by the ambient humidity, humidity cycling. The maximum depth of carbonation occurred at the RH cycle of 50-90%, followed by constant 65% RH, and the coefficient of carbonation decreased with humidity cycling in the range of 70-90%RH. It may be possible to predict on-site carbonation of concrete from accelerated carbonation results with adequate information about the CO_2 concentration, humidity cycles.

Determination of appropriate humidity cycles and rate of change of RH in cyclic loading for this type of testing is an issue that has rarely been discussed in the literature. The approach taken to accelerated carbonation in this study was based on an assumption that the time required to induce a certain depth of carbonation is inversely proportional to the CO_2 concentration.

Uplift Capacity of Shallow Strip Anchors under Static & Seismic Conditions

Anindya Pain

Anchors are commonly used as a part of foundation system for structures which are subjected to uplift forces. Ground anchors are commonly used as part of foundation systems for transmission towers, telecommunication masts, chimneys, pipe lines etc.

Determination of uplift capacity of anchor is a passive earth pressure problem. Curved rupture surface and the upward relative movement of anchor or wall with respect to soil is commonly assumed in the analysis by limit equilibrium method (Meyerhof, 1968). This relative upward movement of anchor or wall with respect to soil is herein termed as the case of negative wall friction angle. The modified pseudo-dynamic seismic forces are used with limit equilibrium method for curved failure surface to obtain the seismic uplift capacity of anchor by considering wall friction angle *ä* >2Õ/ 3. Concave failure surface which is an arc of a logarithmic spiral is considered on both sides in the analysis of horizontal strip anchor.

Modified pseudo-dynamic method is applied to compute the passive earth pressure for concave failure surface (refer to the failure surface DE in Fig 1) and also for composite convex failure surface under seismic conditions. And subsequently these earth pressure values are used to calculate the pullout capacity of shallow horizontal and inclined strip anchors under seismic conditions.

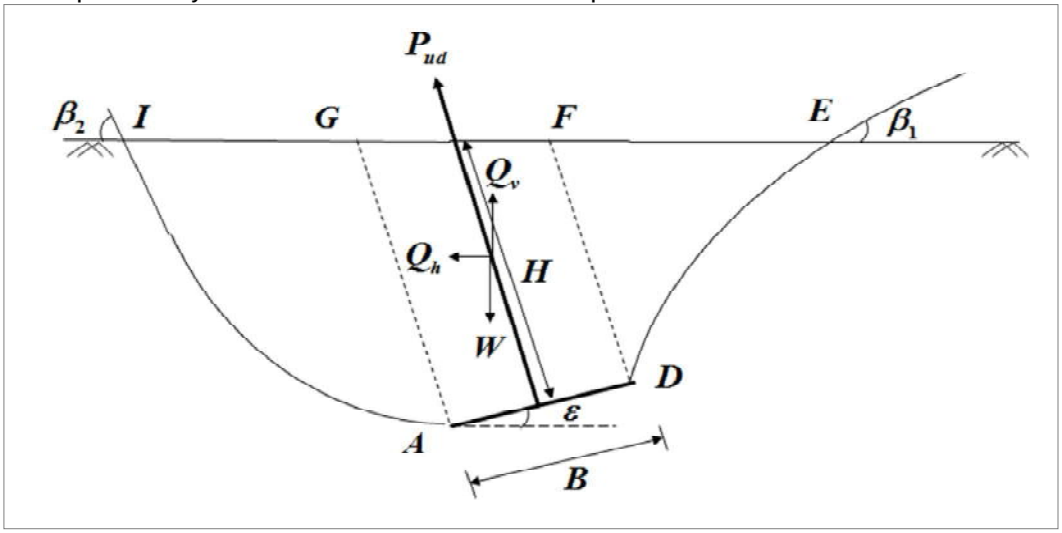


Fig 1: Failure Surface with Seismic Inertia Forces for Inclined Strip Anchor

A laboratory setup is prepared to apply pull to reduce scale model strip anchor. Pull can be applied to horizontal and inclined anchors. Maximum angle of inclination of the anchor is 30° from the horizontal. The arrangement is mounted on a tank having dimensions 0.775m x 0.775m x 1.225m (Fig 2).The machine can apply pull @ 0.95mm/min. The sand used in this study was procured from a local supplier based in Roorkee, India and was classified as SP (poorly graded sand) as per Unified Soil Classification System. Pullout experiments were carried out at an inclination of 15º from horizontal for different embedment depth 2 to 5. The sand

Fig 2: Experimental Setup Fabricated for Pull out Test at CSIR-CBRI, Roorkee

was compacted at relative density of 80%. Pullout experiments were carried out on 50mm wide, 10mm thick MS model anchor plates with aspect ratio 10.The peak resistance was well defined for embedment depth 4 and 5. But for embedment depth 2 and 3 ductile response was observed.

Experimental results are in good agreement with the proposed analytical solution for inclined shallow strip anchors under static condition and the maximum difference between these two is 18%. Experimental results are on the higher side and this difference may be attributed to the interlocking of the grains at low stress levels than at high stress levels. Comparison of the analytical and experimental result is shown in Fig 3.

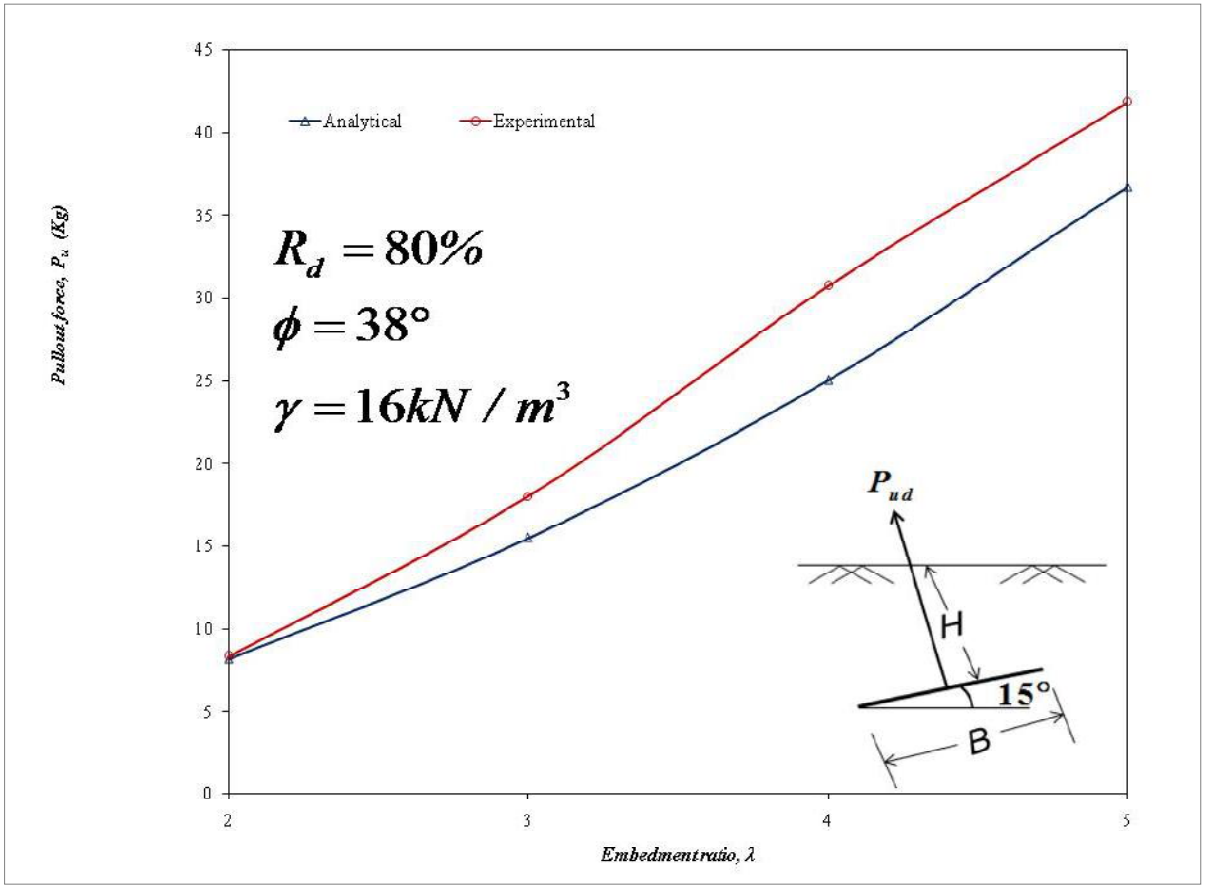


Fig 3: Comparison of Present Analytical & Experimental Results for Anchor Inclined at 15° with Horizontal

Innovative External Binding Strengthening Technique for Elastic Behaviour of Stone Masonry Structure

Navjeev Saxena

The study presents analyses of eight finite element models using ABAQUS out of which NS represents masonry house with No Strengthening (Fig 1), ES-EB represents masonry house strengthened using existing external binding technique (Fig 2), DNS-EB (O1-O6) represent masonry house strengthened using different options of innovative external binding techniques out of which the most promising DNS-EB (O6) is shown (Fig 3) and hereinafter referred as **DNS-EB**.

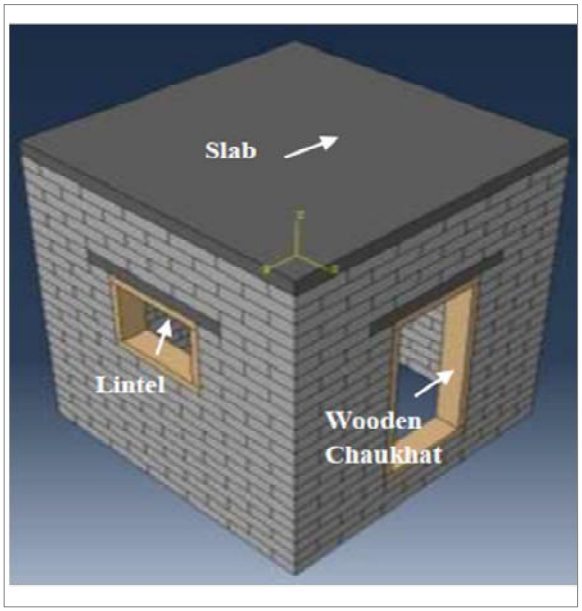


Fig 1: Un-strengthened Model NS

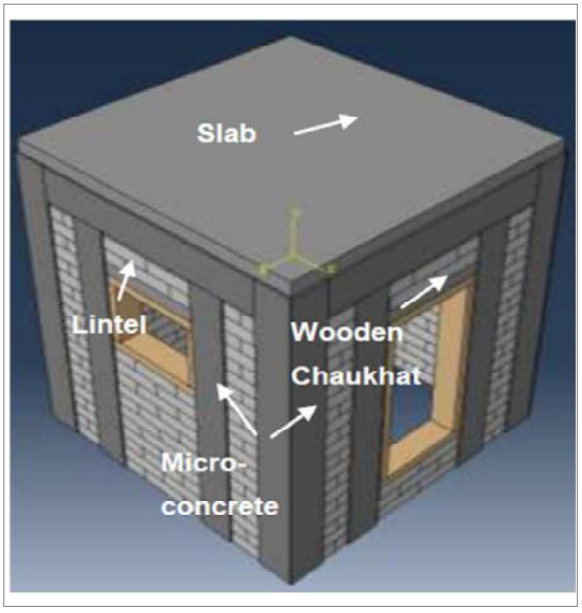


Fig 2: Existing External Binding Scheme Model ES-EB

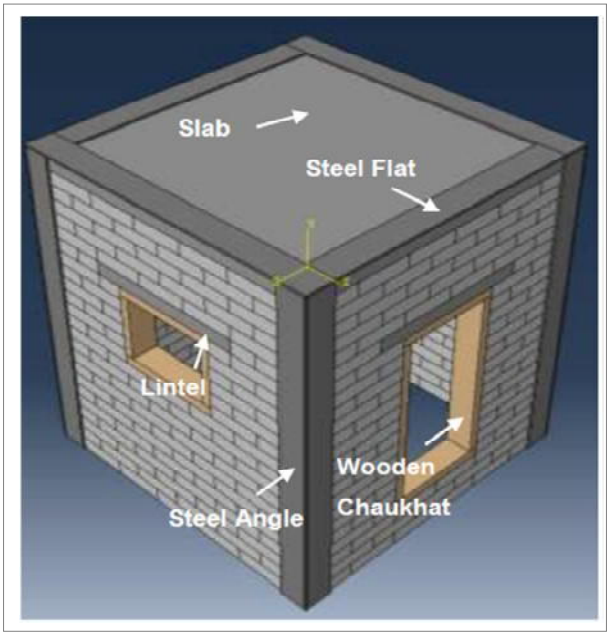


Fig 3: Innovative External Binding Scheme Model DNS-EB

All the models incorporated modeling of all contacts existing between stones-to-stones, stones-to-RCC slab, stones-to-wooden chaukhats, strengthening steel-to-stones and strengthening steel-to-RCC slab to capture response that is more realistic assuming coefficient of friction to be 0.6 everywhere. All structural elements have been modeled by linear solid finite elements.

This study presented finite element modeling and analyses of eight models to arrive at a scheme ensuring elastic behavior even at equivalent Maximum Considered Earthquake loading. The inertial lateral load was applied in both X&Z directions in horizontal plane while vertical gravity load existed throughout the analyses. The peak displacements, tensile stresses & compressive stresses respectively are shown in Fig 4, Fig 5 & Fig 6 where O1…O6 represent DNS-EB (O1…O6). The contours of displacements for NS, contours of peak tensile stresses for ES-EB & DNS-EB are shown in Fig 7, Fig 8 & Fig 9 respectively to compare deformed states. The study draws following conclusions:

- The peak displacements in stones are same in both DNS-EB and ES-EB (Fig 4).
- The peak tensile stress in stones with ES-EB computed to 11.8MPa, much higher than the tensile strength of stones of 2.0MPa, is reduced to 1.6MPa which is well within elastic range.

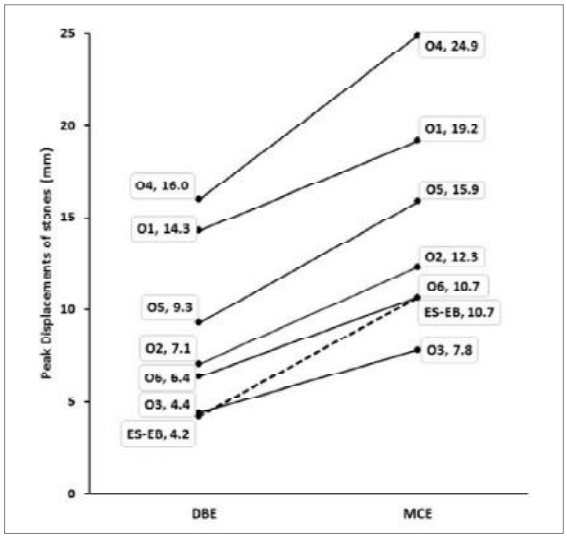


Fig 4: Comparison of Peak Displacements in Stones

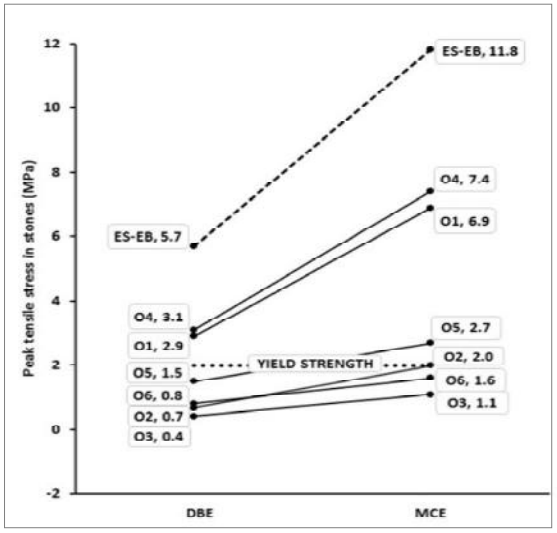


Fig 5: Comparison of Peak Tensile Stress (MPa) in Stones

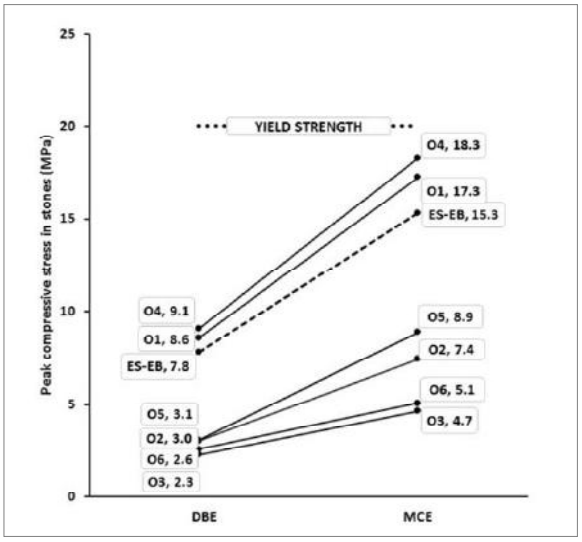


Fig 6: Comparison of Peak Compressive Stress (MPa) in Stones

This reduction is 86% which is quite significant (Fig 5).

- The peak compressive stress in stones with ES-EB computed to 15.3MPa is reduced by 66% to 5.1MPa using DNS-EB (Fig 6).

Therefore, implementation of DNS-EB considerably improved behaviour of stone masonry house owing to significant reduction in peak tensile & compressive stresses in stones dropping them within elastic limit and contributes indirectly to Earthquake Disaster Mitigation (EDM) due to improved IBA.

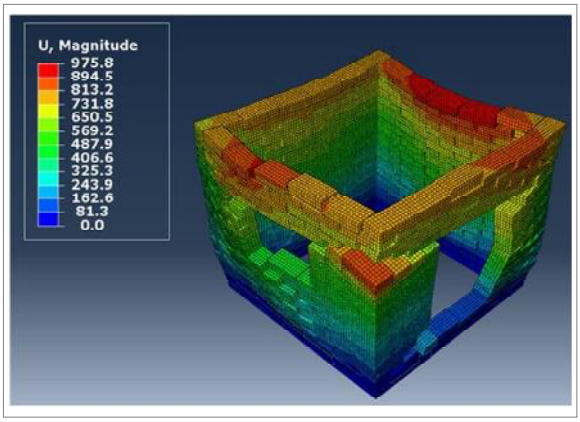


Fig 7: Displacement Contours of Stones in Model NS

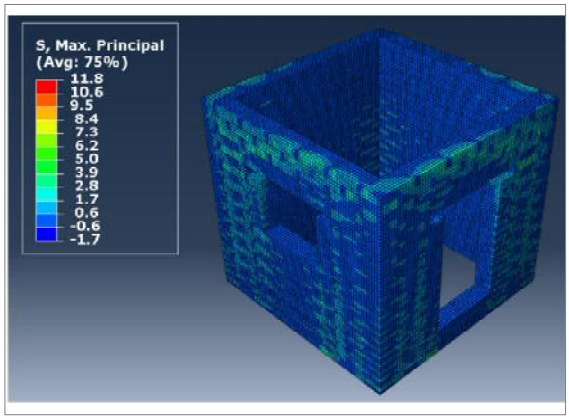


Fig 8: Tensile Stress Contours of Stones in Model ES-EB

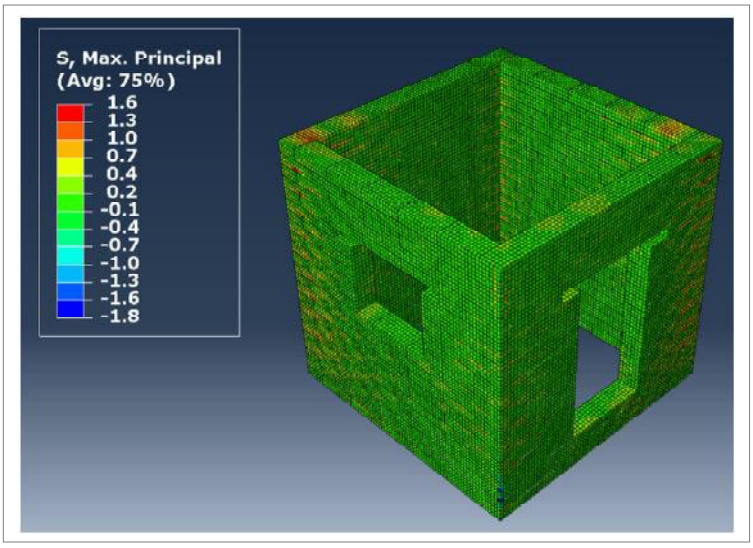


Fig 9: Tensile Stress Contours of Stones in Model DNS-EB

Design Development & Dissemination of Appropriate Rural Housing Systems for Northern India

S.K. Negi & Team

Objective:

- To design rural houses for the hills and plains of North India using newly developed construction systems, appropriate to local conditions, capable of generating employment and improving living conditions at affordable cost.
- Up gradation of audio-visual production facilities of the Institute.
- Production of training video on rural housing

Progress of Work Done:

From the Tropic of Cancer to the Himalayas in the north, is the area of various geographical and climatic disparities. In this area, there are large variations in the building construction techniques according to the geographic condition, climatic characteristics and locally available buildings materials. With the growth of population, the requirement of housing has increased enormously. But as per the socio-economic condition and living pattern, a person of economic and low income group has limited funds at his disposal for house construction. Sharp increase in cost of construction further makes the task difficult. Thus, there is a need to achieve an utmost economy in house construction to suit the resources of an average class family. Majority of the house construction primarily lack proper planning, consume larger quantities of building materials, have inadequate light and ventilation and increased construction cost.

The CSIR-Central Building Research Institute, has conducted extensive studies on planning, design and construction aspects of the houses during the last three decades with a view to obtain optimum utilization of space, increase in functional efficiency and reduction in cost of construction as in Fig 1. Based on these studies, a single storey dwelling unit for a family of four to five members has been planned. The design is functionally efficient, aesthetically appealing and offers an economy of about 20% in the overall cost as compared to conventional houses (Fig 2). The plinth area of the house is 24 square meter and mezzanine area is 30 square meter. The estimated cost of the

Fig 1: Architectural Planning

construction of the house in the year 2015 is around 2.4 lakh rupees.

HD video production facility of CSIR-CBRI has been up-graded with a new camera and video recording studio for producing training videos on appropriate rural housing (Fig 3).

Demonstration construction of improved rural house has been completed demonstrating appropriate housing technologies for both hills and plains of northern India.

The complete process has been video recorded for producing a training video on improved rural house for rural people (Fig 3).

About 300 masons and engineers were trained in innovative housing technologies at U.P, J&K, Uttarakhand & West Bengal etc. (Fig 4).

Fig 2: Technological Interventions for Improved Cost & Performance

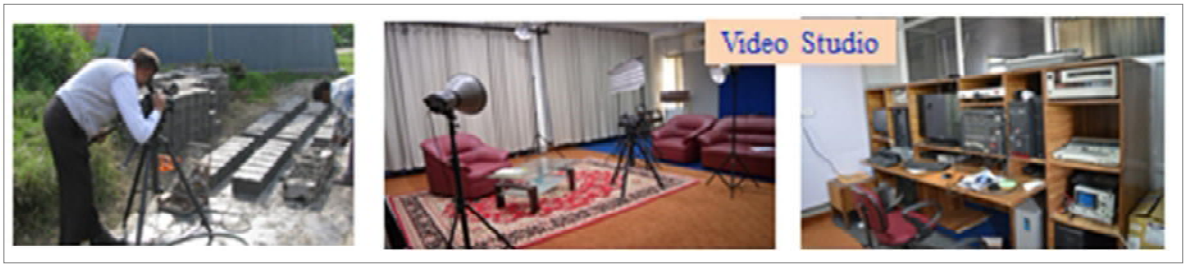


Fig 3: Upgraded Video Production Facility

Fig 4: Training cum Demonstration Programme Organised

Documentation and S&T Intervention in the Traditional Architecture of Rural Areas of the Western Himalayan region

S.K. Negi & Team

Objective:

- Documentation of traditional knowledge and different architectural styles of rural houses of the Himachal Pradesh.
- Identification of niches where S&T intervention is needed.
- Production of short video films on traditional architectural of rural buildings.
- Dissemination, promotion & extension of appropriate housing technology for the rural mass of hilly regions.
- Creation of a technical museum of building science based on innovative studies of CSIR-CBRI R&D outcome.

Progress of work done:

- Documented about 120 traditional houses covering 30 villages in 04 districts of Himachal Pradesh (Fig 1).
- Videography of about 10 traditional houses has been made among the traditional houses documented.
- S & T interventions required based on the study of documented traditional houses are under progress.
- About 400 grass root level officers/persons have been trained at CSIR-CBRI, Roorkee (in-house trainings), Dhudwa (UP), Kudkawala (Dehradun) & Dalatpur (Roorkee).
- Knowledge dissemination and demonstration of innovative building technologies have been shared with about 600 numbers of school/ college/visitors at the institute.
- More than 10 stone masonry houses and 05 numbers of two fit sanitation systems have been constructed using CSIR-CBRI building

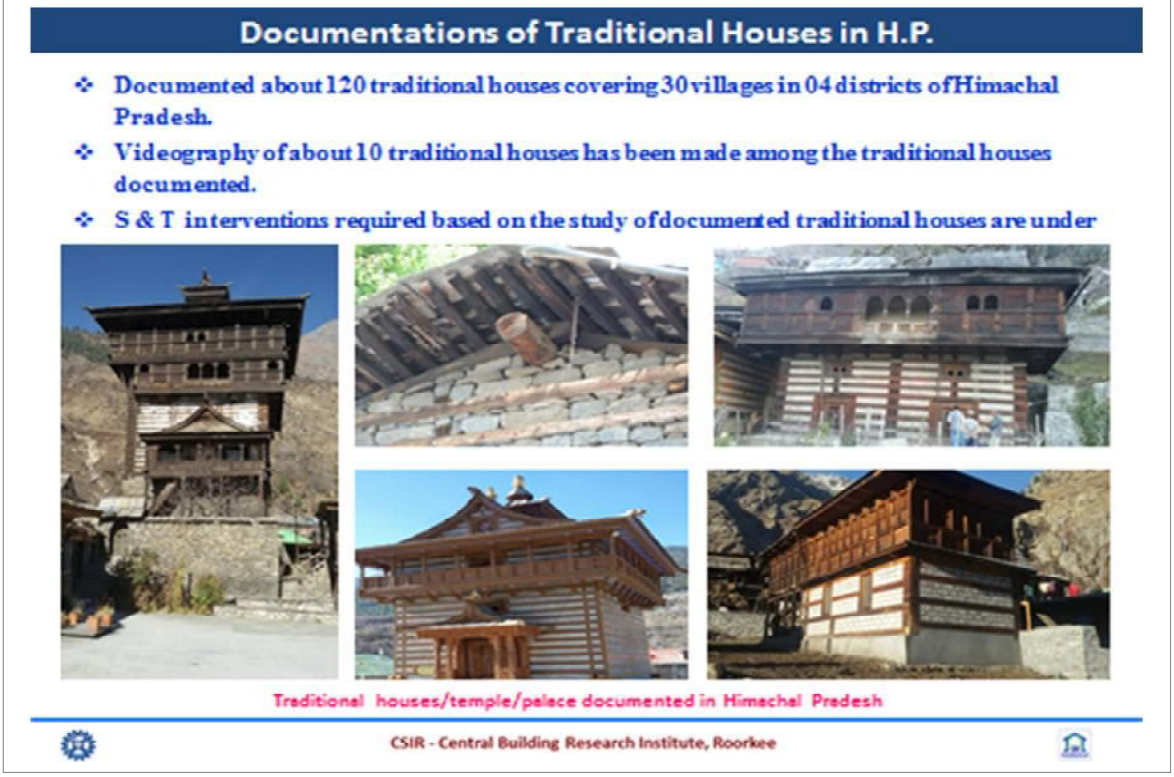


Fig 1: Documentation of Traditional Houses in H.P.

technologies at village Kudkawala (Dehradun) as the outcome of the training/demonstration activities (Fig 2).

- Renovation of Existing building for creation Technical Museum of building science has been completed.

Fig 2: Visits, Trainings & Demonstrations

Preparation of Hand Book in the Area of Heat Transfer in Building

B. M. Suman, Nagesh B. Balam & P.K. Yadav

Objective:

The main objective of this project is to compile and update theoretical and experimental work done in the area of heat transfer in building at CBRI Roorkee and put them in to publish a handbook.

Progress Highlights/ Significant Achievements:

Broadly eight chapters are planned to include in the proposed Hand Book. In this regard, Introduction of building heat transfer has been already included in the first chapter. This chapter consists, evaluation of overall thermal transmittance of building components, Solar Heat Gain Coefficient of window glazing, Sol air temperature, and thermal response factors for building heat transfer.

The other chapters will be determination of indoor air temperatures, estimation of heating /cooling load, Thermal indexes developed at CBRI, methods to reduce energy consumption in building, passive systems for building, different building codes to make building smart and green and Fuzzy Logic approach for determination of indoor thermal comfort level in building.

An empirical relation has been developed by fitting the experimental data between Building Index (BI) value and Indoor air temperature (T_{ia}). The equation correlating BI and T_{ia} has been explored using linear polynomial model with confidence bound 95% level as shown in the Fig 1 given below. The R^2 the coefficient of determination is obtained as 0.997, a statistical measure of how well the regression line approximates the real data point.

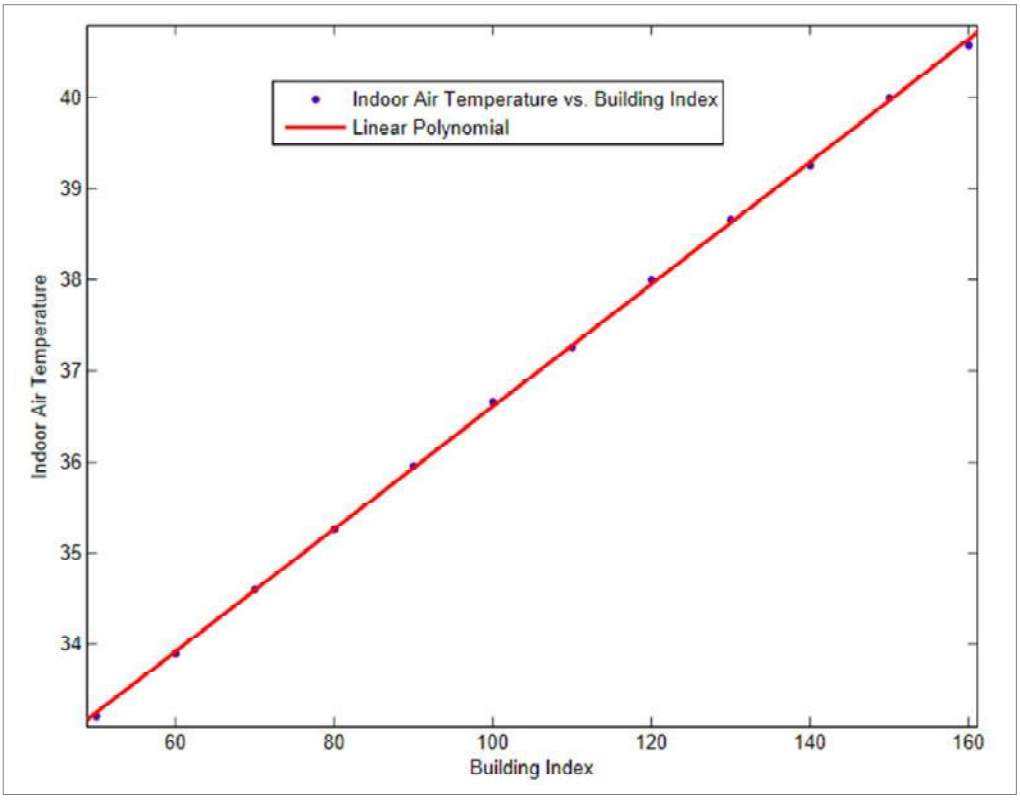


Fig 1: Linear Polynomial, $f(x) = p_1 * (x) + p_2$

Study the Effect of Density on Thermal Behaviour of Twiga Fibre Glass keeping Mean Temperature remains Constant

B. M. Suman & Nagesh Babu Balam

Objective:

Study thermal behaviour of Twiga fibre glass with varying density at constant temperature.

Progress Highlights/ Significant Achievements:

Experimental studies have been carried out to evaluate thermal behaviour of Fibre Glass material for density from 12 Kg/m^3 to 80 Kg/m^3 taking mean temperature constant. It was observed from the evaluation result that as density of fibre glass increases, its thermal behaviour improves simultaneously. It is concluded from the obtained result that overall thermal transmittance value of fibre glass is inversely proportion to its density keeping thickness as well as mean temperature constant. It was found that at low mean temperature the variation is uniform but by increasing mean temperature the level of variation is not uniform. In this regard further work is in progress.

AcSIR

CSIR-Central Building Research Institute (CBRI) is offering an integrated M. Tech - Ph.D. (IMP) programme under the aegis of Academy of Scientific & Innovative Research (AcSIR) in the area of 'Building Engineering & Disaster Mitigation (BEDM)'. The 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

- 1st Batch (2010-12) - 6 Students completed
- 2nd Batch (2011-13) - 8 Students completed
- 3rd Batch (2012-14) - 8 Students completed
- 4th Batch (2013-15) – 5 Students completed
- 5th Batch (2014-16) – 5 Students in 4th Semester
- 6th Batch (2015-17) – 5 Students joined the Institute

Ph.D.

- 4 students joined for Ph.D. in Engineering Sciences and 1 student in Physical Sciences in August 2015.
- Presently total 17 Ph.D. students are enrolled in AcSIR at CSIR-CBRI.

Highlights of the activities:

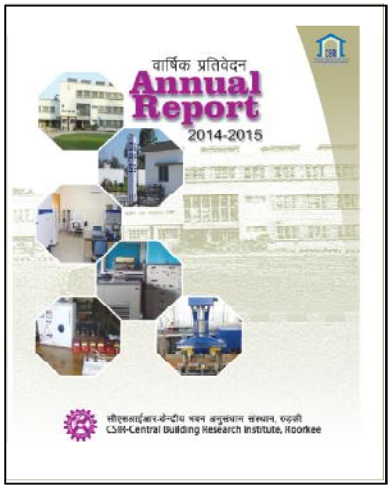
1. Dr. V.A. Sawant, Associate Professor, IIT Roorkee inducted as an Adjunct Faculty Member.
2. Faculty & students of AcSIR attended the "Address by the President of India to Students and Faculty in Institutes of Higher Learning" on August 10, 2015 through video conferencing.
3. AcSIR students observed a minute of silence on July 28, 2015 as a mark of respect to Bharat Ratna A.P.J. Abdul Kalam.
4. Orientation programme of the fresh students was held on August 13, 2015.
5. Students attended PM's Startup India Programme through video conferencing on January 16, 2016.

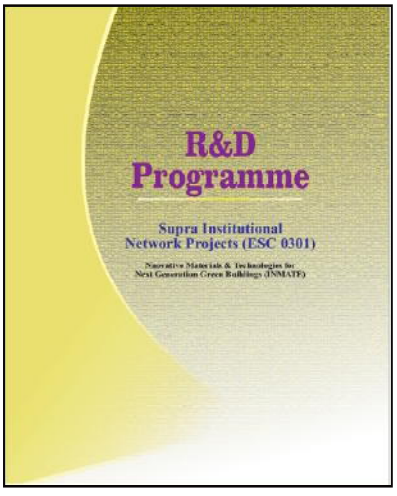
Publication Group

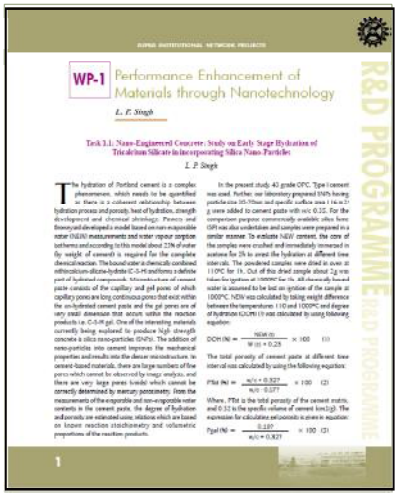
The Publication Group continued to serve as the nerve centre of the Institute conducting and coordinating multifarious activities, such as, collection, storage and dissemination of R&D information; handling scientific and technical enquiries; publicity and public relations, compilation, editing and publication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

1. CSIR-CBRI Annual Report

- **R&D Highlights**
- **Research Output**
- **Glimpse of Activities**
- **R&D Projects**
- **Consultancy Projects**
- **Sponsored Projects**
- **Information, Extension & Project Management**
- **CBRI Family**
- **Lectures, Visits, Honours & Awards etc.**
- **Date Line**







Tasks Involved: Manuscript Evaluation, Editing, Proof-Reading, Graphic Design, Layout, Illustration, Print Production, Binding, Publishing, Dissemination and Feedback

2. CBRI in CSIR Newsletter

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

3. CBRI in CSIR Samachar

4. Bilingual CSIR-CBRI Newsletters/Hkofudk- Newsletters in Hindi

Bhavnika/CBRI Newsletter January –March 2016

Bhavnika/CBRI Newsletter October-December 2015

Bhavnika/CBRI Newsletter July-September 2015

Bhavnika/CBRI Newsletter April-June 2015

Four Issues

5. News-items/R&D Stories in Media covering functions, events, conferences, workshops etc.

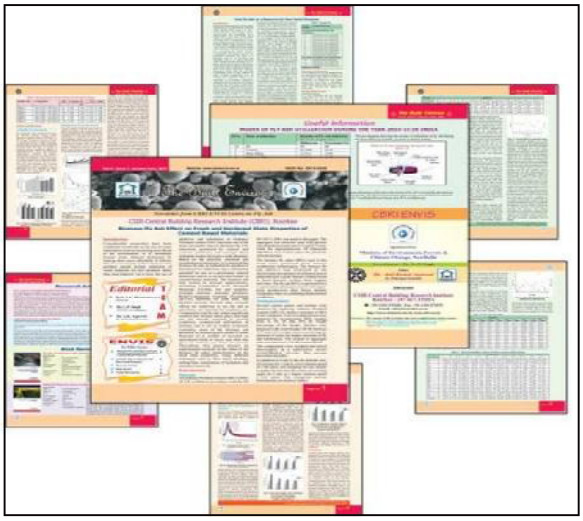
6. Building Research Notes: Print Production of Technical notes

7. R&D highlights/Research output of CSIR-CBRI in **CSIR Annual Report**

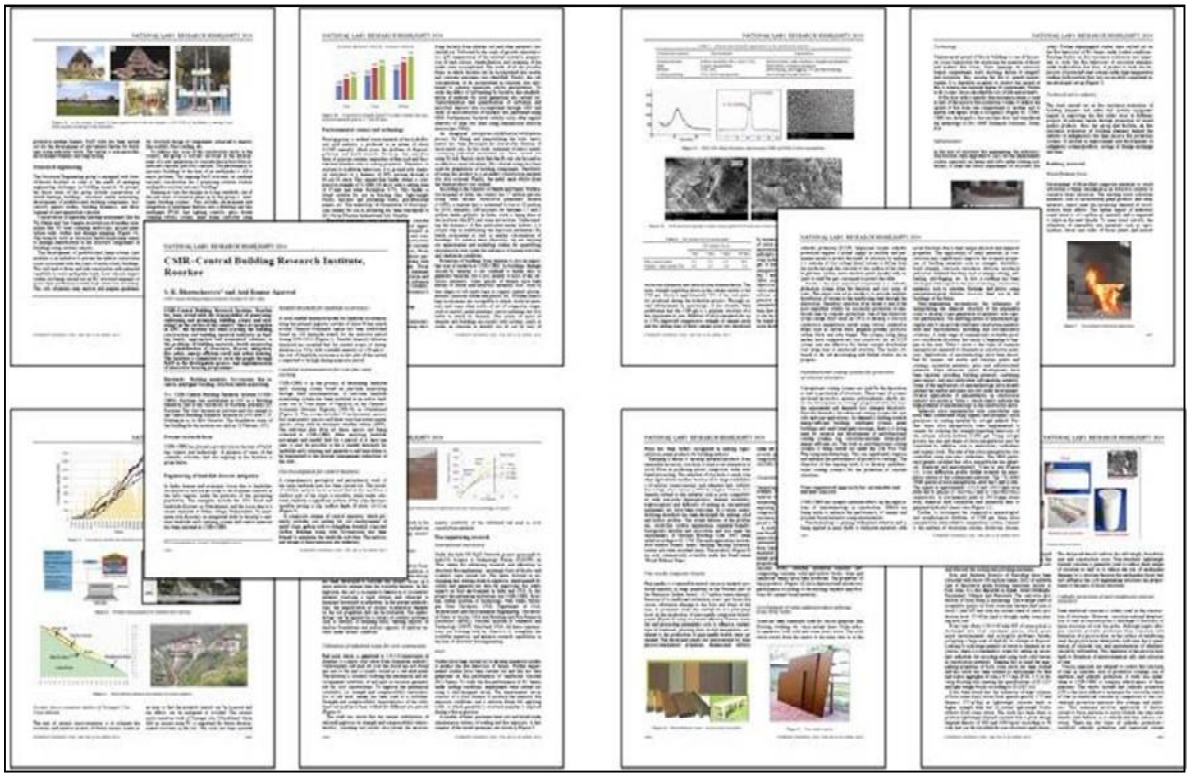
- Contribution to Science
- Contribution to Economy/Society
- S&T Services & Facilities
- Extra-mural Human Resource Development
- Academy of Scientific & Innovative Research
- Awards/ Recognition
- Dateline

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

9. ENVIS Newsletter (2 Issues)



10. CBRI in Current Science



Volume: 108, Issue No.: 8, Date: April 25, 2015, Page: 1444-1453

11. Press Meet – JAN SAMVAD: Two press meets during November 2015 and January 2016 were organized.

Development, Construction & Extension Group

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

Technical & Educational Visits of Professionals & Students:

1. Mr. Arun Kumar, HOD, Babu Ram Degree College, Roorkee along with two faculty members and about 30 computer engineering students visited CSIR-CBRI on March 21, 2016. They were taken to various Labs of the Institute and had discussions with scientists. A technical video was also shown.
2. Mr. Devendra Kumar Saxena, HOD of Civil Engineering, SSVGI, Bareilly visited CSIR-CBRI on March 17, 2016 along with 45 students of civil engineering.
3. Mr. Ashish Pant, Asst. Professor along with a group 40 students, B. Arch. from D.I.T, Dehradun along with 2 faculty members visited this Institute on March 16, 2016 and learnt about new materials, building components and work done by CSIR-CBRI on anthropometrics, Fero-Cement technique, day lighting, ventilation, fenestration design and passive systems of cooling developed for its use in buildings.
4. A group of 100 civil engineering students (3rd year) along with 5 faculty members from M.I.T, Moradabad, visited this Institute on March 02, 2016 particularly learnt and discussed Confined Masonry and other EQ resistant housing techniques.
5. Mr. Manoj Kumar, HOD, Dept. of Civil Engineering, North India Institute of Technology, Najibabad, U.P. visited this Institute along with about 19 students and 2 faculty on October 08, 2015, November 5, 2015 and December 29, 2015.
6. A group of 80 Civil engineering students (2nd year) along with two faculty from Quantum Global campus, Roorkee, visited this Institute on September 18, 2015 and discussed about Confined Masonry and other EQ resistant housing techniques.
7. A group of 15 Students of M. Arch. along with one faculty members from Deenbandhu Chhotu Ram University of Science and Technology, Sonipat, Haryana, visited this Institute on September 18, 2015 particularly to learn and discuss Confined Masonry and other EQ resistant housing techniques. They were taken to various Labs of the Institute and had discussions with scientists.
8. A group of 40 students along with 5 faculty members from Scholar Academy Roorkee, Uttarakhand, visited this Institute on February 19, 2016.

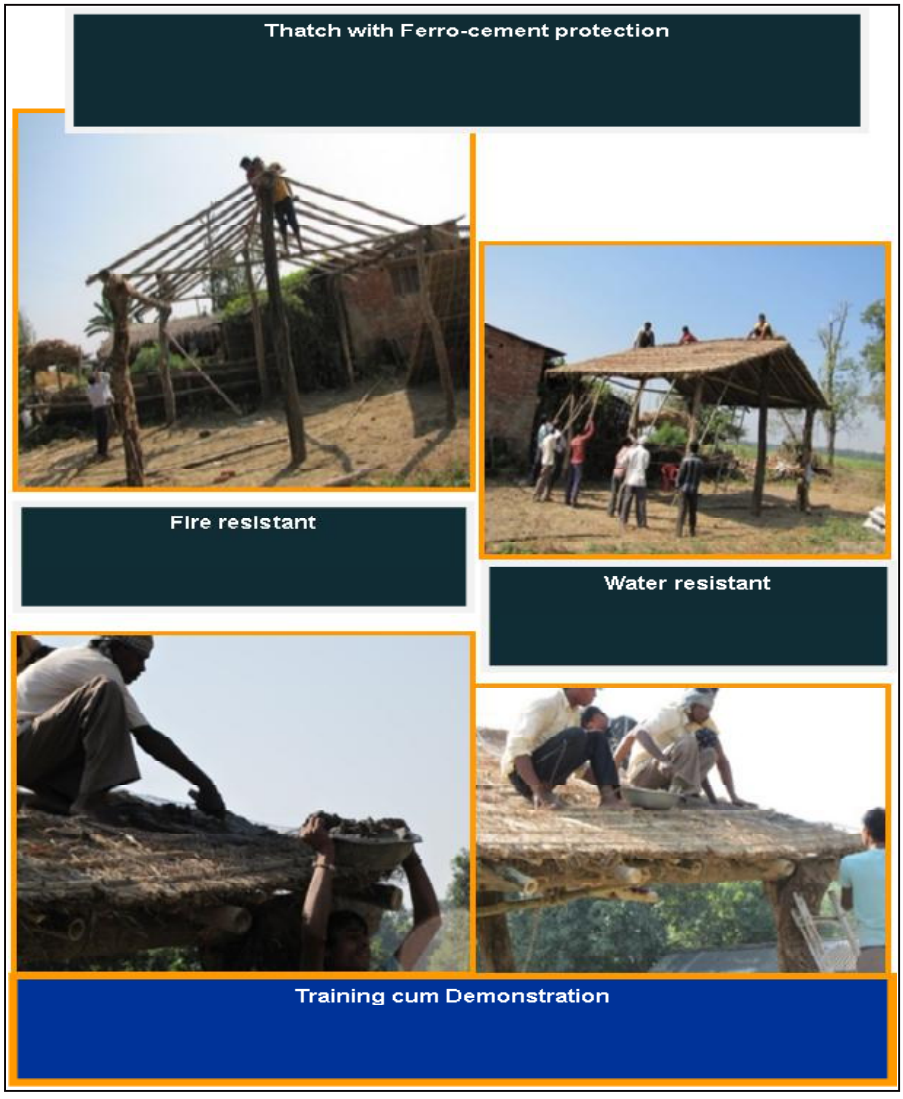
9. A group of 50 students along with 2 faculty members from Kendriya Vidyalaya No. 1, H. B. K Salawala Hathibarkala Dehradun, Uttarakhand, visited this Institute on February 17, 2016.

10. A group of 20 students along with 1 faculty member from R.V.I.T Bijnor, UP, visited this Institute on September 29, 2015 particularly to learn and discuss Confined Masonry and other EQ resistant housing techniques. They were taken to various Labs of the Institute and had discussions with scientists.

11. A group of civil eng. students along with faculty members from T.E.R.I, Delhi, visited this Institute on September 29, 2015. They were taken to various Labs of the Institute and had discussions with scientists.

12. A group of 30 CSE students along with 3 faculty members from Babu Ram Degree College Roorkee, Uttarakhand, visited this Institute on April 17, 2015. They were taken to various Labs of the Institute and had discussions with scientists.

13. A group of 22 Civil Eng. students along with 1 faculty member from Govind Ballabh Pant University of Agriculture & Technology, Uttarakhand, visited this Institute on April 1, 2015. They were taken to various Labs of the Institute and had discussions with scientists.



Production of Technical Videos:

- The Group produced four Technical video i.e. Innovative Building Material (English), ifjc) fpukb (Confined Masonry) Hindi for earthquake resistant houses, which is suitable for the construction of rural houses, Nano Engineered Concrete (English) & Oil Tank Fire Suppression. The video has been loaded on U tube.

Dissemination, Promotion & Extension Activities:

* Training cum Demonstration Programme Improved Mud and Thatch Technology for Tharu Tribes of Dudhwa region (November 1-2, 2015)
* Two BPL families were identified for construction of houses using improved mud and thatch techniques
* CSIR-CBRI provided technical guidance, WWF provided financial assistance and the families worked in self-help mode to construct their houses.
* Village Pradhan and many villagers participated and witnessed the construction process.

Knowledge Resource Centre (Library)

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

Acquisition:

Books: KRC added 309 numbers of books.

Journals: The library has subscribed 49 (26 foreign and 23 Indian) journals. 141 volumes of journals were got bound.

Library Statistics: The present position of library Collection: Books including reports; standards; conference proceedings; theses & maps: 44396; Bound Periodicals: 20589

Institutional Membership: KRC renewed the membership of learned national/international professional societies and received their publications against the membership.

National (India): Indian Building Congress (IBC), Delhi; Indian Geotechnical Society (IGS), Delhi; Institute for Steel Development and Growth (INSDAG), Kolkata, Indian Science Congress Association (ISCA), Kolkata and Life Member of the Institution of Engineers (India) and Indian Green Building Council (IGBC), Hyderabad.

International / Foreign : International Council for Research & Innovation in Building and Construction (CIB), Rotterdam, The Netherlands; International Union of Laboratories & Experts in Construction Materials, Systems and Structures (RILEM), Bagneux, France, International Federation for Structural Concrete (fib), Lausanne, Switzerland and American Concrete Institute (ACI), USA

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

Resource Sharing and Local Networking: CSIR-CBRI KRC is maintaining continuously good relationship with the libraries located in Roorkee viz. Indian Institute of Technology; National Institute of Hydrology library 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:** Paper clipping service is continued through scanning nine no. of newspapers in English and Hindi. The topics of the interest of the institute under eleven major head like-Building Materials; Structure & Foundation; Disaster Management: Earthquake & Landslides; Shelter Planning & Policy; Environment Science & Technology; Fire Research; CSIR/ CBRI etc. The paper clipping are kept in classified order for providing current awareness service to users.
- **List of Latest Addition:** KRC is bringing out a quarterly list of latest arrivals of books for the general awareness of library users.
- **Bibliographic Service:** KRC is providing bibliographic service to users on demand on the subject of interest from in house data base as well as international databases.
- **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 & Access of E-Journals:** Now, access to over 2000 full text of e-journals of leading S&T publisher's viz., ASCE, full text of ASTM Standards, Elsevier (selected), Emerald, ICE (UK), IEEE, Nature, OUP, RSC, T&F, Wiley as well science & patent databases like Web of Science and QPAT/ORBIT as well as iThenticate (plagiarism detection software) are available online under National Knowledge Resource Consortium (CSIR-DST E-journals Consortium) as well as direct subscription.
- **Knowledge Repository:** KRC has created Institutional Repository (IR) through dspace software. Large number of records has already uploaded contains full text database along with metadata of published research papers of S&T staff members of the institute as well as all Building Research Notes (BRN), Project Profiles, Annual Reports of CSIR-CBRI since 1953 and conference proceedings volumes, organized by CBRI. This database can be accessed at http://krc.cbri.res.in/dspace.

Planning & Business Development Group

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 Projects, Sponsored Projects, Grant–In-Aid Projects and Testing Projects etc. Important documents like annual plan document of the institute, manpower deployment, externally funded projects for MC agenda and R&D agenda for the Research Council are also dealt with by PBD group. Besides this PBD group manages Technology transfer to the industries, IPR management activities and Agreements & MoU between the Institute & different organisations.

PBD group monitors and compiles the Monthly and Quarterly Progress of the research activities of the institute as well as the Research Utilization Data for onward transmission to PPD, CSIR, New Delhi. The group regularly maintains & monitors the project folder of all the projects and maintains the records in terms of physical and financial recommendations of internal monitoring committees, Research Council & Management Council.

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 12th Five Year Plan Projects during the year. PBD group coordinated the scheduling of presentations & interacted with the project leaders for putting up the relevant documents. The inputs as an outcome of the meetings were incorporated in the projects prior to placing the same before the Research Council.

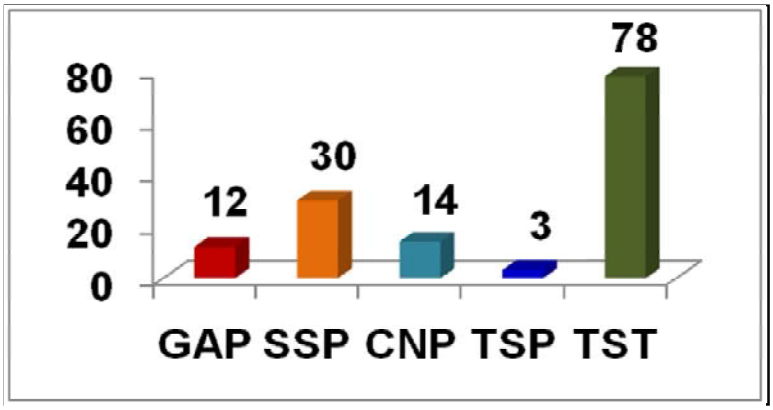
Research Council Agenda

Research Council Meetings are held twice a year to monitor the progress of R&D projects of the Institute. The R&D agenda of 52nd & Special RC meeting 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 externally funded projects on the basis of the expertise in different areas in the form of Consultancy, Sponsored, Grant-in Aid and Testing. During the period following projects were taken.

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



Externally Funded Projects:

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.

Intellectual Property Rights

The following patent has been filed by CSIR-CBRI:

S. No.	Patent	Application No	Date of Filing	Inventors
1	A Process for the Preparation of an Anti-Termite Barrier for New Buildings	201611000547	07/Jan/2016	Dr. Birendra Singh Rawat Prof. Sriman Kumar Bhattacharyya Mr. Ashok Kumar Mr. Surender Kumar Negi

MoUs Signed

CSIR-Central Building Research Institute (CSIR-CBRI) signed Memorandum of Understanding (MoUs) with

1. Indian Institute of Technology, Kharagpur on April 18, 2015.
2. National Cooperative Housing Federation (NCHF), New Delhi on November 30, 2015.
3. Gautam Buddha University, Greater Noida on January 27, 2016.

Budget and ECF

CSIR Resource Input		External Cash Flow	
Revenue	2335.797 Lakh	Private	69.661 Lakh
Capital	352.997 Lakh	Government	535.183 Lakh
Special Projects	296.240 Lakh	Testing	188.237 Lakh
Total	**2985.03 Lakh**	**Total**	**793.081 Lakh**

National Technology Day

CSIR-Central Building Research Institute, Roorkee celebrated National Technology Day on May 11, 2015. Mr. Prakash Chand, Executive Director, BHEL, Haridwar graced the occasion as Chief Guest. He highlighted various scientific achievements and motivated the S&T staff for taking interest in understanding the principles and practical applications of science so that the future of our country may be shined. The Chief Guest further stressed that science should be explored for the benefit of the mankind so as to improve health, income and living standard of the common masses. He highlighted the theme Clean Technology for Swachh Bharat and emphasized that technology development is the soul of a country and we are proud to have excelled in technology advancements in all its branches. He also recalled the actual story behind the celebration of the day. He said, "It is time for us to ponder over the fact that India has entered a phase where technologies are being developed and in the name of fighting MNC domination, we are only hurting indigenous technology development." He explained the various success stories of BHEL Technologies.

Earlier, Prof. S.K. Bhattacharyya, Director CSIR-CBRI, Roorkee in his Presidential address briefed that May 11 is annually observed as National Technology Day to commemorate technological breakthroughs like mastering of nuclear weapons technology (Pokharan II) through a series of controlled tests at Pokharan, test firing of the indigenously developed Trishul missile and test flight of the indigenous aircraft Hansa-3 on May 11, 1998 in a mission entitled 'Operation Shakti. These achievements of Indian technology got a further boost with the test firing of indigenously developed Trishul, Agni and Prithvi missile. The day, which proved the technical prowess of Indian scientists, is marked as the National Technology Day to inspire young minds to achieve high goals and excel at innovations. This historic accomplishment placed our nation into the queue of leading nations with nuclear power. He also highlighted R&D achievements of CSIR-CBRI and its contribution in improvement of economy, health and living standard of the masses. Dr. Suvir Singh, Senior Principal Scientist made a power point presentation on "Development of Fire Resistant Door". On this occasion, Hindi versions of Building Research Notes were released. Dr. A.K. Minocha, Chief Scientist, introduced the Chief Guest and Dr. Shorab Jain Principal Scientist proposed a vote of thanks.

World Environment Day

The CSIR-Central Building Research Institute (CBRI) Roorkee celebrated World Environment Day with a special function held in the Ravindra Nath Tagore Auditorium, CSIR-CBRI on June 5, 2015. The World Environment Day 2015 was observed to promote awareness on the importance of preserving our biodiversity, the need to identify problems related to the environment and ways to take corrective action. It was on this day in the year 1972 that the United Nations Conference on the Human Environment was formed. First celebrated in 1973, World Environment Day, also popularly known as Environment Day, is a means to tackle environmental challenges that include climate

change, global warming, disasters and conflicts, harmful substances, environmental governance, ecosystem management and resource efficiency. Convened under the global theme, "Seven Billion Dreams, One Planet, Consume with Care", the function was graced by Prof. Prem Krishna, Chairman, Research Council, CSIR-CBRI, Roorkee as Chief Guest. The function was presided over by Prof. S. K. Bhattacharyya, Director CSIR-CBRI, Roorkee. Prof. Rajesh Chandra, President, Institution of Engineers (I), Roorkee Local Chapter, Prof. S.K. Bhattacharyya, Director CSIR-CBRI and Prof. Prem Krishna, Chairman, Research Council, CSIR-CBRI Roorkee planted trees in CSIR-CBRI Campus as a gesture of harmonious living with nature.

Prof. Prem Krishna, Chairman, Research Council in his address spoke about the importance of sustainable exploration and consumption of natural resources. He said that as per UN estimate,

the world population would be 10 billion by 2050 which will be a great threat to the planet earth. It is high time that we focus on exploration and not on exploitation of natural resources, check its depletion, check food security, check environment safety issues and so on, he opined. Sharing his message, he urged all to think of sustainability and the future of mankind. While addressing the gathering, he informed that in recent times, the need to promote more earth friendly practices in order to maintain the health of our planet has come to the forefront, as world nations struggle to reverse the present trend of climate change. The World Environment Day is a reminder to show our gratefulness to Mother Nature, which sustains all forms of life. This is the day to focus our thoughts and our energies to make collective efforts towards protecting the environment. This is an urgent appeal to each one of us to recognize the significance of "Elixir of Life" and the role each one of us can play to conserve it. India has rich traditional knowledge and wisdom in the conservation of nature and natural resources. Religious beliefs, culture and folklore have together treated nature and environment with sanctity. Conservation and protection of environment and love for nature have always been part and parcel of Indian ethos and culture. Earlier, Prof. S.K. Bhattacharyya, Director CSIR-CBRI in his presidential remarks advocated optimum use of resources and to surge ahead without compromising the sustenance of the future generations. He shared a famous quote by Mahatma Gandhi which says that, "What we are doing to the forests of the world is but a mirror reflection of what we are doing to ourselves and to one another". Prof. Bhattacharyya apprised that CSIR-CBRI will continue its activity to develop environment-friendly technologies and pursue research to protect the environment and work for conservation of biodiversity of the region.

A Poster Competition was also organized for CBRI wards. Prizes were given to Ms. Lipi Singh, Ms. Srishti Kujur, Krishnanshu Yadav, Simran, Vanya Gupta in Group A, Ms. Nancy and Yash Jain in Group B and consolation prizes were given to Drishi Singh, Kanesh Rathore and Rimsha. On this occasion, Prof. A.K. Pachauri, Prof. B.R. Gurjar and Prof. Satyendra Mittal, IIT Roorkee delivered lectures. Prof. Rajesh Chandra presented a brief introduction of Prof. Prem Krishna. Dr. A.K. Minocha, Chief Scientist, Group Leader EST Group, in his introductory address pointed out that World Environment Day is an annual event that is aimed at being the biggest and most widely celebrated global day for positive environmental action. Vote of thanks was presented by Mr. Akhilesh Verma, Hony. Secretary, IE (I), Roorkee Local Centre, Roorkee. The programme ended with National Anthem.

Brainstorming Session and Industrial Meet on Building Materials and Disaster Mitigation Technologies

CSIR-CBRI has undertaken R&D programmes on "Innovative Materials and Technologies for Next Generation Green Buildings" and "Engineering of Disaster Mitigation and Health Monitoring for Safe & Smart Built Environment" under the 12th Five Year Plan. For effective utilization of the outcome of these projects, a Brainstorming Session and Industrial Meet on "Building Materials and Disaster Mitigation Technologies" was held on July 30, 2015 at CSIR-CBRI, Roorkee under the Chairmanship of Prof. S. K. Bhattacharyya, Director, CSIR-CBRI Roorkee. The objective of the meet was to have exchange of knowledge between scientific community and building industries/user agencies on ongoing R&D activities of CSIR-CBRI and to re-orient the research activities to meet the societal expectations. The meet was primarily aimed for organizations/user agencies, practicing engineers and academic institutes related to the building industry.

The meet was represented by over 50 delegates from industries and government organizations like NDMA, World Bank, Municipal Corporation, Border Road Organisation etc. from all over the country.

Prof. S. K. Bhattacharyya, Director, CSIR-CBRI, Roorkee stressed upon need of quality of interaction between scientific community and end users through clear dissemination of R&D work. Further, he said that a technology should be developed through which buildings can talk by virtue of sensors placement in different structural components and warns the distress in it. The Director CSIR-CBRI emphasized on the need of disaster mitigation technologies with a brief description of various scientific activities which CSIR-CBRI has undertaken during 12th five year plan. The chief guest of the function, Colonel Ajay Kothiyal, Principal, Nehru Institute of Mountaineering (NIM) and Chief of Kedarnath Rehabilitation Programme in his address appreciated the efforts made by CSIR-CBRI, Roorkee for development of newer materials and disaster mitigation technologies to meet the future challenges.

Dr. S. R. Karade, Nodal Scientist of the project "Innovative Materials and Technologies for Next Generation Green Buildings" and Dr. S. Sarkar, Nodal Scientist of the project "Engineering of Disaster Mitigation and Health Monitoring for Safe & Smart Built Environment" presented brief overviews of the projects taken by CSIR-CBRI, Roorkee under 12th Five Year Plan. The main achievements in these programmes were briefed to the industrial representatives and opinion was sought from the industry for possible collaboration and reorientation of the research activity, if required, to meet the societal expectations and explore the new areas of research in building science and technology.

Panel discussion session was chaired by Prof. S. K. Bhattacharyya, Director, CSIR-CBRI and Mr. Y. Pandey, Mr. R. S. Chimote, Dr. Suvir Singh, Chief Scientists, Dr S. Sarkar and Dr. S. R. Karade, Scientists



were the other panellist. Dr. A. K. Mittal, Principal Scientist, coordinated the panel discussions. The industrial partners actively participated in the brainstorming session.

Industry representatives briefly explained their role in disaster mitigation technologies and discussed the same with scientists of CSIR-CBRI, Roorkee. Several new areas of research emerged out during the discussion. Industry representatives emphasized on collaboration of industry and research institutes of prestige like CSIR-CBRI, Roorkee, CSIR-CEERI, Pilani etc. for development of newer techniques, their wide publicity and availability at wider market level. They further stressed for more such events where industry and scientific people can meet and discuss.

Dr. R. M. Mohanty, Scientist, CSIR-PPD thanked the Chairman, industry representatives for their active participation and praised CSIR-CBRI for organizing the event.

CBRI celebrates Independence Day

The Independence Day was celebrated with a deep sense of patriotism combined with gaiety on August 15, 2015 in CSIR-CBRI Main lawns of the Institute.

Celebrating the 69th Independence Day, Mr. Yadvendra Pandey, Chief Scientist, CSIR-CBRI hoisted the flag and took the salute at the March Past performed by the Ex- National Security Squad.

Addressing the gathering, Mr. Y. Pandey recalled the contribution of senior scientists towards the upliftment of the society. He urged the scientists to develop newer technologies and work towards achieving the current government plans and policies.

On this occasion, the school children from CBRI Bal Vidya Mandir and CBRI Junior High School presented various cultural programmes on patriotic themes.

Dr. Harsh Vardhan urges Use of Green Technology in Building Industry at CSIR-CBRI, Roorkee

Dr. Harsh Vardhan, Hon'ble Minister of Science & Technology and Earth Sciences visited CSIR-Central Building Research Institute (CSIR-CBRI) Roorkee on August 23, 2015 urging scientists to use renewable, green and innovative materials and technologies in the Building Industry. He remarked that, "CBRI has a responsibility to implement the PM's vision of housing for all by 2022."

For the first time, the Union Government has set a deadline for providing every family a roof above its head, not only a roof but water supply, sanitation and 24x7 electricity, and we have a plan to construct 20 million houses in the next seven years, that is, 7800 houses per day. "

Dr. Harsh Vardhan said, "Top-class research on construction materials & technologies, improvement & value addition to traditional construction practices

Dr. Harsh Vardhan further said, "At this transition phase where our country is narrowing down the gap with the developed world in terms of economy, technology, and human resources, we need world class innovative, efficient and green technologies for rapidly meeting the demand of millions of *pucca*, comfortable and energy-efficient houses where occupants may live with safety, dignity and pride.

and specialized research work and problem solving for leading industrial sector, socially beneficial extension & dissemination activities carried out by CSIR-CBRI would form an essential component for the Prime Minister's project. I am sure that you people will help us realize the great dream."

"I see that all the major initiatives of the Government of India like Swachch Bharat, Swasth Bharat, Sashakt Bharat, Smart Villages, Smart Cities,

Make in India have some or the other ingrained technologies available in a place like CSIR-Central Building Research Institute. It is my belief that some new technologies may also be generated at CBRI if you people take an oath to make the Housing mission a grand success. ," the Minister said.

Dr. Harsh Vardhan lauded the recent efforts for conservation of great cultural heritage monuments like the Sun Temple at Konark, Taj Mahal, Qutub Minar, Chittaurgarh Fort, etc. using state-of-art techniques. He said, "It is my pleasure to announce that Kashi Vishwanath Temple and Ram Janam Bhumi Temple at Ayodhya are also being benefitted with the expertise available with CBRI."

The Minister also interacted with the staff members and listened to them as they shared the varied

challenges they face in fulfilling the national tasks assigned to them. He emphasized that they should not be satisfied with past laurels and achievements but constantly tries to think of out-of-the-box solutions to the various problems faced by the society and consider them to be world citizens at par with other developed societies.

The Hon'ble Minister inaugurated the "Technology Gallery" where all the ongoing research activities are displayed in pictorial form.

While thanking the industry representatives for supporting CSIR-CBRI, Dr. Harsh Vardhan called for forging greater partnerships to accept the challenges. "Prime Minister has given a call for 'Make in India'. We need to generate millions of jobs within a couple of years so that the great potential of youth power is suitably utilized. Seamless partnership will help in developing the products and technologies for the benefit of the common man," he pointed out. "At the same time, the entrepreneurs should focus on using renewable and green materials of Indian origin which have reasonably low carbon foot print as well are low cost."

Sadbhavna Diwas

The institute observed Sadbhavna Diwas on August 20, 2015 with a view to promote harmony amongst people of all religion, languages and states and goodwill towards everyone. Mr. Y. Pandey, Chief Scientist, CSIR-CBRI administered Sadbhavna pledge to all the staff members of the Institute.

Hindi Diwas

Hindi Diwas was observed at the institute on September 14, 2015 with great zeal and enthusiasm. Dr. Pradeep Sharma, Ex- Senior Principal Scientist, CSIR-NISCAIR, New Delhi graced the function as Chief Guest and Mr. Yadvendra Pandey, Acting Director, CSIR-CBRI presided over the function.

Dr. Pradeep Sharma stressed on the need of paying more attention on the use of Hindi and called upon the staff to do most of their official work in Hindi. Dr. Pradeep Sharma has been honored by Dr. Pratibha Devi Singh Patil, Former President of India, with the 'Atmaram Award' in 2006. He has also been the Chief Editor of the CSIR monthly magazine, 'Vigyan Pragati'. He expressed his concern on many aspects of Hindi language that have been forgotten. He also educated the gathering on writing skills and stated that articles should only be written on one's area of expertise.

Mr. Yadvendra Pandey addressed the gathering stating that working in Hindi language is everyone's constitutional duty, which should be followed religiously. He informed that there are over 7,000 languages in the world, most of which are on the verge of extinction. He also informed that Hindi Diwas will be celebrated throughout the year in form of various activities.

On this occasion bilingual edition of 'CBRI News Letter' and 'Bhavanika' was released. Dr. Shalini Joshi, Principal, S.D. College, delivered touching poems like 'Bhartendu Ki Hindi', 'Desh Azad Hai', 'Ishwar Kya Sachmuch Beghar Hai' etc. Mr. Mehar Singh, Hindi Officer, CBRI, presented the plan for the various Hindi Diwas activities to be held round the year. A training program on 'UNICODE' for administrative staff was organized on the occasion. Also a 'Hindi Workshop-cum-Training Programme' was conducted for the newly-appointed young scientists in the month of July. The employees were encouraged and awarded for successful integration of Hindi for all official purposes. Dr. Pradeep Kumar Singh Chauhan proposed the vote of thanks.

CSIR Foundation Day Celebrations

73rd anniversary of CSIR was celebrated with great enthusiasm at CSIR-Central Building Research Institute, Roorkee on September 26, 2015. Mr. S.B. Dangayach, Managing Director, Sintex Industries graced the occasion as Chief Guest and Mr. Yadvendra Pandey, Acting Director, CSIR-CBRI presided over the function. The superannuated staff of the institute also graced the occasion besides other dignitaries.

Mr. Yadvendra Pandey, highlighted the glorious past of CSIR with the establishment of five labs in 1942 and CBRI in 1947. Since then it has been contributing in the development of the country covering all important areas of science and technology through thirty eight laboratories across the country. He suggested that CSIR should develop game changing, cost benefiting and socially relevant technologies and reach self financing mode soon. He informed that CSIR-CBRI has taken up projects related to conservation of nationally important heritage structures such as Taj Mahal, Konark Temple, Chittaurgarh Fort, etc. He also talked about the major focus areas of R&D, newer

areas of research such as sustainability, nanotechnology, Nano-Engineered Concrete, self healing bio-concrete, translucent concrete, pre fabricated cast technology, developments in testing facilities and certification in fire engineering, application of affordable housing scheme on hilly terrain, instant foldable shelter for Defence forces and disaster mitigation in all kinds of buildings.

Mr. S.B. Dangayach, Chief Guest, expressed his gratitude to CSIR-CBRI. The credibility from CBRI's test approval led to production and distribution of Sintex plastic tanks even to prestigious institutes like CPWD, MES, and PWD etc. He encouraged the institute to apply its latest pre fabricated cast technology to deliver affordable houses for the people of India, as discussed in the Dehradun Declaration. He talked about the necessity of Waste Business Management and stated that even waste can be converted to resource useful in research. He informed about the Net Zero Building technique using renewable and non renewable resources to fulfill energy requirements. He also emphasized the need for collaboration of research institutes with industries to attain a self financing mode.

On this occasion bilingual edition of 'CBRI News Letter' and 'Bhavanika' was released by chief guest. CSIR prize for meritorious staff children, who have secured more than ninety percent marks in three subjects in class XII and getting admission in IITs, were honored. The superannuated scientists/ staff of CSIR-CBRI were honored by presentation of a shawl, samman patra and a wrist watch. Also, CBRI staff members who have completed twenty five years' service in CSIR were felicitated by the chief guest by presenting them a wrist watch. Dr. Suvir Singh proposed a vote of thanks. There have been a number of activities including essay competition for staff students in several categories and various topics including 'Clean India', 'Digital India', 'Smart Cities' etc. The participants of the activities were also awarded on the occasion.

Training Course on 'Housing for All – Innovative Technology for Affordable Housing'

'Housing for all' is one of the priority areas with particular emphasis on the needs of the vulnerable groups as per the national agenda of governance in the country. The construction of affordable housing using innovative technologies is one of the most appropriate planning in the country to provide safe housing. This demands proper planning, design, construction methods, use of innovative materials and trained manpower. CSIR-CBRI is one of the leading institutions in the country which developed innovative technologies for construction of affordable houses during the last few decades mainly on planning and design, building foundation and structural designs, design of multi-hazard resistant construction, efficient and new building materials etc. These building technologies have been demonstrated and provided field level training on hands-on practice to the grass root level functionaries at different parts of the country. It is essential to construct affordable housing using innovative technologies developed by different institutions like CSIR-CBRI for building sustainable built environment which demands development of skills and capacity among the administrative functionaries of the state/district for its systematic implementation. To achieve this, professionals needs to be trained in the application of innovative technologies for the construction of affordable housing.

Recognizing the need to develop a pool of trained professionals in the construction of affordable housing using innovative technology, CSIR-Central Building Research Institute, Roorkee has conducted a three day Training course on "Housing for All – Innovative Technology for affordable Housing" during October 14-16, 2015 at its premises. This training course was particularly aimed at enhancing knowledge and developing skills of the Govt. officers to incorporate innovative technologies for the construction of affordable housing for sustainable built environment through lectures, demonstrations and hands-on exercises.

Twenty six officers attended the Training Programme; out of which 7 Engineers and 3 Architect from PWD; 4 Engineers from Rural Works Department; 4 Engineers were from Sarva Shiksha Abhiyan; 2 Officers from District Rural Development Authority; 02 PhD students from CBRI; and 01 officer each from District Administration, Water Resource Department, North India Institute of Technology & Shree Mata Vishnodevi University were attended.

Mr. Y. Pandey, Acting Director, CSIR-CBRI while inaugurating the course highlighted the importance of 'Housing for All' in the country and the possible technical contributions by CBRI in building the safe and affordable housing using innovative technologies. Subsequently, the technical sessions have been delivered by the in-house faculty of CSIR-CBRI based on the outcome of the R & D activities conducted under different projects.

The concluding session was chaired by Mr. Y. Pandey, Acting Director CBRI and Mr. N. K. Shangari, Ex. – Scientist 'G', CBRI graced as Chief Guest. During this session, course activities have been appraised and the participants expressed that such kind of training programme would enable us in updating the scientific knowledge, adaptation of building technologies at grass root level by the administrators/field level officer with technical support of CSIR-CBRI scientific community. And also, they requested CSIR-CBRI to organize training and demonstration programme at grass root level for the benefit of the society in construction of safe and affordable houses in the country. Further, Mr. N. K. Shangari expressed the importance of the training and knowledge dissemination on building technologies for its implementation at field level is very much essential with the coordination among the administrator/field level officer and scientific community in building the sustainable nation. Finally, Mr. Y. Pandey, assured the trainee officers to provide all kind of technical support, trainings, demonstration made available to the grass root/ district/state level functionaries. The session was concluded with the distribution of certificates to the participants.

Vigilance Awareness Week

The Vigilance Awareness Week was observed in the Institute during October 26-31, 2015 with zeal and delight. The week started with the Inaugural Ceremony in which the Pledge was administered by Mr. Yadvendra Pandey, Acting Director CSIR-CBRI to all the employees of the Institute.

Mr. Ashok Kumar, Senior Principal Scientist gave an overview of the week long activities to be organized. Various programmes were organized during the week to sensitize the employees, students, public and society at large on how Preventive Vigilance can be used as a tool of good Governance - the theme of the awareness week.

A lecture was delivered by Mr. R. S. Chimote, Chief Scientist, CSIR-CBRI on October 30, 2015 on "Preventive Vigilance as a Tool of Good Governance".

Other activities organized during the Vigilance Awareness Week includes debate competition for CSIR- CBRI staff, essay competition for students of 8th -12th standard for staff children and a poster competition for students studying in nearby schools of Roorkee.

An invited lecture was delivered by Mr. R. Bharsakle, DGM (Vigilance) ONGC Dehradun on October 30, 2015 and he stressed on using Preventive Vigilance as a tool of good Governance. He also mentioned the initiatives taken by ONGC, Dehradun in this direction.

Prizes were given to the winners by Mr. Y. Pandey, Acting Director, CSIR- CBRI and Mr. R. Bharsakle, DGM (Vigilance), ONGC Dehradun. Mr. Y. Pandey in his Presidential Address stressed on how preventive vigilance as a tool of good governance is useful to get positive effects on combating corruption. Mr. Alok Sharma, Admn. Officer presented the vote of thanks and acknowledged everyone who directly or indirectly helped in organizing the week long activities.

Press Meet

A press meet 'Jan Samvad' was organized at CSIR-CBRI Roorkee on November 5, 2015 to apprise about the new technologies and development of the institute to the media.

In his Presidential Address, Mr. Y. Pandey informed that the institute aims to develop the latest technologies corresponding to the requirements of the nation and work in accordance with the Prime Minister's visionary projects such as 'Make in India', 'National Mission for Clean Ganga', 'Housing for all', 'Swachh Bharat Abhiyan' etc. He briefed about the important decisions taken in the Dehradun Declaration held at CSIR-Indian Institute of Petroleum in Dehradun during June 12-13, 2015. The Dehradun Declaration was gone to by the directors of all the 38 institute of CSIR and headed by the Director General CSIR. He informed that the institute has started design work as per the PM's vision to build two crore affordable houses of 40- 45 square meter area within the next seven years.

Dr. A.K. Minocha, Chief Scientist, informed about the institute's work in Construction & Demolition waste management. Considerable amount of research work has been carried out at CSIR-CBRI,

Roorkee to utilize these wastes for production of different building components such as paver blocks, tiles, bricks etc. He also informed about the latest fly ash technique and its extensive works in the production of building material. He told that improvements are being made with the goal that structure consume less energy and impact of green house be minimized.

Dr. Rajni Lakhani, Principal Scientist, briefed about the technique to eradicate the negative effect of Kota Stone waste on environment and utilize it to develop useful building material. Kota Stone waste had represented a great threat to the environment causing air contamination, barren soil, and negative effect on terrestrial and aquatic life and human health.

Dr. B. Singh, Chief Scientist informed about the most recent strategy to minimize the utilization of wood in building materials. He discussed rice husk and plastic as an alternative for wood for building materials such as doors, etc. These alternatives would be termite resistant so would last more. Dr. Atul Kumar Agarwal, Senior Principal Scientist proposed a vote of thanks.

Press representatives from Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Punjab Kesari, Uttaranchal Deep, Avam-e-Hind, Jan Bharat Mail and Shah Times etc. have attended the meet.

Diwali Mela Celebration

The Diwali Mela was organized jointly by CSIR-CBRI Staff club and Shanti Nagar Ladies Club Roorkee on November 5, 2015 at Shanti Nagar Colony ground. Mr. Yadvendra Pandey, Acting Director, CSIR- CBRI inaugurated the Mela and visited the stalls organized by members of CBRI Ladies Club. Stalls offering wide variety of delicious traditional food were well appreciated. This annual festival has fun for the entire CBRI family. Activities like Dance Competition, Tambola, and Lucky Dip etc. were also appreciated by audience, viewers and judges. Prizes were distributed to the winners of all the competitions including Lucky Dip. Viewers appreciated the whole programme and perceived the importance of "Festival of Light" in life. In the end "Atishbazi Session" was also prevailed and it makes everyone stunned for an instance.

Constitution Day

The institute observed Constitution Day on November 26, 2015. The institute celebrated 125th Birth Anniversary of Dr. B.R. Ambedkar. The drafting Committee led by Dr. Ambedkar did yeoman service to the nation in presenting the Constitution which was adopted on November 26, 1949. Accordingly, CSIR-CBRI celebrated the day by reading out the 'Preamble' to the Constitution of India. The event was celebrated in the Ravindra Nath Tagore Auditorium in the presence of all staff members.

MoU Signed

Mr. Y. Pandey, Acting Director, CSIR-Central Building Research Institute (CSIR-CBRI) and Dr. M.L. Khurana, Advisor, National Cooperative Housing Federation (NCHF), New Delhi signed an Memorandum of Understanding on November 30, 2015 at CSIR-CBRI, Roorkee to provide Science & Technology Support by CSIR-CBRI, Roorkee to Member Societies of the National Cooperative Housing Federation (NCHF), New Delhi.

National Science Symposium on "Housing Challenges: Natural Disaster & Climate Change"

A two-days National Science Symposium on "Housing Challenges: Natural Disaster & Climatic Change", was organised at CSIR-CBRI during December 10-11, 2015. The objective of the meet was to observe new faced challenges posed by natural disasters and climate change to the housing structures and means to forestall them with the newly developed techniques.

Dr. Raj Dev Singh, Director, National Institute of Hydrology, Roorkee graced the occasion as the Chief Guest for the Inaugural Ceremony. Mr. Yadvendra Pandey, Acting Director, CSIR-CBRI presided over the function. Dr. P.K.S. Chauhan was the organising secretary.

Addressing the gathering, Dr. Raj Dev Singh, Director, National Institute of Hydrology, Roorkee discussed the complications caused by the climate change to the housing structures. He emphasized on the need to build high-rise buildings to conserve agricultural land.

Mr. Yadvendra Pandey, in his Presidential Address highlighted the contribution of CSIR-CBRI towards the development of the country, research and development on all aspects of housing and assistance to the building industry, including disaster mitigation in all kinds of buildings, environment preservation, energy conservation and conservation of nationally important heritage structures. He stressed upon the need of advance preparation against undue damage caused by natural disaster and climate change. He said that incorporating the scientific and technical research in the society and expanding its acceptance in public view is a challenge and a great deal of effort should be applied to achieve this goal.

Prof. Bikash Mohanti, Department of Chemical Engineering, IIT Roorkee, Chief Guest of the Valedictory Function and Member of the Research Council, CSIR-CBRI, in his address, asked the scientists to develop new techniques for early warning of natural disasters, to ensure better application of safety precautions and mitigation techniques.

The Symposium was organized and conducted in Hindi. Scientists and engineers from Mumbai, Pune,

Srinagar (Garhwal), Delhi, Dehradun and Roorkee attended the event. During five technical sessions, 10 invited lectures and 30 papers were presented on various topics including 'Housing & Natural Calamities', 'Climate Change & Housing', 'Conservation of Cultural Heritages', 'Future Housing' etc. with many vivid recent examples and case studies.

On this occasion, the employees were encouraged and awarded for successful integration of Hindi for all official purposes. The "Scientific Incentive Plan" award was also presented for excellent work in Hindi.

Press Meet

CSIR- CBRI, Roorkee organized a Press Meet "Jan Samvad" on January 25, 2016 to apprise about the institute's works related to Cultural heritage sites like Chittaurgarh Fort, Qutub Minar, Taj Mahal, Kashi Vishwanath Temple, Sun Temple, Gorten Castle Shimla, Indian Institute of Advanced Studies Shimla and Kedarnath. The meet acknowledged Mr. Yadvendra Pandey, Acting Director, CSIR-CBRI; Dr. Harsh Verma, CIMFR Regional Centre Roorkee; Dr. B. Singh, Dr. Suvir Singh, Dr. Atul Kumar Agarwal, Dr. Ajay Chaurasia, Dr. P. K. S. Chauhan and many other senior scientists.

Mr. Y. Pandey informed that mining operations were done to study the impact of blasting at the Chittaurgarh Fort on the orders of The Hon'ble Supreme Court. This study was conducted jointly by CBRI Roorkee and Central Institute of Mining and Fuel Research Dhanbad. He also informed about the institute's works to detect the impact of the sound of aircraft on Qutab Minar and the geotechnical and structural investigations of the Taj Mahal. The Himachal Pradesh government has requested CBRI to renovate the Gorten Castle and I.I.A.S. in Shimla using new technology and original building materials.

Addressing the press, Mr. Y. Pandey briefed about the work done at UNESCO World Heritage Site Sun Temple, Konark, Orissa. A portion of the Sun Temple has collapsed and the main building left has been completely submerged by marine sand. The task of removing the sand without damaging the structure of the building has been assigned to CBRI. He also informed about the work done on World Heritage site, the Kashi Vishwanath Temple. Archaeological Survey of India (ASI) has entrusted CBRI Roorkee the task of finding the method to remove the coating of paint from the temple walls without any damage to the temple wall carvings.

Mr. Y. Pandey informed that the institute has also been asked to provide its technical expertise to rehabilitate the disaster afflicted Kedarnath. The institution has fulfilled the obligation successfully. He informed that more than 150 one floor buildings have already been constructed in Kedarnath and work for almost the same number two-storied buildings is in progress. Rock fall barriers and RC counter forts have been constructed for protection. In addition, the design for piers and other amenities has been completed and construction work has begun. The workers were trained to use materials available on site for the construction of the stone masonry. He informed that despite the adversities more than 3000 workers are engaged in construction work in Kedarnath. Dr. Atul Kumar Agarwal, Senior Principal Scientist proposed a vote of thanks.

Press representatives from Amar Ujala, Dainik Jagran, Hindustan, Rashtriya Sahara, Punjab Kesari, Uttaranchal Deep, Awam-e-Hind, Jan Bharat Mail etc. attended the meet.

Republic Day

The Republic Day of the Nation was celebrated with a deep sense of patriotism combined with gaiety on January 26, 2016 at CSIR- Central Building Research Institute main lawns. Mr. Yadvendra Pandey, Acting Director, hoisted the National Flag and addressed the gathering and took the salute at the March Past performed by the security guards. The school children from Bal Vidya Mandir and CBRI Junior High School Shanti Nagar presented various cultural programmes on patriotic themes.

CSIR-CBRI Foundation Day

CSIR-Central Building Research Institute (CBRI), Roorkee celebrated its 70th Foundation Day on February 10, 2016, organized in Ravindra Nath Tagore Auditorium. Dr. Ashwini Kumar, Director General, Indian Council of Forestry Research & Education (ICFRE), Dehradun and Vice-Chancellor, FRI & Colleges, Dehradun was the Chief Guest and Mr. Pramod Adhlakha, Managing Director, M/S Adhlakha Associates Private Limited, Delhi was the Guest of Honor. Mr. Yadvendra Pandey, Acting Director, CSIR-CBRI presided over the function.

Mr. Yadvendra Pandey, Acting Director, CSIR-CBRI addressed the gathering, highlighted the glorious past of CSIR-CBRI, which was established on February 10, 1947. Since then it has been contributing in the development of the country and carrying out R&D on all aspects of housing and assisting the building industry in solving problems of planning, designing, foundations, materials and construction including disaster mitigation in all kinds of buildings, environment preservation and energy conservation. He informed that CBRI, having provided assistance in Rehabilitation of Chamoli earthquake, damage assessment of education and health buildings in earthquake affected Uttarkashi, Landslide zonation of Garhwal districts, strong motion seismic instrumentation, development of solar timber seasoning kilns, building construction of Navodaya Vidyalaya complexes, has been intensively involved in addressing this specificity related items. The institute has also taken up projects for conservation of nationally important heritage structures such as Taj Mahal, Konark Temple, Chittaurgarh Fort, Kashi Vishwanath Temple and Qutab Minar. He also spoke about CSIR-800 project and role of the institute aiming at the upliftment of the life of poor people in the country. He talked about the major R&D projects, newer areas of research such as sustainability, nanotechnology, Use of Kota Stone dust, EPS Door shutters, Nano-concrete, Bio-concrete, Geopolymer, etc. and C&D waste utilization in the production of construction materials and products. He also informed about the involvement of CBRI in Housing for All Mission and Make in India.

Dr. Ashwini Kumar, Chief Guest, in his address complimented CSIR-CBRI for its efforts and achievements, especially for its role in the country's economy by providing one of life's three basic necessities. He spoke about the scientific importance of the day. He stated that CBRI is engaged in producing buildings while ICFRE produce the building products. He shared his concern on the recent climatic changes in the environment and encouraged the efficient use of solar power. He dwelt upon the need of developing energy efficient building products.

Mr. Pramod Adhlakha, Managing Director, M/S Adhlakha Associates Private Limited, Delhi, who has been associated with the institute since 1975, requested CBRI staff to take the lead in the Prime Minister's Make in India movement. He informed that by using CBRI Technologies, we have covered an area of about one crore sixty lakh square meter using the technological advancement made by the institute. He told that CBRI's technology has been used in the construction over twenty thousand houses in Bawana, Delhi.

On this occasion, Diamond Jubilee Director's Best paper Award of Rs 15000/- was awarded to Dr. Rajiv Kumar & Mr. M. P. Singh for the paper "Correlations among Signature for detection of different types of fires". Diamond Jubilee Director's Award for development of best Technology which has maximum impact on the society was awarded to Dr. B. Singh & Dr. Manorama Gupta for "Building Products from Pine Needles" and cash prize of Rs. 20,000/- was given.

On this occasion a publication on "State of the Art on Prefab Technologies for Housing" and two CDs on short films on Innovative Building Materials and Confined Masonry were released. The occasion was also marked by inauguration of a Heritage Gallery having rare photographs of various dignitaries who visited the Institute. Winners of the inter school debate competition held on the occasion, were also awarded. Dr. A.K. Minocha, Chief Scientist conducted the proceedings and proposed a vote of thanks. The superannuated staff of CBRI and all staff members of the institute also witnessed the occasion besides other dignitaries.

Industrial Meet of Kota Stone Small Scale Industries Association

An industrial meeting was organized at CSIR-CBRI on February 11, 2016 in which Mr. Dinesh Bhardwaj, President, Kota Stone SSI Union Kota and Ram Ganj Mandi along with 10 union officials and Mr. Aditya Sharma, Regional Manager, Centre for Development of Stones (CDOS) Jaipur, participated.

Mr. Dinesh Bhardwaj informed that more than five thousand splitting units of Kota Stone are operated in the Kota, Jhalawar and Ram Ganj Mandi area. These splitting units produce stone debris which is ejected to the dumping yards. But these dumping yards fill up within one to two years. So the entrepreneurs dump the debris wherever the space

allows. Therefore in the past 50 years, these units have disposed off more than 650 million tonnes of Kota Stone Waste in Rajasthan's Hadhoti region leading to environmental problems such as air, water and soil pollution as well as numerous health problems.

So to get around this problem, Rajasthan Pollution Control Board, Jaipur in 2012 inspired CSIR-CBRI, Roorkee to produce building materials from this waste. Consequently, keeping all this in mind, the Ministry of Science & Technology New Delhi and Rajasthan Pollution Control Board, Jaipur provided funds to CSIR-CBRI Roorkee. CSIR-CBRI scientists developed advanced quality carpet tiles of various designs, paver blocks and techniques to produce lightweight building blocks. The pilot plants to manufacture tiles and blocks from this waste have also been built here.

The Union from Kota & Ram Ganj Mandi inspected the building materials and pilot plants and expressed their desire to licence the technology and establish the industry at the earliest. Mr. Yadvendra Pandey, Acting Director CSIR-CBRI assured them all possible technical assistance.

Mr. Aditya Sharma, Regional Manager, Centre for Development of Stones, Jaipur presented his views and expressed his full trust on the institute's techniques.

The Meet also acknowledged senor scientists of the institute Dr. (Mrs.) Rajni Lakhani, Dr. B. Singh and all the members of the technology development team. It is expected that wide propagation of this technology will get rid of the problem of environmental pollution.

Workshop-cum-Brainstorming Session on Affordable Housing

A Workshop - cum- Brain storming session on "Affordable Housing" was organized on February 11, 2016. Mr. Yadvendra Pandey, Acting Director, Mr. P.R. Mehta, Architect & Member RC, CSIR-CBRI, Mr. Rajesh Goyal, CMD, Hindustan Prefab Ltd., New Delhi, Mr. Pramod Adhlakha, Managing Director, M/S Adhlakha Associates, New Delhi, Mr. Vishal Goyal, National Housing Bank, New Delhi, Mr. Raj Kumar Negi, National Housing Bank, New Delhi, Dr. P.V. Srinivas, and Mr. Harsh Vardhan, CTSPL Ltd. Hyderabad, Mr. Kundan Singh, Era Construction, New Delhi, Mr. N.K. Shangari, Former Chief Scientist, CSIR- CBRI, and Group Leaders participated in the discussions.

Several recommendations emerged out of the Brain storming:

- The aspirations of the people must be taken into consideration for which the existing case studies needs to be carried out.
- The research has to be valuable and the testing partner has to be the profession. The benefits of research must be shared by a diverse nation as ours, for which there is a need to set up multiple teams and target evolution of alternatives. Do not waste time in reinventing the wheel, if research needs to influence the practice, prioritize the subject.
- Design, materials, technology and finance should go hand in hand and acceptability of the technology / system by the public is a top priority.
  - ➢ CSIR-CBRI must join hands & support associates and open a consultancy wing with other stake holders under one umbrella.
  - ➢ There is a need to develop technical training centers for skill development on CSIR-CBRI technologies.
  - ➢ There is a need to support technical back up and prepare a team of independent persons in the field. Involve contractors as partners for execution.
  - ➢ There is a need to concentrate on both Govt. & private works.
- Mechanization of Prefab technology may be carried out for mass adoption.
- There is a need to collect performance data / monitoring of the already constructed dwellings / buildings for its evaluation and improvement in the technology.
- Evaluate and remove shortcomings based on the feedback and improvise on the technologies looking into the advancements in the construction.
- There is a need to amend the existing IS Codes and issues of aesthetics, noise, heat insulation, fire, durability, sustainability, maintenance, modifications etc.

Training Programme on Design of Disaster Resistant Housing and Risk Mitigation

Design professionals agree that the most successful way to mitigate losses of life and property is to design disaster-resistant buildings. An integrated approach should be incorporated into the project planning, design, and development at the earliest possible stage. A variety of techniques are available to mitigate the effects of natural hazards on the built environment. Depending on the type of hazard, the location and type of construction of a structure can be designed to resist hazard induced loads. To reduce the risk from natural hazards in existing building retrofitting and repairs of the structure can be undertaken. This demands proper planning, design, construction methods, use of innovative

materials and trained manpower. CSIR-CBRI is one of the leading institutions in the country which has developed innovative technologies for architectural and structural design of multi-hazard resistant construction. These building technologies have been demonstrated in field, and hands-on training has been provided of grass root level functionaries in different parts of the country. It is essential to mass implement disaster-resistant innovative technologies developed by different institutions. This demands development of skills and capacity building among the administrative and

technical functionaries at the state/district level for its systematic implementation. To achieve this, professionals needs to be trained in the application of innovative technologies for disaster risk mitigation.

Identifying the need to develop a pool of trained professionals in the construction of disaster resistant building risk mitigation, CSIR-Central Building Research Institute, Roorkee conducted a three day Training course on "Design of Disaster Resistant Housing and Risk Mitigation" during February 24-26, 2016 at its premises. This training course is particularly aimed at enhancing knowledge and skills of the implementing archives to incorporate disaster resistant techniques in building design and construction and to mitigate the risks in existing buildings through lectures, demonstrations and hands-on exercises.

This training programme was attended by 19 officers from different states consisting of eight Engineers from PWD & CPWD; five students from BBD University, Lucknow & KEC, Ghaziabad and six newly recruited Scientist of CSIR-CBRI, Roorkee. The technical sessions have been delivered by invited resource person and in-house faculty (Scientist) of CSIR-CBRI, Roorkee.

The training programme was inaugurated by Mr. Mangesh Ghildiyal, Joint Magistrate Roorkee, Prof. Chandan Ghosh, NIDM New Delhi and Mr. Y. Pandey, Acting Director CSIR-CBRI. Mr. Mangesh Ghildiyal has expressed the importance of construction of disaster resistant houses and mitigation of disaster risks in different parts of the country with the involvement of CSIR-CBRI for providing technical support on building science needed for local administration for the development

of sustainable built environment. He also said that this can be achieved by enhancing the knowledge and skills of implementing authorities through providing training/demonstration/skill developmental activities to the filed level functionaries. Later Prof. Chandan Ghosh on his speech focused on minimization of local level disaster risks such as stabilization of soils slopes using Vetiver plantation. Lastly Mr. Y. Pandey has assured that CSIR-CBRI is always in forefront to provide the technical support for construction of disaster resistant housing using innovative technologies developed by CSIR-CBRI. Soon after the inaugural session of the training programme few Vetiver plants have been planted by the dignitaries at Village Toda Kalyanpur (Roorkee) for stabilization of soil slopes along the major nala in which sewage water flow generated by the village.

Later, the concluding session was chaired by Dr. A.K. Minocha, Chief Scientist of the institute. During this session, training coordinator has appraised about the three days activities of the training programme followed by the feedback from the participants. They expressed that such kind of training programme would enable us in updating the scientific knowledge, adaptation of disaster resistant building technologies at grass root level by the administrators/field level officer with technical support of CSIR-CBRI scientific community. The session was concluded with the distribution of certificates to the participants.

International Women Day

CSIR-CBRI celebrated International Women Day on March 8, 2016. A Panel discussion on "Role of Women Empowerment in Nation Building" was organised. The women working in different profession such as Dr. Madhuraka Saxena, Chairman Rotary Club and Former Principal S. D. Degree College Roorkee ; Dr. Rama Mehta, Scientist N.I.H Roorkee; Dr. Rashmi Panwar, Homeopathy Physician Vardan Clinic, Roorkee; Dr. Renu Saxena, Principal S. D. Inter College Roorkee, Mrs. Anjana Agarwal, President CBRI Ladies Club, Ms. Rashmi Devi, Section Officer participated in the discussion and shared their valuable views on the subject.

Women empowerment and their proper physical, mental and social development can only be achieved when the old mindset is changed and social malpractices such as sexual abuse, dowry practice, women oppression are eradicated from the society. Also, education should be made an essential part in their life from early childhood to make them independent and empowered.

Mr. Yadvendra Pandey, Acting Director, CSIR-CBRI presided over the function. Dr. Rajini Lakhani, Principal Scientist, convened the event. Dr. Abha Mittal, Senior Principal Scientist shared her views on the subject and introduced Dr. Rama Mehta. Mrs. Neeta Mittal, Senior Principal Scientist formally introduced Dr. Madhuraka Saxena and proposed the vote of thanks. The women scientists and CBRI ladies club members also attended the programme and actively participated.

Annual Flowers and Vegetables Show

CSIR-CBRI Staff club organized 49th Annual Flower and Vegetable Show-2016 at CSIR-CBRI Roorkee premises on March 9, 2016. Prestigious organisations of Roorkee such as IIT, NIH, CBRI, BEG&C etc. participated in the Flower Show. In addition to this, many individual participants and staff of CBRI participated in this show. There were several categories for the competition which include garden, pot plants, cut flowers, vegetables and flowers arrangements etc. The first category was open for all institutions, office, clubs and nurseries; second category included all individual participants; the third category was exclusively for CBRI Staff; the fourth category was for the gardeners; and the fifth category incorporated pot plants, cut flowers, vegetables and flower arrangements.

The show was inaugurated by Dr. Ashwini Kumar Minocha, Chief Scientist, CSIR-CBRI and the prizes were distributed by the Chief Guest Prof. S.C. Handa, Director General, Quantum Global Campus Roorkee.






Dr. P.K.S. Chauhan was the convener of the flower show. Overall Trophy in Institutional category was awarded to Director, NIH and in the Individual category trophy was awarded to Brigadier S.K. Kataria. In the CBRI staff category, Mr. Y. Pandey, Acting Director, CBRI won the Overall Trophy.

In the category of Pot plant, Garden, Bonsai, Cut flower, Vegetables, lawns, Garland, Miniature, Rangoli & Salad dressing etc. Mr. Pradeep Batra, Estate & Works Department IIT and G.P.Q.A, Mr. R. C. Saxena, Mr. S. K. Negi, Mrs. Milli Panigrahi, Ms. Megha Panigrahi, Mrs. Madhu Yadav, Mr. Y. Pandey and Brigadier S. K. Kataria won various prizes in their respective categories.

The jury of the flower show comprised of Mr. K. D. Dhariyal, Mr. Satpal Tyagi and Mrs. Amita Simwal.

In-house R&D Projects (2015-16)

S. No.	Project No.	Title of the Project	Principal Investigator Co-Investigator	Duration
Health Monitoring, Rehabilitation & Strengthen				
1.	OLP-0389	Uplift capacity of shallow strip anchors under static and seismic conditions.	Mr. Anindya Pain	0415-0317
2.	OLP 0378	Experimental evaluation of precast beam-beam connection.	Mr. Siddharth Behera Dr. A.K. Mittal	0413-0315-0615
3.	OLP 0386	Group effect of piles in loose sandy soil in earthquake inducted lateral spreading.	Mr. Piyush Mohanty	0414-0316
4.	OLP 0387	Study of carbonation of RC structures.	Mr. Mickey M. Dalbehera	0414-0316
Disaster Mitigation				
5.	OLP 0370	Evolution of publication in the area of duct explosion hazard evaluation, prevention and mitigation based on analysis and compilation of information experimental and theoretical work and knowledge from CSIR-CBRI work and relevant up to date worldwide searched work.	Dr. Manju Mittal	1012-0915
Energy Efficient System & Other Projects				
6.	OLP 0384	Study of residential schools in composite climate for energy conservation.	Mrs. Neeta Mittal	0413-0315-0915
7.	OLP 0388	Design development and dissemination of appropriate rural housing systems for northern India.	Mr. S.K. Negi	0914-0315-0915
8.	OLP 0390	Documentation and S&T intervention in the traditional architecture of rural areas of the western Himalayan region.	Mr. S.K. Negi	1015-0316-0916
9.	OLP 0391	Preparation of a hand book in the area of heat transfer in buildings.	Dr. B.M. Suman	1115-1016

12th Five Year Plan Projects

S. No.	Project	Project Title, PI & Details
01	ESC 0301 (SINP)	**INNOVATIVE MATERIALS & TECHNOLOGIES FOR NEXT GENERATION GREEN BUILDINGS** **WP-1: Performance Enhancement of Materials through Nanotechnology** PI: L. P. Singh **WP-2: Next Generation Concrete for Sustainable Construction** PI: S. K. Singh **WP-3: Green Building Technologies** PI: Ashok Kumar **WP-4: Materials & Technologies for Hazard Reduction** PI : S.R. Karade
02	ESC 0102 Network Project	**ENGINEERING OF DISASTER MITIGATION & HEALTH MONITORING FOR SAFE & SMART BUILT ENVIRONMENT** **WP-1: Engineering of Landslide Disaster Mitigation.** PI: S. Sarkar & D.P. Kanungo **WP-2 : Engineering of Earthquake Disaster Mitigation** PI : P.K.S. Chauhan & Ajay Chourasia **WP-3 : Engineering of Fire Disaster Mitigation** PI: R.S. Chimote & Suvir Singh **WP-4 : Post Disaster Shelter Planning** PI: S.K. Negi **WP-5: Health Monitoring of Buildings using Wireless Sensor Network.** PI: Ajay Chourasia & Soju Alexander **WP-6: Intelligent Building System for Model Residential Unit.** PI: A.K. Mittal & R.S. Bisht
03	05- Network Projects CSIR- CBRI Participating Laboratory	**Removal of Heavy Metals from Waste Water using Fly Ash & Secured Disposal of the Sludge** ESC 0306, [CSIR-NEERI] PI : S. Maiti **Estimation of Crustal Deformation of Garhwal Himalaya** ISC 0301, [CSIR-CMMACS, Advance Research in Engineering & Earth Sciences (ARiEES) : Data Intensive Modelling & Crowd Sourcing Approach] PI : S. Sarkar **Energy Efficient Seed Storage Structures** PSC0103, [CSIR-CSIO, Advanced Instrumentation Solutions for Health Care & Agro-based Applications - ASHA] PI: Nagesh B. Balam **Development of Appropriate Support System for Artificial Pillars for Optimal Extraction of Locked-up Coal from Underground Mines** ESC0105, [CSIR- CIMFR, Dhanbad] PI : Ajay Chourasia **Service Robot for Building and other Structures** ESC 0112 , [CSIR-CMERI, Micro Machines & Robotics] PI : Ravindra S. Bisht

R&D Supporting Activities

(Decision Unit 06)

S.No.	Activity No.	Activity	Coordinator
1	STS 0001	**Knowledge Resource Centre (KRC)** Library Services, Documentation, Books, Publication and Institutional Depository	Dr. S. Sarkar Dr. S.K. Senapati
2	STS 0002	**Planning & Bussiness Development (PBD)** R&D Projects, RC Agenda (R&D), Project Deployment & APAR, Project Evaluation, Plan Documents, Project, Costing, Accounting & Budgeting, Expert Panel, QPR, RUD & Monthly Reports, Parliament, CSIR HQ & Audit Replies, Information Collection, Compilation and Backward & Forward Linkages and Management of Scientific & Technical Queries Technology Transfer (Licensing, Patents, Etc), Legal Agreements, Trend Assessment Including Feedback, Marketing, Industrial Liaison & Externally Funded Projects, Service Tax & MC Agenda (Externally Funded Projects)	Mr. Y. Pandey Mr. Nadeem Ahmad
4	STS 004	**Development Construction & Extension (DC&E)** Inland Liaison Including Exhibitions, Displays, Training, Special Functions & Visitors, Development, Technical Guidance/Aid, & Films, Demonstration, Constructions, Feedback, Human Resource Management, Overseas Collaboration & Deputation and Liaison with BIS & others and Photography Services	Mr. S.K Negi Dr. R. Dharma Raju
5	STS 0005	**Extension Centre, Delhi**	Dr. Rajesh Deoliya
6	STS 0006	**Computer Laboratory Group**	Dr. Abha Mittal
7	STS 0007	**Publication Group**	Dr. Atul K. Agarwal
8	STS 0008	**ICT, ERP, Biometric & CCTV (IT Support Activities)**	Dr. Harpal Singh Mr. Soju Alexander Mr. V.P.S. Rawat

Support Activities

Administrative Support Activities (Decision Unit 08)		Coordinator
General Administration & House Keeping		**Director**
1.	**Director's Secretariat (DTS)**	Director
2.	**Administration**	COA/AO
3.	**Finance & Accounts**	F&AO
4.	**Store & Purchase**	S&PO
5.	**Security**	Security Officer
6.	**Hindi Unit**	Mr. Y. Pandey
7.	**Public Relations**	Dr. Atul K. Agarwal
8.	**Medical Services**	Chairman, Medical Committee Dr. M.K. Sinha (MO I/C)
9.	**Divisional Activities** Including Maintenance of Equipments & Photo Copying Machines, etc	Advisor/Group Leader
10.	**Staff Club**	Sec. Staff Club
11.	**Estate (Civil Works)** Civil Works, New Construction, Maintenance, Cleaning & Sanitation Institute Cleaning Services Horticulture Services & Flower Show Water Supply related Services	Dr. S.R. Karade Incharge (Estate) Dr. D.P. Kanungo Dr. P.K.S. Chauhan Dr. Pradeep Kumar-I
12.	**Technical Services Group (TSG)** Air Conditioning Electrical Services, Maintenance of Vehicles PABX System	 Mr. D.K. Sehgal Dr. A.K. Mittal Mr. D.K. Sehgal Mr. Soju J. Alexander Mr. Nagesh B. Balam Dr. Rajiv Kumar Dr. A.K. Mittal
13.	HRD of Students	Dr. S. Sarkar Mr. Nadeem Ahmad

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
1	CNP 0055	Ajay Chourasia	DDA, ND-12, Narela, New Delhi	Expert Advice on Designs/Drawings of Proposed Prefabricated LIG Type High Rise Buildings
2	CNP 0085	S. Sarkar	Director, CSIR-CIMFR, Dhanbad	Slope Stability Analysis and Control Measures of Landslip at Oil Drilling Site, Mizoram
3	CNP 0275	A.K. Mittal	President's Estate Division, CPWD, Rashtrapati Bhawan, New Delhi	Advice on Structural Assessment and suggesting Earthquake Resistant Provisions for ASHIYANA Building of President's Estate, Dehradun
4	CNP 0365	A.P. Chourasia	Ex. Engineer, Western Div., 8, DDA, Central Nursary, Sector-5, Dwarka, New Delhi	Expert Advice on Structural Detailing of Proposed Multi-Storied Residential Buildings of DDA, Dwarka
5	CNP 0765 Advisory	S.K. Singh	Superintending Engineer CPWD, Shimla -171004, HP	Technical Advice on Technical Specification & BOQ of Repair, Retrofitting & Restoration of Gorton Castle Building (AG Office) at Shimla
6	CNP0030	S.R. Karade	National Thermal Power Corporation, Engineering office complex, A- 8A, Sector- 24, Noida-201301	Health Assessment & Remedial Measures for the Repair of Cooling Towers of NTPC Simhadri
7	CNP0245	Ajay Chourasia	Col. Ajay Kothiyal, Nehru Institute of Mountaineering, Uttarkashi	Technical Advice on Construction of Ghat, 3 Tier Security Measures against Delvge, 120 Cottage for Pilgrims
8	CNP-0375	B. Singh	Kahna Plastic Pvt. Ltd., 122/69 Central Hope Towen Slaqui Industrial Area, Dehradun	Evaluation of KPT Brand PPR Pipes & Fittings for Hot & Cold Water Supply
9	CNP0595	D.P. Kanungo	GM (Water), Moradabad Nagar Nigam, Moradabad (UP)	Investigation on Damage to a Building in Himgiri Colony, Moradabad Due to Operation of Tube Well
10	CNP0625	A.K. Mittal	Executive Engineer, 'C' Mandal. I.P. Bhawan, Central Public Works Department, New Delhi	Rehabilitation and Retrofitting of National Gallery of Modern Art (Jaipur House), New Delhi
11	CNP0675	B. Singh	Skipper Limited, 3A, Loudon Street, 1st Floor, Kolkata	Evaluation of Skipper Brand CPVC Pipes and Fittings for Hot & Cold Potable Water Supply in Buildings

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
12	CNP0685	B. Singh	Skipper Limited, 3A, Loudon Street, 1st Floor, Kolkata	Evaluation of Skipper Brand Lead Free PVC Pipes & Fittings for Potable Water Supply in Buildings
13	CNP0705	Ajay Chourasia	E.E., Navodaya Vidyalaya Samiti, B-15, Sector 62, Institution Area, Noida	Retrofitting Measures for JNV at Pankyong & Rathak District, Sikkim
14	CNP0735	Ajay Chourasia	UPRNN, Unit-4, Sakarita Bhawan, Vishnu Vihar, Deep Nagar, Dehradun	Expert Advice on Structural Drawing of Integrated Housing of MDDA, Dehradun
15	GAP 0062	Ajay Chourasia	DST, New Delhi	Health Monitoring of Buildings using Wireless Sensor Network
16	GAP0024	L.P. Singh	Jt. Director, Ministry of Environment & Forests (EI Division), Paryavaran Bhawan, CGO Complex, Lodhi Rd., New Delhi-3	Capacity Enhancement Programme on Fly Ash Utilization
17	GAP0035	Rajiv Kumar	Department of Science and Technology, Mehrauli Road, New Delhi	Burning Behaviour of Various Materials in Enclosure Fires - Development of Evacuation Strategies for Fire Affected up to Four Storey Row Buildings
18	GAP-0072	A.K. Minocha	Department of Science and Technology, Mehrauli Road, New Delhi	Demolition Waste as Raw Materials for Low Cost Construction Products
19	GAP0075	Leena Chourasia	State Biotechnology Dept., Govt. of Uttarakhand, Biotech Bhavan, P.O. Haldi, U.S. Nagar, Uttarakhand	Studies on Bio-based Calcareous & Siliceous Construction Materials
20	GAP0132	Rajni Lakhani	Department of Science and Technology, Mehrauli Road, New Delhi	Development of Technology for Making Flooring & Wall Tiles using KOTA Stone Waste
21	GAP0213	S.K. Bhattacharyya	Indo-US Science & Technology Forum, Fulbright House, 12 Hailey Road, New Delhi	Fire Centre for Advancing Research & Education in Structural Fire Engineering
22	GAP0433	L.P. Singh	Department of Science and Technology, Mehrauli Road, New Delhi	Studies of Nano-Engineered Cementitious & Polymeric Binders in Developing High-Performance Building Materials
23	GAP0605	A.K. Mittal	Under Secretary (HFA-IV), Ministry of Housing and Urban Poverty Alleviation, Room No. 323-C, Nirman Bhawan, New Delhi	Development of Implementation Manual for Expanded Polysterene Core Panel System
24	GAP0635	S. Sarkar	Department of Science & Technology, Mehrauli Road, New Delhi	Large Scale Geological-Geotechnical Mapping from Rudraprayag-Sonprayag and Sonprayag-Kedarnath

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
25	GAP0695	A.K. Mittal	Department of Science & Technology, Mehrauli Road, New Delhi	Design of Low Speed Wind Tunnel
26	GAP0725	S.K. Panigrahi	International Division, Department of Science & Technology, Technology Bhavan, New Mehrauli Road, New Delhi	Structural Health Monitoring of Tall Buildings using Vibration Based Techniques
27	SSP 0045	A.K. Mittal	Dy.GM (O&M-Civil) NTPC, NCPS, Vidyut Nagar, Dadri (UP)	Health Assessment of the Drift Structures for Natural Draft Cooling Tower at NCPS, Dadri
28	SSP 0195	A.K. Mittal	S.E., CPWD, Central Circle, Kenndy Cottage, Shimla (HP)	Advise on Retrofitting Measures of Distressed Building and Strengthening Measures for Slopes at Grand Hotel Shimla
29	SSP0044	Ajay Chourasia	Executive Engr., CP Division No. 5, Chandigarh	Restoration & Preservation of Reinforced Concrete Heritage Buildings of Chandigarh - Stage 1: Secretariate Building
30	SSP0094	Suvir Singh	Superintending Engr., Shimla Central Circle, CPWD, Kennedy Cottage, Shimla	Post Fire Investigations of Fire Damage Gorton Castle Building & Remedial Measures
31	SSP0103	Suvir Singh	Stanvac Chemicals (India) Ltd., 15-16 old Seva Nagar Market P.O. Lodhi Road, New Delhi - 110049	Toxological & Flame Spread Studies on Coated Cables
32	SSP0105	Rajesh Deoliya	Executive Engineer, PWD Division M-423, Govt. of Delhi, Sukhdev Vihar, New Delhi	Third Party Inspection / Quality Assurance for the Work of C/o Pucca Building for Govt. Sr. Sec. School at Madanpur Khadar, Phase-II, New Delhi
33	SSP0115	Rajesh Deoliya	Executive Engineer, PWD Division M-423, Govt. of Delhi, Sukhdev Vihar, New Delhi	Third Party Inspection / Quality Assurance for the Work of C/o Pucca Building for Govt. Sr. Sec. School at Madanpur Khadar, Phase-III, New Delhi
34	SSP0125	Rajesh Deoliya	Executive Engineer, PWD Division M-423, Govt. of Delhi, Sukhdev Vihar, New Delhi	Third Party Inspection / Quality Assurance for the Work of C/o Pucca Building for Govt. Sr. Sec. School at Kalkaji, New Delhi
35	SSP0162	A.K. Mittal	Superintending Archaeologist, Archaeological Survey of India, Bhubaneshwar Circle, Bhabaneshwar	Investigation at Sun Temple Konark
36	SSP0164	A.K. Mittal	Director (Planning), Army Welfare Housing Orgn (AWHO), South Hutment, Kashmir House, Rajaji Marg, New Delhi	Structural Checking of AWHO Group Housing Project at Panchkula

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
37	SSP0174	Suvir Singh	Jaslonite Konard Hi-Tek Pvt. Ltd, Dharam Industrial Complex, Chhokra Nala, G.E. Road, Raipur	Fire Performance Assessment of Protected Steel Column under High Temperature Loading
38	SSP0205	P.C. Thapliyal	KRIBHCO, Surat Hazira Road, Kribhco Nagar, Surat, Gujarat	Health Assessment of Product Handling Plant (Bagging Plant) & Allied Structures of KRIBHCO, Surat
39	SSP0254	S. Sarkar	Airport Authority of India, Rajiv Gandhi Bhawan, Safdarjung Road, New Delhi	Instrumentation & Monitoring of Buildings & Reinforced Soil Structure at Greenfield Airport at Pakyong, Sikkim
40	SSP0265	S.K. Singh	Member Secretary, Uttarakhand Environment Protection & Pollution Control Board, 29/20, Chandra Villa, Nemi Road, Dehradun	Third Party Quality Assurance & Monitoring of Proposed HQ Building at Dehradun
41	SSP0295	Harpal Singh	Executive Engineer, Construction Division -2, PWD, Faizabad, UP	Fire Retardant Canvas for Fire Protection of Make-shift Structure at Ram Janam Bhoomi, Ayodhya
42	SSP0302	A.K. Mittal	Superintending Archaeologist Archaeological Survey of India Agra Circle Agra 282001	Comprehensive Geotechnical & Structural Investigation of Taj Mahal
43	SSP0324	Rajesh Deoliya	Executive Engr., Civil Buildings Maintenance Division, M-431, Near Gate No. 6, J. L. Nehru Stadium, New Delhi	Third Party Quality Assurance for the Civil Construction Work of Redevelopment of 'C' Block at High Court, New Delhi
44	SSP0333	Ashok Kumar	Director, Central Statistics Office (National Accounts Division-4), Ministry of Statistics & Programme Implementation, Sardar Patel Bhavan, Sansad Marg, New Delhi-1	Study of Improvement in Rates & Ratios used in the Estimates of Gross Value added in Construction Sector & Capital Information
45	SSP0384	S.K. Singh	Addl. General Manager, Bharat Electronics Limited, PO-Bharat Nagar, Ghaziabad	Assessment of Fire Damaged SRE Tower Building at AFS, Hindon & Suggesting Strengthening Measures
46	SSP0424	A.K. Mittal	Mr. Ajay Kr. Awasthi, Chief Executive Officer, Shri Kashi Vishwanath Mandir, Varanasi	Investigation of Kashi Vishwanath Mandir, Varanasi
47	SSP0434	Manojit Samanta	Punjab State Transmission Corporation Ltd., Mall Road, Patiala	Assessment & Strengthening of Existing Pile Foundation of 220 KV Transmission Line Tower, Punjab

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
48	SSP0465	B.S. Rawat	Dr. K. P. Jayanth, V.P., Pest Control (I) Pvt. Ltd., Araker Post, Bangalore	Structural Termite Management of an Insect Growth Regulator (Difunbenzuron 0.025%)
49	SSP0472	B.S. Rawat	Dr. Lakshmipathi Srigiriraju, Crop Protection R&D, Dow Agroscience India Pvt. Ltd., 1st Floor, Block B, 02 Godrej IT park, Pirojshanagar, LBS Marg, Vikroli(West), Mumbai 400079	Bio Efficacy Studies Sentricon Termite Colony Elimination System for Termite Management in Buildings
50	SSP0575	Rajesh Deoliya	Executive Engineer, Building Project Division B-234, L. N Hospital, New Delhi	Third Party Inspection / Quality Assurance for the Civil Work of Extension of Maulana Azad Dental Institute of Dental Sciences, Phase II at Bahadur Shah Zafar Marg, New Delhi
51	SSP0585	Rajesh Deoliya	Executive Engineer, Building Project Division B-232, Sector-9, Dwarka, New Delhi	Third Party Quality Assurance for the Civil Construction Work of 700 Beds Indira Gandhi Hospital, Sector 9, Dwarka, New Delhi
52	SSP0614	Suvir Singh	State Bank of India, Premises & Estate Dept., Local Head Office, 4th Floor, Circletop House, 16, College Lane, Chennai	Post Fire Investigations and Remedial Measures of Fire Damaged SBI Chennai Main Branch Building & Remedial Measures
53	SSP0634	B.M. Suman	Manager - Marketing & Business Development, UP Twiga Fiberglass Ltd., Twiga House, 3 Community Centre, East of Kailash, New Delhi	Study the Effect of Density on Thermal Behaviour of Twiga Fiber Glass at Mean Temperature Remains Constant for Five Mean Temperatures
54	SSP0645	Suvir Singh	Siporex India Pvt. Ltd., 72-76 Industrial Estate, Mundhwa, Pune	Fire Resistance Evaluation of Siporex Reinforced Slab Under Uniform Loading
55	SSP0655	A.K. Mittal	Director (GW & UD), Lok Sabha Secretariat, Parliament House Annexe, New Delhi	Technical Examination of the Extension Building to PHA, New Delhi
56	SSP0755	Neeraj Jain	Sr. Manager, H-06, Construction Division, Tata Motors Pimpri, Pune	Feasibility Studies on Use of ETP Sludge for Development of Value Added Building Materials
57	TSP0025	S.R. Karade	Krishna Conchem Products Pvt Ltd #2, Bidg. 6, Sect 3 Millennium BusinessPark, Mahape, Navi Mumbai-400710	Evaluation of Sacrificial Anodes for Steel Reinforced Concrete
58	TSP0355	Rajni Lakhani	Goldcoin Industries Pvt. Ltd., 601, Kingston, Tejpal Road, Vile Parle (East), Mumbai	Evaluation of Chemically Crosslink Foam (XLPE)

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
59	TSP0505	B.M. Suman/ Ashok Kumar	Executive engineer IIT Jodhpur, Nitman Bhawan, 3- West Patel Nager Jodhpur-342011	Evaluation of Extruded Polystyrene Insulation Board for Thermal Conductivity
60	TST0015	Suvir Singh	Johnson Lifts Pvt. Limited, #17, Poonamallee Bye Pass Road, Poonamallee, Chennai-600056	Fire Resistance Evaluation of Lift Landing Door
61	TST0065	Suvir Singh	Systemair India Pvt. Limited, Plot No. 3, Sector 31, Ecotech-1, Kansa, Greater Noida-201308	Fire Performance Assessment of Fire Dampers
62	TST0074	Suvir Singh	Engineers India Limited, Engineers India Bhawan, 1 Bhikaiji Cama Place, New Delhi-110066	Fire Performance Assessment of Protected Steel I Beam
63	TST0084	Suvir Singh	Saint Gobain Glass India Limited, Plot No. A-1, SIPCOT Industrial Park,Sriperumbudur-602105, Dist-Kanchipuram, Tamilnadu	Fire Performance Assessment of Fire Rated Glazed Door
64	TST0095	A.A. Ansari	Shahsahib Woodwool Enterprises, 583, Mukherjee Nagar, New Delhi - 110009	Reaction to Fire Characteristic Studies on ACUTEX Woodwool Acoustic Board
65	TST0104	Suvir Singh	Siporex India Pvt. Limited, 72-76, Industrial Estate, Mundhwa, Pune-411036	Fire Resistance Evaluation of Siporex Reinforced Slab under Uniform Loading
66	TST0114	Suvir Singh	Ozone Overseas Limited, Trilokpur Road,Kala AMB, Nahan,Srimour-173030, Himachal Pradesh	Fire Resistance Evaluation of Fire Door
67	TST0124	Suvir Singh	Ahlada Engineers Pvt. Ltd., SY#66-68, Bahadurpally (V), Qutubullapur Mandal, R.R. Dist., Hyderabad-500043	Fire Performance Assessment of Fire Rated Door
68	TST0134	Suvir Singh	Ahlada Engineers Pvt. Ltd., SY#66-68, Bahadurpally (V), Qutubullapur Mandal, R.R. Dist., Hyderabad-500043	Fire Resistance Evaluation of Fire Door
69	TST0135	Suvir Singh	Iclean Hollow Metal Systems Pvt. Limited, Survey no. 21/3 & 26/3, Gankapadu, Village – Anumanchipali Panchayant, Jaggaiahpet Mandal, Krishna Dist., Andhra Pradesh, Pin - 521175	Fire Performance Assessment of Fire Door

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
70	TST0145	Suvir Singh	Moreschi Asia Doors Pvt. Limited, Plot No. 6, Shed No. 2, Anrich Industrial Estate, IDA Bollaram, Medak District- 502325, Telangana	Fire Performance Assessment of Fire Door
71	TST0155	A.A. Ansari	Shree Ram Equitech Pvt. Limited, Opp. Bank of Baroda, Ganjpara, Durg-491001, Chhattisgarh	Determination of Non-Combustibility of Rock wool
72	TST0165	A.A. Ansari	ALP Aeroflex India (P) Limited, Rudrapur, Uttarakhand	Reaction to Fire Characteristic Studies on Insulation Product Based on Nitrile Rubber
73	TST0175	Suvir Singh	Trio Elevators Co. (India) Limited, 824, Kothari Industrial Estate, Kothari Cross Road, Santej Dist, Gandhinagar- 382721	Fire Performance Assessment of Elevator Door
74	TST0185	Suvir Singh	Iclean Hollow Metal Systems Pvt. Limited, Survey no. 21/3 & 26/3, Gankapadu, Village – Anumanchipali Panchayant, Jaggaiahpet Mandal, Krishna Dist., Andhra Pradesh, Pin - 521175	Fire Performance Assessment of Fire Door
75	TST0194	Suvir Singh	HILTI India Pvt. Limited, F-90/4, Okhla Industrial Area, Phase-1, New Delhi	Fire Resistance Evaluation of Firestops
76	TST0204	Suvir Singh	Johnson Lifts Pvt. Limited, #17, Poonamallee Bye Pass Road, Poonamallee, Chennai-600056	Fire Resistance Evaluation of Lift Landing Door
77	TST0215	P.C. Thapliyal	Y. Chinna Reddy, 27/7/1846, 8th Street, Ramji Nagar Near Childern Park, Nellore-524002 A.P.	Performance Evaluation of IPNet Protective Coating to be used in PSC Structures between Chengalpattu & Villupuram Section, A.P.
78	TST0225	A.A. Ansari	Paramount Polytreat Chemicals Pvt. Limited, 2/10, II Floor, Opp. Crown Plaza Hotel, New Friends Colony, New Delhi - 110025	Reaction to Fire Characteristic Studies on Starbond 30-36
79	TST0234	Suvir Singh	ECE Industries Limited, A-20, Industrial Area, Meerut Road, Ghaziabad-201003	Fire Performance Evaluation of Elevator Door
80	TST0235	A.A. Ansari	Zeco Aircon Limited, O-1&O-5, Old Industrial Area, Bahadurgarh – 124507	Reaction to Fire Characteristic Studies on Insulated Panel

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
81	TST0244	Suvir Singh	Airport Authority of India, Chandigarh Division, Civil Air Terminal, Chandigarh - 160003	Fire Performance Assessment of Steel Fire Door
82	TST0255	Suvir Singh	Johnson Lifts Private Limited, No.1, East Main Road, Annanagar West Extension, Chennai-600101	Fire Performance Assessment of Lift Landing Doors
83	TST0274	Suvir Singh	Shakti Hormann Limited, Regd office Plot No-20, Sripuri Colony Karkhana, Secunderabad-500015	Fire Performance Assessment of Wooden Fire Rated Door
84	TST0285	Suvir Singh	Tufwud Doors & Accessories, 139, Rajdanga Main Road, Near Kasba New Mkt. & UCO Bank, Kolkata - 700107	Fire Performance Assessment of Fire Door
85	TST0294	Suvir Singh	Assistant Engineer, IMS Sub Division, Under Varanasi Central Division, CPWD Kendranchal, Bada Lalour Lamhi, Varanasi-221007	Fire Performance Assessment of Fire Door
86	TST0304	Suvir Singh	Assistant Engineer, IMS Sub Division, Under Varanasi Central Division, CPWD Kendranchal, Bada Lalour Lamhi, Varanasi-221007	Fire Performance Assessment of Partition & False Ceiling
87	TST0305	A.A. Ansari	AICA Laminates India Pvt. Limited, 33, Jhendewalan Road (Motia Khan), New Delhi - 110055	Reaction to Fire Characteristic Studies on Fire Retardant Decorative Laminate
88	TST0314	Suvir Singh	HILTI India Pvt. Limited, F-90/4, Okhla Industrial Area, Phase-1, New Delhi	Fire Performance Assessment of Firestops
89	TST0315	Suvir Singh	Tecno Doors Pvt. Limited, Plot No. LI, SIPCOT Industrial Park, Mambakkam & Pondur A Village, Sriperumbudur Taluk, Kancheepuram,Pin-602106	Fire Performance Assessment of Fermator Premium Landing Door
90	TST0325	Suvir Singh	Fujitec India Pvt. Limited, Plot No. P-52,IST Cross Road, 8th Avenue, Mahindra World City, Chengalpattu, Kancheepuram Dist., Pin-603002	Fire Performance Assessment of Lift Landing Door

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
91	TST0335	Suvir Singh	Otis Elevator Company (India) Limited, No. 92, KIADB Industrial Estate, Phase-II, Jigani Industrial Area, Anekal Taluk, Bangalore-562105	Fire Performance Assessment of Elevator Door
92	TST0345	Suvir Singh	Ozone Overseas Pvt. Limited, Trilokpur Road, Kheri Kala AMB, Nahan, Dist- Sirmour, Pin – 173030	Fire Performance Assessment of Fire Door
93	TST0354	Suvir Singh	GMP Technical Solution Pvt. Limited, Gunai Road, Mandhala, Via Barotiwala, Dist- Solan, HP, Pin-174103	Fire Resistance Evaluation of Metal Partition
94	TST0364	Suvir Singh	Jotun India Pvt. Limited,101, SNS Synergy, Near Valentine Theatre, Athwa-Dumas Road, Surat-395007, Gujarat	Fire Performance Assessment of Protected Column
95	TST0374	Suvir Singh	Wallmax India Enterprises Pvt. Limited, 12/4, Banga Complex, Main Mathura Road, Faridabad – 121003	Fire Performance Assessment of Cable Firestop
96	TST0385	Suvir Singh	Consolidated Construction Consortium Limited, ONGC-Rajiv Gandhi Urja Bhawan Project, Plot No. 5A & 5B, Nelson Mandela Marg, Vasantkunj, New Delhi - 110070	Fire Performance Assessment of Fire Door
97	TST0394	Suvir Singh	Saint Gobain India Limited, Sigapi Achi Building, Floor No. 7, 18/3 Rukmany Lakshmipathy Road, Egmore, Chennai—600008, Tamil Nadu	Fire Performance Assessment of Cable Firestop
98	TST0395	Suvir Singh	Bhawani Fire Protection Pvt. Limited, 63, Rural Industrial Estate, Loni, Ghaziabad-201102	Fire Performance Assessment of Fire Door
99	TST0404	A.A. Ansari	Jotun India Pvt. Limited, Plot No. D-280, Ranjangaon MIDC, Village-Karegaon, Taluk-Shirur, Dist.-Pune-412220	Determination of Surface Spread of Flame Classification of Jotamastic 80
100	TST0405	A.A. Ansari	Jotun India Pvt. Limited, 502, 5th Floor, Boston House, Suren Road, Behind Cinemax Theatre, Andheri East, Mumbai - 400093	Studies of Smoke Generated by Jotamastic 80 on Steel & Concrete Panels

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
101	TST0414	Suvir Singh	Tecno Doors Pvt. Limited, Plot No. L-1, SIPCOT Industrial Park Sriperumbudur, Mambakkam & Pondur "A" Village Sriperumbudur Taluk, Kancheepuram Dist., Tamil Nadu, PIN-602106	Fire Performance Assessment of Fermator Premium Landing Door
102	TST0415	Suvir Singh	Lloyd Insulations (India) Limited, Kalkaji Industrial Area, New Delhi – 110019	Fire Resistance Evaluation of Llyod Fire Stop Sealing System
103	TST0425	Suvir Singh	Shakti Hormann Limited, (Formerly Shakti Met-Dor Limited),Reg Office Plot No. 20, Sripuri Colony, Karkhana , Secunderabad – 500015 , Telangana	Fire Performance Assessment of Fire Doors
104	TST0435	A.A. Ansari	NTPC Limited, SIPAT Super Thermal Power Project, Post Office Sipat, Dist – Bilaspur, Pin - 495006	Reaction to Fire Characteristic Studies of Strand Ebony
105	TST0444	A.A. Ansari	Sumip Composites Pvt. Limited,Plot No. 1 to 5, Panchratna Industrial Estate,Changodar, Sarkhej-Bavla Road, TA-Sanand, Dist- Ahmedabad, Pin- 382213, Gujrat	Reaction to Fire Characteristic Studies on FRP Pultruded Section
106	TST0445	Suvir Singh	GWS Engineers & Fabricators Pvt. Limited, A-512, TTC Industrial Area Mahape, Navi Mumbai – 400710	Fire Performance Assessment of Fire Door
107	TST0454	Suvir Singh	Signatures Interiors Pvt. Limited,64, RPTS Road, Near Jerryl Lawns, Surendra Nagar, Nagpur-440015	Fire Performance Assessment of Fermator Premium Landing Door
108	TST0455	Suvir Singh	GWS Engineers & Fabricators Pvt. Limited, A-512, TTC Industrial Area Mahape, Navi Mumbai – 400710	Fire Performance Assessment of Fire Door
109	TST0464	Suvir Singh	OTIS Elevator Company (India) Pvt. Limited, No.-92, Kiadb Industrial Estate, Phase-II, Jigani Industrial Area, Anekal Taluk, Banglore - 562105	Fire Performance Assessment of Elevator Door
110	TST0474	A.A. Ansari	GMP Technical Solution Pvt. Limited, Gunai Road, Mandhala, Via Barotiwala, Dist- Solan, HP, PIN-174103	Reaction to Fire Characteristic Studies on PUF Panels

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
111	TST0475	Suvir Singh	Metecno India Pvt. Limited, No. E -11, Sipcot Industrial Area, NH-4, Mambakkam Sriperumbudur, PIN – 602105, Tamil Nadu	Fire Performance Assessment of Fire Doors
112	TST0484	Suvir Singh	Mitsubishi Elevator ETA India Pvt. Limited, 5th Floor, Chennai City Centre, No. 10 &11, Dr. R K Salai Mylapore, Chennai, Tamilnadu, PIN-600004	Fire Performance Assessment of Lift Doors
113	TST0485	Suvir Singh	Sehgal Doors, B-133, Phase-I, Industrial Area, Mayapuri, New Delhi-110064	Fire Performance Assessment of Fire Doors
114	TST0494	Suvir Singh	OTIS Elevator Company (India) Pvt. Limited, No.-92, Kiadb Industrial Estate, Phase-II, Jigani Industrial Area, Anekal Taluk, Banglore - 562105	Fire Performance Assessment of Elevator Doors
115	TST0495	A.A. Ansari	Asiatic Composite Limited, 1963/1/12/B, Village Mankol, Near Hathipura Patiya Sanand-Nalsarovar Road, Tal- Sanand, Ahmedabad - 382110	Reaction to Fire Characteristic Studies on FRP Profile
116	TST0504	Suvir Singh	Valency Compounds Services Pvt. Limited, A-62, M I D C Area, Ahmednagar - 414111	Fire Performance Assessment of “Valency Fire Stop – 401” Cable Coating
117	TST0514	Suvir Singh	Shreeji Woods Craft Pvt. Limited, B-803, Western Edge II, Western Express Highway, Borivali (East), Mumbai	Fire Performance Assessment of Shreeji Fire Retardant Door
118	TST0515	Suvir Singh	Larsen & Turbo Limited, Heavy Civil Infra IC DMRC CC-28 Project, 15, Sivaji Marg, Zakhra, New Delhi – 110015	Fire Performance Assessment of Fire Doors
119	TST0524	Suvir Singh	Kone Elevator India Pvt. Limited, India Land Tech Park Tower-B, 3rd Floor, No.14, 3rd Main Road, Ambattur Industrial Estate, Chennai-600058	Fire Performance Assessment of Elevator Landing Door
120	TST0525	Suvir Singh	Delhi Metro Rail Corporation Limited, Opp. Frank Anthony Public School, Lala Lajpat Rai Marg, Lajpat Nagar – IV, New Delhi - 110024	Fire Performance Assessment of Fire Door

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
121	TST0534	Suvir Singh	Johnson Lifts Private Limited, No.1, East Main Road, Annanagar West Extension, Chennai-600101	Fire Performance Assessment of Lift Landing Doors
122	TST0535	Suvir Singh	The Executive Engineer, IIT Patna Project Division, CPWD Patna, Patna	Fire Performance Assessment of Fire Door
123	TST0544	Suvir Singh	MP Swastik Doors, 207, SHREYAS Industrial Estate, Near Western Express Highway, Goregaon (East), Mumbai-400063	Fire Resistance Evaluation of Fire Door
124	TST0545	Suvir Singh	Bhawani Fire Protection Pvt. Limited, 63, Rural Industrial Estate, Arya Nagar, Loni, Ghaziabad - 201102	Fire Performance Assessment of Metal Fire Door
125	TST0554	Suvir Singh	Shree Engineers, Plot No. 252, Sector No. 7, PCNTDA, MIDC Bhosari, Pune-411026	Fire Performance Assessment of Fire Safe Enclosure
126	TST0555	Suvir Singh	CHEMPHARM, C-71, Sector – 63, Noida – 201301	Fire Performance Assessment of Steel Fire Door
127	TST0564	Suvir Singh	Sehgal Doors, B-133, Phase-I, Industrial Area, Mayapuri, New Delhi-110064	Fire Performance Assessment of Fire Door
128	TST0565	Suvir Singh	The Divisional Engineer (C-II), Greater Mohali Area Development Authority (GMADA), Puda Bhawan, Sector – 62,Sas Nagar, Punjab	Fire Performance Assessment of Fire Door
129	TST0574	Suvir Singh	Sukri Paints & Chemicals Pvt. Limited, 380, Chirag Delhi, New Delhi- 110017	Fire Performance Assessment of Fire Glazed Door Assembly
130	TST0584	Suvir Singh	Pragati Enterprise, Plot No. B-15/24, Road No. 13, Sachin Udhyog Nagar, Sachin, Dist- Surat	Fire Performance Assessment of Fire Door
131	TST0594	Suvir Singh	PVKS Corporation Pvt. Limited, Plot No. 28, Sector – 14, Faridabad - 121002	Fire Performance Assessment of Fire Door
132	TST0604	Suvir Singh	The Executive Engineer, Building Project Division,B-132, Public Works Department, DGFR Complex, Sector – 3, Dwarka, New Delhi	Fire Performance Assessment of Fully Glazed Fire Door

Externally Funded Projects

S. No.	Project No	PI	Party Name	Title
133	TST0615	A.A. Ansari	U P Twiga Fiber Glass Limited, Twiga House, 3, Community Centre, East of Kailash, New Delhi-110065	Reaction to Fire Characteristic Studies on MFMB
134	TST0624	A.A. Ansari	Akzo Noble (India) Limited, Plot#62,A&B, Hoskote Industrial Area, Bangalore-562114	Surface Spread of Flame Studies of Alkyd Paints
135	TST0644	Suvir Singh	Stanvac Chemicals (India) Limited, 552, Sector-37, Pace City-II, Gurgaon, Haryana-122001	Fire Performance Assessment of Cable Fire Barrier System Firex FB - 250
136	TST0665	Suvir Singh	Sukriti Doors & Hardware Pvt. Ltd., 380, Ground Floor Chirag Delhi, New Delhi	Fire Performance Assessment of Glazed Fire Door
137	TST0745	Suvir Singh	Koleshvari Steel Industries, Plot No. 298, Road No. 4, GIDC, Kathwada, Ahmedabad	Fire Performance Assessment of Fire Door

CBRI Family as on March 31, 2016

Group-IV-Scientific Staff

S. No.	Name	Designation
1.	Mr. Y. Pandey	Acting Director
2.	Dr. A.K. Minocha	Chief Scientist
3.	Dr. Brijeshwar Singh	Chief Scientist
4.	Mr. R.S. Chimote	Chief Scientist
5.	Dr. Suvir Singh	Chief Scientist
6.	Dr. Manju Mittal	Sr. Principal Scientist
7.	Dr. (Mrs.) Abha Mittal	Sr. Principal Scientist
8.	Dr. R. Dharma Raju	Sr. Principal Scientist
9.	Mr. Ashok Kumar	Sr. Principal Scientist
10.	Mr. S.K. Negi	Sr. Principal Scientist
11.	Dr. Shantanu Sarkar	Sr. Principal Scientist
12.	Dr. Harpal Singh	Sr. Principal Scientist
13.	Dr. Atul Kumar Agarwal	Sr. Principal Scientist
14.	Dr. Pardeep Kumar-I	Sr. Principal Scientist
15.	Mr. A. A. Ansari	Sr. Principal Scientist
16.	Mrs. Neeta S. Mittal	Sr. Principal Scientist
17.	Dr. Rajni Lakhani	Principal Scientist
18.	Dr. D.P. Kanungo	Principal Scientist
19.	Dr. Achal Kumar Mittal	Principal Scientist
20.	Dr. S.R. Karade	Principal Scientist
21.	Mr. Nadeem Ahmed	Principal Scientist
22.	Dr. Sujit Kumar Saran	Principal Scientist
23.	Dr. Rajesh Deoliya	Principal Scientist
24.	Dr. Navjeev Saxena	Principal Scientist
25.	Dr. A.P. Chourasia	Principal Scientist
26.	Mr. S.K. Singh	Principal Scientist
27.	Dr. P.C. Thapliyal	Principal Scientist
28.	Dr. B.S. Rawat	Principal Scientist

29.	Dr. Shorab Jain	Principal Scientist
30.	Dr. S.K. Panigrahi	Principal Scientist
31.	Dr. L.P. Singh	Principal Scientist
32.	Dr. Rajesh K. Verma	Principal Scientist
33.	Dr. Pradeep Kumar II	Sr. Scientist
34.	Mr. H.C. Arora	Sr. Scientist
35.	Dr. P.K.S. Chauhan	Sr. Scientist
36.	Dr. Leena Chaurasia	Sr. Scientist
37.	Dr. Neeraj Jain	Sr. Scientist
38.	Dr. Vineet Kumar Saini	Scientist
39.	Mr. Syed Ibrahim Sohel	Scientist
40.	Mr. Ravindra Singh Bisht	Scientist
41.	Mr. Nagesh Babu Balam	Scientist
42.	Mr. Manojit Samanta	Scientist
43.	Mr. Soju Joseph Alexander	Scientist
44.	Mr. Soumitra Maiti	Scientist
45.	Mr. Srinivasrao Naik B.	Scientist
46.	Mr. Subash Chandra Bose Gurram	Scientist
47.	Dr. A. Aravind Kumar	Scientist
48.	Mr. Anindya Pain	Scientist
49.	Mr. Mickey Mecon Dalbehera	Scientist
50.	Mr. Piyush Mohanty	Scientist
51.	Mr. Siddharth Behera	Scientist
52.	Ms. Ishwarya G.	Scientist
53.	Ms. Monalisa Behera	Scientist
54.	Mr. Rajesh Kumar	Scientist
55.	Mr. Rakesh Paswan	Scientist
56.	Mr. Chanchal Sonkar	Scientist
57.	Mohd. Reyazur Rahman	Scientist
58.	Mr. Santha Kumar G.	Scientist
59.	Mr. Koushik Pandit	Scientist
60.	Ms. Sayantani Lala	Scientist

61.	Ms. Hina Gupta	Scientist
62.	Mr. Debdutta Ghosh	Scientist
63.	Ms. Surya M.	Scientist

Group III Technical Staff

64.	Dr. Rajiv Kumar	Principal T.O.
65.	Mr. D.K. Sehgal	Principal T.O.
66.	Mr. Sudhir Sharma	Principal T.O.
67.	Mr. Narendra Kumar	Principal T.O.
68.	Dr. B.M. Suman	Principal T.O.
69.	Mr. Rajesh Kumar	Principal T.O.
70.	Mr. Prakash Chand	Principal T.O.
71.	Mr. Rajeev	Principal T.O.
72.	Mr. Jaswinder Singh	Principal T.O.
73.	Dr. P.K. Yadav	Principal T.O.
74.	Mr. Bhupal Singh	Principal T.O.
75.	Dr. S.K. Senapati	Principal T.O.
76.	Mr. Dalip Kumar	Sr. T.O. (3)
77.	Mr. Rajeev Kumar Sharma	Sr. T.O. (3)
78.	Mr. Sushil Kumar	Sr. T.O. (3)
79.	Dr. M.K. Sinha	Sr. T.O. (2)
80.	Mr. Zamir Ahmad	Sr. T.O. (2)
81.	Mr. Rakesh Kumar –II	Sr. T.O. (2)
82.	Mr. Vivek Sood	Sr. T.O. (2)
83.	Mr. Jalaj Parashar	Sr. T.O. (2)
84.	Mr. Ram Ashray Rai	Sr. T.O. (2)
85.	Mr. Bharat Bhushan	Sr. T.O. (2)
86.	Mr. Naresh Kumar	Sr. T.O. (1)
87.	Mr. Rajesh R. Ghadse	Sr. T.O. (1)
88.	Mr. B.K. Kalra	Sr. T.O. (1)
89.	Mr. Itrat Amin Siddiqui	Sr. T.O. (1)
90.	Mr. Amit Kush	Sr. T.O. (1)

91.	Mrs. Gayatri Devi	Sr. T.O. (1)
92.	Mrs. Deepti Karmakar	T.O.
93.	Mr. Ajay Dwivedi	T.O.
94.	Mr. Sameer	T.O.
95.	Mr. D.S. Dharamshaktu	T.O.

Group II

96.	Mr. Rizwanul Hasan	Sr. Tech. (2)
97.	Mr. Rajinder Kumar	Sr. Tech. (2)
98.	Mr. Gopal Chand	Sr. Tech. (2)
99.	Mr. P.K. Yadav	Sr. Tech. (2)
100	Mrs. Neelam Gupta	Sr. Tech. (2)
101.	Mrs. Sangeeta Sharma	Sr. Tech. (2)
102.	Mr. Sheeraj Ahmad	Sr. Tech. (2)
103.	Mrs. Saroj Rani	Sr. Tech. (2)
104.	Mr. Anil Kumar Sharma	Sr. Tech. (2)
105.	Mr. Rishi Pal Singh	Sr. Tech. (2)
106.	Mr. Sushil Kumar	Sr. Tech. (2)
107.	Mr. Himanshu Sharma	Sr. Tech. (2)
108.	Mr. Manmeet Singh	Sr. Tech. (1)
109.	Mrs. Urmila Kotnala	Sr. Tech. (1)
110.	Mr. Amar Singh	Sr. Tech. (1)
111.	Mr. Shiv Prakash Tyagi	Sr. Tech. (1)
112.	Mr. B.S. Bisht	Sr. Tech. (1)
113.	Mr. Rajeev Bansal	Sr. Tech. (1)
114.	Mr. Pradeep Kr. Kapooria	Sr. Tech. (1)
115.	Mr. Arvind Saini	Sr. Tech. (1)
116.	Mr. Harish Kumar	Sr. Tech. (1)
117.	Mr. Sukhbir Sharma	Sr. Tech. (1)
118.	Mr. Arvind Kumar	Sr. Tech. (1)
119.	Mr. Kedar Nath	Sr. Tech. (1)
120.	Mr. Santosh Kumar Mishra	Sr. Tech. (1)

121.	Mr. Sharad Kumar	Sr. Tech. (1)
122.	Mr. Mam Chand Agarwal	Sr. Tech. (1)
123.	Mr. Arvind Kumar Sharma	Sr. Tech. (1)
124.	Mr. Tahir Husain	Sr. Tech. (1)
125.	Mr. Ghanshyam Mittal	Sr. Tech. (1)
126.	Mr. Francis Charles	Sr. Tech. (1)
127.	Mr. Iqbal Ahmed	Sr. Tech. (1)
128.	Mr. Manoj Kumar Tyagi	Sr. Tech. (1)
129.	Mr. Jai Pal	Sr. Tech. (1)
130.	Mr. Shorab Khan	Sr. Tech. (1)
131.	Mr. Jameel Hasan	Sr. Tech. (1)
132.	Mr. U.C. Bhatnagar	Sr. Tech. (1)

Group I Supporting Staff

133.	Mr. Harpal Singh	Lab. Asstt.
134.	Mr. D.P. Yadav	Lab. Asstt.
135.	Mr. Amar Singh (SE)	Lab. Asstt.
136.	Mr. Deepak Singh	Lab. Asstt.
137.	Mr. Gurucharan Singh	Lab. Asstt.
138.	Mr. Rajeshwar	Lab. Asstt.
139.	Mr. Rishi Pal (SE)	Lab. Asstt.
140.	Mr. Vijay Kumar	Lab. Asstt.
141.	Mr. Vishwas Kumar	Lab. Asstt.
142.	Mr. Jagdish Pal	Lab. Asstt.
143.	Mr. Deepak Kumar	Lab. Asstt.
144.	Mr. Hira Lal	Lab. Asstt.
145.	Mr. Subhash Chand	Lab. Asstt.
146.	Mr. Shiv Kumar (SE)	Lab. Asstt.
147.	Mr. Rajesh Kumar	Lab. Attd. (2)

Administrative Staff /House-Keeping

148.	Mr. Parag Saxena	A.O.
149.	Mr. Vinod Kumar	A.O.

150.	Mr. R. K. Manjhiwal	F&AO
151.	Mr. R.C. Saxena	Sr. H.O.
152.	Mr. Sukhvir Singh	S.O. (S&P)
153.	Mr. S. K. Jakhwal	S.O. (G)
154.	Mr. Constan Kujur	S.O. (G)
155.	Ms. Rashmi Devi	S.O. (G)
156.	Mr. V.K. Sharma	S.O. (G)
157.	Mr. K. Arora	P.S.
158.	Mr. Satya Pal	P.S.
159.	Mr. V.P.S. Rawat	Security Officer
160.	Mr. Mehar Singh	Hindi Officer
161.	Mr. Suba Singh	Hindi Officer
162.	Mr. Naresh Yadav	Sr. Steno
163.	Mrs. Archana	Sr. Steno
164.	Mr. Arvind Kumar	Sr. Steno
165.	Mr. Dalpat Singh	Sr. Steno
166.	Mr. Dharam Singh Negi	Sr. Steno
167.	Mrs. Nisha Tyagi	Asstt. (G) Gr. I
168.	Mrs. Sarita Khanna	Asstt. (G) Gr. I
169.	Mrs. Sheema Farhat	Asstt. (G) Gr. I
170.	Mr. R.K. Johar	Asstt. (G) Gr. I
171.	Mr. Sudhir Kumar	Asstt. (G) Gr. I
172.	Mr. Yogesh Kumar	Asstt. (G) Gr. I
173.	Mr. Shiv Kumar	Asstt. (G) Gr. I
174.	Mrs. Sunita	Asstt. (G) Gr. I
175.	Mr. Pawan Kumar	Asstt. (G) Gr. I
176.	Mrs. Mamta Sharma	Asstt. (G) Gr. I
177.	Mr. Dharam Pal Singh	Asstt. (G) Gr. I
178.	Mr. Virendra Singh	Asstt. (F&A) Gr. I
179.	Mr. Aman Kumar	Asstt. (F&A) Gr. I
180.	Mr. Vipin Kumar Sharma	Asstt. (F&A) Gr. I
181.	Mr. Suraj Pal Singh	Asstt. (F&A) Gr. I

182.	Mr. Satyarth Prakash	Asstt. (F&A) Gr. I
183.	Mrs. Rubina Zaidi	Asstt. (F&A) Gr. I
184.	Mr. Sanjeev Bansal	Asstt. (S&P) Gr. I
185.	Mrs. Anju Rani Simon	Asstt. (S&P) Gr. I
186.	Mr. Arpan Maheshwari	Asstt. (S&P) Gr. I
187.	Mr. Kalam Singh Chauhan	Asstt. (S&P) Gr. I
188.	Mr. Vishwash Tyagi	Asstt. (S&P) Gr. I

Group C

189.	Mrs. Arun Lata	Asstt. (G) Gr. II
190.	Mr. Sushil Kumar	Asstt. (G) Gr. II
191.	Mr. Sanjay Kr. Tyagi	Asstt. (G) Gr. II
192.	Mrs. Seema Ahuja	Asstt. (G) Gr. II
193.	Mr. Ravinder Kumar	Asstt. (G) Gr. II
194.	Mr. Radhey Shyam	Driver (NT)
195.	Mr. Sushil Kumar	Driver (NT)
196.	Mr. M. Ramakrishna	Driver (NT)
197.	Mr. Satya Pal	MTS
198.	Mr. Ram Samajh	MTS
199.	Mr. Raj Kumar	MTS
200.	Mr. Kailash Chand	MTS
201.	Mrs. Usha	MTS
202.	Mr. Mukesh Kumar	MTS
203.	Mrs. Kusum Lata	MTS
204.	Mrs. Bala	MTS
205.	Mr. Subhash Chand	MTS
206.	Mr. Inder Pal (ACP)	MTS
207.	Mr. Desh Raj	MTS
208.	Mr. Rakesh Kumar	MTS
209.	Mr. Ramesh Kumar	MTS
210.	Mr. Santosh Kumar	MTS

211.	Mr. Rakesh Kumar	MTS
212.	Mr. Krishna Gopal Thakur	MTS
213.	Mr. Mani Ram	MTS
214.	Mr. Rohitash Kumar	MTS
215.	Mr. Radhey Shyam	MTS
216.	Mr. Ranbeer Singh	MTS
217.	Mr. Devendra Kumar	MTS
218.	Mrs. Prakash Kaur	MTS
219.	Mrs. Anju	MTS
220.	Mr. Khalil Ahmad	MTS
221.	Mr. Subhan Singh	MTS
222.	Mr. Anit Kumar Pal	MTS
223.	Mr. Pritam Giri	MTS
224.	Mr. Pooran Vassi	MTS
225.	Mr. Kirat Pal	MTS
226.	Mr. Kiran Pal	MTS
227.	Mr. Rajesh Kr. Yadav	MTS
228.	Mr. Jai Prakash	MTS
229.	Mr. Ranjeet Singh	MTS
230.	Mr. Satya Pal	MTS
231.	Mr. Satya Pal Singh	MTS
232.	Mr. Mehraj Deen Khan	MTS
233.	Mr. Dharam Singh	MTS
234.	Mr. Sunil Kumar	MTS
235.	Mr. Rakesh	MTS
236.	Mr. Arun Kumar	MTS
237.	Mr. Ravinder Kumar	MTS
238.	Mr. Dil Bahadur	MTS
239.	Mr. Rajinder Pal	MTS
240.	Mr. Malkhan Singh	MTS
241.	Mr. Dheer Singh	MTS

Superannuation

Following Staff members superannuated from CSIR-CBRI family during the year

Mr. Sant Ram	Farrash	30.06.2015
Mr. Ashok Kumar Sharma	Principal Scientist	30.06.2015
Mr. Govind Singh	Mechanic	30.09.2015
Mr. Hemant Kumar Jain	Senior Tech. Officer	30.09.2015
Mr. Vijay Kumar	Driver	31.10.2015
Mr. Anil Kumar Jain	Tech. Officer	30.11.2015
Mr. Rajendra Singh	Driver	31.12.2015
Mr. Yakub Ali	Tech.	31.12.2015
Mr. Babu Ram	S.O(F&A)	31.01.2016
Mr. S.P. Kapil	P.S.	31.01.2016

Transfer

Mr. S.P. Singh	Store & Purchase Officer	30.10.2015(F.N.)	CSIR-CSIO, Chandigarh
Mr. Alok Sharma	Administrative Officer	20.11.2015(A.N.)	CSIR-IHBT, Palampur
Mr. Anil Kumar	Controller of Administration	27.11.2015(A.N.)	CSIR-IITR, Lucknow

Promotion

Dr. R. Dharam Raju	Senior Principal Scientist	28.09.2009
Dr. L.P. Singh	Principal Scientist	27.04.2012
Dr. Rajesh Kumar Verma	Principal Scientist	01.04.2013
Dr. S. K. Senapati	Principal Tech. Officer	12.12.2012
Mr. Rishi Pal Singh	Sr. Technician (2)	02.04.2013
Mr. Itrat Amin	Sr. Technical Officer (1)	29.05.2013
Mrs. Gayatri Devi	Sr. Technical Officer (1)	08.09.2013
Mr. Bhupal Singh	Principal Tech. Officer	01.10.2013
Mr. Jameel Hasan	Sr. Technician (1)	01.02.2014
Mr. Umesh Chandra	Sr. Technician (1)	01.02.2014

Mr. Amit Kush	Sr. Technical Officer (1)	28.02.2014
Mr. Sushil Kumar	Sr. Technician (2)	16.03.2014
Mr. Himanshu Sharma	Sr. Technician (2)	16.03.2014
Mr. Anil Kumar	Controller of Administration	31.07.2015
Mr. Alok Sharma	Administrative Officer	31.07.2015
Mr. Satya Pal	Private Secretary	16.02.2016
Mr. Constan Kujur	Section Officer (G)	16.02.2016

Obituary

Mr. Ashwani Kumar Mishra	Sr. Technician	28.09.2015
Mr. Dharam Singh	MTS	23.11.2015

Recruitment

	Mohd. Reyazur Rahman	Scientist (Area: Civil Engineering)	08.01.2016
	Ms. Ishwarya G	Scientist (Area: Civil Engineering)	08.01.2016
	Mr. Santha Kumar G.	Scientist (Area: Civil Engineering)	08.01.2016
	Mr. Rakesh Paswan	Scientist (Area: Civil Engineering)	08.01.2016
	Mr. Rajesh Kumar	Scientist (Area: Civil Engineering)	08.01.2016
	Ms. Monalisa Behera	Scientist (Area: Civil Engineering)	08.01.2016
	Mr. Chanchal Sonkar	Scientist (Area: Civil Engineering)	08.01.2016

	Ms. Surya M.	Scientist (Area: Civil Engineering)	31.03.2016
	Ms. Hina Gupta	Scientist (Area: Civil Engineering)	28.03.2016
	Ms. Sayantani Lala	Scientist (Area: Civil Engineering)	28.03.2016
	Mr. Debdutta Ghosh	Scientist (Area: Civil Engineering)	29.03.2016
	Mr. Koushik Pandit	Scientist (Area: Civil Engineering)	16.03.2016

Research Publications

Foreign Journal

1. A.A. Ansari and Rakesh Kumar, "Fire Performance of Plywood Treated with Chemical Surface Barrier", International Journal of Housing & Human Settlement Planning, Vol. 1, No. 1, 26-34, 2015, ISSN: 2455-8516 (online).
2. A. Aravind Kumar and Rajiv Kumar, "Prediction Time for Sprinkler Activation and Fire Suppression for Polyurethane Foam Fire using Computational Fluid Dynamics", Fire Engineer, 30-32, 44, July-September, 2015.
3. Ajay Chourasia, S.K. Bhattacharyya, Pradeep Bhargava and N.M. Bhandari, "Seismic Performance of Different Masonry Buildings: A Full-scale Experimental Study", International Journal of Performance of Constructed Facilities, American Society of Civil Engineers, ISSN 0887-3828, DOI 10.1061/(ASCE)CF.1943-5509.0000850.
4. Ajay Chourasia, Y. Tarannum, S.K. Bhattacharyya and J. Parashar, "Fragility Analysis for Seismic Vulnerability Assessment of Buildings: A Review", International Journal of Earthquakes & Structure, International Research Journal of Engineering & Technology, Vol. 2, No. 6, 502-508, September 2015, 3-ISSN: 2395-0056, p-ISSN: 2395-0072.
5. Ajay Chourasia and S.K. Bhattacharyya, "Confined Masonry Construction for India: Prospects & Solution for Improved Behaviour", IBC Journal, Vol. 1, September 2015, ISSN 2349-7467.
6. A. Pain, D. Choudhury and S.K. Bhattacharyya, "Seismic Uplift Capacity of Horizontal Strip Anchors using a Modified Pseudo-Dynamic Approach", International Journal of Geo Mechanics, ASCE, Vol. 16, No. 1, 2016, 04015025, DOI: 10.1061/ (ASCE) GM.1943-5622.0000471, (IF: 1.197/ 2013).
7. Ashok Kumar, P.S. Chani and Rajesh Deoliya, "Low Embodied Energy Sustainable Building Materials and Technologies", Special Volume of Key Engineering Materials, Vol. 650, 13-20, April-May 2015, © (2015) Trans Tech Publications, Switzerland, DOI:10.4028/www.scientific.net/ KEM.650.13.
8. B.M. Suman and R.K. Garg, "Energy Efficient Building through Energy Simulation using Different Insulating Materials", European Journal of Applied Engineering and Scientific Research, Vol. 4, No. 1, 7-15, 2015.
9. B.M. Suman, "Thermal Conductivity Measurement of Powder Material and its Optimum Application for Energy Efficient Cold Storage", International Journal of Applied Engineering and Technology, Vol. 5, No. 1, 78-83, 2015.
10. B. Singh, Ishwarya G., M. Gupta and S. K. Bhattacharyya, "Geopolymer Concrete: A Review of Some Recent Developments", Construction and Building Materials, 85, 78-90, 2015.
11. B. Singh, M.R. Rahman, R. Paswan and S.K. Bhattacharyya, "Effect of Activator Concentration on the Strength, ITZ and Drying Shrinkage of Fly Ash/Slag Geopolymer Concrete", Construction and Building Materials, 118, 171-179, 2016.
12. Harpal Singh, "Synergistic Effect of Phosphorus-Halogen Fire Retardant Additives on the Flammability of Polyurethane Foams", Polyurethanes, Vol. 10, No. 3, 26-29, 2015.

13. Leena Chaurasia and Vishakha Bisht, "Resistance of Bio-based Cementitious Material to Acid Attack"' International Journal of Current Research, Vol. 7, No. 11,23,112-118, November, 2015.

14. L.P. Singh, D. Ali and U. Sharma, "Studies on Optimizations of Silica Nano-Particles in Cementitious Material", Cement Concrete Composites, 70, 60-68, 2016.

15. L.P. Singh, S.K. Bhattacharyya, S.P. Shah, G. Mishra, and U. Sharma, "Studies on Early Stage Hydration of Tricalcium Silicate incorporating Silica Nano-Particles: Part II", Construction & Building Materials, 943-949, 102 2016.

16. L.P. Singh, S.K. Bhattacharyya, A. Goel, U. Sharma and G. Mishra, "Hydration Studies of Cementitious Material using silica Nano-Particles", Journal of Advanced Concrete Technology, Vol. 13, 345-354, 2015.

17. L.P. Singh, S.K. Bhattacharyya, A. Goel, and G. Mishra, "Quantification of Hydration Products in Cementitious Material incorporating Silica Nano-Particles", Frontiers of Structural and Civil Engineering, 1-6, 2015.

18. L.P. Singh, S.K. Bhattacharyya, S.P. Shah, G. Mishra, S. Ahalawat and U. Sharma, "Studies on Early Stage Hydration of Tricalcium Silicate incorporating Silica Nano-Particles", Construction & Building Materials, Vol. 74, 278–286, 2015.

19. M.K. Dwivedi, Neeraj Jain, Pragati Sharma and Chanchal Alawa, "Adsorption of Safranin from Waste Water using Coal Fly Ash", IOSR Journal of Applied Chemistry, Vol. 8, No. 4, 27-55, April 2015.

20. M. Mittal, "Model for Prediction of Explosion Pressures of Organic Dust Clouds in Industrial Units", International Journal of Advanced Engineering Technology, Vol. 6, No. 2, 19-28, April-June, 2015.

21. Neeraj Jain and Mridul Garg, "Formulation of Sulphate Resistant Super Sulphated Cement Using Fluorogypsum and Granulated Blast Furnace Slag", IOSR Journal of Mechanical and Civil Engineering, Vol. 12, No. 3, 153-159, May 2015.

22. Neeraj Jain, M.K. Dwivedi, Rashmi Agarwal and Pragati Sharma, "Removal of Malachite Green from Aqueous Solution by Zeolite-Iron Oxide Magnetic Nano-Composite", IOSR Journal of Environmental Science, Toxicology and Food Technology, Vol. 9, No. 6, 42-50, Jun 2015.

23. R.K. Verma and A. Chourasia, "Protection of Bio-Deteriorated Reinforced Concrete using Concrete Sealers", International Journal of Materials Chemistry and Physics, USA, Vol. 1, No. 1, 11-19, August 2015.

24. R.K. Verma, L. Chaurasia, V. Bisht and M. Thakur, "Bio-Mineralization and Bacterial Carbonate Precipitation in Mortar and Concrete", Bioscience and Bioengineering, USA, Vol. 1, No. 1, 5-11, April 2015.

25. S.R. Karade, "Potential of Cork Cement Composite as a Thermal Insulation Material", Key Engineering Materials, Theme: Materials and Construction Technologies for Sustainable Development, Vol. 666, 17-29, November 2015.

26. Vivek Sood, B.M. Suman and Ashok Kumar, "Effect of Plasters/Coatings on the Thermo-Physical Behaviour of Light Weight Pond Ash Blocks Based on Non Autoclaving", Special Topic Volume Invited Peer Reviewed Papers on Materials and Technologies in Construction with Reference to Energy Efficiency and Sustainable Development, Trans Tech Publications, Switzerland, December, 2015.

National Journal

1. Ashok Kumar, Rajesh Deoliya and P.S. Chani, "Evaluation on Thermal Behaviour of a Green Roof Retrofit System Installed on Experimental Building in Composite Climate of Roorkee, India", Refereed Journal of the Institution of Engineers (India): Series A, Vol. 96, 277-284, December 2015.
2. Ashok Kumar and Vijay Raj Deopa, "Concept of Public Spaces for All in Sustainable and Smart Cities", Special Issue, Nirman Sarika, BMTPC, New Delhi, Vol. 4, No. 3, 8-11, October 2015.
3. Achal Mittal, M.M. Dalbehera, S.K. Bhattacharyya, Bharat Bhusan and Sachin Kumar," Performance of High Strength Reinforced Concrete Beams under Multiple Impact Loading: Experimental Study", Indian Concrete Journal, 2016.
4. B.S. Rawat, J. Ballabh and Rahul Kumar, **"**Imidacloprid 200 SL: An Odorless Termiticide for Buildings", Pestology, Vol. 39, No. 3, 10-14, 2015.
5. M.Mittal, "Particle Size Moderation for Reducing Dust Explosions in Process Industries", Chemical Products Finder, Vol. 33, No. 12, 15-18, May 2015.
6. M. Mittal, "Domains of Flammability and Thermal Ignitability of Organic Dust-Polyethylene", Chemical Industry Digest, Vol. 28, No. 8, 67-73, 2015.
7. M. Mittal, "Flammability and Thermal Ignitability Diagram for Lycopodium Dust", Chemical Engineering World, Vol. 50, No. 9, 40-48, 2015.
8. M. Mittal, "Electrostatic Explosion Hazard for Ignition Sensitive Dusts", Chemical Products Finder, Vol. 34, No. 5, 40-43, Oct 2015.
9. S.K. Bhattacharyya and Atul Kumar Aggarwal, "CSIR-CBRI- Central Building Research Institute, Roorkee", Current Science, Vol. 108, No. 8, 1444-1453, April 25, 2015.

Papers in Conference/Seminar/Workshop

1. ,- xk;y ,o ,l- vkj- djkM] l/kkj.kh; ¼lLVucy½ dØhV cuku e leæh ty dh mi;kfxrk] lkj lxg] jk'Vh; oKkfud lxk'Bh] vkokl&çk—frd vkink ,o tyok; ifjoru dh pukfr;k] lh,lvkbvkj&dUæh; Hkou vul U/kku lLFkku] :Mdh] Hkkjr] fnlEcj 10&11] 2015A
2. A.K. Mittal, M.M. Dalbehera, C. Sonkar, S. Behera, I.A. Siddiqui, "Prefabrication in Building Construction-Trends & Future Outlook", National Seminar on Pre-Emerging Building Structures in MES, March 2, 2016, MES, Bareilly, Ministry of Defence, Government of India.
3. A. Pain, Deepankar Choudhury and S.K. Bhattacharyya, "Computation of Sliding Displacements of Gravity Retaining Walls by Modified Pseudo-Dynamic Method", In the Proceeding of 50th Indian Geotechnical Conference, College of Engineering, Pune, India, 2015, Paper ID – 567.
4. Ashok Kumar, P.S. Chani, Rajesh Deoliya and E. Rajasekar, "Quantification of Different Parameters for Energy Efficiency in Buildings", Proceedings of the National Seminar RENCON 2016, Institution of Engineers (India), Roorkee, February 12-13, 2016, 97-107.
5. cky edUn leu] çk—frd vkink d rjr ckn m'ekjk/kh iofufer Lyc l cu Hkouk dh mi;kfxrk] lkj lxg] jk'Vh; oKkfud lxk'Bh] vkokl&çk—frd vkink ,o tyok; ifjoru dh pukfr;k] lh,lvkbvkj&dUæh; Hkou vul U/kku lLFkku] :Mdh] Hkkjr] fnlEcj 10&11] 2015A
6. ch-,l- jkor] Hkfo'; d vkokl k enhed fu;=.k gr cfVx fl LVe ,d lokUke fodYi] lkj lxg] jk'Vh; oKkfud lxk'Bh] vkokl&çk—frd vkink ,o tyok; ifjoru dh pukfr;k] lh,lvkbvkj&dUæh; Hkou vul U/kku lLFkku] :Mdh] Hkkjr] fnlEcj 10&11] 2015A
7. B. Singh, Humaira Athar and S.K. Bhattacharyya, "Translucent Concrete: An Emerging Green Building Material", International Seminar on Emerging Building Materials and Construction Technologies, March 21-22, 2016, New Delhi.

8. B. Singh, Humaira Athar and S.K. Bhattacharyya, "Characterization of Plastic Optical Fibers and their Use in Translucent Concrete Panels Manufacturing", International Conference on Advanced Materials and Process Engineering, December 14-15, 2015, Karachi, Pakistan.

9. Harish Chandra Arora, Umesh Kumar Sharma, Anupam Chakraborti and B.K. Rao, "Experimental Investigations on Complementary Benefits of FRP for Corrosion Prevention in Concrete Structural Elements", ICI Acecon 2015, International Conference on Advancement in Structural Concrete, October 8-10, 2015, Kolkata India.

10. gjh"k pUæ vjkjk] me"k dekj "kek ,o vuie pØcrh] bektnk ljpukvk dh c<h Hkkj ogu {kerk dh ekx o ,Q vkj ih rduhdß] lkj lxg] jk'Vh; oKkfud lxk'Bh] vkokl&çk—frd vkink ,o tyok; ifjoru dh pukfr;k] lh,lvkbvkj&dUæh; Hkou vul U/kku lLFkku] :Mdh] Hkkjr] fnlEcj 10&11] 2015A

11. gjiky flg ,o l"khy dekj] ^^vfXu vojks/kh rFkk Åtk d"ky ikY;jFku Qke] lkj lxg] jk'Vh; oKkfud lxk'Bh] vkokl& çk—frd vkink ,o tyok; ifjoru dh pukfr;k] lh ,l vkb vkj & dUæh; Hkou vul U/kku lLFkku] :Mdh] Hkkjr] fnlEcj 10&11] 2015A

12. Harpal Singh, "Fire Retardant and Thermally Insulative Rigid Polyurethane Foam: A Versatile Building Material", International Seminar on Emerging Building Materials and Construction Technologies, March 21-22, 2016, Building Materials and Technology Promotion Council (BMTPC), Ministry of Housing and Urban Poverty Alleviation, Govt. of India, Stein Auditorium, India Habitat Centre, Lodhi Road, New Delhi.

13. L.P. Singh, A. Goel, S.K. Bhattacharyya and G. Mishra, "Improving the Durability of Cementitious Materials using Silica Nano-Particles", 5th International Symposium on Nanotechnology in Construction, May 24-26, 2015, Chicago, USA.

14. L.P. Singh, S.K. Bhattacharyya, S.P. Shah and U. Sharma, "Studies on Hydration of Tricalcium Silicate incorporating Silica Nano-Particles", 5th International Symposium on Nanotechnology in Construction, May 24-26, 2015, Chicago, USA.

15. L.P. Singh, D. Ali and U. Sharma, "Performance Enhancement in Cementitious Materials using Nanotechnology", International Seminar on Emerging Building Materials and Construction Technologies, March 21-22, 2016, BMTPC-New Delhi.

16. L.P. Singh, D. Ali and U. Sharma, "Studies on Early Hydration of Tricalcium Silicate", Advanced Materials for Energy, Environment and Health, ICAM-2016, March 4-7, 2016, IIT Roorkee.

17. ih-d- ;kno] oh- luh ,o ch-,e-leu] HkeMyh; rkiØe of) d dkj.k ,o mld jkdFkke d mik;] lkj lxg] jk'Vh; oKkfud lxk'Bh] vkokl&çk—frd vkink ,o tyok; ifjoru dh pukfr;k] lh,lvkbvkj&dUæh; Hkou vul U/kku lLFkku] :Mdh] Hkkjr] fnlEcj 10&11] 2015A

18. ih- lh- Fkify;ky vkj vkdk{kk iMh] Hkouk d lj{k.k e inkFk foKku dk ;kxnku] lkj lxg] jk'Vh; oKkfud lxk'Bh] vkokl&çk—frd vkink ,o tyok; ifjoru dh pukfr;k] lh,lvkbvkj&dUæh; Hkou vul U/kku lLFkku] :Mdh] Hkkjr] fnlEcj 10&11] 2015A

19. P.C. Thapliyal, P. Tyagi, D. Mehrotra and S. Choudhury, "Aerogel - A Wonder Thermal Insulating Solid", 9th National Conference on Solid State Chemistry and Allied Areas, May 13-15, 2015, Delhi University.

20. P.C. Thapliyal, "Developing Multifunctional Protective Coatings for Sustainable Built Environment", Proceedings of National Conference on Green Chemistry and Sustainable Technologies for Society, NCGCSTS-2016, 11-12 January, 2016, Department of Chemistry, Govt. Women Engineering College, Ajmer, IL5, 4.

21. P.C. Thapliyal, Vibhrant and Aakansha Pundir, "Recycling of Precious Metals from E-Waste", Proceedings of National Conference on Green Chemistry and Sustainable Technologies for Society,

NCGCSTS-2016, January 11-12, 2016, Department of Chemistry, Government Women Engineering College, Ajmer, 7-8.

22. P. C. Thapliyal, Vibhrant and Aakansha Pundir, "Green Building Materials from Industrial Wastes- A Sustainable Approach", Proceedings of National Conference on Green Chemistry and Sustainable Technologies for Society, NCGCSTS-2016, January 11-12, 2016, Department of Chemistry, Government Women Engineering College, Ajmer, 61-63.

23. P.C. Thapliyal, S.R. Karade and Aakansha Pundir, "Improvement of Energy Efficiency of Modified Acrylic Coatings by Nano-Additives", National Conference on Advanced Materials and Applications, NCAMA-2016, March 4-5, 2016, Department of Physics, Fergusson College, Pune, 9.

24. Rajni Lakhani and Rajesh Kumar, "Effective Utilization of Limestone Slurry Waste as Partial Replacement of Sand for Non-structural Cellular Foamed Concrete Blocks", International Conference on Sustainable Structural Concrete, September 15-18, 2015, La Plata Argentina.

25. Rajni Lakhani and Rajesh Kumar, "Potential use of Kota Stone Waste in the Production of Value Added Products", International Seminar on Emerging Building Materials and Construction Technologies, March 21-22, 2016, BMTPC, New Delhi, India.

26. R.S. Chimote, "Impact of HFC Fire Extinguishing Clean Agents on Climate Change and its System Design Requirements for Fire Hazards in India- A Brief Study", International Conference on Water, Environment, Energy & Society , jointly organized by the Texas A&M University, Texas, USA and AISECT University, Bhopal, India, March 15-18, 2016 in Bhopal in association with ICE WaRM, Australia, Environment Management & Human Welfare Council, Water and Land Management Institute, MANIT Bhopal, M.P. Council of Science & Technology, International Institute of Solid Waste Management, CIPET, IISS, WALMI, Institute of Disaster Management, University of Western Sydney, etc.

27. Soju J. Alexander, Ravindra S. Bisht, Jogender Kumar and Rahul Sharma, "Path Planning of Autonomous Wheeled Mobile Robot for Efficient Coverage within a Specified Area," 10th Uttarakhand State Science and Technology Congress, February 10-12, 2016, Dehradun.

28. ,l- vkj- djkM] ^^tyok; ifjoru dk /kkr l{kkj.k ij çHkko**] lkj lxg] jk'Vh; oKkfud lxk'Bh] vkokl&çk–frd vkink ,o tyok; ifjoru dh pukfr;k] lh,lvkbvkj&dUæ; Hkou vul U/kku lLFkku] :Mdh] Hkkjr] fnlEcj 10&11] 2015A

29. S. Naik, L.P. Singh and S. Sinha, "Studies on Encapsulated Phase Change Materials for Energy Efficiency in Buildings", Advanced Materials for Energy, Environment and Health, ICAM-2016, March 4-7, 2016, IIT Roorkee.

30. S. Naik, L.P Singh and S. Sinha, "Encapsulation of Phase Change Material by Insitu-Polymerization", CHEMCON- 2015, December 27-29, 2015, IIT Guwahati.

31. S. Naik, L.P. Singh and S. Sinha, "Micro-Encapsulation of Phase Change Materials for Energy Efficient Buildings", 10th USSTC, February 13-16, 2016, Dehradun.

32. S. Sarkar, A. Pain and D.P. Kanungo, "Hill Slope Stability based on Generalized Hoek-Brown Criterion–A Case Study from Sikkim Himalaya", International Conference on Engineering Geology in New Millennium, IIT Delhi, India, 2015, 1274-1281.

33. V. Bisht, L. Chaurasia and L.P. Singh, "Performance Evaluation of Bio-Based Cementitious System under Aggressive Acid Environment", Advanced Materials for Energy, Environment and Health, ICAM-2016, March 4-7, 2016, IIT Roorkee.

In Magazine

1. B.M. Suman , “A Case Study on Application of Exterior Insulation Finishing System and Heat Reflective Coating for Energy Efficient Building”, New Building Materials & Construction World, NBM&CW, Vol. 20, No. 11, 150- 156, May 2015.
2. B.M. Suman, “Impact of Admixture on Heat Gain through Mixed Concrete Roof into a Building”, New Building Materials & Construction World, NBM&CW, Vol. 21, No. 4, 210- 222, October 2015.
3. gjh”k pUæ vjkjk] me”k dekj ”kekZ] vuie pØcrh ,o jkgy dekj] Þ,Qvkjh pknjk vkj lyVk }kjk dØhV ljpukvk dh ”kfä e of)ß] ^eFku** okf”kZd if=dk] vd 13] vkb-vkb-Vh- #Mdh] flrEcj 2015A

Book Chapters

1. Harpal Singh, “Rigid Polyurethane Foam: Versatile Energy Efficient Material”, in Materials and Technologies in Construction with Reference to Energy Efficiency and Sustainable Development, Trans Tech Publications Ltd, Churerstr.20, 8808, Pfaffikon, Switzerland, ISBN-13: 978-3-03835-658-5, Vol. 666, 88-98, October 2015.

Lectures, Workshops, Seminars, Visits, Meetings, Facilities Created, Honours and Awards

1. Lecture Delivered:

- Dr. Harpal Singh, Scientist, delivered an Invited Lecture on "Fire Retardant Materials" in the workshop on "Innovative Construction Machinery, Materials & Methods", (ICMMM-2015), at Civil Engineering Department, Indian Institute of Technology, Roorkee during October 26-27, 2015.

- Dr. (Mrs.) Rajni Lakhani, Scientist, delivered lecture on "Value Added Products from Kota Stone Waste" in the workshop on "Innovative Construction, Machine, Materials & Methods", (ICMMM-2015) at IIT, Roorkee during October 26-27, 2015. She also delivered lecture on "Value Added Products from Kota Stone Waste" in a workshop on "Gainful Utilization of Kota Stone Slurry Waste" organized by CDOS Jaipur and Kota Stone Small Scale Industries Association at Ramganj Mandi Kota on July 14, 2015.

- Mr. Ashok Kumar, Scientist delivered lectures on:
  - "Architectural Design & Planning for Affordable Housing", on October 14, 2015 to participants of the course on Affordable housing organized by CSIR-CBRI, Roorkee.
  - "Public Spaces for All", World Habitat Day, organized by The Institution of Engineers, Meerut Centre, Meerut, (U.P.), on October 5, 2015.
  - "Affordable Housing & Low Cost Design Technology", ARCHOTSAV – 2015, "Celebrating Architecture", Sunderdeep Group of Colleges, Ghaziabad on November 1, 2015.
  - "Green Building Retrofits, Use of Glass in Buildings & Sustainable Materials & Technologies, School of Planning and Architecture (SPA), New Delhi, on February 15, 2016.
  - "Planning & Architectural Design Considerations in Earthquake Resistant Buildings", during the Training Course on Design of Disaster Resistant Housing & Risk Mitigation organized by CSIR-CBRI, Roorkee on February 24, 2016.
  - "Vernacular Architecture, Traditional & Innovative Building Materials, Built Forms, and Technologies", Department of Architecture & Planning, IIT, Roorkee on August 7, 2015.

- Dr. Ajay Chourasia, Scientist delivered lectures on:
  - "Seismic Retrofitting of Secretariat Building, Chandigarh"; at the meeting of Chandigarh Heritage Conservation Committee, on April 27, 2015 at Chandigarh.
  - "Masonry Buildings: Types of Failures & Codal Recommendations" & "Design, Construction of Confined Masonry Buildings" at the Training Workshop on Earthquake Resistant Buildings in Bihar, organized by Bihar State Disaster Management Authority during May 27-31, 2015.
  - "Repair, Rehabilitation & Maintenance of Buildings", in a seminar organized by BEG & Centre, Roorkee on April 25, 2015.

2. Honors & Awards:

- Mr. Ashok Kumar, Scientist
  - Received cash Award of Rs. 10,000/ (Professional Category) for the paper presented on "Quantification of Different Parameters for Energy Efficiency in Buildings", in the National seminar RENCON 2016, held at Institution of Engineers (India), Roorkee, on February 11, 2016.
  - Nominated by International Institute for Management Development (IMD), Lausanne, Switzerland as Member of the Reputed Panel of Experts from India for the IMD World Competitiveness Year book 2016- Executive Opinion Survey.
  - Acted as Jury Member for the National Design Competition for the students of Architecture and Engineering on theme, "Affordable Housing and Low Cost Design Technology", during ARCHOTSAV – 2015, November 1, 2015.
  - Acted as Reviewer for International Journals Springer and Elsevier.
  - Nominated Member of the Working Group to develop, revise and recommend a Section on 'Glazing Systems' for inclusion in NBC 2015.
- Mr. Ajay Chourasia, Scientist was awarded Ph.D. on the topic "Performance Evaluation of Confined Masonry Buildings under Cyclic Lateral Loads" by IIT Roorkee, after successful defense of viva-voce examination held on May 30, 2015.
- Ms. Priyanka Tomar has been awarded Women Scientist Fellowship under WOS-B scheme of DST, New Delhi for her project submitted under the supervision of Dr. (Mrs.) Rajni Lakhani.

3. Participation in Workshop/Seminar:

- Mr. Ravindra Singh Bisht, Scientist participated in a Seminar on Sizing & Selection of a DC motor by Dr. UrsKafader from Maxon Motor Switzerland at LeMeridien Windsor Place, Janpath, New Delhi on June 30, 2015. He also participated in a QIP workshop on Experiments for Robotics Class held at IIT Roorkee on February13, 2016.

4. Visits Abroad

- Dr. Ajay Chourasia, at the behest of National Disaster Management Authority (NDMA), visited Nepal during May 9-14, 2015, as a part of Expert Member of Indian Team. The objective was to render guidance to the stakeholders in Nepal to facilitate rapid assessment of damages to buildings in Nepal due to earthquake. During the visits, One-day orientation program was organized to train 250 Nepal Engineers for Rapid Damage Assessment. Also post-earthquake damage survey was conducted. A detailed report on Twin-Nepal Earthquake, along with retrofitting of India House (Residence of Indian Ambassador) was submitted to NDMA.

5. Meetings Attended/Organized

- Dr. Ajay Chourasia, Scientist attended:
  - Chandigarh Heritage Conservation Committee meeting, on April 27, 2015 at Chandigarh.
  - A meeting on Safety Audit & Resilience Assessment of the Lifeline & Critical Buildings; NDMA, New Delhi, on June 10, 2015.

- A meeting on Prefabricated Building Component Manufacturing & Prefab Housing, DDA, New Delhi, June 22-23, 2015.

- Dr. S. Sarkar & Dr. Ajay Chourasia, Scientists attended a meeting on Construction of Greenfield Airport at Pakyong (Gangtok). Review meeting by NITI Aayog and Ministry of Civil Aviation, New Delhi, on April 14, 2015 at Pakyong.

6. Major Facilities Developed:

- **New facility added for Water-Mist fire Extinguishers characterization:**

  A new facility for water-mist fire extinguishers characterization of different sizes, has been created as per IS:15683-2006 on Class B flammable liquid fires, such as:

  - Class 5B fires
  - Class 8B fires
  - Class 13B fires
  - Class 21B fires
  - Class 34B fires

A New Facility for Water-Mist Fire Extinguishers Characterization of Different Sizes as per IS : 15683-2006 on Class B Flammable Liquid

Date Line

S. No.	Date	Salient Details
1.	May 11, 2015	National Technology Day
2.	June 5, 2015	World Environment Day
3.	July 30, 2015	Industrial Meet
4.	August 15, 2015	Independence Day
5.	August 20, 2015	Sadbhavna Diwas
6.	August 23, 2015	Visit of Hon'ble Minister of Science & Technology at CSIR-CBRI
7.	September 14, 2015	Hindi Diwas
8.	September 26, 2015	CSIR Foundation Day
9.	October 14-16, 2015	Training Programme
10.	October 26-31, 2015	Vigilance Awareness Week
11.	November 5, 2015	Press Meet- Jan Samvad
12	November 5, 2015	Diwali Mela
13.	November 26, 2015	Constitution Day
14.	November 30, 2015	MoU Signed
15.	December 10-11,2015	National Science Symposium
16.	January 25, 2016	Press Meet- Jan Samvad
17.	January 26, 2016	Republic Day
18.	February 10, 2016	CSIR- CBRI Foundation Day
19.	February 11, 2016	Industrial Meet
20	February 11, 2016	Workshop-cum-Demonstration Programme
21.	February 24-26, 2016	Training Programme
22.	March 8, 2016	International Women Day
23.	March 9,2016	Annual Flower and Vegetables Show