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**Realty Review 2020: India’s Resilient Realty**

**Precast: Precast Construction to the Rescue**

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**Concrete: HPC & Geopolymer**

Dr. L. R. Manjunatha

Shivram B Bagade

Dr. R V Ranganath
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Infrastructure Development

Govt. revamps VGF scheme for infrastructure sector
To encourage investment in economic and social infrastructure projects, CCEA has approved the revamping of the viability gap funding (VGF) scheme envisaging an outlay of ₹8,100 crore. The scheme is meant for financial support to public-private partnerships (PPPs) in infra sector till 2024-25.

AP launches ₹459-cr high-level canal network
Andhra Pradesh CM has laid the foundations to build the second phase of Somasila high-level canal involving an investment of ₹459 crore. The government has set a three-year deadline to complete the second phase which is expected to provide irrigation water to about 50,000 acres and drinking water for 2.5 lakh people in Atmakur and Udayagiri areas.

Govt. infuses liquidity in infrastructure segment
The Government has provided another push to the infrastructure sector by infusing liquidity in companies and lenders. It has relaxed earnest money deposit (EMD) and performance security on government and public sector tenders. It will also put in ₹6,000 crore as equity in the NIIF, which will be used to create a debt platform for infrastructure financing and the platform will help NIIF provide a debt of ₹1.1 trillion for infrastructure projects by 2025.

Cabinet clears ₹10,211-cr under DRIP project
The cabinet committee on economic affairs (CCEA) has approved a ₹10,211-cr project to improve the safety and performance of select dams in India. The dam rehabilitation and improvement project (DRIP)—phase II and phase III is financially supported by the World Bank and Asian Infrastructure Investment Bank.

AP invites bids for ₹1,769-cr water infra project
The Irrigation & CAD Department in Andhra Pradesh has floated tender for water infra project including the construction of Joladarasi water reservoir with 0.8 TMC across Kundu River at Joladarasi (V), Koilkuntal (M) in Kurnool district involving an investment of ₹1,769.16 crore.

Private players win coal blocks in mining auction
Real estate, infrastructure and pharmaceutical companies are among the winners of India’s first coal mine auctions open to the private sector without restrictions on end-use. Coal Minister, Pralhad Joshi informed that coal production in India has largely been restricted to state-run Coal India Ltd and another smaller government-controlled company, but the PM has opened up the industry to the private sector this year.

Odisha approves ₹464-cr industrial infra projects
Odisha has approved four industrial projects of ₹464.72 crore for which Chief Secretary Asit Tripathy gave in-principle approval for projects in the metal and metal downstream and food processing sectors. The projects, among others, included a medium density fibreboard (MDF) manufacturing facility with an annual capacity of 72,000 cubic metres being set up by Galax Industries by investing ₹93 crore and also a proposal of Envirocare Infrasolution Private Limited’s new unit at Lathikata in Sundergarh to set up a pellet plant of 1.6 MTPA at an investment of ₹120 crore.

Authorities expedite Sonbhadra airport project in UP
Air connectivity in UP has received a big boost with the Centre and the state government joining hands to expedite construction of an airport in Sonbhadra under the regional connectivity scheme (RCS). The plan to develop Myorpur (Sonbhadra) airport came after the Union ministry of environment gave in-principle approval to the conversion of land use of over 0.6 hectare of forest land for construction of a terminal building near Myorpur. The terminal is proposed to be built close to the existing airstrip which is 1.4 metre long and 25 metre wide and is currently used for small aircraft.

Virgin Hyperloop- BIAL inks airport corridor pact
Virgin Hyperloop and Bangalore International Airport Ltd (BIAL), the operator of the Kempegowda International Airport, Bengaluru signed a first-of-its-kind MoU to conduct a feasibility study for a proposed hyperloop corridor from BLR Airport to the city centre. The pre-feasibility study, which focuses on technical, economic and route feasibility, is expected to be completed in 2 phases of six months each. With speeds of up to 1,080kph, hyperloop could transport thousands of passengers per hour from BLR Airport to the city centre in less than 10 minutes.
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MoRTH issues safety-related notification for CE industry

The Ministry of Road Transport and Highways has issued a notification GSR 673 (E) dated 27 October 2020 for the Construction Equipments Vehicles (CEVs) to address the issue of safety requirements, safety of the operator and to ensure safety while such machines are running on public roads along with other vehicles in a phased manner. Certain safety requirements are already mandated for CEVs in CMVR, 1989. This standard aims to introduce AIS (Automotive Industry Standard) 160, to introduce several safety requirements like Visual Display Requirements, requirements for Operator Station and Maintenance Areas, Non-metallic Fuel Tanks, Minimum Access Dimensions, Access Systems for steps, primary access, alternate exit path and opening, maintenance opening, handrail and handholds, Guards, Visual Display Requirements, Machine mounted audible travel alarms, Articulated Frame Lock, Lift Arm Support Device, Dimensions and requirements for Operator’s Seat, Electro Magnetic Compatibility (EMC), Seat Belt and Seat belt anchorages, Rollover Protective Structure (ROPS), Tip-over protection structure (TOPS), Falling Object Protective Structure (FOPS), Operator Field on View and Operator Seat Vibrations for suspended seats, among others. Additionally, requirements concerning the pass-by noise and noise measured at operator ear level were proposed, by amending CMVR 96-A and 98-A for brakes and steering effort and turning circle diameter respectively.

Road project worth ₹805-cr up for grab

The National Highways Authority of India (NHAI) has floated tender for construction of the four-lane Nagpur-Katol section of the national highway, involving an investment of ₹805.29 crore. The project is a part of NH-353 starting from 13.000 km to 62.900 km (design chainage) in the Nagpur area of Maharashtra.

Dilip Buildcon inks ₹1,905-cr road project pact

Dilip Buildcon, through its arm Narenpur Purnea Highways Limited, has signed the Concession Agreement with NHAI for the execution of a highway project costing ₹1,905 crore. The scope of work includes the construction and upgradation of NH 131A from Km 34.600 near Narenpur to Km 79.970 near Purnea to four-lane standard in Bihar on Hybrid Annuity model.

World Bank approves $120-mn loan for road upgrades

The World Bank has approved loan worth $120 million to improve road connectivity in Meghalaya where state’s Integrated Transport Project (MITP) project will upgrade 300-km of state highways, including major district and urban roads. The MITP project includes the construction of three major bridges and missing links in strategic corridors connecting the under-served communities to the mainstream.

Govt. mulls easier norms for HAM model

To make the hybrid annuity model (HAM) model more attractive for the concessionaire, the government has planned to make upfront payment supporting the project concessionaire under the model in 10 tranches against 5, subject to the overall ceiling of 40% of the project cost. The frequenting of the installments comes in the backdrop of a declining share of the HAM model in the overall highway project awards by the NHAI falling from peak of 55% in 2016-17 to just 28% in 2019-20.

MoRTH floats tender for ₹611-cr highway

The Ministry of Road Transport & Highways (MoRTH) has floated tender for road upgradation of the existing stretch to four-lane with paved shoulder from 108.60 km to 144.00 km and 158.42 km to 173.30 km of NH-58 (old NH-8) (Beawar-Gomti section) in Rajasthan (Package-2) on EPC model, involving a cost of ₹281.73 crore. This part of the work will entail an investment of ₹329.33 crore. Both the projects will be completed in 24 months with a combined investment of ₹611.06 crore.

NHAI invites bids for ₹931-cr national highway

NHAI has floated tender for phase III of the Chennai-Bengaluru national highway project, under the Bharatmala Scheme, involving an investment of ₹931 crore. For the 24 km long four-lane highway stretch, which will connect Walajapet with Gudipala in Andhra Pradesh. Bids are to be submitted online.

Tripura gets ₹2,752-cr road projects in NE

The Union transport minister has laid the foundation stones of nine NH projects in Tripura covering a distance of 262 km with an investment of ₹2,752 crore. The construction of these highways will provide faster and hassle-free inter-state as well as international road connectivity to the neighbouring countries including Bangladesh. The projects will offer better connectivity, fast and safe traffic movement to various tourist, religious and historical places in the entire state.
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**MoRTH approves ₹3,800-cr Kalvakurthi-Karivena NH project**

The Union transport ministry has approved the construction of a 122 km national highway from Kalvakurthi in Telangana to Karivena in Andhra Pradesh under the Bharatmala scheme. The new national highway, which will reduce the distance from Hyderabad to Tirupati by 80 km, will connect Kalvakurthi, Nagar Kurnool, Kollapur, Atmakuru and Nandyal. Construction of Somashila Siddeshwaram Bridge is also a part of the project. The central government will spend ₹800 crore on the road crisscrossing both Telangana and Andhra Pradesh and both the projects will involve a combined investment of ₹3,800 crore.

**Dilip Buildcon turns L-1 bidder for ₹1,000-cr e-way**

Dilip Buildcon, with its joint venture Altis Holding Corporation, has emerged as the lowest bidder for the eight-lane access-controlled Delhi-Vadodara expressway in Rajasthan. It is to be built under the Bharatmala Parivarjna on EPC model with a completion period of 30 months.

**NHAI begins ground work for e-way in Faridabad**

NHAI has started ground work on the Faridabad-Sohna bypass road, an extension of the Delhi-Mumbai expressway to DND Flyway in Delhi. In Faridabad, the work has started near Chandawali Bridge and Sector 37, which is near the proposed interchange without disturbing the traffic. A third spot has been identified at Kaili Mod in Ballabhgarh.

**Sinnar-Shirdi road widening off to a flying start**

People travelling on the Sinnar-Shirdi highway to visit the holy Shirdi temple can expect a smoother ride as the NHAI has started widening the Sinnar-Shirdi section of the highway on HAM model. Director, NHAI Nashik, Dileep Patil informed that work on the 51-km long highway has been taken up on a fast-track basis and will take two years for completion.

**Metro & Rail**

**L&T secures yet another 87-km bullet train contract**

After securing the C4 Package of the Mumbai-Ahmedabad High Speed Rail (MAHSR) from the National High-Speed Rail Corporation Limited (NHSRCL), the biggest EPC contract for the construction of the 237.1 km stretch awarded in the country to date, the construction arm of Larsen and Toubro, has bagged yet another mega contract - the construction of 87.569 km stretch of the same project, popularly known as the bullet train. The C6 package includes construction of viaducts, one station, major river bridges, maintenance depots, and other auxiliary works.

**CMRL launches ₹61,843-cr Phase-II of metro project**

Union Home Minister has laid the foundation stone for the Phase II of the Chennai Metro Rail project with a length of 118.9-km and involving an investment of ₹61,843 crore. CMRL has issued the first Letter of Award to a firm for the construction of a sub-station at Villivakkam, days ahead of the event. The minister launched the project via Video conference from a hall in Anna Salai.

**DMRC unveils ₹2,000-cr Metro Neo corridor**

The Delhi Metro Rail Corporation (DMRC) has decided to build a Metro Neo corridor between Kirti Nagar and Bantwal near Dwarka involving an estimated investment of ₹2,000 crore. Metro Neo is a rail-guided urban transport system with rubber-tyred electric coaches and is powered by an overhead traction system running on elevated or at-grade sections. The light transit system costs about 20-25% of a Metro and also has lower maintenance cost.

**Centre plans standard specifications for tier 2 & 3 cities**

The Centre is planning to approve national standard specifications for Metro-Neo project – a no-frills, low-cost urban rail transit system – for tier 2 and tier 3 cities. Dr Brijesh Dixit, MD, Maharashtra Metro said that Metro-Neo is a mass rapid transit system providing low-cost, energy-efficient and eco-friendly urban transport solution to cities. Drawing traction power from overhead wires Metro Neo will not run on track but on road.

**Ashoka Buildcon secures financial closure for ₹1,000-cr road project**

The wholly-owned subsidiary of Ashoka Buildcon, Ashoka Kandi Ramsanpalle Road, has achieved financial closure of a road project involving an investment of ₹1,000 crore in Telangana. The project involves four laning of NH-161 from Kandi to Ramsanpalle under the Bharatmala Parivarjna on Hybrid Annuity Model (HAM).

**Project worth ₹798-cr up for grab in Maharashtra**

NHAI has floated tender for four-laning of Mohol-Alandi section of national highway involving an investment of ₹798.43 crore on EPC model. The project includes the construction of existing two-lane stretch into a four-lane national highway, starting from Dharmapuri at 117.000 km to Lonand at 166.400 km (Package-IV) on Mohol-Alandi section (design length - 49.400 km) of NH-965 on EPC model with a completion period of 24 months.
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Centre clears ₹12,396-cr ring rail network in Bangalore

The Union government has cleared the 148-km long suburban rail project for Bengaluru connecting towns across seven directions at a cost of ₹12,396 crore. The towns included Mysore, Mandya, Tumkur, Hosur, Bangarapet, Kolar, Doddaballapur and Chikkaballapur and the ones fall between these townships and Bangalore city. The Suburban Rail project is a joint venture between the Centre and State Government with each contributing ₹2,479 crore and the State borrowing another ₹7438 crore from other sources.

NDB injects $500-mn booster in RRTS corridor

The New Development Bank (NDB) has fired a $500 million funding booster amounting to about ₹3,700 crore in the Delhi-Ghaziabad-Meerut RRTS Corridor. The funds are meant to be invested to finance rolling stock, signaling system and operational structures, among others.

CMRL invites bids for building underground stations

Chennai Metro Rail has invited bids to build 29 underground stations of Chennai’s new 45.81 km Line-3 which will connect Madhavaram and SIPCOT in the 118.9 km Chennai Metro Phase 2 project. These stations are on 26.7 km long underground section between Madhavaram Milk Colony and Taramani Road Junction and will be built through 5 civil packages.

UPMRC starting work on Agra Metro project

The construction work on the Agra Metro is all set to start with the Uttar Pradesh Metro Rail Corporation (UPMRC) and the state government finalizing an alignment plan for the twin corridors crisscrossing the city. The first phase — a 29.4-km-long corridor with three metro stations — will be completed in 26 months at an estimated cost of ₹272 crore. A large part of the corridor — 78% — would be underground, MD Kumar Keshav said.

Chandigarh Baddi rail line back on track

The construction work of laying Chandigarh-Baddi rail line, which was entangled in land acquisition tangle, is all set to start soon with the Haryana government agreeing to transfer 77.73 hectares of land to the railways.

NHSRCL floats tender for Mumbai-Hyderabad HSR corridor

NHSRCL has floated tender for preparing a detailed project report (DPR) for the Mumbai-Pune-Hyderabad high-speed railway corridor project. Currently, Central Railway operates Hussainsagar Express, which is the fastest train between Mumbai and Hyderabad taking 13 hours to complete the 711-km journey. The new project will reduce travel time by 50%.

Ircan invites bids for rail contract in J&K

Ircan International has invited bids for carrying out works including balance work of cut slope stabilization, earthwork in excavation and filling, sub-soil drainage system, reinforced earth wall and other slope support system for Sumber Station yard (110.883 km) on Dharm-Gazigund section of Udhampur-Srinagar-Baramulla New BG Railway Link project of the Udhampur-Srinagar-Baramulla BG Railway Link costing ₹131.9 crore.

Toshiba Johnson Elevators secures its Largest-ever Order

Toshiba Johnson Elevators (India) Pvt. Ltd. (TJEI) received its largest residential segment order for Design, Supply, Installation, Testing and Commissioning of 161 Toshiba elevators (fully Imported) spread across eight (08) residential projects of VTP Group, Pune. The 161 elevators running at 1.75 meters per second, would be serving at VTP Group’s revered projects like Blue Water, Pegasus, HiLife, Solitaire, and Purvanchal.

Delighted by this order and a newly forged association, Katsuhiko Sato, Managing Director, Toshiba Johnson Elevators said, “Toshiba has been a trusted name for developers and architects of residential properties for mobility solutions that are safe, durable, environmentally sound, and highly efficient. This order from the prestigious M/s VTP Realty gives impetus to our commitment of serving the vertical transportation needs using the power of technology while offering superlative customer experience. With lighting, fixtures and colors that amalgamates with developer’s vision and building’s design, we stay steadfast on quality and safety along with excellent after-sales services.”

Continuing its growth momentum, TJEI has established a foothold in 17 of India’s major cities and is working with over 200 renowned customers across the country. Early this year, TJEI established a Training Centre & Distribution Centre (TCDC) to further improve the efficiency of on-site work. “We have registered a Y-o-Y CAGR of over 15% in the last 7 years, taking our orderbook to a 4181-unit mark. We will continue to consolidate our market share in both residential and commercial market segments with our highly reliable products”, added Sato.
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Real Estate

Govt announces ₹18,000-cr for urban housing scheme
The Union Finance Minister has announced ₹18,000 crore, an additional outlay for the urban housing scheme to help complete real estate projects that remained incomplete due to severe cash crunch. The amount would be provided over and above the Budget Estimates for 2020-21 for the Prime Minister Awas Yojana (Urban) through additional allocation and extra budgetary resources and also over and above ₹8,000 crore already provided this year.

Kalyan Developers launches three realty projects
Kalyan Developers, a wing of Kalyan Jewellers, has launched 3 luxury apartment projects across Kerala in Calicut, Trivandrum and Thrissur respectively. The project is a 21-storied building with 94 apartments of 2 & 3 BHK equipped with luxurious amenities such as swimming pool, gym, multi-purpose hall, centralized gas supply and door phone.

YEIDA developing two cities in Vrindavan, Agra along e-way
The Yamuna Expressway Industrial Development Authority (YEIDA) has planned to develop two new cities — one in Vrindavan and the other in Agra — along the e-way stretching across 6,500 hectares. CEO, YEIDA, Arun Vir Singh informed that the city in Vrindavan will cover 4,000-hectare and in Agra, the city will spread across 2,500 hectares.

Shapoorji Pallonji wins ₹392-cr IIM-V campus contract
Shapoorji Pallonji has emerged as the successful bidder in the tendering process for the construction of a 240-acre Indian Institute of Management-Visakhapatnam (IIM-V) campus at Gambheeram in Vizag suburbs for which the company quoted a price of ₹392 crore.

Ozone Group unveils twin townships
Real estate developer Ozone Group has planned Ozone Urbana, a 200-acre project on the northern fringes of Bengaluru where the project will house residences, offices, a hotel and homes for senior citizens. The other project, Ozone Greens, a 45-acre project in Chennai, will house residential and commercial buildings.

Signature Global plans ₹500-cr realty projects
Real estate building firm Signature Global has decided to invest over ₹500 crore on developing two new affordable housing projects in Gurugram, Haryana. Founder and Chairman Pradeep Aggarwal informed that the projects will house about 2,400 units and will be developed under the Haryana government's affordable housing policy.

Vasavi Group launches luxury towers in Hyderabad
Vasavi Group has launched the premium residential project housing five towers of 32 floors each across an area of over 6 acres in Hyderabad city. It includes oxygen-rich open landscapes with 70% open area and 30% built-up space, Yerram Vijay Kumar, Chairman and MD of Vasavi Group said.

Shapoorji Pallonji wins ₹600-cr construction contract
Construction and infrastructure building giant, Shapoorji Pallonji, has won a contract for the construction of a new secretariat complex in Telangana entailing ₹600 crore. The complex, which will stretch across an area of seven lakh square feet, has to be completed within a year.
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Power Technique
Haryana scouts builders for 3,000-acre low-cost housing

The department of town and country planning (DTCP) in Haryana has invited applications from builders to develop affordable housing projects on the 3,000-acre area in New Gurgaon and along Golf Course Extension Road and other districts. The housing project has to be completed within four years from the date permissions given to the builder.

Wipro innovating cloud solutions to real estate

Wipro has announced that it will co-innovate with SAP SE on cloud-based solutions for the real estate industry. Building on the Intelligent Enterprise strategy, SAP is expanding its vertical solutions to fill the whitespace in its portfolio with an ecosystem of industry cloud applications that leverage SAP Cloud Platform with advanced technologies, and are interoperable with SAP Business Network and the intelligent suite.

DTC ropes in NBCC for developing land parcels

The Delhi Transport Corporation (DTC) board has decided to rope in NBCC India as a project management consultant (PMC) for the development of land parcels under a plan that includes the construction of multi-level bus parking depots, construction of residential units for employees, commercial and allied facilities at these depots.

Tunnel & Bridge

L&T turns L1 bidder for ₹4,997-cr Bridge in North East

L&T has emerged as the lowest (L1) bidder for building India’s longest river bridge connecting Dhubri in Assam with Phulbari in Meghalaya. The 19.3 km long bridge will be built over the Brahmaputra and will reduce travel distance by 203 km and involves an investment of ₹4,997.04 crore.

Noida speeds up work on twin elevated corridors

The Noida authority has fast-tracked the construction work on two major infrastructural projects which are aimed to ease traffic congestion at major intersections in the city. The projects include a 5.96 km-long Chilla elevated road from Sector 14 A to Mahamaya flyover and the 5.5 km-long Aghapur elevated road near Banghel.

Hidco floats tender for construction of tunnel in Kolkata

The Housing Infrastructure Development Corporation (Hidco) in Kolkata has floated tender to conduct feasibility and cost study for the construction of an underground utility tunnel in the New Town in Kolkata. The authorities have identified a 4.5-km stretch in the central business district of New Town to set up the utility tunnel.

CMRL invites online tenders for elevated corridor

CMRL has invited online tenders for the construction of 11.61 km long part of the elevated stretch of the corridor-5 of Phase II of the Chennai Metro Rail project for contract package C5-ECV 03 with the scope of work comprising the construction of elevated viaduct of 11.61 km and 11 elevated stations.
L&T presents a full range of high-performance Komatsu Hydraulic Excavators from 7 ton to 45 tons – PC71/ PC130/ PC210-10/ PC300-8I/ PC350-8/ PC450, D85 Crawler Dozer and GD535 Motor Grader for the Construction and Infrastructure Sector. Cutting-edge technology, intelligent hydraulics, powerful engine and well-engineered attachments enable the machines deliver outstanding productivity. The latest KOMTRAX, the revolutionary tracking system, gives the users a distinctive edge in pushing efficiency by remote management. L&T’s after-sales support through nationwide Dealer network enhances the equipment life.

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JCB India launches industry’s first dual-fuel CNG Backhoe Loader

JCB India Limited has launched the Industry’s first dual-fuel CNG (Compressed Natural Gas) Backhoe Loader in India. Called the JCB 3DX DFi, this new machine can operate on CNG and diesel simultaneously using the HCCI (Homogeneous Charge Compression Ignition) technology.

The machine was launched at New Delhi by the Honourable Minister for Road Transport & Highways and Micro, Small and Medium Enterprises, Shri Nitin Gadkari who has been a leading voice for the development of Construction machinery that uses alternate fuels and an inspiration on CNG interventions in Construction Equipment Vehicles.

The utilisation of alternate fuels is a significant step-change in the Construction Equipment Vehicle Sector. Since the JCB 3DX DFi operates on a mixture of CNG and diesel, there is a substantial drop in particulate emission and proportionate CO2 emissions. CNG is also more economical and helps lower the operating costs to the end customer. With the global concern on environment and sustainability, JCB is committed to supporting the cause through the launch of this Dual Fuel CNG Backhoe Loader. The machine has been developed in India and has been tested in various operating conditions before its launch. It will be built at the company’s Delhi-NCR factory at Ballabgarh.

JCB India’s CEO and MD, Deepak Shetty said, “This dual-fuel machine can substitute Diesel with CNG and has been developed to cater to the evolving needs of our customers. It will contribute to the creation of Infrastructure in the country and will also be exported to countries around the world.”

This dual-fuel CNG Backhoe Loader is based on the same 3DX model which is well established in the Indian market. It offers flexible fuelling, which will help customers sustain in remote areas, where a CNG refilling point is unavailable. Deepak Shetty informed that JCB has been working on this product with the inputs of its Customers, Dealers and Suppliers. These machines have been tested at actual customer sites across various geographies and their feedback has been incorporated in the development of the product.

The machine will come fitted with JCB’s advanced telematics technology - JCB LiveLink. Through this, machines can be tracked and monitored in real-time. This technology also gives updates on Service, Operations and Security of the machine, online or through a mobile application.

Sany India: Leading by Example

Sany India has taken a slew of measures to help its partners sail through the pandemic with ease. It helped all its 35 dealers steer through the challenging phase by implementing multiple initiatives to sustain and improve the cash flow.

The measures included an extension of credit period on all the receivables against supply of construction equipment and spare parts; extended warranty support to customers; and helping the dealers with salary support for around 1100 employees who were on their pay role across India and South Asia. Sany’s timely financial support resulted in a three-pronged effect as the dealers were able to sustain their business, retain their manpower, and bounce back with full force when markets reopened.

Sany’s actions have further reaffirmed the dealers’ faith in the company, for whom its dealers are the pillars of growth. By providing financial support, the company has once again demonstrated its commitment to help its partners in difficult times – and by putting value ahead of profit.

Commented Deepak Garg, Managing Director, Sany India & South Asia, “I feel that we have channelized the financial robustness of our company in the right direction by helping our dealers in their times of need. Our judicious support has helped all our dealers combat this crisis without the fear of an imminent shutdown of their business. COVID has taught us that if we support each other during difficult times, we will emerge as a stronger and a more committed workforce. We have also ensured that the pandemic does not affect our employees in any way.”
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India’s Resilient Realty

India’s real estate sector, which had been facing rough weather for the past 2-3 years, was dealt a crippling blow by the Corona pandemic. However, despite the onslaught, the sector has shown great resilience and is on the path to recovery.

Vinod Behl

The magnitude of the hit that the real estate sector got due to a weakening economy, following the Corona induced lockdown, was evident from the depressing data in H2, 2020, especially the June quarter. According to Anarock Property Consultants, the resident segment saw sales declining by 49% in H1 2020, in comparison to H1, 2019. It was 37% lower than the previous trough of H2, 2016. The year 2020 saw a half yearly decline of 56% in new launches.

The commercial real estate (office realty supply) was expected to go up this year. However, due to the pandemic disruption, it too was severely hit. As per Knight Frank India, the office realty segment witnessed a decline of 27% to 17.3 msf in H1 20. The NCR and Pune markets, respectively, saw the sharpest fall of 86% and 87%. The office leasing dropped by 37% yoy to 17.2 msf - the lowest in a decade. Transaction activity fell 79% yoy during the Q2 period.

The retail segment was the severest hit due to closure of shopping malls for several months. Multiplexes, the major revenue driver, were shut for an even longer period, badly hitting mall revenues and the mall space supply was also badly hit.

But with the pick-up in economic activity post June quarter, the depressed real estate started to look up. Consequently, the office market saw an improvement over Q2. According to JLL India, the office market witnessed a net absorption of 5.4 msf in the quarter ending September, registering an increase of 64% over the June quarter. Bangalore and Hyderabad led this growth. Prestige Estates, which leased 17 msf to Accenture, OLA Technologies, and an electronic giant, is upbeat about more demand for office spaces in the coming months.

Housing, the major segment of real estate, also saw a significant rise in demand, especially September onwards, with the onset of the festive season. Cash-starved builders resorted to aggressive marketing to push sales to cut down the unsold inventory. Developers came
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Reliability in Action
Anuj Puri, Chairman of Anarock

to move, which buyers of super luxury homes prefer,” says to the reason that the inventory in this segment is mostly ready-

hit), came as a pleasant surprise. “Demand for super luxury

A pick-up in the sales of luxury housing (which was also massively

rise with 573 units sold, followed by Bangalore registering a

According to leading Institutional Channel Partner, 360 Realtors, there is a steep jump in home sales (on a monthly basis) in most major markets like NCR, Pune, MMR, Bangalore, Kolkata, Lucknow etc. NCR-based real estate marketing company, Square Yards, successfully clocked Rs 225 crore of sales during Diwali this year. Leading property consultancy Anarock sold a record 1805 homes during the September-October period, up 78% yoy against sales of 1016 homes in the corresponding period in 2019 across top 9 cities in India, besides Dubai. MMR registered a 116% yearly rise with 573 units sold, followed by Bangalore registering a 76% jump. NCR saw sales of 333 units against 260 units last year. NCR-based real estate marketing company, Square Yards, successfully clocked Rs 225 crore of sales during Diwali. Property Consultancy Anarock marketed residential properties worth ₹102 crore during Diwali, surpassing last year’s sales during the same period. Ankit Kansal, MD, 360 Realtors, attributed the spurt in residential sales to improved affordability.

Says Pradeep Aggarwal, Founder & Chairman, Signature Global and Chairman, Assocham National Council on Real Estate, Housing & Urban Development, “Affordable housing contributed significantly to the pick-up in residential sales. Home purchase affordability rose this year with home loan rates dropping below 7%; more than offsetting the adverse impact of low incomes due to the Corona onslaught. The desire to be in the safe environs of our own home during the Corona lockdown also helped boost home sales. The growing concept of Work From Home (WFH) generated demand for bigger homes. Buyers would not mind going to the suburbs of big cities or even moving to tier 2-3 cities to maintain home affordability. Also, because of social distancing norms, demand for plotted developments went up. A pick-up in the sales of luxury housing (which was also massively hit), came as a pleasant surprise. “Demand for super luxury (₹15-20 crore) homes gained traction. This could be attributed to the reason that the inventory in this segment is mostly ready-to-move, which buyers of super luxury homes prefer,” says Anuj Puri, Chairman of Anarock.

Despite these positive developments, the most question is whether the real estate recovery will be sustainable in the months ahead. Several challenges remain on the realty horizon. The unsold home inventory has increased due to the pandemic. According to Liases Foras, at the end of FY 20, it took 15 quarters to clear the inventory, which increased to 19 quarters by H1 FY 21. Financially weak and small developers faced difficulty in raising capital at reasonable rates. Despite the debt restructuring announced by the RBI, many found themselves unable to avail it, and developers saddled with huge debts were burdened with debt servicing. On top of that, a marginal increase in unsold stock did not help in improving the cash flows. Further, there is still uncertainty about controlling the Corona spread and the associated risks to the economy.

However, what is reassuring is that promises outweigh pitfalls, raising hopes that the real estate recovery will sustain in 2021. Ankit Kansal is positive that rise in home sales would continue beyond the year end, neutralizing the demand slump triggered by Covid-19. There could even be a significant rise in new launches. Godrej Properties, for instance, has a pipeline of 22 projects till March 2021. Developers are confident that the Finance Ministry’s decision not to impose additional tax liability on buyers and sellers for transactions with price difference of up to 205 in circle rates and market rates, will help keep the sales momentum going. The stamp duty cut by Maharashtra till March 2021 will be another propeller.

There is a positive sentiment in the real estate market of stable and even declining property prices. An all-time low interest rates and zero GST on ready-to-move homes with just 1% on affordable homes, will boost sales. Keki Mistry, VC & CEO, HDFC, says that the lower interest rate regime will continue for another 2-4 quarters, providing a good home buying opportunity. Ridham Desai, MD, Morgan Stanley India, opines that reality and infrastructure will do well with government push as the stimulus finds its way into real economy – which appears to be playing out.

Ramesh Nair, CEO & MD, JLL India, who is positive on the growth prospects of the real estate sector, says: “The growth prospects in 2021 look brighter. Residential sales in the affordable and mid-segment is expected to show the fastest turnaround. Office real estate should also be leading the recovery, along with the promising alternate asset class of warehousing.”

The APAC Capital Market Forecast by Knight Frank India also points to a stable run for commercial real estate. Says Shishir Baijal, Chairman & MD, Knight Frank India, “The prime industrial sector was the biggest beneficiary, with a spurt in e-commerce, pushing the demand for warehousing. And considering that office space demand came back in the July-September quarter, though short of the pre-Covid level, office space could remain strong in the new year.”

On the residential front, Anuj Puri expects the top 7 cities to cumulatively record a 35% jump in housing sales in the October-December festive period, against the July-September quarter. “If this pans out, housing sales in the whole of CY 2020, will have rebounded to more than 50% of the overall sales of 2,61,500 units. Comparing housing sales on q-o-q basis in the whole of 2020, overall industry-level sales are likely to rebound to nearly 90% of the pre-Covid level (Q1 2020) in Q4, 2020,” he adds. Clearly, real estate will be on a rejuvenated path in 2021.

The writer is Editor, PropTOQ – a real estate magazine.
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As India speeds ahead with development and wants to become a global economy, there are many issues that are hampering the country’s progress. There is a growing demand for high quality building infrastructure – both in the residential and commercial space – and for buildings that are durable and affordable for both, the present and next generation of users. Getting capital financing for plants and machinery is still a big problem in India. Builders have to shell out a substantial investment and loans have higher interest rates.

Because of the lack of affordable and sustainable alternatives, the housing shortage has grown to unmanageable proportions. To address this problem, the government has set an ambitious target of constructing 11 million homes by 2022. But achieving this won’t be easy, unless one employs proven technologies like the precast, that offers both speed of construction and affordability.

In fact, the construction industry’s challenges can be solved with technologies such as Precast. Firstly, precast technology uses reinforced concrete, the cheapest raw material on the planet. Secondly, it is compatible with existing building codes and suited to seismic zones as India is prone to earthquakes. Thirdly, it is efficient due to its ability to save raw materials and manpower.

Precast technology can help to build India as a modern nation, but there needs to be greater recognition of the technology so that it becomes an integral part of the country’s infrastructure development efforts, and becomes an acceptable standard. This would enable the precast industry to access subsidies and support.

Elematic’s solutions are available even at low-costs, and as construction activities grow across India, so can a precast plant expand and enhance its capacities to meet the increasing requirements. The precast industry would welcome more architects and designers to come on board as their involvement would advance the cause of precast construction, such that it enters the mainstream as a standard means of construction by the builders and contractors. This move could also be supported by institutions and industry bodies.

Apart from providing housing for India’s growing population, precast can also be the answer to the rising demand for faster building of commercial properties, which, in turn, would bring faster revenues to businesses and help them grow fast. Precast construction takes less time than using traditional methods and since ‘time is money’, on-time project completion is very valuable to builders.

The next phase of the country’s development will be technology-driven. As more people begin to adopt precast construction, we will see the industry becoming more organized, with more efficient use of raw materials, machinery and manpower.

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A report by Off-Highway Research indicates that the excavator industry's long-term trend remains positive, with demand expected to grow at a CAGR of 16 percent during 2021-2023 and reach 28,000 units, but is anticipated to decline to 25,000 units in 2024 due to the election year.

Anticipating a demand recovery in 2021 with stalled projects taking off, excavator manufacturers are aggressively promoting their products, focusing on technologically advanced features and a range of attachments. Escalating competition in design and technology is driving manufacturers to make operational advancements in their excavator engines, hydraulic systems, structures, tracks, and cabs to enhance fuel-efficiency and productivity.

OEMs are also making more advancements in their telematics, which has gained increasing popularity with equipment owners keen to optimize their machine’s uptime and safety.

Excavators: Demand on the Rise

Beating the Covid-19 pandemic blues, manufacturers are offering a range of excavators from mini to heavy capacity, loaded with telematics for better machine management and attachments for a range of multi-utility jobs. Moreover, they are also looking at renting, leasing, and refurbishing their machines as a new avenue of business growth, report S. A. Faridi & P. P. Basistha.

To make their excavators usable in a wider variety of applications, most of the companies are offering a range of attachments for deep digging, drainage cleaning, braking, crushing, soft soil areas, digging/loading of different types of materials etc. Attachments include buckets, breakers, tracks, booms, bucket crushers, arms etc. The demand is visible across projects like irrigation, mining, quarrying, and municipal applications like drainage cleaning and infra development in urban spaces.

The revival may not be in absolute terms as was witnessed during the pre-Covid period, however, through improvisations being made in the machines and with more product support, the manufacturers are looking to maximize their customers' return on investment, even as profit margins remain under pressure.

In the current market scenario, where liquidity has become an issue, equipment buyers are also looking at options like leasing, and refurbishing of their existing fleet. In view of this, many CE companies are seriously considering expanding their services to meet these needs. They are offering flexible leasing to prospective buyers and the option of renting their machines to contractors, which they see as another avenue to grow their business.
Tata Hitachi: In tune with customer demand

“We see a trend in customers upgrading to a higher class of excavators such as the 35-ton in projects like irrigation and some areas of mining and quarrying to boost performance and efficiency to new heights,” says Singh.

He informs that after equipping their ZAXIS GI series of excavators with telematics, Tata Hitachi subsequently developed a telematics suite for their home-grown machines and their EX Super + excavators. “Integrating Telematic in the machines brings them virtually into customers’ offices as information from the machines reaches them via email, sms and mobile apps. Armed with this information, our internal information system helps us reach our customers for the required support. Customers can monitor, analyze, and improve the performance of their machines based on the guidance provided by the system. For instance, timely maintenance alerts help customer in keeping their machines in good condition and thus reduce their downtime,” he says.

To enable varied applications, Tata Hitachi offers customized solutions as well as standard offerings with options of standard arms, long arms and super long reach booms and arms. Bucket types include bulk excavation, general purpose, heavy duty, light duty, extra light duty, coke handling, salt handling, ditch cleaning, skeleton type, sand loading, granite handling and block handling scoop buckets. The undercarriages can be adapted for various applications like general purpose, quarry applications, marshy underfoot conditions, etc. Additional customized front attachments include rock breakers, quick couplers, augers, grabs and grapples, magnets, and clamshells.

Tata Hitachi has also entered the rental business. Observes Sandeep Singh, “The CE market in India lags behind the world in rentals. We still do not have an efficient and sizeable rental business model in place. But post Covid, there will definitely be a move to expand the rental business as companies will look for efficient allocation of their resources and capital. In fact, we are already seeing an initial movement towards organized rentals and the benefits of cost, quality, and customization are being recognized. We started our rental business in 2019 and will be promoting our machines along with their attachments and customizations. All our products will be backed by our commitment towards their upkeep and an assurance on their hours of usage.”
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JCB India: Investing in technology

Covid-19 has had an unprecedented effect on several industries, including excavators. In the new normal, there is going to be more and more focus on digitization and automation to improve machine efficiency and productivity. Affirms Deepak Shetty, Deputy CEO & MD, JCB India, “JCB is committed to being a complete infrastructure equipment partner with a wide range of products. We have made significant investments in our excavator range. A year ago, we introduced our intelligent NXT range in the 14 - 24.5-ton category and our robust Quarry Master in the 14 to 38-ton category. The new Quarry Master range includes models from JCB 140QM to 380QM in 14T, 21.5T, 22.5 LC and 38T. They come with a choice of power modes for a variety of excavation capacity requirements.”

The 20T and 21T models save up to 32% fuel in the economy mode vs outgoing models and have a robust dig end and X-type frame, designed for the arduous quarry jobs. The JCB 225QM has 8 power modes, giving operators the flexibility to work in the right mode and in a variety of applications. The machine is powered by ecoMAX engine which produces 170 HP and provides excellent torque of 695 Nm. The model comes with reduced maintenance and a warranty provision of 2 years or 5,000 hours of operation. With a deep section boom design, improved hydraulic filtration, and heavy-duty track chain assembly, it is exceptionally durable; and the heavy-duty cab guards ensures more safety to the operator.

JCB NXT range of excavators, designed for high productivity and fuel efficiency, comes with 10 working modes and increased efficiency of up to 32% in the Eco mode on models JCB NXT205 and JCB NXT215LC. The low maintenance excavator range offers a standard warranty of 2 years or 5,000 hours. The deep section boom design, improved hydraulic filtration give the excavators increased durability. JCB NXT 245 HDLR can dig to a depth of up to 40 feet and has a reach up to 51 feet. Equipped with energy saving JCB eco hydraulics, it stands out as an extremely fuel-efficient machine. Its strong X-type frame coupled with pre-installed hose burst check valve for boom and arm make it one of the most robust and safest excavators. ‘intellicontrol’ - a Live Link-enabled solution gives critical information on the operations of the equipment remotely.

JCB mini excavators are being used for urban development projects that demand compact machines to work in restricted spaces and municipal jobs. The range includes the 3-ton to 6-ton category in models such as 30 plus, 50z, 51R and 55z. The 50z and the 55z come with a zero tail swing design for higher performance and versatility when used in tight spaces. They also have a range of attachments like soil drills, rock breakers, etc, and customized mode selection which allows the operator to choose from light, eco, heavy or heavy+ depending on the work.

“With infrastructure being developed in many urban areas, our mini excavators are finding great utility,” says Deepak Shetty. “The mini has a lot of potential for use in space-constricted urban/semi-urban areas and our compact-mini excavator finds great utility in fields like power, irrigation, and housing projects.”

Elaborating on JCB’s Live Link advanced telematics, Shetty informs that the technology has improved the productivity, reliability, and efficiency of JCB machines by relaying information on their productivity, maintenance, location etc, in real time, 24x7. Till date, approximately 1,60,000 Live Link-enabled JCB machines have been sold. These machines can be monitored for security, operations and service (SOS) on our customers’ mobile devices; they can be geo-fenced, time-fenced, and located anywhere. Customers get to know their machine’s health, fuel level, battery conditions, service schedule, and other critical parameters.”

JCB India, which currently has 700 customer service outlets and over 60 dealers, is also looking at providing product and parts support directly as a major business avenue. Its ‘JCB genuine parts application’ enables customers to order JCB parts online. Says Shetty, “Our online sales of parts have increased from 3% to 15% due to the Covid lockdown. Online sales also provide us an opportunity to service our customers at their doorstep.” He informs that an internal tool – Smart Serve has been developed by the company to help dealerships to support engineers to improve efficiency and productivity, thereby improving profitability.
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As mechanisation continues to gain ground in India, newer applications and attachments are being fitted on excavators enhancing their versatility and utility. L&T is promoting its Komatsu PC210-10M0 for tough applications like stone, granite, and marble quarrying as well as mass earthwork. The machine has robust structures, a more powerful engine and a bigger hydraulic pump, the travel performance is superior. The operator enjoys the ease of digging and fast cycle time, while the controllers in the machine silently work on fuel reduction. Innovative use of technology such as the viscous fan clutch in place of belt-driven fan has resulted in substantial fuel savings. Eco-guidance features in the monitoring system continuously indicate operational cautions to the operator so that he can take corrective action instantly, when required.

To make the PC210-10M0 suited to varied applications, there are different undercarriage options such as standard and long-crawler (LC), and shoe widths of 600 mm and 800 mm. The excavator comes with attachments like rock breakers, crusher buckets, slope compactors, long reach, attachments for drilling, piling, and demolition, and clamshell for material handling, etc. Slope compactor attachments and crusher buckets are manufactured in-house by L&T, while the rock breakers and demolition tools are sourced from Komatsu and Rammer, and the piling hammers from Movax.

Buckets in the Komatsu PC210-10M0 range from 0.90 to 1.7 cum; while the Komatsu, PC300-8M0 and PC350-8M0 excavators have 1.4 to 2.3 cum buckets. For mass earthwork, Komatsu has developed the ME (More Efficient) bucket, designed to reduce resistance while digging, and thereby increasing the fill factor and enhancing productivity. Besides these, there are specific block handling buckets for granite and marble mines. “Our application specialists recommend the excavator model, bucket size, and undercarriage based on an understanding of the customer’s application. More attachments for specialized applications are in the offing,” says Garg. Komatsu and L&T were the pioneers in introducing advanced telematics with the patented health monitoring system KOMTRAX; it provides a detailed analysis of the machine’s performance remotely along with alerts on maintenance and any abnormalities. “The user can virtually see almost all performance parameters and plan the maintenance and preventive repairs accordingly,” says Garg. A special feature of eco-guidance indicates the operator skills in real-time and helps in identifying training needs subsequently. It also provides mode selection and idle time for better site optimization and improved efficiencies.

The company is also targeting a wider customer base with its standard product offerings. Says Garg, “Generally, about 40% of customers buy the low-cost, mid-size machines for rental purposes, so our...
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base models are the most suitable for this segment. We also offer certified used equipment which is attractive to customers facing a liquidity crunch.”

The Machine Care Program (MCP) - Suraksha - launched by Komatsu and L&T, offers extended power train warranty for its flagship models PC210, PC300 and PC350. Garg informs, “We recently upgraded our MCP to Suraksha 10,000, which extends the power train warranty up to 4 years / 10,000 hours of operation from the date of commissioning. This is an unprecedented and an unbeatable offer in the industry. We also offer value-added services like periodic and preventive maintenance, undercarriage inspection, training on energy saving for buyers of Komatsu premium equipment. Other schemes include the L&T Vishwas for excavator models PC71 and PC130.” He adds that Komatsu and L&T had extended the warranty period for all the equipment during the lockdown and supplied Covid-19 kits for operators and mechanics.

L&T has 6 service centers equipped to undertake complete refurbishment of components and machines, which also undergo complete load and performance tests. The company also offers ‘component RECON exchange’ to its customers as a quick repair solution to reduce breakdown time of their machines.

Kobelco Excavators has introduced a 22-ton model for use in irrigation, mining, and quarrying jobs, which is also suitable for municipal applications like drainage cleaning. “We have priced the product attractively and it has received a good response despite the prevailing challenges,” avers E. Moses, VP & National Head - sales & Marketing, Kobelco Construction Equipment India.

“Our mini excavators are also gaining popularity in select pockets.”

The company is showcasing its technological competence and excavating solutions in the highly competitive Indian market. “Our in-house R&D facility in Japan is constantly working on meeting customer needs and expectations to come up with the best solutions. Our cabins, for instance, are designed to ensure a safe, healthy, comfortable, and efficient working environment for the operator. Our undercarriage provides stability and ease of movement over rough terrains due to the best-in-class traction power. All these features help deliver maximum value to the end-user,” says Moses.

Kobelco excavator owners rely on the company’s Geoscan to get timely data, based on which they can monitor their machines’ performance, get timely maintenance alerts, and information on the machines’ utilization and fuel consumption. “Our dealers are also able to resolve several issues remotely through the telematics platform ensuring higher uptime. Our advanced telematics has self-diagnostic capabilities for quick resolution,” informs Moses.

To enable wider applications of its excavators, Kobelco is offering a choice of attachments like buckets, breakers, devices for specific jobs, demolition tools, long reach attachments, clamshell grab, vibro-dipper, etc. Kobelco India dealers are servicing their customers’ operational and maintenance requirements of their machines, besides which, their is a company-owned component repair workshop in Chennai and one in Noida.
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Hyundai: Innovating for fuel efficiency, reliability and performance

“The excavator industry that started well in Jan-Feb 2020, took a major hit due to the pandemic, but we are seeing the CE Industry recovering since September, and if the momentum continues, we could expect the market to return to the pre-Covid level,” observes Rajiv Chaturvedi, Vice President, Sales & Marketing, After Service & Parts, Hyundai. “Roads, Irrigation, mining and quarrying will continue to fuel growth for excavators.”

He adds: “Hyundai has a wide range of crawler excavators from 3T to 50T to work in all types of applications. In fact, we have been working continuously to upgrade our existing products for such applications and based on customer requirements for customization.

He informs that to make the excavators more application driven, Hyundai and the company’s in-house R&D and TD departments collaborate with the Global HQ at Korea to develop the best products, including futuristic models. “The core of design focus is fuel economy, reliable hydraulics, robust structures, and ergonomics. The cabin design of Hyundai Excavator, for instance, has an integrally welded low stress, high strength steel to meet ROPS/FOG standards for operator safety. The in-built RMS system allows online monitoring of all performance parameters by the machine owners.”

Hyundai has a fleet of 30,000 excavators working in India. To cater to varied application requirements, the company offers a range of product configurations such as long reach boom of 14.5M to 18.5M for well digging, deep digging and cleaning. The long crawler excavator is designed for better stability, especially for quarry application where the machine needs to be very stable during digging and lifting.

The excavators come with a range of buckets from heavy-duty for tough applications to general purpose buckets for light materials, buckets for desilting, canal cleaning etc. Hyundai rock breakers are designed for a variety of tonnage class of excavators and offer different types of chisels for different applications. The undercarriage is suitable for both general purpose and heavy-duty applications. For marshy areas and soft underfoot conditions, the company offers wider shoes on the excavator’s undercarriage for lower ground pressure and to work more efficiently. Says Chaturvedi, “The growing scarcity of manual labor and the need for better productivity, together with the nature of projects in urban and semi-urban areas, have been instrumental in leading to the development of a variety of attachments for use in road construction, irrigation, mining, quarrying, etc.”

Hyundai’s advanced remote management system - Hi-Mate - enables fleet monitoring, detects location, geo fencing, gives reports on equipment performance, periodic maintenance, fuel management, working hours summary, and real time alerts on critical parameters.

“We are seeing a global trend of application-specific excavators in India as well. For example, the mini excavator market (< 5T class) has grown significantly during the last 5 years. We are expecting the mini excavator industry to touch around 2500 units by 2023. Demand for mini excavators is likely to be necessitated by urban infrastructure projects, where excavators will be required to work in congested areas,” he says.

“We believe that innovative products will become the need of the hour, triggered by the global pandemic. We are offering our customers several finance options through tie-ups with leading NBFCs and banks. We also offer a customized finance package to our key customers and fleet owners to ensure the lowest Owning & Operating costs. Our financial support extends not only for acquiring new machines but also during their disposal and for buying new ones,” adds Chaturvedi.
Japanese Engine Technology Drives India into the Future

Kubota's Japanese quality and service is giving India a boost

Specifically designed for a wide variety of applications, Kubota is the world’s leading brand in compact diesel engines for industrial and construction machinery. With a wide product range, great versatility and high power density, Kubota caters Indian clients’ needs, continuously expanding support network in India.
Sany India: Tech-rich solutions

“We are confident that the growing number of private and public infrastructure projects, increasing economic development activities, as well as government focus on key projects, will drive demand. To meet the upcoming demand for high capacity excavators required in big infra projects, customers are looking for high productivity and fuel-efficient machines - the reason why the market is seeing a surge in demand for higher HP and higher tonnage machines,” says Dheeraj Panda, Director - Sales, Marketing & Customer Support, Sany Heavy Industry India.

Sany excavators are designed for heavy-duty operating conditions with fuel economy. A powerful, fuel-efficient engine ensures high peak torque for optimum performance in the toughest of jobsites. Equipped with an advanced positive flow control hydraulic system and digging force, the machines can handle heavy duty operations very effectively.

The excavators have different work modes for adaptability and optimum performance. A revolutionary staged auto idle system reduces engine speed automatically in two stages when the machine is not in use, thereby saving more fuel. For smooth controllability, the excavators have special joystick controls, optimized valve core structures with regenerating channel, and added intelligent interflow control. The pressure loss is reduced; and operation control is improved resulting in smooth handling of equipment. Other safety provisions include an emergency stop switch, battery cut-off switch, seat belts, fire extinguisher, pilot controlled cut-off levers, etc.

The Dynamic Optimization Matching Control System (DOMCS) in Sany’s IoT enabled excavators ensures superior performance with higher fuel efficiency as per the external load demand by intelligent control on engines and the hydraulic pump power. It can capture the machines’ performance, including operating hours, location, maintenance alerts, fault alarms etc. Says Dheeraj Panda, “Telematics has improved customer engagement to a great extent. Our in-house developed EVI app helps customers to monitor and analyze the real-time performance of their machines onsite. Our GPS installed hardware helps them manage a single machine or a fleet of machines based on the real-time updates on their performance. What’s more, the daily performance information and historical data on the machines when analyzed, helps us in making more improvisations in our machines and in our support services.”

Sany’s comprehensive range of attachments expand the application areas of its excavators. Says Panda, “We offer customized solutions like scoop buckets, coal buckets and salt buckets depending on the application of the machine. There is a heavy-duty bucket for hard strata. The arms can be customized to different types and sizes as per the site requirement, for instance, our long reach arm is curated for our medium excavator segment due to its multi utility purpose. In the mini excavator segment, we offer customized solutions like auger with coupler, trench bucket and rubber track pads. Sany is also promoting its mini excavators given their fair amount of demand in municipal applications. All these attachments help in multi-utility of the machines. In the large excavators, we offer customized demolition attachment and a ripper attachment.”

With the rental market becoming an attractive business avenue, the company is also considering renting its machines to contractors. Says Panda, “The concept of equipment rental is picking up pace, especially during the current pandemic situation as customers are refraining from investing in the machines. We also offer prospective customers internal financing so that leasing our machines becomes fast and convenient for them.”
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Case India: Optimizing solutions

Owing to the growing demand for technologically advanced and productive excavators in India, Case India showcased its first excavator in 2019, replete with advanced features. It comes with the world-class FPT Industrial engine that saves up to 4% fuel due to its hydraulic system control and brings 6% more efficiency.

“The advanced hydraulic system enables higher breakout forces, improved swing speeds, and greater swing torque, resulting in faster cycle times with a power boost function. The electronic management of

speed and power lowers fuel consumption and increases output,” says Sandeep Mathur, Brand Leader, Case India.

He informs that the product has been developed keeping the Indian working conditions in mind. The boom and arm plate thickness have been increased by 33% and feature heavy-duty brackets and reduced tolerances, which increases component life, thereby minimizing the machine’s downtime. The excavator develops a gross power of 117 KW (157 hp) and peak torque of 622 Nm at 1800rpm due to the powerful engine, which reduces the transient time, making the hydraulic system immediately reactive to any load. The excavator has 5 energy saving controls which help in constant consumption monitoring, and an ECO gauge function that keeps the owners and operators updated on the machine’s usage. Two variable displacement axial piston pumps with a regulating system are combined with the CASE main valve (designed in Japan) for precise and efficient operations.

The HVAC cabin of Case excavators features an integrated 7-inch LCD monitor for real time monitoring, while an onboard diagnostic system gives the status of the machine with notifications on repair or maintenance. An ergonomically designed mechanical seat in the cabin has 8 different adjustments, and a system of vibration dampening, that protects the operator against fatigue. The excavators are equipped with CASE Intelligent Hydraulic System (CIHS) for machine control and fuel saving.

The Eagle Eye Telematics in Case excavators gathers critical data about the maintenance, tracking, utilization, and security of the machines and sends alerts in real time on fuel usage, battery, geofencing, engine etc. “It is a great way to boost productivity and reduce downtime,” says Mathur. “We have recently launched our Site Watch Platform with an all-new dashboard. The more intuitive navigation and new overview sections highlight critical information without requiring the user to search extensively for the data.”

CASE’s financial arm - CNH Capital – is tackling the liquidity issue faced by prospective customers. Informs Mathur, “We’re offering lucrative schemes that can facilitate easy purchase of our products and we even came up with multiple schemes during the pandemic. We have also introduced a 48-hour loan approval policy to provide easy loan service.”

“We offer extended warranties and service support so that our customers can use their machines more confidently knowing that CASE will support them through the machine’s lifecycle. CASE Care is a cost-effective service contract under which we monitor the machine’s performance and usage for preventive maintenance. CASE Protect is a comprehensive extended warranty which ensures expert care, round the clock availability, and hassle-free operations. For fleet owners, Case offers maintenance contracts with dedicated service manpower available at site to ensure uptime. For spare parts and product support, the company maintains a stock of spares at key locations. Even in these challenging times we are delivering parts and scheduling services via our comprehensive dealer network, keeping all the safety precautions in mind,” avers Mathur.
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SDLG: Strengthening Volvo’s market presence

SDLG, a member of the Volvo Group serving the Indian construction industry with a range of wheel loaders and motor graders for more than a decade, has now made its debut in the Indian excavator market with the launch of SDLG E6135FI, a 13-ton tracked excavator.

Says Surat Mehta, Head, SDLG Operations India, “There is a sizeable market for the 13-ton range in India, with an estimated 3000 units, annually. The excavator is specifically designed as per the parameters required for the tough Indian jobsite conditions, and has a robust structure, which means that it requires maintenance only every 250 to 500 hours, and all service points can be easily accessed from the ground level.”

He informs that the number one application for the new SDLG E6135FI excavator is expected to be road construction, besides use in small quarries, small road construction projects, and for contractors/sub-contractors involved in ancillary jobs. Another potential application would be for digging irrigation channels, as the Indian government looks to bring greater efficiencies to the agriculture industry and to provide safe drinking water.

This new machine is loaded with technology, an advanced hydraulic system, and the cab has been designed with operator comfort in mind. Air conditioning is installed as standard and the cab is extra spacious with all the joysticks and controls laid out ergonomically. The superior all-round visibility of the jobsite also helps to make operations safer and more productive. A coloured LCD screen in the cab updates operators on the health and movements of the machine for preventative maintenance, promoting high uptime and thereby low total cost of ownership.

Power driven by the Deutz engine, it delivers 75 kv @ 2000 rpm, and features a strong undercarriage. A H-link casted head gives strength to the arms. The excavator comes with varied work modes that enable fuel saving, which is a standard feature in Volvo CE machines. SDLG is offering attachments such as buckets of 5.5 cum to 6.4 cum, rock breakers, grapples, and quick couplers so that the excavator can do various jobs.

Mehta informs that the excavator will be initially imported from SDLG’s Linyi facility, but once demand picks up, the company will consider manufacturing it in India. “After the introduction of motor graders and wheel loaders to the Indian construction industry, and now excavators, we will consider launching some more of our products in the Indian market. We will be looking at rental companies also,” he informs.
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To strengthen its position in the Indian excavator market, Schwing Stetter, will begin local production of 14 and 20-ton excavators at its upcoming plant near Chennai, from early 2021. The plant will cater to both Indian and export markets and have a capacity to produce 1000 units per annum, to start with.

Says V. G. Sakthikumar, MD, Schwing Stetter India, “We will be offering a higher value proposition through our premium and economy range of excavators. They will have a robust structure, efficient hydraulics, a fuel efficient engine, and will be attuned to varied applications. Customers will have the option of having their machine fitted with a premium Indian engine or a foreign brand.”

He adds, “Our XCMG excavators (imported from China) have established their ability to work in the rougher Indian conditions. The fact that we have sold 250 units in 2020 bears testimony to their popularity in India. For now, we will not be offering any attachments with the excavators, and as part of our product support, we will be training the operators. So far, we have been largely visible in India’s Southern markets; but we are now expanding our dealer network in Maharashtra, West Bengal, Odisha, Bihar, Jharkhand, and North East India.”
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Soil compactors are used to rearrange particles, reduce the void ratio, and increase density. Soil compaction improves the shear strength and load-bearing capacity of the soil. Improper soil compaction results in structural distress from excessive settlement – both total and differential. It is therefore important to select the right soil compactor with efficient technology and durability.

One such machine is the Ammann ARS 121 Soil Compactor. It combines tried-and-tested features with intelligent compaction technology, and has great compaction output while offering improved efficiencies and cost savings as well.

The Ammann ARS 121 is suitable for compaction of a wide range of soils, from silt to crushed stones. The machine is equipped with an efficient turbocharged, water-cooled engine, ensuring non-stop performance with maximum reliability and lower operating costs.

The ARS machine features a newly designed operator console that sets new standards in operator comfort and visibility. The single-drum rollers are designed for fast and easy daily maintenance and a long life. The powerful and robust 4-cylinder engine and heavy-duty hydrostatic drive of the differential axle ensure great traction and travel performance, even under extreme circumstances. The roller provides the necessary flat base, which enables the crucial support for construction foundations, pavements, roads, and various other structures.

The Advantages

ARS 121 utilises intelligent systems that helps to achieve the requisite density for soil. It has several added advantages:

- Outstanding productivity, in part because the heavy-duty hydrostatic drive of the differential axle ensures great traction
- It is designed with a low center of gravity for stability and manoeuvrability
- It features high ground clearance and gradeability
- The clear dashboard layout comes with a fully isolated operator platform and adjustable seat
- A two-stage vibratory system maximises transfer of compaction force to the material
- High productivity – fewer passes are required
- Service and maintenance points are easily accessible
- Superior fuel efficiency

Applications

- Medium and large jobsites
- Transport construction (motorways, railways, airfields)
- Construction (industrial zones, harbours)
- Compaction of all kinds of soils and wet mixes

For further details, please contact:

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Construction projects designed to be completed in an extremely short time are demanding in many respects. In densely populated areas, particularly, the requirement for road rehabilitation to be completed rapidly is becoming more and more urgent, as job sites on busy major roads cause traffic jams. They require precise planning, a high degree of process reliability and reliable machinery. They also demand experience and competence from users and experts. All these parameters were important for rehabilitating a 3.6 km section of the A3 motorway near Duisburg. As this busy commuter route carries some 120,000 vehicles on weekdays, the highways authority, Straßen.NRW, decided to carry out the rehabilitation project by closing the road completely.

The works started with a full road closure in both directions. After that, the right hand carriageway, which is made of concrete and did not require rehabilitation, was separated from the adjacent asphalt lane using a side milling wheel. Four WIRTGEN cold milling machines - W 210i, W 220i and W 250i - started removing the surface and binder courses which required rehabilitation. About 20 hours were scheduled for this part of the work, and the asphalt paving started before milling work was even complete. Paving had to be complete to allow enough time for follow-up tasks such as the application of road markings. The route was set to be opened to traffic to enable commuter traffic to start the week normally.

Six VÖGELE pavers in service simultaneously

A window of just 27 hours was available to pave an area of 60,000 m². The contractor’s team met this challenge with six VÖGELE pavers. Two SUPER 2100-3i machines first paved the binder course. One of the two Highway Class pavers worked in one direction of travel whilst the other paver simultaneously started at the other end of the job site, working in the opposite direction. The surface course consisting of low-noise stone mastic asphalt (LOA) was then paved by two SUPER 1800-3i SprayJet machines using the “hot to hot” method.

WIRTGEN GROUP machines lead to Motorway rehabilitation in record time

Contractor JOHANN BUNTE Bauunternehmung showed how to rehabilitate the surface and binder courses of a section of motorway successfully in an incredibly short time. On the A3 near Duisburg, the paving team rehabilitated an area of 60,000 m² in just 55 hours using four WIRTGEN cold milling machines and six VÖGELE pavers.
THE MIXING SOLUTION

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“Hot to hot” paving with two SUPER 1800-3i SprayJet pavers: VÖGELE spray technology has proved itself over many years in a variety of projects all over the world – including the high-speed motorway job site near Duisburg.

Three mixing plants were commissioned with production of the asphalt to guarantee material supply on this tight schedule, with a further plant in reserve in case needed. 130 trucks made 500 trips to transport the hot asphalt to the job site between the junctions at Duisburg-Kaiserberg and Breitscheid. In all, 16,000 t asphalt (12,000 t for the binder course and 4,000 t for the surface course) had to be produced, transported and paved.

VÖGELE material feeder ensures a continuous supply of mix

Two VÖGELE PowerFeeders of the MT 3000-2i Offset type accepted the mix from the trucks to guarantee a continuous supply to the pavers. Use of two feeders was essential on this time-critical project: as the material feeder operators were coordinating unloading, this allowed the paver operators to give their full attention to the paving process. Given a whole 500 truckloads in a few hours and the high pave speeds, this was essential.

Spraying on emulsion and paving asphalt in just one operation

The VÖGELE SUPER 1800-3i SprayJet spray pavers also ensured an efficient process: they sprayed on the bitumen emulsion and paved the asphalt surface course in just one operation. In addition to saving time, paving the A3 with VÖGELE SprayJet technology had other benefits: as the freshly-applied film of emulsion was paved over immediately following application, construction vehicles were unable to drive over the binder film and damage it. This improves interlocking and thus also the service life of the road.

Road opened to traffic; objective achieved

The smooth interaction of the team and the machine technology from WIRTGEN and VÖGELE meant that finally, the A3 motorway reopened to traffic. “That was an incredible performance by the whole team. Everyone supported everyone,” said construction manager Niklas Lehmann after the project was complete.

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Axle Shaft India expands range of excavator parts and attachments

Manufacturer of excavator parts, Axle Shaft India has increased its range of products, including attachments like rock breakers for use in mining and road construction projects. Says Vikrant Soni, CEO, Axle Shaft India, “The demand for excavators, their parts and attachments is on the rise in view of the demand for completing stalled and delayed projects, especially road construction. Our technical know-how of machining, metallurgy and heat treatment is what keeps us ahead of our competitors. We undertake constant R&D to manufacture high quality products such that they add value to the machines of major OEMs.”

The company, which started in 2012, has a full-fledged manufacturing unit in Ambala (Haryana) for machining, heat treatment, CNC, SPM, sawing, milling etc. Parts are supplied from its warehouse in Ambala within 5-6 days, besides which, the company keeps a ready stock of parts with its dealers based in Bangalore, Hyderabad, and Coimbatore. It is also planning to set up a warehouse in south India. “We have the most modern and updated technology, a robust infrastructure, and a vast supplying unit, and our products are made in accordance with international standards. We are also suppliers to the automobile and agriculture sectors,” informs Soni.

Axle Shaft product range includes Chisel Lock Pins, Excavator Pins, Rock Breaker Chisels, Through Bolts, Agricultural Shafts, Excavator Bushes, Spline Shafts and Automotive Axle Shafts. Says Soni, “Our products are fabricated from high grade raw materials. We are also capable of custom designing and manufacturing our products to suit the specific requirements of our clients. Our major strength lies in the high precision design of shaft and automotive axles.”

“We are appreciated for our quality products and their timely availability by the aftermarket people, plus we are highly competitive in terms of affordable pricing. We also advise our buyers on how to identify good quality parts (since they all look alike), and not to go for cheaper varieties. One can distinguish the quality only through their chemical specifications, and some tests like hardness, spectro tests, grading etc. Since the OEMs do not believe in certifications, they do the complete testing and research at their end. However, we are confident of our products as we maintain a consistent quality – the reason why our brand is so highly trusted,” he adds.

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BKT’s New 57” Giant Tire: EARTHMAX SR 468

EARTHMAX SR 468 - the biggest ever tire made by BKT, has been designed to fit out rigid dump trucks. So far the prototype has been made in the 40.00 R 57 size and is ready to be tested in the coming months by BKT engineers.

The new machinery to make this enormous tire reached the Indian plant in Bhuj last January, just before the pandemic lockdown, and could not be immediately installed. After a temporary shutdown of BKT’s manufacturing facilities, which was necessary to implement a rigorous safety plan for all staff, did activities finally return to full operation; including the installation of the new machinery for the 57” tire, with the online help of the manufacturer and the BKT engineers on site.

Says Rajiv Poddar, Joint Managing Director, BKT, “With this giant 57” tire, the prototype of which has been made thanks to the determination of my fellow workers, we wish to send a positive message to the market, to our partner distributors and to our end-users. Our Research and Development into new products continues to evolve, as we find new ways to progress, even in the most complex situations.”

Adds Dilip Vaidya, President & Director of Technology at BKT, “It is a very important moment for us - a giant product has been created - which will now be subject to the most rigorous testing up to the spring of 2021. Once we are absolutely sure that we have achieved the highest possible level of quality and reliability, we will officially launch the new 57” tire.”

A winning feature of the EARTHMAX SR 468 is the special tread design and the compound, created to limit the heat generated. The E-4 depth of the tread provides extreme resistance in highly challenging conditions. Other products in BKT’s EARTHMAX series include a range of radial tires used on off-road vehicles and equipped with an All-Steel structure, which provides greater resistance to the casing and, hence, against damage.
Concrete is a durable and versatile construction material; it is not only strong and economical, but it also takes the shape of the form in which it is placed, and is aesthetically satisfying. However, experience has shown that concrete is vulnerable to deterioration unless precautionary measures are taken during the design and production stage.

The term ‘high performance’ is somewhat pretentious because the essential features of this concrete is that its ingredients and proportions are specifically chosen so as to have particularly appropriate properties such as high strength and low permeability, for the expected use in the structure. High-strength concrete and high-performance concrete are not synonymous because strength and performance of concrete are different properties of concrete. High-strength concrete is defined based on its compressive strength at a given age whereas high-performance concrete is defined based on performance criteria, namely, high durability, high strength, and high workability.

There are no unified definitions for High Performance Concretes (HPC) and different institutions and experts define High Performance Concrete differently. The American Concrete Institute defines HPC as: “Concrete which meets special performance and uniformity requirements that cannot always be achieved routinely by using only conventional materials and normal mixing, placing and curing practices”. The requirements may involve enhancement of characteristics such as placement and compaction without segregation, long-term mechanical properties, and early age strength or service life in severe environments.

In simpler words, HPC is a concrete that has at least one outstanding property viz. Compressive Strength, High Workability, Enhanced Resistances to Chemical or Mechanical Stresses, Lower Permeability, Durability etc. as compared to normal concrete. For example, Self-Compacting Concrete is a specific part of High Performance Concrete, which distinguishes itself with self-consolidation properties coupled with high flowability.

Earlier, to fulfill the structural needs, cement content in the concrete mixture was increased in order to produce high-strength concrete. But it was done with least concern towards reducing the carbon footprint of the concrete as well as durability parameters. In this regard, as per IS – 456: 2000, maximum cement content has to be restricted to 450 kg/m³. With such limitation on use of cement, Supplementary Cementitious Materials (SCMs) such as Fly Ash, ground granulated blast furnace slag (GGBS), Silica fume (SF), Rice husk ash (RHA), Ultrafine slag and ultrafine flyash, etc. have been used to reduce the amount of total cement content and thereby produce sustainable concrete, without compromising on the performance part of concrete. Research has shown that addition of mineral admixtures to substitute Ordinary Portland Cement (OPC) in concrete results in more hydrated products and reduces the porosity as compared to conventional concrete.

**Composition of High-Performance Concrete**

HPC is comprised of the same materials as that of conventional cement concrete. The use of some mineral and chemical admixtures enhances the strength, durability, and workability qualities to a very high extent. The composition of HPC usually consists of the following materials:

1. **Cement**: Chemical and physical properties of cement can help in selecting the desired cement to produce high-performance concrete. For instance, cement with lower C3A is the most desired type of cement to produce high-performance concrete because the C3A creates incompatibility of cement with a superplasticizer. Nonetheless, a certain quantity of C3A is important for cement from a strength point of view.

2. **Water**: Water is a crucial component in HPC, and it should be compatible with cement and mineral/chemical admixtures. The water used for mixing and curing should be clean and free from injurious quantities of alkalis, acid, oils, salt, sugar, and any organic materials.

3. **Fine Aggregate**: Coarse fine aggregate is desired compared to finer sand to produce high-performance concrete,
since finer sand increases the water demand of concrete.

4. **Coarse Aggregate**: The selection of coarse aggregate is crucial since it may control the strength of high-performance concrete. It is advisable to avoid flaky and angular aggregates.

5. **Superplasticizer**: It is an essential component of HPC and is added to the concrete mix to reduce water to cement ratio.

6. **Cementitious Materials**: Ground Granulated Blast Furnace Slag is suitable for use in high-strength concrete at dosage rates of about 50% and above, based on the applications and performance requirements. However, for very high strengths of more than 100 Mpa, it is necessary to use the slag in conjunction with ultrafine materials like silica fume, Ultrafine slag, Ultrafine Flyash, Metakaolin etc.

   Fly ash has been used extensively in concrete for many years. Fly ash is, unfortunately, much more variable than silica fumes in both their physical and chemical characteristics. Most fly ashes will result in strengths of not more than 70 MPa. Therefore, for higher strengths, ultrafine SCMs must be used in conjunction with fly ash. For high strength concrete, fly ash is used at dosage rates of about 15 to 25% of cement content. Sometimes, quartz flour and fiber are the components for HPC for achieving high strength and ductility, respectively.

**Features of High-Performance Concrete**

- Compressive strength > 60 MPa
- Quite brittle but introduction of fibers can improve ductility
- Water binder ratio (0.25-0.35), therefore very little free water
- Densified cement paste
- Low bleeding and plastic shrinkage
- Less capillary porosity is achieved through use of low water to cementitious materials that produce dense micro-structure; so migration of aggressive elements would be difficult; hence, durability is improved greatly
- Stronger transition zone at the interface between cement paste and aggregate
- Low free lime content
- Low heat of hydration due to use of supplementary cementitious materials

HPC works out to be economical, even though its initial cost is higher than that of conventional concrete. This is because use of HPC in construction enhances the service life of the structure as it will suffer less damage, which would reduce the overall costs.
The swift shift in the dynamics of concrete during recent years have posed a lot of challenges for concrete technologists and concrete professionals across the globe. In the process of making modern concrete, one needs to pay greater attention not only to aspects such as the mix design but also to its performance with respect to handling, pumping, placing, finishing, and curing. Durability and sustainability are the buzz words now. Hence, its essential to have a better know-how on concrete making materials, such that one can extract the best potential from these ingredients.

Emerging trends in construction and construction practices demand a holistic approach by various stake holders of the construction industry for successfully specifying and making Urban Concrete. Alternative aggregates, requisites and remedies to make urban concrete, poor rheology, stickiness, workability retention, pumppability and placement of modern concrete are some of the major pain points, which need immediate attention. Advancements in concrete technology because of newly developed materials such as chemical admixtures have assisted in improving the properties of concrete and address most of the above-mentioned pain points.

Infrastructure is one of the important elements of economy. It comprises the basic framework, facilities, networks (Water, Sewerage, Transport, Power, Communications) and buildings that must function efficiently and improve the people’s standard of living. There are enormous renovation needs in developed countries, while in emerging markets, infrastructure and urbanization are essential for reaching their expansion goals. Another reason for a surge in infrastructure spending (encouraging urbanization) is the political will to boost economic prospects in as many regions as possible.

It’s time now for construction professionals to align with emerging technologies and make use of advancements in building materials, construction equipment and construction methods to address the needs of affordable housing, well-functioning infrastructure for water, traffic, energy, sanitary and waste treatment, environmental protection, Smart cities, Green Cities, efficient mode of transport, and so on. Due to the high demand for infrastructure, the construction industry needs more resources such as manpower, material and machineries. In such a scenario, resource efficiency is and will be a challenge for the construction fraternity.

Infrastructure Challenges For Ready Mix Industry

The ready-mix business is a diverse and demanding sector with its own requirements and challenges despite several technological advancements in the field of ready mix. Ready-mix operations are always local, with key factors such as financial resources and transportation playing a central role in decision making. Challenges include Operational challenges; Supply Chain challenges, and Technical challenges.

Strength, durability and place-ability are at the forefront of challenges faced by ready mixed concrete producers as well as the need for concrete that is aesthetically pleasing, more sustainable, and safer to use. Hence, there is a need for technologically advanced concrete admixtures for the ready-mix industry that meet industry codes and meet or exceed.
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the demands of challenging construction applications and adverse placement conditions.

One of the wishes from the wish list of ready-mix producers is to have the right Admixture partner with broad-based product solutions which can provide added value to increase the service life of concrete, enable speed of construction, bring environmental efficiency and liquid colouring products for aesthetically pleasing architectural concrete.

Innovative Admixtures & Technologies

Today, in the field of Concrete Technology, there is a revolutionary shift; any properties of Concrete (Green or Grey) can be achieved without difficulty. This has been aided due to the developments in the field of Construction Chemicals, especially in Admixtures. To quote Mr. V.M. Malhotra who 37 years ago had said: “There have been very few major developments in concrete technology in recent years. The concept of air entrainment in the 1940s was one; it revolutionized concrete technology in North America. It is believed that the development of superplasticizers is another major breakthrough which will have a significant effect on the production and use of concrete in years to come.” This has been proven correct.

Ready-mix concrete is characterized by a great number and variety of different mix designs. Utilizing different types of fillers, cements, and binders together with the increasing requirement for better performance and durability-based concrete specifications. At the same time, ready-mix producers must maintain their profitability in the face of rising materials, labour and equipment costs. As a result, producers are optimising their production and logistic costs. The innovative admixture systems from Master Builders Solutions of BASF, support these goals by providing the capability of delivering high-quality concrete at any time to the jobsite. This new concept facilitates the production of concrete with both extended workability and a low water/cement ratio. Cost savings in production may be realized through mix design optimizations for cement types and aggregate composition. As a result, these technologies enable ready-mix producers to optimize inventory, facilitate logistics, and reduce investments in tanks and dispenser equipment and thus also decrease maintenance costs.

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Admixture Solutions for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
<td>1. Higher Usage of Manufactured Sand</td>
</tr>
<tr>
<td></td>
<td>2. More Sustainable Concrete Mixtures</td>
</tr>
<tr>
<td>Mixing</td>
<td>3. Faster Mixing Times</td>
</tr>
<tr>
<td></td>
<td>4. Production of Ultra High Strength</td>
</tr>
<tr>
<td>Transit</td>
<td>5. Improved Slump Retention</td>
</tr>
<tr>
<td>Placing</td>
<td>6. Reduction of Concrete Stickiness</td>
</tr>
<tr>
<td></td>
<td>7. Easier &amp; Faster Placement of Concrete</td>
</tr>
<tr>
<td>Hardening</td>
<td>8. Faster Early Strength Development</td>
</tr>
<tr>
<td>Hardened Properties</td>
<td>9. Reduction in Shrinkage and Cracking</td>
</tr>
<tr>
<td></td>
<td>10. Replacement of Steel Reinforcing</td>
</tr>
</tbody>
</table>

Admixture tailored for extended workability retention

As shown in Figure 1c), SuperPlasticiser-Super Retaining Polymer (SP-SRP) contains a large amount of building block A, responsible for workability retention. Hence, the composition should qualify this admixture for RMC application where long transportation times are typically encountered, under severe conditions like hot weather or difficult aggregate or cement conditions. We decided to apply SP-SRP in a 30 MPa strength class concrete, where the designed slump upon delivery to site is 10-14 cm.

In this case, SP-SRP enables the RMC station to adjust initial slump at the batching station to the designed slump at delivery. The perfectly flat performance of SP-SRP ensures that, no matter when the concrete arrives at the site (as long as it is within 2 hours), the specification is matched.
Retarded Naphthalene based, however, cannot be treated that way. Due to the severe slump loss, the batching plant would have to adjust to a slump higher than the specification requires, with consequences for the mix proportion. Furthermore, due to the slope of the slump loss curve, the actual slump delivered on site is dependent on the actual transportation time, which makes it challenging to hit a tight specification like in the example given, and re-tempering at the jobsite eventually has to occur.

**Admixture tailored for precast applications**

Super Plasticiser-High Early Strength (SP-HES) molecules are rapidly adsorbed on the surface of the cement grains and act through electrostatic and steric repulsion to powerfully disperse the individual particles of cement.

The molecular structure of polycarboxylate ether polymers is essential for the early development of strength. With conventional PCE superplasticisers, the molecules cover the entire surface of the cement grain and build a barrier against contact with water. Therefore, the hydration process takes place slowly.

The unique, proprietary molecular structure of SP-HES exposes increased surface of the cement grains to react with water. As a result of this effect, it is possible to obtain earlier development of the heat of hydration, faster development of the hydration products and, as a consequence, higher strengths at very early age. This advantage can even be utilized at low temperatures.

The unique mechanism of this new polymer technology allows it to be adsorbed into the cement without inhibiting the hydration of the cement. Thanks to this technology, SP-HES exhibits 10-20% higher early strength development than traditional technology while providing good slump retention.

The composition of SP-HES indicates that the performance would be useful in precast applications, where workability retention requirement is often only for less than 1 hour, due to batching plant being in the proximity of the precast yard. In fact, SP-HES provided sufficient slump retention in the actual application under hot climate conditions. Applying SP-HES in a high slump concrete, leads to a slump loss not greater than 4 cm after one hour, even at 35°C ambient temperature. The slump retention of conventional PCE admixture, on the contrary, is only acceptable for approximately 20 minutes.

With the slump life extended, one would anticipate early strength is inferior in case of SP-HES. However, SP-HES shows not only equal early strength compared with conventional PCE, but after 28 days at standard curing conditions the strength exceeds the benchmark by 12%.

It is noteworthy, that due to the chemical nature of the mechanism of the new admixtures, its effect is quite dependent on the cement composition. Apparently, even though the early strength development can differ significantly, it is always improved, and differences are leveled out at later ages, where a strength increase of up to 15% can be expected, compared to conventional PCE admixture. The mechanism behind the difference in strength development, which is dependent upon the cement composition, is currently under investigation and remains unclear at this point of time.

**Admixture tailored for Concrete Rheology enhancement**

In case of Urban concrete, given the expected service life of structures, authorities and consultants specifies stringent durability requirement. In the process of making urban concrete, one needs to pay greater attention not only to aspects such as the mix design but also to its performance with respect to handling, pumping, placing, finishing and curing. Durability and sustainability are the buzz words in modern concrete world. Durability is at fore front in making urban concrete.

To achieve the desired durability requirements, concrete technologists must make use of higher amount of supplementary cementitious materials, ingredients like micro silica becomes an essential, lower water content in concrete mixes is mandatory. Such concretes with lower water and higher powder creates enormous challenges in batching and mixing of concrete. Longer mixing times reduces the operational efficiency and the concrete stickiness will be a major issue during pumping, placing and finishing of concrete.

The concrete technologist has limited options to reduce the stickiness of mixes given the lower water binder ratio and higher binder contents which are essential to achieve the desired durability parameters. This creates a demand for a solution to minimize the stickiness and hence Concrete Rheology is one of the important parameters when it comes to making urban concrete. An advancement in polymer science and the innovation know-how, scientists have developed a new generation of polymers bringing a significant improvement in the rheological properties of concrete.

Urban concrete mixes often demonstrate a higher viscosity due to their low water contents. Although having a high level of workability, the concrete often appears harsh, sticky and therefore difficult to pump and process. This is especially true for engineering concrete with low water/cement ratios optimized towards having a low environmental impact. To overcome these challenges BASF has developed MasterEase, a new admixture range developed for low-viscosity concrete. With the new technology, plastic viscosity can be reduced by up to 30%, which results in a substantial reduction of pumping pressure required to pump the concrete on the construction site.

Placing and finishing of the concrete is much easier, faster and hence more economic than using standard concrete. Ease stands for easiness of mixing, pumping, placing, leveling and finishing of concrete. Flexible and adaptable with improved workability retention Concrete producers and users benefit in many ways from the new technology. It is flexible and can be adapted to challenging situations such as temperature variations. Moreover, the high level of rheology and workability retention minimizes the risk of jobsite addition of water. This is a real added value for the contractors in terms of concrete durability. The concrete is easy to place, trowel and pump.

Utilizing this concrete save time and cost in every single construction project, it improves the utilization of the transportation fleet and equipment and reduces the wear of mixers, pumps and pipelines. In addition, the possibility to reduce mixing water even further without impacting the concrete rheology, opens new possibilities for improvement in concrete mix designs. Less water in concrete mixes implies higher performance and better durability. The new technology is particularly suitable
for concrete mixes which are optimized for advanced engineering properties and sustainability. High strength concrete with low water/cement ratios, as well as mixes with higher levels of secondary cementitious materials, reduce the CO2 footprint and are easier to produce and place. This helps engineers and investors to improve sustainability ratings of their projects.

**Admixture tailored for Concrete Strength Enhancement**

Given the fluctuations in concrete making materials and the concreting practices, achieving desired Concrete strength in modern days is a new challenge. Inferior Concrete workability at time of placing encourages the workforce for addition of water, which in turn reduces the concrete strength. Inconsistency in concrete making ingredients and variations from batch to batch of materials is a major pain point for Concrete professionals. The necessity of switching to alternative ingredients such as natural/river sand to crushed rock fines/manufactured sand impacts a lot on concrete strength, if appropriate changes in concrete mix design are not adopted.

Urban concrete and its durability requirements will demand higher replacement of Supplementary cementitious material. Not only the higher replacement of Supplementary cementitious material but also to accommodate the inconsistency of these materials, concrete professionals need a whole new approach of mix design to achieve the desired strength of concrete. Hence a robust solution to address the concrete strength issues is need of the hour.

With the advancement in chemistry and concrete admixture science, BASF Mater Builder solutions have developed, a revolutionary technology that refines concrete strength and durability. It allows concrete producers to expand concrete performance while reducing the environmental impact. Master X-Seed STE is an innovative strength-enhancing admixture solution for the construction industry, which significantly improves both early and late-age strength development in concrete. The new solution, Master X-Seed STE, also helps make production of concrete more efficient.

The concept originated from BASF’s X-Seed, a unique seeding technology used to promote cement hydration and speed up concrete hardening. Master X-Seed STE further enhances concrete’s strength development and performance characteristics. Specially formulated for Asia Pacific concrete market, Master X-Seed STE admixture utilizes calcium silicate hydrate (CSH) nanoparticles, along with other technologies (admixture solutions), to facilitate and improve strength development at all ages of the concrete. Master X-Seed STE enables the increased use of supplementary cementitious materials, thus helping to reduce carbon footprint associated with concrete production. Master X-Seed STE admixture allows concrete producers to expand the performance space of a given concrete mixture and optimize the cementitious content, by permitting a strength safety factor up to 15%. This allows earlier stripping of forms to improve production efficiency. It is recommended for use in ready-mixed and precast concrete and Self-Consolidating Concrete (SCC).

**Concluding Remarks**

While we build more and more urban cities to accommodate the needs of future urbanization, concrete and its importance as a building material cannot be denied. In fact, the innovative use of concrete can only add to its importance in coming times. For Infrastructure business to increase its commercial viability and its relevance, contractors and builders need to look beyond the traditional boundaries defined by existing construction practices, market segments and the built structures. A holistic approach by all the stakeholders in the construction industry is required to address the urban construction and concrete challenges.

New and rapid developments in nano chemistry can certainly aid in the progress of concrete technology. This, in turn, can make the construction processes more efficient, faster and economical. Admixtures have the potential to minimize costs related to wastage and energy usage. More importantly, these factors contribute towards achieving good construction practices with lower carbon footprints.

Cost and time savings remain the twin objectives of the project owners, developers, contractors, and ready-mix companies. Today, the construction industry awaits a breakthrough solution that addresses the escalating need for speed and sustainable development. Modern architecture, large scale and high-rise constructions demand building materials that provide durability and energy efficiency. The innovative admixture technology will be the driving force for the development and growth of infrastructure. The Master Builder solutions from BASF meet most of the challenges and requirements.

The construction industry professionals need to look at newer, more energy efficient, environmentally friendly materials and technologies that minimize skilled inputs and deliver faster results at affordable prices.

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27th Conference on OUR WORLD IN CONCRETE & STRUCTURES: 29 - 30 August 2002, Singapore


Concrete, being a physical mixture of cement, aggregate (sand and crushed rocks), and water, is the key construction material across the world. There is now a huge demand for infrastructure which has increased concrete consumption to a great extent. The demand for concrete has led to various researches to develop High Performance Concrete (HPC) by improving its two major characteristics: strength and durability. Higher strength concrete demands higher cement content (600 kg/m³ to 700 kg/m³) which is not allowed as per the IS code, as it increases the heat of hydration, resulting in the formation of thermal cracks and thereby deteriorating the performance of the structure. Increase in OPC content means increased carbon footprint which is hazardous to the environment. Keeping sustainability as the prime factor, the present work is performed using Ground Granulated Blast Furnace Slag (GGBS) as the Supplementary Cementitious Material (SCM), which is a waste by-product from steel industries. In this study, four grades of concrete were designed with the powder content ranging from 550 kg/m³ to 700 kg/m³ of which about 40% of OPC was replaced by GGBS, to produce sustainable and economical high-performance concrete. Crushed stone sand is used instead of natural river sand; and 12.5mm downsized coarse aggregates and PCE based Superplasticizer are used as the other ingredients in the design. Fresh and hardened properties such as workability, compressive strength, tensile strength, and flexural strength of concrete are evaluated by standard test methods. From the study, it can be observed that 40% replacement of OPC by GGBS renders the desired properties without causing any adverse effect. Concrete is being used for a variety of purposes to make it withstand different atmospheric conditions. In such cases, ordinary concrete may not exhibit the required quality performance and durability. Concrete properties like high strength and high-performance demands greater cementitious material, but it is known that to reduce the carbon footprint of the concrete and as per IS – 456:2000, the maximum cement content has to be limited to 450 kg/cum. Also, increasing the cement content alone will not only increase the cost of concrete per m² but also increase the heat generated during hydration, and shrinkage cracks in the initial period itself. These issues can be addressed by incorporating supplementary cementitious materials (SCMs) such as Fly Ash, Ground granulated blast furnace slag (GGBS), Silica fume (SF), rice husk ash (RHA), etc. to replace OPC in a compressive way and hence produce environmentally sustainable concrete. Therefore, great attention has been paid to produce HPC with less cost and lower emission while providing the equivalent properties.

The concept of high strength concrete (HSC) started during the 1970s due to the demand for speedy construction. In many instances, HSC typically consists of a high cement content resulting in the high heat of hydration and shrinkage cracks. Only the strength criterion is not sufficient to decide the quality of concrete but durability should also be considered. This is the key factor to focus on the concept of high-performance concrete (HPC). The raw materials for both HSC and HPC are the same, but the knowledge about the materials, their properties and their interaction plays a very important role in making HPC differ from HSC. Researchers started using industrial by-products (which are pozzolanic/cementitious in nature) in concrete so that the problem of high cement content along with high carbon footprint is solved to a greater extent.

GGBS is one of the promising cementitious materials that can be blended with Portland cement for production of durable concrete, and at the same time, it is a value-added product. Addition of GGBS to Portland cement not only improves the early strength of concrete but also forms a calcium silicate hydrate (CSH) gel around the cement particles which is highly dense and less porous. This may increase the strength of concrete against cracking. GGBS is used as a direct replacement for Portland cement, on a one-to-one basis by weight. Replacement levels for GGBS vary from 30% to 85%. Typically, 40 to 50% is used in most cases.

Applications of HPC

HPC offers various application opportunities for infrastructure work, building construction, and many non-structural products which are of architectural importance. Within the last two decades, research projects have been extensively conducted across the world to industrialize HPC technology as the future sustainable construction material. Around 200 bridges have been constructed using HPC in one or more of its components. Few other areas of application include building components such as sunshades, cladding, and roof components. HPC is preferred in the precast industry as it can produce light, slender, durable, and aesthetic structures. It is also widely used as an overlay to the existing concrete structures, thus improving its mechanical and durability properties, resulting in lesser maintenance work. It is used in marine construction as well due to its great resistance to aggressive agents. UHPC has become an innovative and economical solution in many areas where conventional concrete has been a struggle.
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Objectives

The objective of the research is to develop High-performance concrete (HPC) using mineral admixture GGBS contrary to the traditional method of using pure OPC cement in concrete production with the following key factors in mind while designing the concrete mixes. GGBS Produced from JSW Cement was used in the current study. Key factors in developing high-performance concrete are:

- Need for early strength for early de-moulding to increase productivity.
- High Flow requirement.
- Improve Surface finishing.
- Compatibility with cement replacements.

Materials and Proportion

Normally, HPC is composed of the following components: Ordinary Portland Cement (OPC), fine aggregates, coarse aggregates, mineral admixtures, chemical admixtures like superplasticizers and water. OPC 53 conforming to IS 12269-2013 was used in the present investigation. Crushed Stone Sand (CSS) is used as fine aggregate and 12.5mm downsize coarse aggregate (retained on 4.75mm sieve) of granite origin is used as coarse aggregates. GGBS which is a by-product from steel plant is used as Supplementary Cementitious Material. Superplasticizer is used as a chemical admixture which aids to reduce the water content in the concrete and to reach the required workability of HPC. In this work, a different proportion of GGBS has been used to form the HPC, and the strength is calculated through the compressive strength and split tensile strength.

Ground Granulated Blast Furnace Slag (GGBS)

GGBS, being the by-product from blast furnace, contains cementitious properties. To develop ultra high-performance concrete, higher cement content (>600kg/m³) is required, which in turn, results in higher heat of hydration. To overcome this and to increase durability, cementitious materials such as GGBS can be used as the partial replacement for the % cement volume. Replacement levels for GGBS may vary from 20% to 70%. Typically, 40 to 50% is replaced in most instances. For the present study, GGBS is procured from JSW, meeting the requirement of IS 10289:1987 and properties are as shown below.

<table>
<thead>
<tr>
<th>Table 2.1: Properties of GGBS</th>
<th>Brand</th>
<th>JSW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Particle size (µ)</td>
<td>0.1 to 40</td>
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</tr>
<tr>
<td>Fineness (m²/kg)</td>
<td>360</td>
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<tr>
<td>Bulk Density (kg/m³)</td>
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<tr>
<td>Colour</td>
<td>Off white</td>
<td></td>
</tr>
</tbody>
</table>

GGBS has similar surface morphology as that of cement showing finer yet angular and non-spherical particles. Figure 3.2 shows the SEM image of GGBS sample.

Mix Proportion

Developing High-Performance Concrete requires careful selection and a good understanding of the materials to be used, basic properties and its behaviour when used in concrete. It is a well-known fact that voids in concrete inhibit its mechanical properties; hence, it is necessary to keep the volume of voids as less as possible. Taking this into consideration, concrete mix was designed by absolute volume method considering least voids of aggregates as the volume of paste.

The least voids possible for different percentage combinations of CA and FA blended together are studied initially. To begin with, the specific gravity and density of different percentage combination of coarse and fine aggregates were calculated and then by using the formulae percentage voids is calculated. The formulae used to calculate % voids is

\[ \text{Percentage voids} = 100 \times \left( \frac{G - \gamma}{G} \right) \]

Where,

- \( G \) = Specific gravity of aggregate,
- \( \gamma \) = Bulk density of aggregate in g/cc. [IS 2386 (III)]

The percentage of the least void obtained was 20.35% for the combination of 47:53 (CA: FA) by adopting the above-mentioned procedure. Based on the least void established by aggregate proportioning, the paste content was varied from 27% onwards. On performing repeated trials 36% to 39% of paste volume provided the optimum results, hence the volume of paste (Vp) for concrete mixes was fixed at 36% to 39%.

Four different grades of concrete were designed, with cement content varying from 380 Kg/m³ to 450 Kg/m³. But to obtain HPC/ UHPC the cement content should be as high as 600 Kg/m³ and above. The permissible limit of cement content per meter cube as per IS 456: 2000 is 450Kg/m³. Therefore, it was necessary to replace some amount of cement with mineral admixtures. As per IS 10262: 2019 about 25% to 50% of the total cement can be replaced by GGBS. Hence in the present study, about 40% of the cement was replaced by GGBS, taking care that paste volume remains in between 0.36 to 0.39. Mix designs are performed using a volumetric approach.

Results

Flow and Compressive Strength

High-performance concrete is not only about strength, but it is also about other parameters of concrete. In the present work, flow values above 600mm were achieved without compromising with the strength parameter of HPC. Even by keeping the water to cement ratio as low as 0.23, we were able to achieve the flow of 680mm without any segregation or bleeding.
Compressive strength is the measure of the capability of the concrete to carry the load without any cracking or deflection. The test was performed using Compression Testing Machine (CTM) conforming to IS 14858, which is of 3000KN capacity. The test was conducted at 1 day, 3 days, 7 days and 28 days as per IS 516:2018. Cubes of size 100*100*100 mm were tested at a loading rate of 14 MPa per minute. Satisfactory results were achieved in all four grades of concrete and the compressive strength results are as shown in the table below.

<table>
<thead>
<tr>
<th>Mix</th>
<th>Flow (mm)</th>
<th>Compressive strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1day</td>
<td>3days</td>
</tr>
<tr>
<td>M1</td>
<td>640</td>
<td>11.02</td>
</tr>
<tr>
<td>M2</td>
<td>690</td>
<td>13.25</td>
</tr>
<tr>
<td>M3</td>
<td>650</td>
<td>15.06</td>
</tr>
<tr>
<td>M4</td>
<td>680</td>
<td>24.25</td>
</tr>
</tbody>
</table>

Split Tensile and Flexural strength
Split tensile strength test was conducted based on the IS: 5816:1989 on cylindrical specimens of 100mm diameter and 200mm height. The test was performed on Compression Testing Machine conforming to IS 14858. Tensile strength is a measure of maximum load at which the concrete may crack. It is directly correlated with the compressive strength.

Flexural strength is the measure of the ability of a concrete member to resist bending failure. The test was conducted on the beam specimen of dimension 500mm*100mm*100mm. Strain Controlled Flexure Testing Machine was equipped to conduct the test.

<table>
<thead>
<tr>
<th>Mix</th>
<th>28 days Split Tensile Strength (MPa)</th>
<th>28 days flexural strength (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>5.27</td>
<td>5.31</td>
</tr>
<tr>
<td>M2</td>
<td>5.34</td>
<td>6.22</td>
</tr>
<tr>
<td>M3</td>
<td>6.17</td>
<td>7.18</td>
</tr>
<tr>
<td>M4</td>
<td>6.93</td>
<td>8.63</td>
</tr>
</tbody>
</table>

Conclusion
One should plan to utilize mineral admixtures like GGBS in the construction industry to make it financially savvy and eco-friendly. We could achieve the desired concrete products with all the quality prerequisites. Components with good surface finishing can also be achieved. We can even increase the quantity of GGBS by reducing the OPC content in concrete. This will spare the characteristic assets from diminishing ozone-depleting substances and CO2 discharges.

- The adopted method of obtaining HPC with least voids of aggregate is beneficial in achieving high strength concrete even with as less as 380kg/m³ of Cement content.
- Using GGBS as SCM proved to be beneficial in achieving HPC with flow greater than 600mm without any segregation or bleeding.
- Targeted compressive strength is achieved for all the grades of the concrete easily by using GGBS.
- It is evident that even with OPC content of 450 Kg/cum, we can achieve 100 MPa concrete with the help of GGBS.
- Concrete also behaves satisfactorily well in tensile and flexural parameters when GGBS is incorporated in the mix.
- Use of GGBS not only enhances the quality of concrete but also gives commercial benefits as its cost is way lesser than OPC.

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Codal References
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- IS 5816:1999- “Methods of Test Splitting Tensile Strength of Concrete”, BIS, New Delhi.
- IS 516-2018, "Methods of tests for strength of concrete".
India has been using age-old methods of construction, depending largely on traditional construction, and using natural materials like wood, slates and other stones, bamboo, etc. Some mechanization came in the last 2-3 decades after liberalization and globalization.

But it is still a long way to go before we achieve our targets. There is a shortage of trained manpower in the construction sector, particularly, skilled manpower.

Apart from the requirement of housing, there is an urgent need to provide better sanitation, potable water, communications, better road connectivity, telephones, railways, water ways, flyovers, metro rail corridors, ports, bridges, airports, uninterrupted water and power supply, etc.

Types of Construction

There are several types of construction like:

- Traditional (Built at site)
- Precast
- Prefabricated
- Pre-engineered
- Modular

Traditional (Built at site)

As the name implies, the term “traditional” implies the construction done by assembling materials at the construction site and engaging the work force to do the linear construction. Each step of construction is not only constructed entirely (or largely) at site but needs to be completed before the project moves on to the next phase. The conventional method of building a house is to transport bricks, timber, cement, sand, steel, and construction aggregate, etc. to the site, and to construct the house on site from these materials.

Precast

While in traditional construction, the concrete is cast in-situ, in precast construction, the concrete is cast at another location, either at the building site or in a factory, transported and lifted to its final resting place and fixed securely. This means that unlike cast-in-situ construction, which is monolithic or continuous, precast concrete buildings are made of separate pieces that are connected or bolted together.

Prefabrication

Prefabrication flourished during the prehistoric times as an innovative creation, and showed the way to future developments. The cultural background and period of construction are easily recognized from the materials used, the construction techniques, and the architectural style. The evolution of prefabricated construction is noticeable by observance of the original ancient models that continued over centuries. Different techniques and materials have been adopted since ancient times for the construction of buildings and the processes have evolved along with the skill.

The Process and Theory of Prefabrication

In prefabricated construction, only the foundations are constructed at the site, while sections of walls, floors and roof are prefabricated.
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(assembled) in a factory (possibly with window and door frames included), transported to the site, lifted into place by a crane and bolted together. Prefabrication is used in the manufacture of ships, aircraft and all kinds of vehicles and machines where sections previously assembled at the final point of manufacture are assembled elsewhere, before being delivered for final assembly.

The theory behind the method is that time and cost is saved if similar construction tasks can be grouped, and assembly line techniques can be employed at a location where skilled labour is available, while congestion at the assembly site, which wastes time, can be reduced. The method finds application particularly where the structure is composed of repeating units or forms, or where multiple copies of the same basic structure are being constructed. Prefabrication avoids the need to transport large numbers of skilled workers to the construction site, and other restricting conditions such as lack of power, lack of water, exposure to harsh weather or a hazardous environment are avoided. Against these advantages must be weighed the cost of transporting prefabricated sections and lifting them into position as they will usually be larger, more fragile and more difficult to handle than the materials and components of which they are made.

**History of Prefabrication**

It might sound like a technological advancement in the modern world, but the fact is that the prefab method is one of the oldest known construction methodologies and the most versatile. Over the years, there have been modifications in its perception and execution as per the local materials available and the impact on the environment.

**Pre-historic**

The earliest known civilizations, i.e. the Stone Age, Bronze Age and Iron Age had limited construction materials and little construction experience, so caves were used as shelters. Later, with the use of tools, tents began to be built of bones, stones, wood, grass and animal fibers. It was while making the tools that the early man realized the technique of fixing and jointing.

**Sri Lanka (3000 BC)**

![Figure 1: Vatadage Temple, Polonnaruwa](image)

**Sinhalese Structures** (3000-2000 BC) (Temples) specially in the Kingdom of Anuradhapura and Kingdom of Polonnaruwa. The components of the building were prepared individually offsite and then assembled at site.

**B. River Valley Civilization**

- MESOPOTAMIA (2500-600BC)
- Stone Henge, England (3100-Neolithic Period)
- The Sweet Track, England (3800-Neolithic Period)
- Egyptian Civilisation: 3000-100 BC (Prefabricated stone slabs & stone blocks)

![Figure 2: Stone Henge](image)

![Figure 3: The Sweet Track – Prefabricated timber logs](image)

![Figure 4: Construction with mud Blocks](image)
• EGYPTIAN CIVILIZATION (3000-100BC)  
• River Valley Civilisation: 2500-600 BC: Dry wall construction (Palaces, temples, ziggurats), bridges by using wooden logs

C. Historic  
• Vedic-Aryan Civilisation: 1500-500 BC (Huts built by using timber, bamboo and temples built with stone for columns and beams)

• Roman forts (Built with pre-assembled stone blocks)  
• Atlantic to American Colonisers: 16th Century AD (Panelised timber houses shipped from UK/Europe to America)

• 18th Century AD (i) Great Lisbon earthquake of 1755-a new Pombaline style of architecture and urban planning arose, which introduced early anti-seismic design features and innovative prefabricated construction methods, according to which large multistory buildings were entirely manufactured outside the city, transported in pieces and then assembled on site.  
(ii) The town of Vila Real de Santo António was constructed using prefabricated construction in about 3 years.

• 19th Century:  
  o Crystal Palace London: 1851 (Elements partially prefabricated on the ground & then lifted up) using iron and glass.
  o Eiffel Tower: 1889 (Prefabricated iron elements)

• 20th Century:  
  o Between the World Wars 1 & 2  
  o After World War 2

Many eastern European countries had suffered physical damage during World War II and their economies were in a poor state. There was lot of damage in the UK and in Western European countries too. There was a need to quickly reconstruct cities which had been severely damaged due to the war. Prefabricated buildings served as an inexpensive and quick way to alleviate the massive housing shortage associated with the wartime destruction and large-scale urbanization. Various building systems were developed in the process.
However, these houses were mainly utilitarian and there was hardly any sound architectural systems used. They had some inherent defects but lived longer than expected.

The post-war prefabricated buildings, especially those built using light systems, were seen to deteriorate extensively, and increasingly failed to meet minimum waterproofing and fire safety requirements, among others.

Two instances of accidents in prefabricated houses led to the unpopularity of the prefabricated houses:

- A fire in a residence for the elderly built in England in 1974
- The collapse, due to a gas explosion, of a 24-story block of flats constructed with precast panels in Ronan Point, London in 1968.

The 1980s: There was a new emphasis on the added value of industrialized architecture and technologies; these included the ability to provide higher quality within minimum construction timeframes, increased possibilities for customization.

The 1990s: Totally mechanized construction systems developed and applied, such as the Japanese T-UP system.

21st Century:

The 2000s: prefabricated architecture saw many initiatives to reduce environmental impact and development of improved prefabricated systems. The enhanced sustainability features led to increased costs in the new prefabricated products and technologies and efforts have been put to reduce the costs.

New products have the following advantages:

- They incorporate local and natural materials
- Allow the possibility of disassembling and reusing even the foundations
- Solve integral rehabilitation of façades for better environmental performance of a building
- Offer reasonably priced homes to internationally accepted standards.

Moreover, advances in Computer Numerical Control (CNC) technologies and building information modeling (BIM) research and software tool have led to improvements in prefabricated construction.

Prefabrication in India

Prefabrication in India began with the emergence of the Hindustan Housing Factory (HHF). The company was set up as a solution to the housing crisis that resulted from the influx of refugees from West Pakistan in the 1950s. It is now known as the Hindustan Prefab Limited or HPL. When the company was set up, it was intended to produce low-income housing solutions.

Pre-Engineered Buildings

The PEB is a suitable construction technique for developing countries. It is a combination of precast and prefabricated structures. PEBs are generally low-rise buildings meant for offices, houses, showrooms, shop fronts etc.

PEBs reduce total construction time of the project by about 40%. This allows faster occupancy and earlier realization of revenue.

In structural engineering, a PEB is designed by a PEB supplier or PEB manufacturer and is fabricated using the best suited raw materials and manufacturing methods that can efficiently satisfy a wide range of structural and aesthetic design requirements. Within some geographic industry sectors these buildings are also called pre-engineered metal buildings (PEMB) or, as is becoming increasingly common due to the reduced amount of pre-engineering involved in custom computer-aided designs, simply Engineered Metal Buildings (EMB).

These buildings can be optimized to meet specific design criteria and are purpose-built such as hangers for aircraft, warehouses, manufacturing and repair facilities, captive power plants, cold storages, office buildings, hospitals, living shelters etc. In automotive manufacturing plants, high altitude living shelters and cold storages, considerable economies have been registered by such optimized designs.

The term PEB was coined in the 1960s. Typically, this metal building consists of light gauge metal standing seam roof panels on steel purlins spanning rigid frames with light gauge metal wall cladding. In other words, it has a much greater vertical and horizontal deflection.

In building a regular steel structure, the time frame will be more, and the cost will be higher. In a pre-engineered building, the complete design is done in the factory, and as per the design, members are pre-fabricated and then transported to the site where they are erected within 6 to 8 weeks.

The first rigid-frame buildings introduced in the late 1940s could span only 40 ft. In a few years, 50-, 60-, and 70-ft buildings became possible. By the late 1950s, rigid frames with 100-ft spans were made; ribbed metal panels became available, allowing the buildings to look different from the old tiered corrugated types.

When collared panels were introduced by a US company in the early 1960s, it permitted some design customisation. At about the same time, continuous span cold-formed Z purlins were invented. The first factory-insulated panels were developed, and the first UL-approved metal roof appeared on the market. The first computer-designed metal buildings also made their debut in the early 1960s.

With the advent of computerization, the design possibilities became almost limitless. All these factors combined to produce a new metal-building boom in the late 1950s and early 1960s. As long as the purchaser could be restricted to standard designs, the buildings could be called pre-engineered.

Benefits

- Optimised design of steel reducing weight
- Easy future expansion/modification
- Voluminous space (up to 60M clear spans, 30M eave heights)
- Weather-proof.
- No fire hazards
- International quality standards
- Seismic & Wind pressure resistant.
- Quality design, manufacturing, and erection
- Quick delivery and quick turnkey construction.
Types of Construction

- Architectural versatility
- Energy-efficient roof and wall system using Rockwool & PUF insulation.
- Water-tight roofs & wall coverings
- Pre-painted and low maintenance
- Easy integration of all construction materials
- Fast erection of the building
- Can be dismantled and relocated easily.
- Future extensions can be accommodated without much hassle.

Applications

Applications of pre-engineered steel buildings include (but are not limited to) the following:

- Houses • Factories • Warehouses • Sport Halls • Aircraft Hangers
- Supermarkets • Workshops • Distribution Centres • Commercial Showrooms • Restaurants • Office Buildings • Labor Camps
- Petrol Pumps/Service Buildings • Schools • Community Centres
- Railway, Metro & Bus Stations • Equipment housing/shelters
- Telecommunication shelters • Almost any low-rise building

Modular PPVC

Prefabricated Prefinished Volumetric Construction (PPVC) is a construction method whereby free-standing 3-dimensional volumetric modules (complete with internal finishes for walls, fixtures, fittings, floors and ceilings) are constructed and assembled, or manufactured and assembled. In an accredited off-site fabrication facility, in accordance with any accredited fabrication method, they are transported and then installed in a building under building works.

Key benefits of PPVC

- Speeds up construction and achieves a productivity improvement of 35-50% in terms of manpower and time savings, depending on complexity of the project.
- Dust and noise pollution is minimized as more activities are done off-site.
- With the bulk of the installation activities and manpower moved off-site to a factory-controlled environment, site safety is improved.

Productivity Improvement

- Fabrication of PPVC in the factory can proceed alongside other ongoing worksite activities to streamline the construction process.
- The on-site construction activities can be significantly reduced through use of PPVC.
- It can potentially achieve a productivity improvement of 35% to 50% in terms of manpower on site and more than 20% in time savings, depending on complexity of the project.

Better Construction Environment

- As more activities are done off-site, there is reduced environment pollution as dust and noise are minimised.
- Reduced disturbance to the surrounding neighborhoods during construction.
- Prefabrication of the building modules leads to cleaner worksites by generating less overall construction waste on-site.

Reduction of Onsite Manpower

- This will enhance worksite safety and direct the manpower to better working conditions. More construction off-site leads to less time on-site and fewer individual man-hours working at height.
- By reducing construction and installation activities and manpower from the site, and placing them off-site in a controlled factory environment, fewer workers will be on site, which in turn leads to fewer accidents and less downtime.

Better Quality Control

- PPVC delivers most of the final product from a controlled factory environment leading to increased reliability with higher quality finishing.
- Sequence of work can be planned more efficiently with better logistics coordination.

Application of PPVC

PPVC can be considered for building multi-room accommodations such as:

- Residences • Institutions • Hotels and hostels
- Nursing homes • Dormitories

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[8]. https://en.wikipedia.org/wiki/Prefabrication
Traditional masonry units are not sustainable and eco-friendly due to consumption of fuel or cement. It is essential to find sustainable alternatives. This paper reports about preparation of geopolymer bricks, masonry prisms and wallets using flyash, GGBS and M-sand which were cured in open air. They were tested for compression, water absorption, initial rate of water absorption, dimensionality and modulus of elasticity etc. It was found that the properties of geopolymer bricks were superior to the traditional masonry units. Masonry efficiency increases with the thickness of geopolymer mortar. The compressive strength of axially and eccentrically loaded masonry wallets was found to be 1.9 and 1.6 MPa respectively. Hence, they can be recommended for structural masonry.

Masonry units are the main component of a masonry structure. They fill up the bulk of the space in the structure. They play a major role in the compressive strength of masonry and in resisting the structural loads [1]. There are many types of masonry units, for example, burnt clay bricks, hollow and solid concrete blocks, stabilized mud blocks etc. They are selected based on the consideration of required compressive strength, accessibility, cost and ease of construction [2]. Cement is the chief ingredient for manufacturing concrete blocks. Production of one tonne of cement liberates approximately same amount of carbon-di-oxide to the atmosphere. Cement industries are responsible for 5% of the total CO2 emissions and are subsequently responsible for 4% of the manmade global warming [3]. Due to increase of green house gas emissions, the consumption of cement needs to be reduced. Geopolymer technology is one in which conventional cement can be replaced by products such as fly ash and GGBS. Geopolymer is the term coined by professor Joseph Davidovits for the family of high alkali (K-Ca)-poly-(Sialate-siloxo) binders formed in a reaction called as geopolymerization resulting in three dimensional zeolitic frameworks [4]. Geopolymers are the family of binders formed using alkaline solutions and alumino silicates like fly ash, Ground granulated blast furnace slag (GGBS), resulting in three dimensional aluminosilicate polymeric gel. Geopolymers are environment-friendly as they make use of industrial by-products and eliminate the use of conventional cement.

Radhakrishna has reported that, it is also possible to manufacture geopolymer masonry units using class F fly ash by open curing [5-9]. Kunal et al. have reported that the extent of alkali silica reaction in flyash based geopolymers is relatively less than that of conventional concrete [10]. Other researchers have studied the optimum dosage of flyash and concluded that the bricks attained the highest compressive strength when 20% of clay was replaced by flyash [11-14]. It is reported that the bricks were porous, light weight, had low thermal...
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conductivity and satisfactory compressive strength [15]. Anastasias et al reported the masonry prisms exhibited 10 times more strength than the mortar [16-18]. Though there is considerable research reported on brick and block masonry, the production of these masonry units is not sustainable. Hence there is a need to develop alternative masonry units, one of which can be geopolymer unit. This paper addresses the technology of making geopolymer units, prisms and wallets.

**Objectives of the Research**
1. To determine the properties of geopolymer masonry units.
2. To evaluate the properties of geopolymer masonry prisms.
3. To determine the properties of the geopolymer masonry wallets.

**Materials and Methods**
The following materials were used to prepare geopolymer masonry bricks:

i. Class F Fly ash and Ground granulated blast furnace slag (GGBS),

ii. Manufactured sand of zone II having specific gravity of 2.55.

iii. Recycled water

iv. Commercially available Sodium hydroxide and Sodium silicate.

Low calcium Class-F fly ash and ground granulated blast furnace slag (GGBS) were used as binders. The specific gravity of fly ash and ground granulated blast furnace slag were 2.40 and 2.90 respectively. 8 molarity alkaline solutions were prepared having Sodium hydroxide to Sodium Silicate ratio of 1:1.5. The ratio of solution and binder was maintained at 0.2. Fly ash, GGBS and manufactured sand were mixed thoroughly in dry condition. Alkaline solution was added to the dry mix to get fresh geopolymer mortar. The aggregate to binder mix ratio was 1:1. The percentage of fly ash to GGBS was 80:20. Brick making compression machine was used to cast the geopolymer bricks. The geopolymer bricks were cured in ambient temperature. These bricks were tested for compression, Initial Rate of absorption [IRA], density, waster absorption, dimensionality and modulus of elasticity. They were also tested for alternative drying and wetting.

The microstructure of the bricks was also analyzed. The geopolymer masonry units were tested and the masonry effciency for the prisms was also evaluated. Masonry prisms and wallets were constructed using geopolymer brick and conventional cement mortar/geopolymer mortar as the case may be. They were tested for axial and eccentric loading. Recycled water was tested for different parameters.

**Results and Discussion**
The results of water absorption test and density of the bricks are shown in Table 1. It was found that the water absorption of the masonry units was 8.25% which is considerably less compared to the conventional bricks [17]. The density of the masonry units ranges from 1800 to 2000 kg/m³ which are at par with the traditional masonry units. IRA of geopolymer bricks at 28 days was found to be less than 5% which indicates that the masonry mortar will have good water retentivity [17]. These properties are much less than the value specified in IS 2185: 2005.

The dimensionality test of the masonry units was conducted as per IS 1077:1992. The test results are shown in Table 2. It was found that the variations (dimensions) of the bricks are within the permissible of codal provisions.

The variation of the compressive strength of the masonry units with age is shown in Fig. 1. It was observed that the compressive strength of the masonry units at the age of 24 hours is more than 5 MPa. This order of strength would be sufficient to handle the masonry units for various purposes. Also, the minimum compressive strength for a brick is 3.5MPa at the time of using them in masonry construction [17]. The strength increases with age ranging from 5-22 MPa for the masonry units. This high strength of masonry units can be recommended for high raised buildings by avoiding framed structures.

Scanning Electron Microscope image of 8M NaOH brick is as shown in Fig.3 at the age of 28 days. Microstructure shows the presence of some unreacted flyash particles and aluminosilicate gel phases. The unreacted flyash particles were of size less than 2µm. Low molarity of alkaline solution may not have been influenced by all the fly ash available. There is a possibility of activating these particles at higher molarity and develop higher strength.
The compressive strength was evaluated after completion of 7 cycles of alternative drying and wetting test. The typical variation in the weight of geopolymer brick are represented in Fig. 4. It was found that percentage weight gain after 7 cycles was 5.20% and the percentage of reduction in strength of geopolymer brick was 26.66%. These properties are comparatively better than the traditional masonry units [17].

The test setup for the geopolymer masonry prisms are shown in Fig. 5. The variation of compressive strength and masonry efficiency for geopolymer prisms with geopolymer mortar and geopolymer prism and cement mortar is shown in Fig. 6 and 7 respectively. It was observed that the masonry efficiency and strength were increased with the increase in mortar thickness in geopolymer prisms with geopolymer mortar joints. Whereas, the efficiency and strength increased as the mortar thickness reduces for prisms with cement mortar. The vertical cracks were developed from top of a brick and it propagates till the bottom of the brick in the prism. It was observed that bottom most brick was crushed to considerable extent.

The normalized stress strain curves for the geopolymer masonry prism with geopolymer mortar are shown in Figs. 8 (a), (b) & (c) and the geopolymer prisms with cement mortar joints are shown in Fig. 9 (a), (b) & (c) respectively [18]. It was observed that the...
young’s modulus increased with the increase in mortar thickness in geopolymer prisms with geopolymer mortar joints. Whereas the young’s modulus increased as the mortar thickness reduces for prisms with cement mortar.

The test setup of geopolymer masonry wallets are shown in Fig 10. It is observed that the average compressive strength of the axially loaded and eccentrically loaded wallets was 1.99 and 1.66 MPa respectively. It is comparatively higher to the conventional block wallets of same geometry [18]. The vertical cracks were developed from top of a wallette and propagated till one third of the height from top of the wallette as shown in Fig. 13(b). This behaviour is in line with any masonry wallet.

The normalized stress strain curve for the geopolymer masonry wallettes with cement mortar are shown in Figs. 11 (a) & (b) and the modulus of elasticity for the axially loaded and eccentrically loaded wallettes was found to be 3528 and 2791 MPa respectively.

Following are broad conclusions based on the limited study on geopolymer masonry:

• The compressive strength of geopolymer brick attains more than 5MPa within 24 hours which influences the user to handle without any issues.
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• The water absorption, initial rate of water absorption, dimensionality, alternative drying and wetting method and modulus of elastic of the units were well within the limits prescribed in the relevant codal provision.

• Geopolymer mortar can be used as mortar in building masonry structures as it exhibits better compressive strength than cement mortar. Its compressive strength was higher than that specified in IS 2250-1981.

• The use of geopolymer bricks and cement mortar joints have a great influence in the preparation of masonry units.

• The performance of the axial and eccentrically loaded wallette was found to be superior compared to the conventional cement brick masonry. They satisfy the requirements of IS 2185:2008 (part 4)

Acknowledgement
The authors would like to thank the authorities of Jain University-Bangalore for their continuous support and encouragement.

References
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Dr. Radhakrishna is presently Associate professor at R V College of Engineering, Bangalore, India. He has over 25 years of teaching experience in various Civil Engineering Programs. He has published 60+ research papers in various journals/conferences. He is a life member of Indian Concrete Institute, Association of Consulting Civil Engineers (I), Swadeshi Vignana Andolana. He is a reviewer for seven international journals and has guided two Ph.D scholars. Presently he is guiding five Ph.D scholars. His areas of interest is alternative building materials with particular reference to geopolymers, FaL-G and high volume fly ash concrete.

Col. Sasalatti Vinod M was born on 15th July 1963 in Karnataka state of India. He obtained bachelor’s degree in Civil Engineering from Karnataka University, Dharwad, India during 1986 and completed M Tech in Structural Engineering during 1998 from Jawaharlal Nehru University, New Delhi, India. He is presently pursuing his Ph.D in Concrete Technology under Visvesvaraya Technological University, Belgaum, India. He is Presently Staff Officer Grade-1 (Design), Headquarter Chief Engineer Jodhpur Zone, Jodhpur, India. He has over 02 years of teaching experience in Civil Engineering Programs and 26 years of military service which includes 06 years “experiences in designing of RCC structures for Defense and 03 years” experience in construction of RCC structures for the Indian Navy. Attended 01 International seminar at Indian Institute of Technology, Chennai, India. He is life member of Indian Building Congress (ML-6297).His areas of interest are structural engineering and fly ash based geopolymer concrete.

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Geo-polymer mortar (GPM) is proven for its strength, durability and sustainability [2 &3]; strength of GPM is a function of alkaline to binder ratio, and has an adverse effect on consistence properties of mortar. Early research proven the art of sundry curing GPM, with a combined binder fly-ash and GGBFS [11]. The fresh properties of GPM can be improved with the dilution of alkaline to binder ratio (Free Moisture) up to limit with refer to flow table test. Consistency of GM increases with increase in the water-to-alkaline binder ratio, but in the mean way which affect inversely with compressive strength. The present investigation of pH in alkaline solution evident the degree of dilution of solution may not alter the mechanism of Geo-polymerization with addition of water. Commercial available Sodium silicate solution as alkali and 4 molar sodium hydroxide solutions were used as alkaline activators. Activated alkaline solution to binder ratio of 0.5 - 0.8 for Rich mortar (1:3) and lean mortar (1:6) by mass was maintained constant for the study of dilution and bond strength properties of GPM. FA and GGBFS based 1:3 and 1:6 GPM offers early strength of order 5-12 MPa for three days Sundry curing regime. GPM with alkaline to binder ratio 0.23 to the dilution up to 0.8 may offers good shear bond strength of 0.52N/mm²&0.31N/mm² for 10mm -5mm masonry joint.

The geopolymer concrete solutions has gained momentum in the recent times, due to environmental concern related to the production of cement in terms of energy consumption and carbon foot print. One such alternative material for the cement is the use of alkali-activated binder using industrial by-products containing silicate materials. The most common industrial by-products used as binder materials are fly ash and blast furnace slag. Slag has been used as cement replacement material due to the latent hydraulic properties, while fly ash has been used as pozzolanic material to enhance physical, chemical and mechanical properties of mortars. The utilization of large proportion of by-products would contribute to the elimination of an environmental problem and to the development of potentially new high-performance material. Recent research has shown that it is possible to use fly ash or slag as a sole binder in mortar by activating them with an alkali component. The activation of material containing mostly silicate and aluminates by a highly alkaline solution will form an inorganic binder through a polymerization process in 1979 [1&3].

The current research is evident that GPM can be cured in sun-dry condition with proportionate combine binder FA&GGBFS [11]. Alkaline to binder ration place significant role in predicting the properties
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of GPM. To achieve a good consistence in GPM, increasing the alkaline binder ratio, there is significant effect setting of mortar. In this study attempt is made to enhance the consistency of GPM, with dilution of alkaline solution and its impact on Geopolymerization and some basic harden properties are studied.

Material And Methods

Fly ash and GGBS
In the present investigation Class F fly ash and GGBS are considered as binders. The physical characteristics are reported in Table-1.

Aggregate
Locally available river sand is chosen as filler, which confirm the requirements Indian standards.

Alkaline solution
The locally available sodium silicate and sodium hydroxide solution are used in the present investigation as alkaline solution. The sodium hydroxide is in flakes and pellet with about 98% purity. These pellets were mixed with distilled water to obtain the sodium hydroxide solution of required molarity. In the present study, 4M (4*40g=160g) NaOH solution is considered for investigations. The commercial grade of sodium silicate which has purity of 78% and contains 27% of water is used in the present investigation [7].

Curing of the specimens
The GPM specimens are cured in sun-dry for atmospheric humid factor and varying temperature. The sun-dry curing specimens were covered with a thick polythene sheet in order to reduce the moisture cracks and conventional impression curing is adopted for conventional cement mortar.

Results & Discussion

Influence of addition of water on pH value of combined alkaline solution.
The defining properties for GPM are the alkaline to binder ratio. In the view of enhancing the workability for required strength, an attempt has been made to replace alkaline to binder ratio with water to binder ratio in the mix. The effect of addition of water on the alkalinity of solution is evident thorough pH observation of combined solution of NaOH and Na₂SiO₃.

The results clearly show that the alkalinity of combined solution does not vary much with the addition of water and there is no significant change in the pH of alkaline solution for the observation of 1, 2 and 3 days in laboratory condition. Hence it can be said that there is no change in the alkalinity of geopolymer solution for continues incremental addition of water.

Influence of dilution of Alkaline to binder ratio on the properties of GPM.
As the geopolymer consists of binders and alkali solution, it is necessary to optimize the solution content required for the matrix. Therefore, the solution content required for the different alkali solution to binder ratios were done for the mixes considered for the study i.e., 1.3 and 1.6. Different ratios have been considered starting from 0.36 to 0.72. The optimum values from the ratios will result in required flow. Primarily few trial mixes were made to fix up the alkali solution to binder ratio using flow table test. Three trials for each mix have been made and tested. The average of all the three trials per each mix has been tabulated in table-4.

<table>
<thead>
<tr>
<th>Table 1: Physical Properties of Binders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulars</td>
</tr>
<tr>
<td>Residue on 45μ sieve</td>
</tr>
<tr>
<td>Specific gravity</td>
</tr>
<tr>
<td>Fineness (Blaine’s air permeability)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: PH Value of Alkaline Solution with Respective Addition of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline solution (ml)</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>80</td>
</tr>
<tr>
<td>70</td>
</tr>
<tr>
<td>60</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>40</td>
</tr>
<tr>
<td>30</td>
</tr>
<tr>
<td>20</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3: Flow and compressive strength for different mix proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix No</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>S1</td>
</tr>
<tr>
<td>S2</td>
</tr>
<tr>
<td>S3</td>
</tr>
<tr>
<td>M4</td>
</tr>
<tr>
<td>M5</td>
</tr>
<tr>
<td>M6</td>
</tr>
</tbody>
</table>

Figure 1: Graph showing the pH values of the alkaline solution with respective addition of water
Figure 2: Compressive strength v/s Mix proportions
The trend (fig.3) between the flow values in % and the Alkaline/Binder (A/B) ratio follows an approximately linear relationship; this relationship is more convenient to use the Alkaline/Binder ratio curve for interpolation.

The strength of mortar primarily depends upon the strength of the binder paste. The strength of paste increases with binder content and reverse with voids and alkaline content. The strength of mortar is only depending upon water/alkaline ratio, provided the mix is workable in GPM. The relation between the water/alkaline ratio and the strength is shown in fig 4 and 5. It is observed that lower water/alkaline ratio achieves higher strength, whereas comparatively higher water/alkaline ratio give lower strength.

**Shear Bond Strength of Geopolymer Mortar**

The geopolymer mortar bond strength of masonry specimen is determined by testing masonry triplet under shear. The main objective is to evaluate the strength of mortar mixes with varying proportions by determining the shear strength of triplets and comparing it with the conventional mortar mixes.

---

**Table 4: Alkaline binder Ratio for Mortar**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Mix Proportions</th>
<th>Alkaline/Binder Ratio</th>
<th>Flow Values (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1:3</td>
<td>0.4</td>
<td>Nil</td>
</tr>
<tr>
<td>2</td>
<td>1:3</td>
<td>0.5</td>
<td>157.5</td>
</tr>
<tr>
<td>4</td>
<td>1:6</td>
<td>0.8</td>
<td>Nil</td>
</tr>
<tr>
<td>5</td>
<td>1:6</td>
<td>1</td>
<td>Nil</td>
</tr>
</tbody>
</table>

**Table 5: Effect of variation of water to alkaline ratio (w/a) for a/b ratio 0.4 of 1:3 mortar mix**

<table>
<thead>
<tr>
<th>Mix No</th>
<th>Added W/A ratio</th>
<th>Binder (kg)</th>
<th>Alkaline solution (kg)</th>
<th>Sand (kg)</th>
<th>Added water (kg)</th>
<th>Flow Rate (%)</th>
<th>Dry Density (Kg/cu-m)</th>
<th>Avg Compressive strength (MPa)</th>
<th>Sun-dry curing</th>
<th>Water curing</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>FA</td>
<td>GGBS</td>
<td>Na₂SiO₃</td>
<td>NaOH</td>
<td>1575</td>
<td>78.75</td>
<td>75</td>
<td>2119</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>M2</td>
<td>0.375</td>
<td>472.5</td>
<td>52.5</td>
<td>105</td>
<td>105</td>
<td>1576</td>
<td>91.77</td>
<td>65</td>
<td>2080</td>
<td>10.33</td>
</tr>
<tr>
<td>M3</td>
<td>0.522</td>
<td>472.5</td>
<td>52.5</td>
<td>105</td>
<td>105</td>
<td>1575</td>
<td>109.2</td>
<td>110</td>
<td>2110</td>
<td>8.94</td>
</tr>
</tbody>
</table>

**Table 6: Effect of variation of water to alkaline ratio (w/a) for a/b ratio 0.5 of 1:3 mortar per cu-m**

<table>
<thead>
<tr>
<th>Mix No</th>
<th>Added W/A ratio</th>
<th>Binder (kg)</th>
<th>Alkaline solution (kg)</th>
<th>Sand (kg)</th>
<th>Added water (kg)</th>
<th>Flow Rate (%)</th>
<th>Dry Density (Kg/cu-m)</th>
<th>Avg Compressive strength (MPa)</th>
<th>Sun-dry curing</th>
<th>Water curing</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>FA</td>
<td>GGBS</td>
<td>Na₂SiO₃</td>
<td>NaOH</td>
<td>1575</td>
<td>47.75</td>
<td>75</td>
<td>2120</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>M2</td>
<td>0.183</td>
<td>472.5</td>
<td>52.5</td>
<td>131.25</td>
<td>131.25</td>
<td>1576</td>
<td>52.5</td>
<td>85</td>
<td>2060</td>
<td>15.71</td>
</tr>
<tr>
<td>M3</td>
<td>0.223</td>
<td>472.5</td>
<td>52.5</td>
<td>131.25</td>
<td>131.25</td>
<td>1575</td>
<td>57.75</td>
<td>110</td>
<td>2100</td>
<td>12.10</td>
</tr>
</tbody>
</table>

**Table 7: Effect of variation of water to alkaline ratio (w/a) for a/b ratio 0.8 of 1:3 mortar.**

<table>
<thead>
<tr>
<th>Mix No</th>
<th>Added W/A ratio</th>
<th>Binder (kg)</th>
<th>Alkaline solution (kg)</th>
<th>Sand (kg)</th>
<th>Added water (kg)</th>
<th>Flow Rate (%)</th>
<th>Dry Density (Kg/cu-m)</th>
<th>Avg Compressive strength (MPa)</th>
<th>Sun-dry curing</th>
<th>Water curing</th>
</tr>
</thead>
<tbody>
<tr>
<td>S2N1</td>
<td>0.473</td>
<td>270</td>
<td>30</td>
<td>120</td>
<td>120</td>
<td>1800</td>
<td>113.52</td>
<td>180</td>
<td>2000</td>
<td>2.94</td>
</tr>
<tr>
<td>S2N2</td>
<td>0.509</td>
<td>270</td>
<td>30</td>
<td>120</td>
<td>120</td>
<td>1800</td>
<td>122.16</td>
<td>195</td>
<td>2045</td>
<td>2.31</td>
</tr>
<tr>
<td>S2N3</td>
<td>0.545</td>
<td>270</td>
<td>30</td>
<td>120</td>
<td>120</td>
<td>1800</td>
<td>110.8</td>
<td>210</td>
<td>2019</td>
<td>2.94</td>
</tr>
</tbody>
</table>

GPM offers good early strength and it is evident that strength of GPM is based on the percentage of alkaline solution, hence, for further work, min alkaline to binder for good flow values are chosen as from TABLE VII and have been kept constant and increasing the amount of water on basis of the flow value or workability in the study. According to IS 2250-1981, the mortar flow should be around 100% to 110% i.e., 200 to 210mm flow depending upon the purpose of mortar.
may not alter the Geo polymer mechanism in GPM.

• Utilization of GGBS as binder to a certain extent (i.e.5-10%) improves the setting time and compressive strength of the geopolymer mortar as compared to conventional mortar. And also added the word self-curing for sundry curing application.

• The results are evident that using fly ash along with GGBS as base material and alkaline solution dilution of free moisture, it is possible to produce mortar of compressive strengths of the order of 5-15MPa. And offers an early strength (about 5-7 MPa in 3 days of sun dry curing) as compared with conventional mortars.

• Bond strength of the GPM (of thickness 5mm and 10mm) is found to be 0.31N/mm² for horizontal plane and 0.52N/mm² for vertical plane than the conventional cement mortar.

Reference


This article discusses pre-stressing of concrete to get lighter and slender beam sections for six different four-storied concrete building frames of different spans/lengths by the application of post-tensioning, and whether the use of post-tensioning reduces the volume of concrete used in the beams for small, medium, and large spanned buildings. Optimized beam sections without pre-stressing forces are designed following Indian Code provisions using computational analysis. The design procedure satisfies both strength and serviceability criteria. Six building frames having different span lengths of three, six, ten, twelve, sixteen, and twenty meters are designed. The loads are considered as per IS 875 part-2. The deflection obtained for the dead and live load is calculated and then neutralized by counteracting the load by introducing stress in concrete using post-tensioned force and section reduction. The optimization is done through subsequent iterations i.e. by simultaneous increments of pre-stressing force and reduction of section dimension.

Pre-stressing allows us to introduce internal stresses of a suitable magnitude and distribution so that the stresses resulting from external loads are counteracted to a desired degree. For reinforced concrete members, the pre-stresses are used either by introducing tension to the steel reinforcement itself, before pouring concrete-mix to the formwork also known as pre-tensioned concrete or by providing provisions for High tensile high yield steel wires, bar cables or strands used as tendons which are introduced to the section after the concrete has been casted and tension is given to the tendons which are released with proper anchorage to transmit the pre-stressing force to the concrete section as explained in Figure 1. The ducts providing tendon provisions (Figure 2) are then grouted. Generally high strength
concrete (≥M40) is necessary as in anchorage zone, the bearing stress being higher; high-strength concrete is invariably preferred to minimize costs. High strength concrete is also less liable to shrinkage cracks, and has higher elastic modulus and smaller ultimate creep strain, resulting to smaller loss of pre-stress in steel.

The uses of pre-stresses are spreading in all the construction fields namely bridges, tanks, pipes, marine, railway, etc. Thorough literature review shows substantial amount of work being done on pre-stressing in the last century. Development of a simplified flexural design method for partially pre-stressed concrete beams was done in the late twentieth century where the design procedure satisfied simultaneously both strength and serviceability criteria. This resulted in more efficient elements than those designed by the conventional approach using allowable working stress and then checking strength.

The purpose of the present study is to create six different optimized RCC building frames and check for further optimized frame structure when post-tensioning is used. The study is done to check whether there are any savings in concrete volume if the beams are pre-stressed instead of RCC. Six building frames are taken, each of which contains a four storied building frame; has three bays along its length as well as breadth. Each of the bays is of three meter, six meter, ten meter, twelve meter and sixteen meter length in their respective five cases. Other aims include the effectiveness of pre-stressing in reducing depth of beam, reduction in deflection due to loading cases and combinations and also to determine the role of pre-stressing as a cost efficient method in building construction.

**Methodology**

To achieve the goals, buildings of three span sizes (viz. small, medium and large) are considered. Firstly the RCC building is designed for the cases with the corresponding loads and M40 grade of concrete as defined in Table 1. The models are first checked for condition of collapse using STAAD.Pro V8i (select series 6) and the vertical maximum deflection at different members is noted. If the value of the maximum deflection at any member is greater than permissible value for concrete design (permissible: L/250 or 20mm whichever is less; L in mm), the section is reassigned and the structure is redesigned. On obtaining an optimized frame structure for the six building frames, the section dimensions for beams and columns, volume of concrete consumed, percentage save in concrete and maximum compressive and tensile stress in the beams are noted.

Figures 3 and 4 represent the building frame model of 20m and 3m span length. Similar models were created by changing the span lengths according to the cases as defined in Table 1.

Once all required data is extracted the design for post-tensioning is done. Depending on the span length pre-stressing forces are assigned to the beams. The post-tensioning force reduces the tension in the beams by inducing additional compression. Thus for the present work the dead load and live load is balanced by the pre-stressing force. Thus the maximum downward deflection obtained for the PSC section should be lesser than that obtained for RCC section, here taken as greater than or equal to zero. Thus by dropping the dead load by reducing the section dimension of beam and by increasing the value of pre-stress applied, the beam section is optimized to show zero maximum downward deflection or positive value for deflection that is the beams cambers up.

The stresses are monitored so they do not cross the compressive strength of concrete. Again the section dimensions for beams and columns, volume of concrete consumed,
Table 2: List of design parameters used for the building frame analysis

<table>
<thead>
<tr>
<th>SL. NO.</th>
<th>DESCRIPTION OF PARAMETER</th>
<th>SYMBOLS</th>
<th>VALUE</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Compressive strength of concrete</td>
<td>FC</td>
<td>40000</td>
<td>kN/m²</td>
</tr>
<tr>
<td>2</td>
<td>Yield strength for main reinforcement</td>
<td>FYMAIN</td>
<td>50000</td>
<td>kN/m²</td>
</tr>
<tr>
<td>3</td>
<td>Yield strength for shear reinforcement</td>
<td>FYSEC</td>
<td>50000</td>
<td>kN/m²</td>
</tr>
<tr>
<td>4</td>
<td>Distance from surface of member to edge of outermost reinforcement</td>
<td>CL.EAR</td>
<td>0.035/0.05</td>
<td>m</td>
</tr>
<tr>
<td>5</td>
<td>Max. % of longitudinal reinforcement/ allowed</td>
<td>RATIO</td>
<td>3</td>
<td>%</td>
</tr>
</tbody>
</table>

Results

Following the above methodology, the results obtained are tabulated accordingly. Table 3 and Table 4 records the parameters like concrete take off, percentage of concrete saved and volume of concrete saved for comparison between RCC and PSC structure of Case I as mentioned in Table 1 i.e. building frames having span lengths of 3m and 6m are considered to be short span. Table 5 and Table 6 give the results for Case II i.e. for building frames of span lengths of 6m and 12m. Similarly, Table 7 and Table 8 give results for Case III for building frames of large span of 16m and 20m respectively. For PSC, the two ends of the cable profile are at the neutral axis of the beam section while the eccentricity of the midpoint is mentioned in the tables below.

Table 3: Comparative study of RCC and PSC building frames with 3m span.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FRAME STRUCTURE</th>
<th>MAX DEFLECTION (mm)</th>
<th>CONCRETE (m³)</th>
<th>MAX COMPRESSION (N/mm²)</th>
<th>MAX TENSION (N/mm²)</th>
<th>ECCENTLE (m)</th>
<th>BEAM DIM (m/min)</th>
<th>COLUMN DIM (m/min)</th>
<th>PSC FORCE (KN)</th>
<th>% CONCRETE SAVE</th>
<th>CONC. SAVED (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC</td>
<td>DL+LL</td>
<td>4.701 0.701 down</td>
<td>25.9</td>
<td>33.167</td>
<td>-33.13</td>
<td>200X150</td>
<td>300X300</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSC</td>
<td>DL+LL+POST</td>
<td>2.861 0.715 up</td>
<td>25.9</td>
<td>38.21</td>
<td>-28.25</td>
<td>-0.065</td>
<td>200X150</td>
<td>300X300</td>
<td>150</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4: Comparative study of RCC and PSC building frames with 6m span.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>FRAME STRUCTURE</th>
<th>MAX DEFLECTION (mm)</th>
<th>CONCRETE (m³)</th>
<th>MAX COMPRESSION (N/mm²)</th>
<th>MAX TENSION (N/mm²)</th>
<th>ECCENTLE (m)</th>
<th>BEAM DIM (m/min)</th>
<th>COLUMN DIM (m/min)</th>
<th>PSC FORCE (KN)</th>
<th>% CONCRETE SAVE</th>
<th>CONC. SAVED (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCC</td>
<td>DL+LL</td>
<td>8.750 1.217 down</td>
<td>90.7</td>
<td>33.33</td>
<td>-33.44</td>
<td>450X450</td>
<td>850X850</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSC</td>
<td>DL+LL+POST</td>
<td>8.777 1.217 up</td>
<td>90.7</td>
<td>37.48</td>
<td>-39.26</td>
<td>-0.185</td>
<td>450X450</td>
<td>850X850</td>
<td>380</td>
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Table 5: Comparative study of RCC and PSC building frames with 10m span.

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<th>TYPE</th>
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<th>MAX DEFLECTION (mm)</th>
<th>CONCRETE (m³)</th>
<th>MAX COMPRESSION (N/mm²)</th>
<th>MAX TENSION (N/mm²)</th>
<th>ECCENTLE (m)</th>
<th>BEAM DIM (m/min)</th>
<th>COLUMN DIM (m/min)</th>
<th>PSC FORCE (KN)</th>
<th>% CONCRETE SAVE</th>
<th>CONC. SAVED (m³)</th>
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<td>RCC</td>
<td>DL+LL</td>
<td>17.452 2.714 down</td>
<td>426.7</td>
<td>33.266</td>
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<td>600X500</td>
<td>950X950</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>PSC</td>
<td>DL+LL+POST</td>
<td>17.452 2.714 up</td>
<td>426.7</td>
<td>38.337</td>
<td>-30.824</td>
<td>-4.25</td>
<td>600X500</td>
<td>950X950</td>
<td>700X700</td>
<td>1175</td>
<td>33.15</td>
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Table 6: Comparative study of RCC and PSC building frames with 12m span.

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<th>MAX TENSION (N/mm²)</th>
<th>ECCENTLE (m)</th>
<th>BEAM DIM (m/min)</th>
<th>COLUMN DIM (m/min)</th>
<th>PSC FORCE (KN)</th>
<th>% CONCRETE SAVE</th>
<th>CONC. SAVED (m³)</th>
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<tr>
<td>RCC</td>
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<td>15.599 3.55 ms up</td>
<td>726.2</td>
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<td>800X600</td>
<td>850X850</td>
<td>NA</td>
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<tr>
<td>PSC</td>
<td>DL+LL+POST</td>
<td>17.096 3.55 ms up</td>
<td>638.7</td>
<td>18.169</td>
<td>-30.328</td>
<td>-0.3</td>
<td>700X600</td>
<td>850X850</td>
<td>1795</td>
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Figure 5: Flow chart of design and optimization of RCC building frames.

Figure 6: Flow chart of design and optimization of prestressed concrete building frames.
Conclusions

From the above study, following conclusions about relevancy of use of PSC beams over RCC beams in a building frame, depending on their span lengths, can be drawn-

● For short span beams there is no possible scope for concrete savings and the use of PSC will not be a good choice.

● Medium span building frame with 10m span showed 13.15% of concrete saving as compared to RCC frame. Similarly building frame with 12m span showed 12.05% of concrete saving.

● Long span building frame with 16m span showed 14.83% concrete saving as compared to RCC frame. Similarly building frame with 20m span showed 31.18% saving of concrete.

References

1. IS 456-2000. Indian Standard Code of Practice for Reinforced Concrete (Fourth Revision)
2. IS 1343-1980. Indian Standard Code of Practice for Pre-stressed Concrete (First Revision)
4. Users’ Manual, STAAD.Pro, V8i (Select Series 6), Bentley
The Government is keen to accelerate the country’s economic growth momentum through construction projects that provide the much-needed thrust to the beleaguered economy. Through the National Infrastructure Pipeline (NIP) it has announced an ambitious plan to spend ₹111 lakh crores by the year 2025 and has so far listed 6,835 projects across sectors such as energy, social and commercial infrastructure, communication, water and sanitation, roads, airports, and ports etc. Government initiatives such as Swachh Bharat, developing 100 smart cities, world-class highways, shipping infrastructure, housing and urban development, water and energy infrastructure, metro rail etc. have attracted huge investments through FDI, private players and from budgetary allocations.

The restrictions on construction activities due to the pandemic lockdown, labour migration, and supply chain interruptions have had a cascading impact on construction projects. The Government has put on hold a large number of projects and deferred major spending on already planned and on-ground projects. However, the government is taking necessary steps to protect the construction industry and has announced a ₹1.7 lakh crore relief package. The state governments have been asked to use the building and construction workers welfare funds to provide relief to the workers. RBI is taking steps to combat the slowing GDP growth and is helping the industries with restructuring of loans and deferring payments to arrest the falling economy and the declining construction sector, which is also the backbone of several other sectors and industries.

The long-awaited measures in infrastructure development, labour policy reforms, digitization of business, technological advancement in project execution, privatization of assets and utility services and more resilient business models can now be implemented. Despite the Q1 traction, India is taking swift remedial actions and international financial organisations are positive about India’s growth prospects in coming times. A rapid and sustained economic growth with about 8% of GDP expansion annually, fuelled by heightened productivity and critical reforms, will enable the nation to achieve the ambitious target of becoming an economic power in the world order. McKinsey Global Institute has suggested that manufacturing and construction are the two sectors that would need to amplify the most, adding 9.6% and 8.5% annual GDP growth while creating 11 million and 24 million jobs, respectively, from 2023 to 2030.

In the current scenario when almost all the sectors are on a decline, initiatives for water infrastructure development schemes, including the ambitious Jal Jeevan Mission, and an exclusive budgetary allocation of ₹3.6 lakh crores, are going to be the growth drivers of the construction sector during the next few years.

**Developing Water Infrastructure**

Water has become everybody’s business now. As human needs water to survive, similarly business needs water to thrive. The reality is that we are heading towards a ‘no water’ scenario if we continue using it unsustainably. Across the globe, major cities like Cape Town and numerous metropolitan areas and over 20 Indian cities are facing the threat of a diminished water supply.

The situation becomes more threatening as India has just a fraction of the world’s fresh water sources for a formidable (almost) 18% of global population. Imagine the crisis if 80% of our surface water is contaminated. In fact, nearly 60% of India’s ground water reserves are already contaminated with...
biological, organic, and inorganic pollutants. The Central Pollution Control Board (CPCB) has found that 18 major rivers in India are unfit for domestic and industrial water use.

The policy think-tank Niti Aayog has flagged the issue in their water report last year saying that the water situation in the country is quite stressful and around 100 million people will be affected by the shortage of ground water in 21 Indian cities including mega cities like Delhi, Bengaluru, Chennai and Hyderabad, unless strong measures are taken immediately for replenishing our water sources.

Dramatic changes are required to develop a robust water infrastructure and maintain it with a view to long-term demand and supply. The affliction point is insufficient availability of clean water for distribution and scarcity. The water pollution, in general, and degradation of groundwater quality, in particular, are the other pitfalls of water scarcity.

**Jal Jeevan Mission**

The United Nations under its Sustainable Development Goals (SDGs) has raised the issue of water as an important subject and has advised its member countries the world over to target and ensure universal and equitable access to safe and affordable drinking water for all by the year 2030. The Government of India has taken up the cause of water and made it the theme subject for social and economic development.

With a renewed focus on water supply and, more importantly, on sustainable water management practices, the Jal Jeevan Mission is developing fast across the nation as several states have received central funding and are focusing on infrastructure development. A look at the Ministry of the Jal Shakti dashboard clearly states that the percentage of connected households at present varies from 100% in Goa to just 2.4% in West Bengal. There is a large scope for rural water infrastructure development not only for water companies, but also for manufacturers of pipes, valves, pumping systems and other ancillary companies.

Jal Jeevan Mission, the first in Indian history to have such a large financial allocation for a rural water supply scheme, is envisioned to provide safe and adequate drinking water through individual household tap connections by 2024 to all households in India. Presently 65% of the people (900 million) of India live in rural areas. The task under the Jal Jeevan Mission is to provide functional household tap connection (FHTC) to almost 160 million unconnected households by 2024. The development so far has provided 25.6 million households with tap water connection, so currently 134.4 million still remain. This is a mammoth task for which a budget of ₹3.6 lakh crore has been earmarked by the government.

It has been decided that every rural household in the country will be provided clean drinking water at the rate of 55 litre per capita per day (LPCD) through functional household tap connections. Under the provision, every village will be required to prepare a village action plan (VAP) consisting of three important components: identification of water source and its maintenance, developing and operating water supply system, and management of domestic wastewater for reuse. The Mission will take a community-driven approach for water infrastructure development and operation and maintenance, along with information, education, and communication. Of the budgetary allocation, about ₹30,000 crore will be made available from the Centre to the States during 2020-21 under the Jal Jeevan Mission. While ₹6,429.92 crore is the opening balance for States, an additional ₹22,695.50 crore has been allocated for 2020-21 to ensure “assured availability” of the ₹29,125.42 crore of the central funds to States and Union Territories in 2020-21. Of the amount allocated for 2020-21, ₹11,500 crore has been provided in the Union Budget, and ₹12,000 crore has been considered as extra-budgetary resources.

Under the scheme, Union Territories without legislature will receive 100% central funding, whereas it will be 90% for the North-Eastern and Himalayan states and the Union Territories with a legislature. All other States will receive 50% central funding and the remaining will be arranged by the States themselves. The Government has also assured that additional funding will be available for States which will show good physical and financial progress and, accordingly, several large States have planned to complete the 100% functional household tap connection before the targeted time of 2024.

All States and Union Territories have received funds in the current year ranging from ₹12.40 crore to Goa and ₹2,760.76 crore of central share funds, along with ₹5,770 crore of the states’ share in West Bengal to provide household tap connections. The Chief Ministers of the States are visiting villages and projects’ progress review meetings are being held by the Prime Minister himself. On Mahatma Gandhi’s 151st birth anniversary on 2nd October 2020, the Ministry of Jal Shakti launched a mini scheme within the large Jal Jeevan Mission - a 100-day campaign to ensure potable water supply in all schools and Anganwadi centres across the country.

These large budget allocations and project executions at the ground level are certainly encouraging for the construction sector and as the situation becomes normal, a number of other large infrastructure development projects will again be started according to the plans of spending ₹111 lakh crore on infrastructure projects in the next four years to help achieve the target of $ 5 trillion economy by 2025. -
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