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Scaling New Heights with High Performance Concrete


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With a population of over 20 million people, Mumbai has long been plagued by a massive housing shortage, despite being the economic capital of India. In light of this urgent need for expanding its residential capacity, vertical construction has rapidly sprung up across the city in the form of high-rise buildings and skyscrapers.

Owing to their height, high-rise buildings are primarily used as residential structures, hotels, and office buildings, as they can house a large number of residents, while taking up considerably less surface area. This has led to the growing demand for high-rise buildings, especially in metro cities with a vast and ever-growing population. In fact, high-rise buildings have actually been referenced so far back as in the bible itself, vis-à-vis the Tower of Babel. Today's modern high-rise buildings, have, however, advanced much further in technological and structural capabilities, offering a wide range of advantages, thanks to the high performance concrete.

Not only high rise structures are extremely suitable for densely populated cities with a shortage of land like Mumbai, Delhi, Hyderabad etc, they make the maximum possible utilisation of a land parcel, by consuming a high Floor Area Ratio (FAR). As a result, the overall cost of constructing the structure, including land, preliminaries, foundations, and roofing, is significantly less, compared to single or two story horizontal buildings with the same residential capacity. In addition, they also offer enhanced security, natural light, ventilation, reduced noise, and offer residents the feeling of exclusivity, along with spectacular views.

One of the best examples of this is the Lodha World One tower, located in Lower Parel. With a height of 442 meters, and more than 300 apartments, it is envisaged to become the tallest residential skyscraper in the world. As such, the structure will be constructed using 800,000 m^3 of High Performance Concrete (HPC).

In fact, the quality of HPC has improved immensely, since the 1980s, resulting in a significant increase in its usage. Today, it not only offers hugely impressive compressive strengths, above 65 MPa classified as High Strength Concrete as per Indian Standard codes, but also imbibes structures with higher tensile strength, enhanced durability, and increased resistance towards wear and tear. In addition to that, HPC is also designed to facilitate efficient utilisation of resources, owing to which, columns built using it are considerably smaller in size. As a result, HPC has helped reduce the overall cost of construction greatly, despite the higher cost of HPC compared to conventional concrete. In turn, it also helps reduce the environmental impact, and makes it possible to have an increased floor space.

The above advantages where exploited by GAR Corporation, Aurbindo Realty and Gowra Ventures in Hyderabad and M3M India in Delhi - NCR for their respective high rise construction.

Project	City	Number of Floors	High Performance Concrete Grade	Application Area
World One – Lodha Group	Mumbai	117	M95 & M70	Core / Shear Wall & Columns
Laxmi Infobahn – GAR Corporation	Hyderabad	14 Towers of 27 Floors	M70	Core Wall, Column Capital & Columns
65th Avenue- M3M India	Delhi - NCR	5 Towers of 47 Floors	M80	Core / Shear Wall & Columns

However, the construction of tall high-rise buildings is also accompanied by a number of prominent challenges, both with regards to their design and the HPC required. Since the wind force and its impact on building structures is much stronger at greater heights, the taller and more slender a structure, the more wind resistant it is. Exceptionally tall buildings usually consist of elegant and slender complex super structures, and a massive sub structure. For instance, the proposed "World One Tower" in Mumbai will constitute 117 floors, with an approximate height of 440 meters. As a result, the construction of the tower will require a huge amount of specialised HPC, produced by dedicated RMX plants.

What makes it so noteworthy is that for the first time in India, a super structure, which is a sheer wall design based on a grade C95-M125 of concrete with a MOE (Modulus of Elasticity) of 48-52 Gpa, was used for the construction. The specialised HPC used also offered minimal shrinkage and creep, and allowed vertical pumping for over 400 meters. The reason why the developer used HPC adhering to such specific requirements is that if conventional concrete had been used, it would have offered much less usable space, besides compromising on wind resistance. The biggest uncertainty was regarding whether an HPC of such kind, required by the structural design, could be developed, with the materials available locally. The challenge was addressed by the Construction Development and Innovation Centre (CDIC) of Nuvoco, which specialises in the research and development of innovative solutions to meet the unique needs of the Indian construction industry.

By conducting a thorough analysis and research into the raw material characterisation within economical ranges and the design mixed methodology which was beyond IS Codes, it was able to device an adequate solution to meet the requirements of the project. Conducted over a period of six months, the entire process constituted a range of extremely specialised tests like Creep, which measures inelastic deformation, and can only be performed by very few agencies, like the National Council for Cement and Building Materials (NCCBM) and IITs, among others. Once all the technical details had been addressed in the lab, the next step, and one of the more challenging ones, was to decide how such a large volume of concrete can be mass produced and transported to the site. Finally, an in-house RMX plant, adhering to strict QA/QC procedures, along with the help of highly motivated staff, helped produce a consistent and adequate supply amount of HPC during the last five years, for the project.

However, once the floors started increasing, Nuvoco's team found that regular pumping systems were unable to meet the needs of the project. In light of this, the team brought in high productive static pumps for the project. Despite this, the challenges of high rise pumping still existed, particularly regarding the jellification of concrete in long pumping lines. At this point, the Nuvoco team realised that the HPC needed to be redesigned to address the challenge. So, by revisiting the drawing board, it created an HPC with lower viscosity and thixotropic stability, which was adequately suited for the end productivity needs and the low pump pressure.

Furthermore, it was also critical to maintain the plastic and mechanical performance of concrete, along with its durability aspect, since the project is located in Mumbai, and subject to severe exposure due to its coastal proximity. Therefore, in order to ensure that the concrete possessed a high resistance to the same, an in-depth analysis of the carbonation, chloride attack, and sulphate attack, was conducted. A stringent and continuous test plan was also set up in Nuvoco's laboratories, to ensure the quality of the concrete for the World One Tower Project. Along with conventional tests for shrinkage and durability, over 100 cylinders of C95 concrete are also being subjected to tests for strength and modulus of elasticity, in order to provide an end-to-end solution for the project.