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Challenging Indian project in prefabricated and in-situ concrete

Infosys multi level car park

With the steady rise in the Indian economy, the construction industry has become the second largest industry which contributes to the country's growth. This growth magnified demands for quick, clean and hassle free construction technologies and has thus laid 'concrete' foundations for the precast technology in India. An example of this trend is the Infosys multi level car park in Pune (photo 1). The challenging project is constructed fully in concrete, without any other materials, with the combination of prefabricated elements and in-situ concrete.

Precast India IPL built the Multi-Level Car Park for their client, Infosys Ltd, in their Pune campus. This eye-catching, half a million square feet multi-level car park was used for the cover page of fib Bulletin 78 and was also named as 'The Outstanding Concrete Structure of India-2016' by Indian Concrete Institute (ICI). Special awards were also won in architectural, structural and precast construction categories.

In total there were 3500 elements in the building of the Infosys multi level car park, consisting of: 16 m span precast TT slabs, 15 m precast concrete columns, and 1300 façade elements each around 7 m long and weighing 2.5 tons, triangular in profile, fixed in around 160 days on-site, with a self-designed and electronically managed factory and construction site coordination, culminating in the installation of all elements within an erection tolerance limit of +/- 10 mm.

Er. Ajit Vasant Bhate
Precast India Infrastructures Pvt Ltd

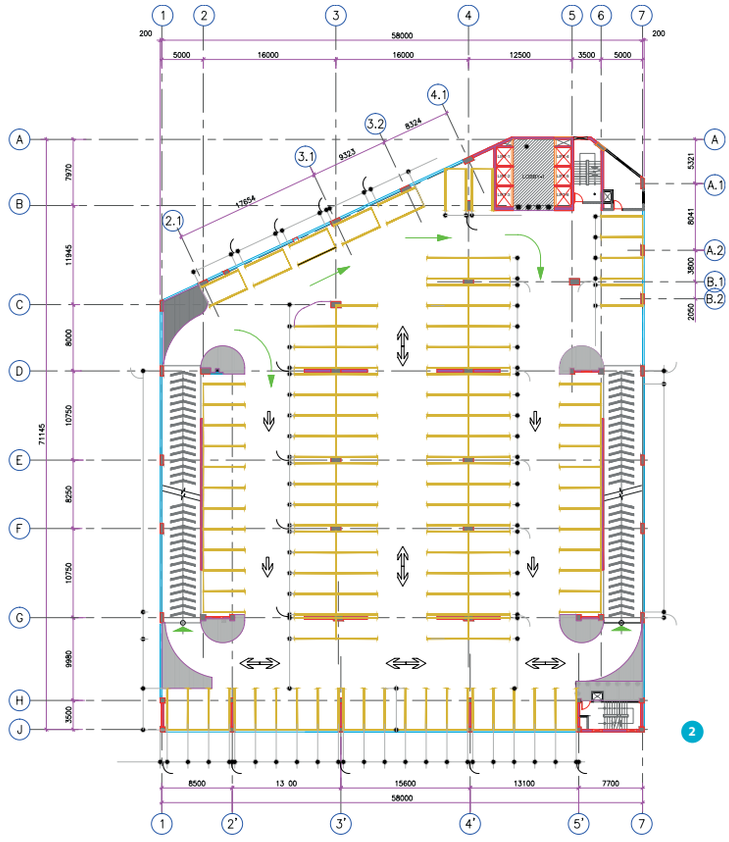
1 The Award winning façade elevation of the completed structure of the Infosys multi level car park
2 Typical architectural floor plan
3 The architectural design is inspired on a woolen weave pattern
4 The woolen weave concept elevation

The precast concrete elements in the building speak volumes about the innovations and the cutting edge technologies that were used for the construction of this magnificent structure. Concrete was chosen over glass, which resulted in excellent natural lighting and ventilation factors, minimizing future maintenance costs, and enhancing safety.

International architectural design competition

To meet the client's requirements, Precast India conducted an international design competition for the façade. From a number of designs, the entry from Arch Domingo Seminario was selected. The architecture of this structure is a perfect example of how uber modern structures can be designed to blend with the basic architectural concept evolved from and resembling the warmth of woven wool, with a virtue of unharmed air circulation along, with sufficient mild sun light entrainment in all the area.

The parking structure comprises of a basement and ten floors with a parking capacity of around 1300 cars. In addition to precast concrete columns, beams, double tee slabs, hollow core slabs, staircases, and spandrels, the uniqueness of the building lies in its 1300 odd, 100 mm thick precast concrete façade elements (photo 4) [5], all of which were produced and transported from Precast India's plant (photo 5) 45 km away from the site.
This is a unique structure of its kind in India, where, instead of glass or aluminum composite panels, structural concrete prefabricated elements are used for the façade.



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Structural design

The structure lies in seismic zone 3 [1] and was designed and analyzed by a team of experienced structural designers, led by prof. Sypros Tsoukantas and mr. Tryfon Topintzis. The structural design of the precast elements [4] was complex as it involved intricate connections between prefabricated basement walls-columns/rafts, and floor to façade elements. The

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5 Precast India plant which made intricate prefab projects possible
6 Bare façade element (a) and a mock up façade-spandrel connection (b)
7 Spandrel element with dowels for connection to column corbel (a) and column sides (b)

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6a 6b

connections are ductile [3], sturdy and unyielding. Shear forces between spandrel and façade elements are transferred by the monolithic corbels in the spandrels which are also interlocking each façade element against overturning (photo 6). The ductility [3] of connection between the façade element and building spandrel was achieved by use of mild steel bolts to offer moment of resistance for 1.50 m cantilevering façade element. The use of mild steel bolts offers sufficient warning before failure in the seismic event.

Integrated it systems

A 3D Tekla model including all reinforcement and precast connections was made. Highly accurate production drawings were generated from this model and the production of the elements was carried out accordingly.
Completely in-house developed, cloud based planning and tracking software, generated production and erection schedule along with sequence for installation and a full-fledged data base of elements. Other IT systems facilitated online booking of

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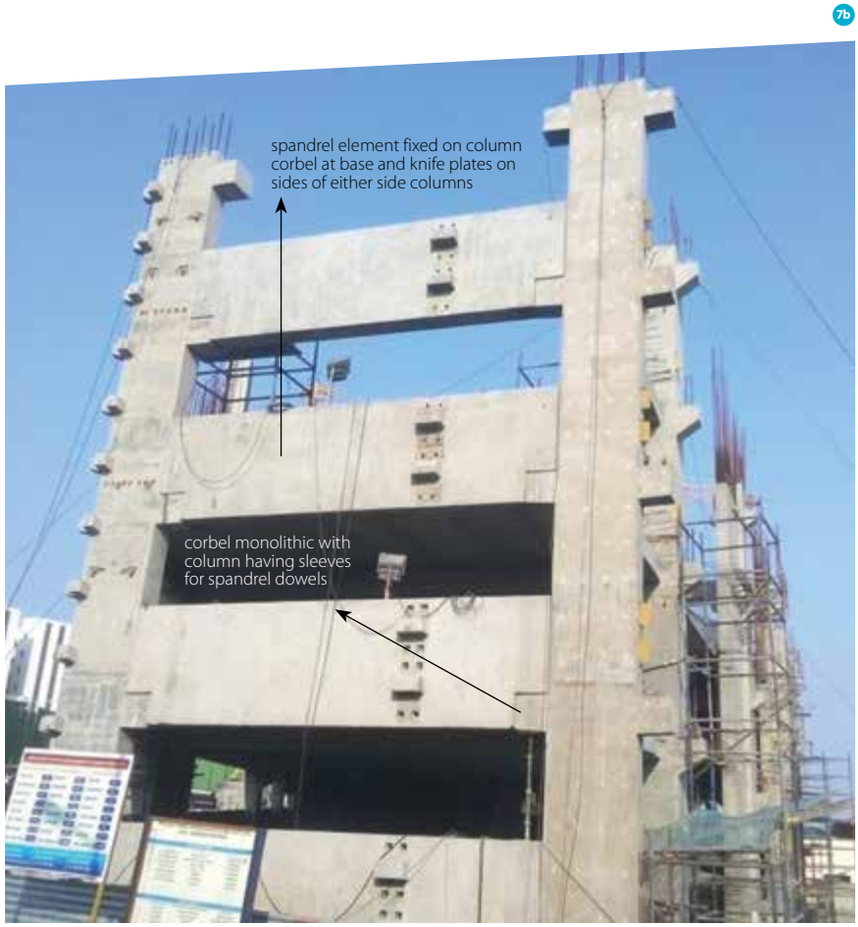

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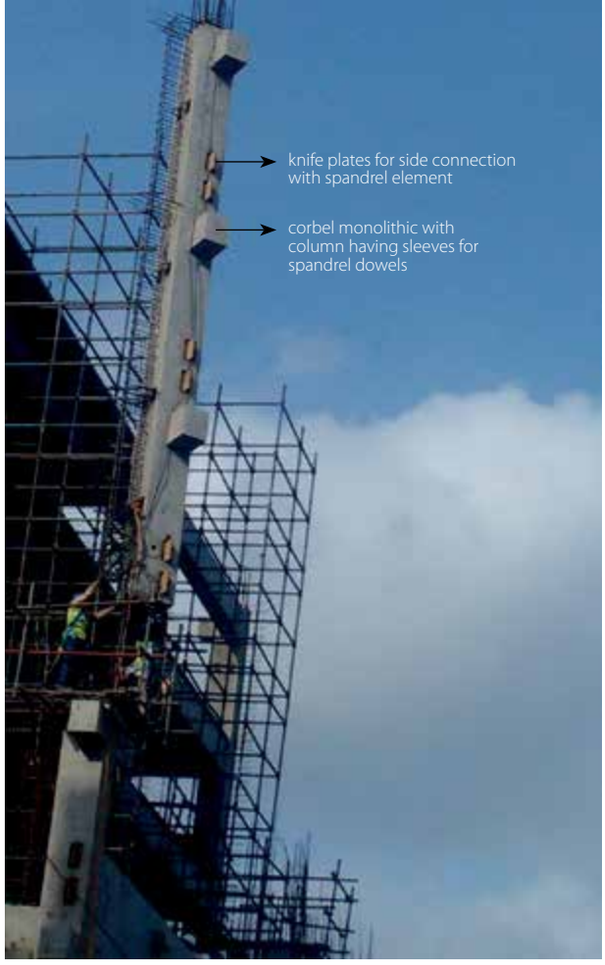

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8 Three-storey column erection
9 Lifting frames (a) and stacking (b) of façade elements
10 One of the many innovations: the double decker transport system

resources (RMC, trailers, cranes), logistics management purchase orders, material management and budget tracking.

Production and quality control systems

Even the smallest details and activities were planned well in advance before production drawings were made and unique element IDs were generated to be able to pinpoint the life cycle stages of each individual element from design stage up to final installation on site.
The state of art production facility, consisting of a hollow core slab unit, Carousel unit (for solid slabs, walls), mechanically and hydraulically operated adjustable beam and column moulds giving smooth surface finish, special batching plants, tilting tables, shear cut bend lines (steel cutting), gantry cranes, steam curing facilities, etc., produced all precast elements in the project, with a concrete grade of M40 MPa.

All the risks and challenges like demoulding, lifting, installation, anchoring etc. were eliminated and structurally approved by mockup tests. Sample prototypes were cast multiple times, and representative elements were tested till failure.
Multiple tests on raw materials, load tests for representative elements were done and certified by third party testing agencies, before full scale production began. Each test and control greatly helped in achieving the high quality and consistency with regards to strength and finish, resulting in the good durability.

Stacking

Long spans and critical geometry of elements (photos 9a and 9b) were a concern while stacking. A separate special support lifting system was designed to de-mould and stack the elements, avoiding lifting and handling stresses thereby lifting the façade elements delicately, but quickly.

Transportation to site

Transporting fragile elements 45 km through narrow and choked roads was a challenge, considering the road conditions, lifting and handling stresses. This prompted attention to

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11 Intermediate stage of façade installation, showing a corner column
12 Interior of the fully finished structure
13 Exterior of the fully finished structure

the economical considerations and resulted in the decision to transport multiple elements simultaneously. The transportation experts innovated a double decker transport assembly system designed and fabricated as a removable attachment, ready to shift eight façade elements per trip (photo 10). This improved installation speed and enabled meeting the target dates.

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Installation on site

The entire erection of the 3500 elements was a pre-planned activity, even before the production planning, considering all the major constraints at site like restricted side margin availability, limited access, availability of special tools and tackles etc. The installation of the odd façades was accomplished with an average erection time of 25 minutes per façade element.
For installation of TT slabs, columns, beams and other elements of the structure, a 50MT rail mounted Liebherr tower crane was set up on rails in the center of the building, considering element weight and available crane capacity at the required radius (16 tons at 48 m). 50 ton and 120 ton mobile cranes were also used.

Accuracy, tolerances and precisiom

An overall accuracy up to 15 mm without any adjustment anywhere was achieved despite the complex nature of all the precast elements. The 20 mm bolts in the façade element passing through the spandrel sleeve of 40 mm, had overall tolerance of 20 mm only, including also other tolerances during erection of foundations, columns, beams etc. This came as a result of constant coordination and exchange between all the stakeholders [9] including design, planning, production, transportation and installation of all the elements. Finally, perfect coordination between all stakeholder teams, ensured the creation of milestone and a unique game changer in the Precast industry in India. ☒

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