Design and construction of DELTA CITY shopping mall concrete structure in Belgrade

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ABSTRACT: The structure of DELTA CITY shopping mall in Belgrade consists of two separated structures: the structure of the mall and the structure of the multi-story open garage. The overall dimensions of the irregular layout of the structure are 210 m × 110 m, with four main levels in the mall and five parking levels in the garage. Because of the different exposure conditions, the structure of the garage is separated from the mall’s structure with an expansion joint at all the levels, except at the level of the foundation slab. The mall’s structure is designed without any expansion joints, except for temporary joints during the construction stage. It consists mainly of reinforced concrete cantilevered columns cast in place, at typical spans of 8.2 m × 8.2 m, precast reinforced concrete simple beams and precast prestressed hollow core slabs. The reinforced concrete frames cast in place are designed at the facades and at few locations in the interior, to provide additional seismic resistance. The main structure of the open multi-story garage consists of reinforced concrete frames and precast hollow core slabs and it is designed for exposure class XD3, with special attention paying to durability conditions. Due to mainly precast structure, especially hollow core slabs as a floor solution, the complete concrete structure of approximately 80,000 m² is constructed for less then 12 months.

1 INTRODUCTION

DELTA CITY shopping mall is the first shopping mall built in Belgrade, in 2007. The Investors were companies Delta M d.o.o. and Delta City d.o.o from Belgrade, general designer was Slavija Biro d.o.o. from Belgrade in cooperation with Moore Architects from Israel and the general contractor was company Poor from Austria.

The whole building is functionally devided into two separated blocks: shopping mall and multi-story open garage. The overall dimensions of the irregular layout of the structure are 210 m × 110 m, with four main levels in the mall (storey height of 5.80 m) and five parking levels in the garage (storey height of 2.90 m). Because of the different exposure conditions, the structure of the garage is separated from the mall’s structure with an expansion joint at all the levels, except at the level of the foundation slab. Besides in the multi-story open garage, parking places are provided in the common underground level, also. The other levels of the shopping mall are provided for the shops, fast food restaurants, bowling facilities, cinemas etc.

2 THE SHOPPING MALL STRUCTURE

The structure was analyzed and designed in two steps: analysis and design of individual precast structural elements, and analysis and design of spatial framed structure. The following loads for the completed structure were considered: gravity loads, lateral loads: seismic (ground acceleration equal to 115 cm/sec²) and wind loads. As the building is air-conditioned in the service, the structure was designed without any expansion joints, except for temporary joints during the construction stage. Because of 210 m of the overall length, it was decided to design the structure for accidental temperature change equal to ±10°C, in the case of the air conditioning system failure. Besides, the structure was designed for XC1 exposure class and 90 minutes fire resistance.

The mall’s structure was designed as a spatial frame structure which consisted mainly of reinforced concrete cantilevered columns cast in place, at typical spans of 8.2 m × 8.2 m, and precast reinforced concrete beams with hinge connection to the column's corbels, Figure 1.
Figure 1. Assembly of precast beams of shopping mall and hollow core slabs of multy-storey garage structure.

The only possible location for shear walls was either in the facade or at the staircases location. This layout of the shear walls was considered as undesirable for resisting of the seismic forces as well as for the controlling the forces associated with temperature changes and reducing the effects of volumetric restraint. So, the system of cantilevered reinforced concrete cast in place columns was designed as a main structural system for resisting the lateral seismic and wind forces. To provide a spatial structural stiffness and reduce the deformations from lateral loads, reinforced concrete frames with stiff connections were cast in place in the facades and along the edges of the main pedestrian’s corridors which formed elliptical shape of skylights.

The precast prestressed hollow core slabs, supported by the precast beams, with depth of 20 cm–35 cm, depending on the live load, were designed for floor structure. The 7.5 cm reinforced concrete topping was cast in place over the slabs and other usual steel ties between slabs and beams were provided to enable the rigid diaphragm action of the composite floor.

3 THE MULTI-STORY GARAGE STRUCTURE

The main structure of the open multi-story garage, with the overall dimensions of the layout being 92.0 m × 33.0 m, consisted of reinforced concrete frames cast in place in shorter direction at a distance of 8.2 m, and shear walls in both directions. Shear walls were used to resist lateral loads and were located near the center of the garage layout, to prevent a significant restraint forces from temperature related volume changes. The same as in the shopping mall, precast prestressed hollow core slabs, with 10 cm reinforced concrete topping cast in place, were designed as a floor structure. The beams of the frames were casted in two phases: in the first phase the lower half of the beams was casted, and in the second phase, after the hollow core slabs were mounted, the upper half of the beams, together with topping, was cast in place. The structure was analyzed and designed for following loads: gravity loads, lateral loads; seismic and wind loads, and car impact on the barriers, and temperature changes: −32°C and +20°C for all the slabs, except for the top level slab which was under direct sunlight and exposed to +40°C temperature change.

Special attention in design was paid to durability requirements. The garage structure was designed for exposure class XD3 and following measures were undertaken to provide adequate durability: good quality, air-entrained concrete of class C37, adequate drainage slope of the slabs with 1.5 percent slope, minimum concrete cover of 4.5 cm for all structural elements, high-quality sealants at construction and expansion joints and traffic-bearing membranes which consisted of a multi-layer elastomeric polyurethane material with an integral, nonskid traffic topping. These membranes protect the parking slabs against deterioration and leakage and are capable of bridging the small cracks, up to 0.2 mm width.

4 CONCLUSION

Although designed as a combination of cast in place and precast elements, DELTA CITY shopping mall concrete structure, of approximately 80,000 m², was constructed in less then 12 months. The most time-consuming operation on the site – casting of the floor slabs was avoided, and utilization of precast beams and hollow core slabs was proved as time-saving and cost effective solution in this case.

REFERENCES