

RECENT RESEARCH WORK RESULTING IN IMS BUILDING TECHNOLOGY IMPROVEMENTS

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ABSTRACT

IMS Building Technology is based on prefabricated concrete elements of the structure, assembled on-site and joined using prestressing. This construction method, developed in 1950s and implemented worldwide, is still in use. This paper describes recent improvements and the research work that initiated and enabled them, as well as on-site experiences from the process of implementation.

Keywords: industrialization of building; IMS Building Technology; prestressing; prefabrication

ABSTRACT

Tehnologia de construcție IMS este bazată pe elemente structurale prefabricate, montate pe șantier și asamblate prin precomprimare. Această metodă de construcție, dezvoltată în anii '50 și implementată la nivel internațional, este încă utilizată. Articolul descrie îmbunătățiri recente ale metodei, cercetările care au contribuit la inițierea ei, precum și experiența dobândită pe șantier în procesul de implementare a acesteia.

Cuvinte-cheie: industrializarea execuției construcțiilor; tehnologia de construcție IMS; precomprimare; prefabricare

1. WHAT IS IMS BUILDING TECHNOLOGY?

IMS Building Technology is an advanced system for industrialized building. It is based on prefabricated reinforced concrete elements of the skeleton frame structure, assembled on-site and joined using post-tensioning tendons.

The prefabricated concrete frame consists of columns, beams, floors slabs, shear walls and staircases. It enables the construction of a wide variety of different buildings, produced out of relatively small number of typical elements, precast industrially in large series.

An important characteristic of the IMS Building Technology is that it represents an open system, which can accommodate various subsystems, differing in both technology and materials. (Petrović, 2006)

Figures 1 and 2 depict the concept of this technology: multi-storey columns with floor slabs between them and horizontal prestressing force applied through tendons anchored at the edges of the building.

Note that the floor slab supports shown here are only temporary, used during assembly and removed after prestressing, leaving a flat

ceiling surface without any visible girders or short elements.

Figure 3 shows the column – slab joint in IMS Building Technology. Top view is shown, with standard floor slabs to the left and cantilevers to the right. Steel tendons are visible, already post-tensioned and awaiting the casting of concrete for system girders. Two steel temporary supports for cantilevered slabs are also partially shown.

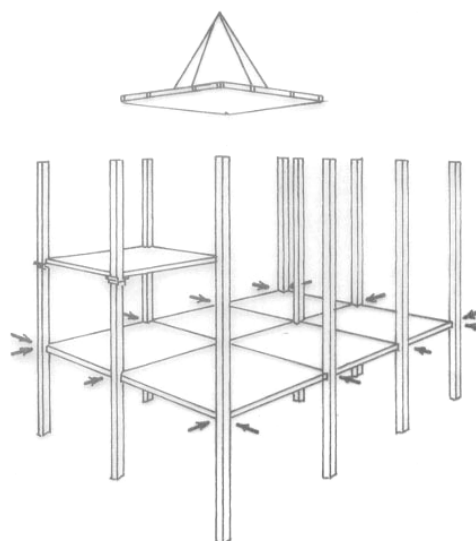


Fig. 1. The concept of operation – sketch



Fig. 2. The concept of operation – photo

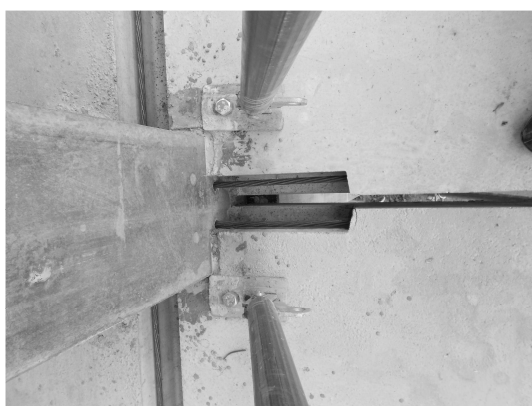


Fig. 3. Detail of the column – slab joint

The system shows great performance under horizontal loads, as the frame structure (columns and floor slabs, without shear walls) can be designed to accept up to 25% of the seismic force. This characteristic has been proven both in laboratory testing and during exploitation, since no structural failure has ever been recorded in IMS buildings exposed to strong earthquakes and winds (*ibid.*).

Used in numerous large-scale projects in former Yugoslavia and various parts of the world, providing safe and affordable housing for thousands of families in the second part of the XX century, the IMS Building Technology is the last surviving „old” concrete prefabrication system, still in use today. (Petrović and Milovanović, 2012)

2. RECENT IMPROVEMENTS TO THE IMS BUILDING TECHNOLOGY

IMS Building Technology was first implemented in 1957 and is, since then,

constantly being upgraded. It required numerous researches and tests, first of all, in the field of durability and stability of the structure, but also in the field of architectural design.

This paper mainly deals with research and implemented improvements in the period 2006 to present (2013), all in the process of revitalization of the IMS Building Technology for Gradnja construction company in Osijek, Croatia.

The building system, previously used by Gradnja Osijek was based on the solutions developed by professor Branko Žeželj. This system was in use in Osijek, Croatia, since 1964 and enabled, through almost three decades, the construction of numerous residential and commercial buildings. The 1990's civil war brought the end of the application of the IMS Building technology, and the production and assembly equipment was ruined.

After preliminary analyses and communication with the IMS Institute, present management of the Gradnja company from Osijek decided to reimplement the IMS Building Technology, in order to respond in the most efficient and most economical way to the prevailing trends in residential housing construction (increased demand, lack of qualified workers, need for optimization).

Through the process of revitalization of the system, a new, contemporary solution was created, in accordance with present market demands (Petrović and Napijalo, 2012).

2.1. Key improvements

The modernization of the system, carried out through this project, includes numerous significant technical improvements. Key differences from the previously used technology, that are the result of long-term development and application of the IMS system, include post-tensioning with the use of tendons, innovations of the elements and joints, production in flexible moulds, innovations of assembly equipment, as well as the use of advanced structural analysis software. All these enhancements ensure a contemporary process of design, production

and assembly through the application of the IMS Building Technology.



Fig. 4. Prestressing in progress

2.2. Prestressing

SPB SUPER prestressing system is implemented (Fig. 4), using steel tendons. The previous solution, used by Gradnja, was based on the prestressing of steel wires (IMS System).

2.3. Production of elements

In order to match the existing technology at the Gradnja production facility, casting of floor slab elements is done in moulds with interchangeable modular sides. Some sides are fixed on the side of a steel platform, while others slide over the surface and are fixed in place using magnets (Fig. 5).

Simple and quick replacement of sides enables the design demands for different modules (360 x 360, 360 x 420, 360 x 480, 360 x 540, 420 x 420, 420 x 480 cm).



Fig. 5. Production of floor slab elements

2.4. Simplified elements and assembly

The cross-section of the side of the mould and element is simplified to the maximum extent, in terms of geometry, production and assembly procedures.



Fig. 6. Assembly of cantilevered floor slabs

The assembly equipment is innovated based on all positive experiences (decreased dimensions, easier operation, see Fig. 6).

2.5. Structural analysis

Structural analysis and modeling of the IMS structure is done using contemporary software and according to European norms. It confirmed the experimental results, as well as experiences of several decades of application of the IMS Building Technology in numerous countries (Petrović and Milovanović, 2012).

2.6. Load testing of a floor slab

In 2013, the team of the Laboratory for Testing of Structures of the IMS Institute carried out the load testing of a floor slab at the construction site of the pilot building in Osijek, Croatia. The main objective of load testing was the stress-strain comparison between numerical and experimental model of the structure.

According to the design load of IMS building, dead load is defined as $2.25 + 2.65 \text{ kN/m}^2$, with an imposed load of 2.00 kN/m^2 . The total load for correlation, with exception of self-weight, is 4.65 kN/m^2 . The testing load is presented in Fig. 7.

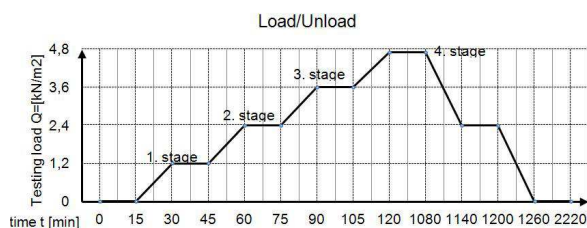


Fig. 7. Testing load

The load testing was performed according to Serbian standard test method SRPS.U.M1.047:1987. During the slab testing, deflection and vertical displacement were measured. The total number of deflection measurement points was 46, with a total of 18 vertical displacement measurement points (Fig. 8).

The results of load testing have shown that the tested slab was without visible marks of damage. Also, the design values of deflection and vertical displacement proved to be almost identical to the test values (difference of no more than ± 0.1 mm). The maximum vertical displacement was 0.58 mm at the middle of the span (420 cm). The maximum measured stress was 0.4 MPa, differing from the design values with no more than 0.2 MPa.



Fig. 8. Load testing in progress

3. FINAL REMARKS

As an open system, IMS Building Technology proved to be an ideal solution to contemporary problems, such as the lack of qualified workers, need for optimization, quality control, as well as architectural demands for flexible organization of

apartments. The research done at the IMS Institute enabled various improvements to be implemented, making it possible for this over 50 year-old technology to successfully meet the new demands.

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