TECHNICAL AND ECONOMIC COMPARISON OF MONOLITHIC CONSTRUCTION AND THE COBIAX SYSTEM IN COMMERCIAL BUILDINGS

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ABSTRACT

This paper presents a comparative analysis between conventional monolithic reinforced concrete construction and the COBIAX voided slab system used in commercial buildings. The study evaluates structural behaviour, construction efficiency, economic performance, and seismic response of both systems. Traditional monolithic construction is compared with modern reinforced concrete slabs incorporating recycled plastic void-forming elements.

The COBIAX system reduces concrete consumption and structural self-weight while maintaining the structural capacity and stiffness of the slab system. Reduction of dead load significantly improves seismic performance and enables optimisation of columns, foundations, and supporting elements.

The analysis was conducted according to Eurocode 2 and Eurocode 8 standards using conventional reinforced concrete design principles and verified engineering methods for voided slab systems.

The results demonstrate that the COBIAX system provides reduced construction costs, shorter execution time, improved sustainability, and better structural efficiency compared with conventional monolithic slabs. Furthermore, reduced slab thickness and lower material consumption allow larger spans and increased usable floor space.

Keywords: monolithic construction, reinforced concrete slabs, COBIAX system, voided slabs, structural efficiency, Eurocodes, commercial buildings

INTRODUCTION

Modern construction engineering continuously seeks methods for reducing structural weight, material consumption, and construction time while maintaining safety and durability. Reinforced concrete remains one of the most widely used construction materials due to its high compressive strength, durability, and adaptability in structural systems.

Traditional monolithic reinforced concrete slabs are widely applied in commercial and residential buildings. However, one of their major disadvantages is their significant self-weight, which increases seismic forces, material consumption, and foundation loads.

To overcome these limitations, innovative slab systems such as the COBIAX voided slab technology have been developed. The COBIAX system incorporates recycled plastic void formers within reinforced concrete slabs, replacing non-structural concrete in the neutral zone of the slab.

As a result, the slab weight is significantly reduced without negatively affecting structural performance. This allows larger spans, thinner slabs, reduced column dimensions, and more economical foundation systems.

In seismic regions, reduction of permanent loads is particularly important because seismic forces are directly proportional to structural mass. Therefore, lighter structural systems contribute to improved ductility and seismic resistance.

This paper presents a comparative technical and economic analysis between conventional monolithic construction and the COBIAX system in commercial buildings.

MONOLITHIC CONSTRUCTION SYSTEM

Monolithic construction systems are based on reinforced concrete frame structures consisting of foundations, columns, beams, slabs, and shear walls. These structural systems are constructed entirely on site using formwork, reinforcement, and cast-in-place concrete.

The execution process begins with earthworks and preparation of the foundation base. After excavation and soil compaction, a crushed stone layer is placed to improve load transfer and groundwater drainage.

The foundation slab is then constructed using reinforced concrete with dimensions determined through structural analysis. Basement walls and vertical structural elements are also executed in reinforced concrete.

The superstructure generally consists of:

- Reinforced concrete columns
- Beams
- Flat slabs
- Staircases
- Shear walls

The main advantage of monolithic construction is its simplicity and widespread application in engineering practice. However, this system has several disadvantages:

- High structural self-weight
- Increased seismic forces
- Greater concrete consumption
- Larger column and foundation dimensions
- Longer construction time

Because of these limitations, alternative slab technologies have become increasingly important in modern structural engineering.

Figure 1. *Conventional Reinforced Concrete Monolithic Slab System*

The COBIAX system is an innovative biaxial voided slab technology designed to reduce the self-weight of reinforced concrete slabs. The system uses hollow recycled plastic spheres or ellipsoidal modules positioned between upper and lower reinforcement layers. These void formers replace non-effective concrete in the central zone of the slab, where concrete contributes minimally to bending resistance.

The main objectives of the COBIAX system are:

- Reduction of concrete volume
- Reduction of slab self-weight
- Improvement of structural efficiency
- Reduction of seismic forces
- Larger structural spans
- Sustainable construction

The system allows bidirectional load transfer similarly to conventional solid slabs.

Two principal systems are commonly used:

Eco-Line System

- Spherical void formers
- Suitable for slab depths from 40 cm to 70 cm

Slim-Line System

- Flatter void formers
- Suitable for slab depths from 20 cm to 56 cm

The modules are placed between reinforcement layers according to the structural design plan.

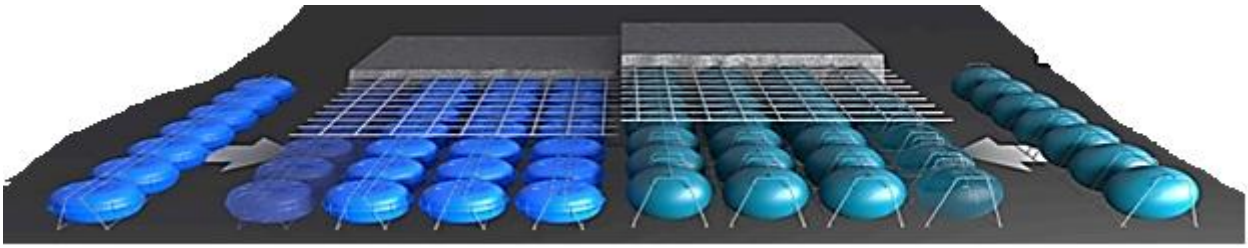

Figure 2. *COBIAX Eco-Line and Slim-Line Systems*

The structural analysis of COBIAX slabs can be performed using standard finite element software according to Eurocode regulations.

The design procedure includes:

1. Preliminary estimation of slab thickness
2. Selection of appropriate COBIAX modules
3. Determination of load reduction factors
4. Structural analysis considering reduced stiffness
5. Verification of punching shear zones
6. Final structural verification

Due to the reduction of concrete in the neutral zone, slab stiffness decreases only slightly, generally between 5% and 13%, while substantial weight reduction is achieved.

The system also enables the creation of solid zones around columns and supports where higher shear resistance is required.

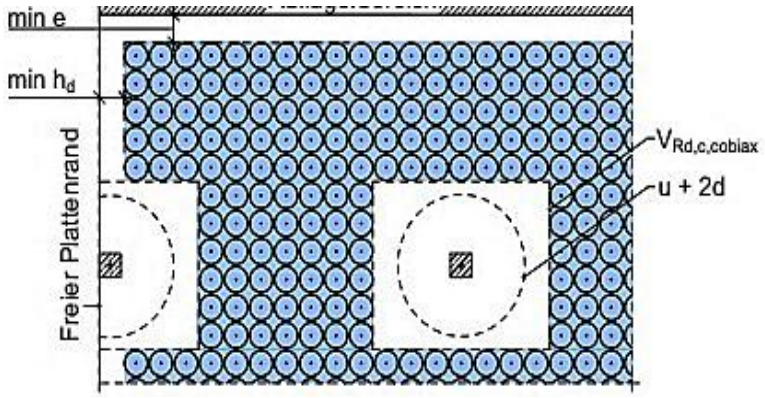

Figure 3. *Placement of COBIAX Modules Within Reinforced Concrete Slabs*

The use of recycled plastic void formers contributes significantly to environmental sustainability by reducing concrete consumption and lowering CO2 emissions.

COMPARISON BETWEEN MONOLITHIC AND COBIAX SYSTEMS

The main difference between conventional monolithic slabs and COBIAX slabs lies in the internal slab composition.

In monolithic slabs, the entire slab volume consists of solid reinforced concrete. In contrast, the COBIAX system removes non-structural concrete from the slab core and replaces it with lightweight void formers.

This reduction in concrete volume leads to several structural and economic advantages.

Structural Performance

The reduced self-weight decreases the total dead load acting on columns, beams, and foundations.
Consequently:

- Smaller structural elements can be designed
- Foundation dimensions can be reduced
- Seismic forces become lower
- Larger spans can be achieved
- Slab thickness can be reduced by approximately 5–10%

Despite the reduced concrete volume, the slab maintains adequate flexural stiffness and load-bearing capacity.
Construction Efficiency

The COBIAX system accelerates construction because:

- Less concrete is required
- Transportation loads are reduced

• Formwork demands are minimised
• Construction becomes more practical

The installation of modules is relatively simple and can be integrated into standard reinforced concrete construction procedures.

Environmental Benefits

The COBIAX system contributes to sustainable construction through:

• Reduced concrete usage
• Lower cement consumption
• Reduced CO2 emissions
• Use of 100% recycled plastic modules

Concrete production is one of the largest sources of global carbon emissions. Therefore, reducing concrete volume has significant environmental advantages.

Seismic Advantages

In seismic design, lower structural mass directly reduces earthquake forces.

Because the COBIAX system significantly reduces dead load, buildings demonstrate:

• Improved seismic behaviour
• Better ductility
• Reduced dynamic response
• Lower risk during earthquakes

These advantages make the system particularly suitable for seismic regions

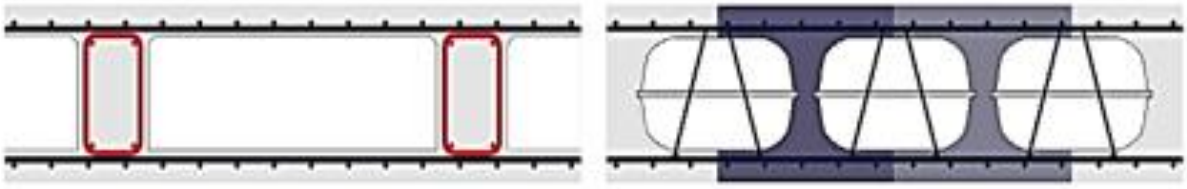

Figure 4. *Comparison Between Conventional Slabs and COBIAX Slabs*

COST ANALYSIS

Economic efficiency is one of the most important advantages of the COBIAX system. Although the initial cost of void formers increases slab production expenses, the overall project cost is reduced due to savings in:

• Concrete quantity
• Reinforcement requirements
• Foundation dimensions
• Transportation costs
• Construction time

The reduction in slab weight allows optimisation of the entire structural system.

According to the performed analysis, COBIAX slabs can reduce concrete consumption by approximately 25–30% compared with conventional monolithic slabs.

In the analysed case study:

• Conventional slabs required approximately 600 m3 of concrete
• COBIAX slabs required approximately 420 m3 of concrete

This represents a saving of approximately 180 m3 of concrete.

Additionally, approximately 1400 tons of CO2 emissions can be avoided through reduced material consumption.

Another advantage is the reduction in floor height due to flat slab construction without deep beams. This creates additional usable space and architectural flexibility.

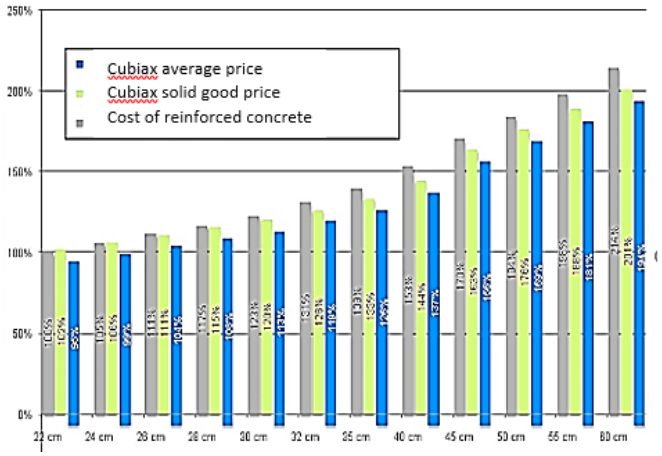

Figure 5. *Cost Comparison Between Conventional and COBIAX Slab Systems*

CONCLUSION

The conducted analysis demonstrates that the COBIAX system represents a highly efficient alternative to conventional monolithic reinforced concrete construction.

The system successfully reduces structural self-weight while maintaining the required structural safety, stiffness, and durability. Compared with conventional reinforced concrete slabs, the COBIAX system offers several important advantages:

- Reduced concrete consumption
- Lower structural dead load
- Improved seismic performance
- Faster construction process
- Reduced environmental impact
- Larger structural spans
- Lower foundation costs
- Greater architectural flexibility

The use of recycled plastic modules additionally contributes to sustainability and environmental protection. Based on the structural and economic analysis presented in this study, the COBIAX system can be considered a modern, sustainable, and economically justified solution for commercial buildings, particularly in regions exposed to seismic activity.

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TEHNIČKO-EKONOMSKO POREĐENJE MONOLITNE GRADNJE I SISTEMA COBIAX U POSLOVNIM ZGRADAMA

SAŽETAK

Ovaj rad prikazuje komparativnu analizu konvencionalne monolitne armiranobetonske gradnje i COBIAX sistema olakšanih ploča u poslovnim objektima. Studija analizira strukturno ponašanje, efikasnost gradnje, ekonomske performanse i seizmički odgovor oba sistema. Tradicionalna monolitna gradnja se poredi sa modernim armiranobetonskim pločama koje uključuju elemente za formiranje šupljina od reciklirane plastike.

COBIAX sistem smanjuje potrošnju betona i vlastitu težinu konstrukcije, dok istovremeno održava strukturni kapacitet i krutost sistema ploča. Smanjenje stalnog opterećenja značajno poboljšava seizmičke performanse i omogućuje optimizaciju stubova, temelja i potpornih elemenata.

Analiza je provedena u skladu sa Eurokod 2 i Eurokod 8 standardima korištenjem konvencionalnih principa projektovanja armiranobetonskih konstrukcija i verifikovanih inženjerskih metoda za sisteme olakšanih ploča.

Rezultati pokazuju da COBIAX sistem osigurava smanjene troškove izgradnje, kraću izvedbu radova, poboljšanu održivost i bolju strukturnu efikasnost u poređenju sa konvencionalnim monolitnim pločama. Nadalje, smanjena debljina ploče i manja potrošnja materijala omogućuju veće raspone i povećanu korisnu površinu poda.

Ključne riječi: monolitna gradnja, armiranobetonske ploče, COBIAX sistem, olakšane ploče, strukturna efikasnost, Eurokodovi, komercijalne zgrade

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