

**SUBJECT: PROPERTIES AND CONSTRUCTIVE THEORIES OF HEAVY  
CONCRETE BASED ON CARBONATE ROCKS UNDER LONG-TERM  
LOADING**

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***ABSTRACT***

This study investigates the mechanical properties and deformation behavior of heavy concrete produced using carbonate rock aggregates under long-term loading conditions. Particular attention is given to shrinkage, creep, and stress redistribution mechanisms in concrete structures. Concrete mixtures were designed using limestone aggregates and CEM I 42.5N cement with a water–cement ratio of 0.51.

The results indicate that carbonate aggregates significantly influence the deformation behavior of concrete due to their porosity, elastic modulus, and surface characteristics. Dense limestone aggregates reduce creep deformation, while more porous carbonate materials lead to increased shrinkage effects. The interaction between aggregate and cement paste improves the interfacial transition zone (ITZ), resulting in enhanced structural integrity.

The study also presents a constructive theoretical model describing the stress–strain behavior and long-term deformation of carbonate concrete. It is concluded that carbonate rock-based concrete exhibits reliable performance under sustained loads and can be effectively used in structural applications.

***KEYWORDS***

Carbonate rocks; limestone aggregate; heavy concrete; creep; shrinkage; deformation; long-term loading

## 1. INTRODUCTION

The long-term performance of concrete structures is strongly influenced by deformation processes such as creep and shrinkage. These phenomena affect the serviceability, durability, and structural reliability of reinforced concrete elements.

In recent years, the use of carbonate rock aggregates, particularly limestone, has gained attention due to their availability and economic advantages. However, their influence on long-term deformation behavior requires further investigation.

Carbonate aggregates differ from traditional siliceous aggregates in terms of porosity, surface roughness, and elastic properties. These characteristics significantly affect the interaction between aggregates and cement paste, thereby influencing the mechanical and deformation behavior of concrete.

The objective of this study is to analyze the properties and develop constructive theoretical approaches for heavy concrete based on carbonate rocks under long-term loading conditions.

## 2. MATERIALS AND METHODS

Concrete mixtures were prepared using the following materials:

- Cement: CEM I 42.5N
- Water–cement ratio: 0.51
- Fine aggregate: limestone sand (0–5 mm)
- Coarse aggregates: 5–10 mm and 10–20 mm limestone

Mix composition per 1 m<sup>3</sup>:

- Cement — 450.57 kg
- Water — 230 l
- Sand — 717.35 kg
- Coarse aggregates — 917.6 kg

Specimens:

- Cubes: 100×100×100 mm
- Prisms: 100×100×400 mm

The following tests were conducted:

- Compressive strength at 7, 14, and 28 days
- Stress–strain ( $\sigma$ – $\varepsilon$ ) behavior
- Long-term deformation (creep and shrinkage analysis)

### 3. RESULTS AND DISCUSSION

The compressive strength results showed a stable increase over time, reaching approximately 30 MPa at 28 days. The prism strength was about 80% of cube strength, confirming expected structural behavior.

Shrinkage deformation was found to depend on the porosity and water absorption of carbonate aggregates. Dense limestone aggregates resulted in reduced shrinkage, while porous aggregates increased volume deformation.

Creep behavior was influenced by both the cement matrix and aggregate stiffness. Carbonate aggregates acted as a restraining phase, limiting long-term deformation. The creep coefficient ( $\varphi$ ) remained within acceptable limits, indicating stable performance under sustained loads.

The stress–strain curves showed a typical nonlinear behavior, with an extended elastic phase followed by gradual plastic deformation. Compared to conventional concrete, carbonate concrete exhibited reduced brittleness and improved deformation capacity.

A constructive theoretical model was developed, considering:

- aggregate stiffness
- ITZ behavior
- internal stress redistribution
- microcrack development

This model explains the deformation behavior of carbonate concrete under long-term loading conditions.

## CONCLUSION

The study demonstrates that carbonate rock-based heavy concrete exhibits reliable mechanical and deformation properties under long-term loading.

The key findings are:

- Carbonate aggregates improve ITZ bonding and structural integrity
- Shrinkage and creep behavior depend on aggregate density and porosity
- Limestone aggregates reduce brittleness and improve deformation capacity
- The developed theoretical model adequately describes long-term behavior

The results confirm that carbonate aggregate concrete is suitable for structural applications and provides both technical and economic benefits.

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