



## Energy Absorption Capacity Of Layered Lightweight Reinforced Concrete Beams With Openings In Web

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### Abstract

This research presents the flexural behavior on reinforced concrete beam with transverse web opening constructed from layered concrete. The layered concrete combining normal concrete and lightweight aggregate concrete (LWC) are depended in present study. In the experimental program, 13 models of normal and layered reinforced concrete beams are tested under the effect of four-point loads. All beams had the same overall geometrical dimensions and main longitudinal top and bottom with internal diagonal reinforcement provided around the openings. One of the beam specimen is tested as control beam and the other specimens are divided into three groups [G1, G2, and G3] to study the effects of the following variables: effect of presence of web openings, layered system, lightweight aggregate (partially volumetric replacement of normal aggregate by thermestone) on the ultimate load, cracking load, cracking pattern and energy absorption capacity. The existing of an opening in beam specimens reduced the flexural capacity of beams with a percentage depending on the size of opening and opening number. The test data obtained from the adopted layered technique of (NEW) and (LWC) have shown that for beams constructed from two layered concrete (LWC with thermestone in the web and bottom flange of I-beam section) ultimate load is decreased about (9.3%-48.8%). It has also, the beams constructed from three-layered of concrete (LWC with thermestone in the web of I-beam section), their ultimate load is decreased about (25.6%-58.1%). On the other hand, magnitude increased of energy absorption capacity are achieved by the decreased opening size, introducing the full size opening of dimension (100×1000) mm reduces the energy absorption capacity of the RC I-section beams at least 80% compared to solid beam while the beam with opening size (100×100) mm decrease up to 16%. In the case of the layered concrete beams specimen, the real influence of lightweight concrete (LWC) type in the layered reinforced concrete is observed significantly after increasing the length of opening more than 100 mm.

*Keywords:* Layered Concrete; Lightweight Aggregate Concrete; Openings; Thermestone Aggregate; Energy Absorption Capacity.

### 1. Introduction

In civil engineering construction, the objective of using or selecting any material is to make full utilization of its properties in order to get the best performance for the formed structure. The features of a material are based on factors such as availability, workability, structural strength, durability, and cost. As it is difficult to find a material, which possesses all these properties to the required level, the engineer's problem consists of an optimization involving different materials and methods of construction.

Hybrid layered systems of various strength materials can be used in civil engineering construction. The hybrid concrete structure under flexural as consists of two layers; for an example the compressive layer, which is made of a

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