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Faculty of Engineering
Civil Engineering Department**

**“Analytical Study For Behavior Of Reinforced Light-Weight
Concrete Deep Beams With Web Openings”**

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STATEMENT

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The work included in this thesis was carried out by the author at reinforced concrete unit lab in the faculty of engineering in the Department of Civil Engineering (Structural Division), Ain Shams University.

No part of this thesis has been submitted for a degree or qualification at any other University or Institute.

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ABSTRACT

Light weight aggregate and light weight concrete are old and new materials in the world of the engineering design and construction. Concrete structures such as bridges and buildings are constantly getting high consideration to determine the design loading. Dead load is the first consider for any structural design. Finding any way either in the method of construction application or in the type of the construction materials to reduce the dead load will be a magnificent benefit for structural design.

Light weight aggregate brought the benefit of the dead load reduction. Various types of lightweight aggregate with good and carefully mix proportioning could produce a lightweight concrete with adequate concrete compression strength. Desirable concrete strength and durability had been achieved by using light weight concrete as much as achieved by using normal weight concrete.

Beside the benefit of dead load reduction, there are many more advantages by using light weight concrete including: reduction in dimensions of the structural elements then their steel reinforcement, reduction the transporting equipment expenses. Increasing the space availability by reduction in the sizes of columns, slabs and beams dimensions. In addition, Light weight aggregate provides better heat and sound insulation than normal weight concrete, maintains good fire resistance, provides great buoyancy for the offshore and marines structures, and the environmental advantage by using fly ash for light weight aggregates and light weight concrete.

The behavior of the deep-beam is examining using the finite element software ANSYS. Non Linear Finite Element Analysis (NLFEA) used to predict the behavior of reinforced light weight concrete deep-beams, Results from nonlinear finite element analyses are compared with experimental results carried in the literature which reveals the reasonable accuracy of the modeling, Parametric study and Strut and Tie modeling for Light weight concrete deep- beams with and without web openings.

This Analytical research work was lead up to study the shear behavior of reinforced Light-Weight Concrete (LWC) and Normal-Weight Concrete (NWC) simply supported deep-beams with and without web openings under the effect of one vertical concentrated load.

The program included ten Light-Weight reinforced concrete deep beams and four Normal-Weight deep beams. All specimens with an overall cross-section of (80 x 400 mm.) and length of deep beams (1100,1580 and 1900 mm). There is one Light-Weight concrete specimen without web opening and the thirteen-remaining light and normal weight concrete specimens with web openings.

The openings developed in different three locations in shear span zone, openings dimensions are (80 x 80 ,140 x 80 and 180 x 80 mm), number of openings one or two openings in shear span zone. The main reinforcement of all studied deep beams was kept constant and equal to 4Ø16 while top steel 2Ø10 for all specimens. The basic variables of this study were the size and position of the opening, the concrete type, and span-to-depth ratio. The general deformational behavior of the deep-beams was examined and reported (cracking, load deflection behavior and crack pattern, deformations).

The obtained results indicated that the presence of web openings (equal to 20% and 40 % of the total web height, respectively) in the load path led to a reduction in the ultimate shear strength of LWC simple deep-beams by about 10% to 55 % when compared with a similar beam without opening.

A comparison between the results of Non Linear Finite Element Analysis (NLFEA) obtained from the numerical analysis and experimental study results of other research. A non-linear finite element analysis (NLFEA) model was established to emulate the shear behavior of tested beams from other research, in another site of load deflection behavior and crack pattern. It can be concluded that a good agreement between the numerical and experimental results was achieved. The ratio of the predicted to the experimental ultimate strength ranged between 0.90 and 0.99.

A parametric study included one hundred eleven deep beams were modeled by using ANSYS program. For the shear lightweight reinforced concrete deep beams. The parameters considered are the tensile steel, openings additional top and bottom reinforcement, openings additional sides reinforcement, and openings additional sides, top and bottom reinforcement. the performing of the comparison was concerning about those parameters. mid-span maximum deflection and ultimate loads had been determined by using ANSYS V.15.

A non-linear finite element analysis (NLFEA) model using ANSYS was created for LWC and NWC deep beams. The concrete was modeled by Solid65 with a stress-strain relationship

based on unconfined conditions. The reinforcing bars were modeled by using 3D-Link180 element adopting a bilinear stress-strain relationship.

A theoretical study was performed using Strut-and-Tie Models and the results were compared with analytical results from non-linear finite element analysis.

The results of this analytical work were combined with some other available information to formulate some recommendations for designers and researchers concerning the analysis, design, and construction of Light-Weight concrete beams. The observed behavior of the Light-Weight concrete specimens up to failure greatly encourages the use of Light-Weight concrete in all structural elements.

Keywords: *Light-weight concrete, Deep Beams, Shear, Nonlinear Finite Element Analysis.*

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