WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

A Review-Analysis of Deep Beam Using Ansys Software

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ABSTRACT:

Reinforced concrete deep beams are structural members having depth much greater than normal in relation to their span, while the thickness in the perpendicular direction is much smaller than either span or depth. The strength of deep beams is usually controlled by shear, rather than flexure. In this study, the previous researches related to reinforced concrete deep beams will be reviewed. These researches approximately started in the second half of the past century. Large numbers of researchers studied the behavior of concrete deep beams and the determination of their capacity. Some of these researches are experimental investigations carried out by testing a number of deep beams with variation in some parameters, while the others are theoretical to estimate deep beam capacity by developing some theories and suggestion of equations for calculating its capacity and comparisons were made with those adopted by some codes.

Keywords: Simply Supported Beam, Fixed Beam, ANSYS, Point load, Deep Beam

I. INTRODUCTION

Beams with large depths in relation to spans are called deep beams. As per the Indian Standard, IS 456:2000, Clause 29, a simply-supported beam is classified as deep when the ratio of its effective span L to overall depth D is less than 2. Continuous beams are considered as deep when the ratio L/D is less than 2.5. The effective span is defined as the centre-to-centre distance between the supports or 1.15 times the clear span whichever is less. They are structural elements loaded as simple beams in which a significant amount of the load is carried to the supports by a compression force combining the load and the reaction. As a result, the strain distribution is no longer considered linear, and the shear deformations become significant when compared to pure flexure. Because of their proportions deep beams are likely to have strength controlled by shear rather than flexure. On the other hand, their shear strength is expected to be significantly greater than predicted by the usual equations, because of a special capacity to redistribute internal forces before failure and to develop mechanisms of force transfer quite different from beams of common proportions

II. LITERATURE REVIEW

Limited studies have been reported in the literature on the behaviour and strength of deep beams a fairly common structural element in tall buildings, offshore structures and in foundations systems.

A. K. Sachan [1] performed an experimental study on “Behaviour of Fibre Reinforced Concrete Deep Beams”, a total of 14 concrete deep beams were tested to failure and the effects of fibre content, percentage reinforcement and the type of loading were studied. It was found that the addition of steel fibres to concrete results in a significant increase in ultimate strength of deep beams. It was also observed that the failure of fibre reinforced concrete beams was more ductile and gradual compared with the failure of plain and reinforced concrete beams.

H. K. Lee [2] worked on “Behaviour and Performance of RC T-Section Deep Beams Externally Strengthened in Shear with CFRP sheets”. In the paper a series of experimental tests were carried out to investigate the behaviour and performance of reinforced concrete (RC) T-section deep beams strengthened in shear with CFRP sheets. A total of 14 RC Tsection deep beams were designed to be deficient in shear with a shear span-to-effective depth ratio (a/ d) of 1.22. Crack patterns and behaviour of the tested deep beams were observed during four-point loading tests. It was concluded from the test results that the key variables of strengthening length, fibre direction combination, and anchorage have significant influence on the shear performance of strengthened deep beams. In 10 addition, a series of comparative studies between the present experimental data and theoretical results in accordance with the commonly applied design codes were made to evaluate the shear strength of a control beam and deep beams strengthened with CFRP sheets.

H. S. Kim [3] worked on “Structural Behaviours of Deep RC Beams under Combined Axial and Bending Force”. The paper presents experimental studies of deep reinforced concrete (RC) beam behaviours under combined axial and bending loads. In order to investigate the effect of axial loads on the structural behaviours of the deep RC beams, specimens were prepared to have different shear span-to-depth ratios and subjected to axial loads of 235kN or 470kN. From the experiments, structural behaviours such as failure modes, load-deflection relationships, and strains of steel bar and concrete are observed. As results, for the deep beam with shear span-to-depth ratio of 0.5, load at the beam failure decreases as applied axial load increases, while the deep beams with shear span-to-depth ratios of 1.0 and 1.5 shows that the applied axial load delays the beam failure. In addition, failure mode of the deep beam changes from shear failure to concrete crushing due to compressive stress at the top corners of RC beams as shear span-to-depth ratio decreases. From the experiments, it is important to notice that deep beam with relatively small span-to-depth ratio under axial load shows early failure due to concrete crushing, which cannot be directly applied to widely known design method for deep beam, strut-to-tie model.

Keun-Hyeok Yang [4] worked on “Shear Characteristics of High Strength Concrete Deep Beams without Shear Reinforcements”. A total of 21 beam specimens were tested to investigate their shear characteristics with the variables of concrete strength, shear span/depth ratio, and overall depth. Experimental results showed that the decrease in shear span/depth ratio and the increase in overall depth under the same shear span/depth ratio led to more brittle failure with wide diagonal cracks and high energy release rate related 11 to size effects. The high-strength concrete deep beams exhibited more remarkable size effects with regard to brittle behaviour.

M. R. Islam [5] studied on “Shear Strengthening of RC Deep Beams using Externally Bonded FRP systems”. Six concrete deep beams were fabricated and tested to failure. One of the beams was tested in its initial condition to serve as reference, while the remaining five beams were tested after being strengthened using carbon fibre wrap, strip and grids. Tests have shown that the use of a bonded FRP system leads to a much slower growth of the critical diagonal cracks and enhances the load carrying capacity of the beam to a level quite sufficient to meet most of the practical upgrading requirements.

Abdur Rashid [6] studied on “Behaviour of Reinforced Concrete Deep Beam under Uniform Loading”, a total of 14 concrete deep beams were tested under four point loading condition simulating approximately the uniform distributed load. The test beams were simply supported and were made with brick aggregate concrete. The test beams were divided into two series in which first beam of each series was designed and detailed as per recommendations of the ACI Building Code 318-89 (ACI, 1989). In the remaining six beams of each series, the amount of either the flexural reinforcement or, the horizontal web reinforcement or, both were increased in relation to that of first beam of the corresponding series. Results shown that the diagonal crack develops first in relatively deeper beams and flexural cracks develop first in the shallower beams provided the beams have sufficient reinforcements.

Mohd. Zamin [7] studied on “Failure Modes and Serviceability of High Strength Self Compacting Concrete Deep Beams”. The main purpose of the study was to facilitate the prediction of deep beam failure related to tensile bar and web reinforcement percentage variations. Six high strength self-compacting concrete (HSSCC) deep beams were tested 12 until failure. Strains were measured on concrete surface along mid span, tensile bar and compression strut trajectory. The load was incrementally applied and at each load increment new cracks, their widths and propagation were monitored. The results clearly showed that, at ultimate limit condition, the strain distribution on concrete surface along mid-span is no longer parabolic. In deep beams several neutral axes were obtained before ultimate failure is reached. As the load increased, the number of neutral axis decreased and at failure load it reduced to one. The failure of deep beams with longitudinal tensile steel reinforcement less than that suggested by ACI codes is flexural and is accompanied by large deflections without any inclined cracks. As the longitudinal tensile steel reinforcement increased, the failure due to crushing of concrete at nodal zones was clearly observed. The first flexural crack at mid-span region was always vertical. It appeared at 25-42% of peak load. The crack length was in the range of 0.24-0.6 times the height of section. As the tensile bar percentage increases number of cracks increases with reduced crack length and crack width.

Mohd. Zamin [8] studied on “An Experimental Investigation of the Stress-Strain Distribution in High Strength Concrete Deep Beams”. The paper discusses the behaviour, design and analysis of high strength reinforced concrete (HSC) deep beams regarding the neutral axis variation. Six(HSC)deep beams designed and casted with self-compacted concrete (SCC). The paper deals with the study of the stress-strain distribution along the beam section at mid-span and the variation of the neutral axis within the depth. Strain gauges were been attached on the concrete surface, on the tensile reinforcement and on the horizontal and vertical web bars to monitor the strains, both in concrete and in the different reinforcement bars. The data show clearly that the distribution of strains, and hence of stresses, in the deep beams studied is completely different from the linear one, commonly accepted for ordinary beams. 13 They also have more than one neutral axis, making the ordinary beam theory used in flexural design not justified in deep beams.

Sangdon Park [9] worked on “Strut-and-Tie Method (STM) for CFRP Strengthened Deep RC Members”. STM was used for the analysis of CFRP strengthened deep reinforced concrete members since a bonded CFRP element acts as an addition tension tie. A practical analysis and design process for CFRP strengthened deep RC members using the STM was presented in the paper. In addition, seven effective factor models accounting for reduction of strength in cracked concrete were also investigated. A total of 17 experimental deep beam test results were compared with the proposed STM approach results. It has been shown that the proposed STM approach with an effective factor model depending on the strut angle provides the best agreement with the test results.

T. M. Roberts [10] worked on “Shear Failure of Deep Fibre Reinforced Concrete Beams”. Totally nine deep, steel fibre reinforced concrete beams were tested to investigate the influence of fibres on the shear failure of deep beams. Only one type of fibre ’Duoform’ brass coated fibre, 0.38mm diameter by 38mm long was used in test programme. Results confirmed that the steel fibres can prevent shear failure in deep beams.

Tamer El Maaddawy and Sayed Sherif [11] worked on "FRP composites for shear strengthening of reinforced concrete deep beams with openings" The paper presents the results of a research work aimed at examining the potential use of externally bonded carbon fibre reinforced polymer (CFRP) composite sheets as a strengthening solution to upgrade reinforced concrete (RC) deep beams with openings. A total of 13 deep beams with openings were constructed and tested under four-point bending. Test specimen had a cross section of 80 x 500 mm and a total length of 1200 mm. 14 Two square openings, one in each shear span, were placed symmetrically about the mid-point of the beam. Test parameters included the opening size, location, and the presence of the CFRP sheets. The structural response of RC deep beams with openings was primarily dependent on the degree of the interruption of the natural load path. Externally bonded CFRP shear strengthening around the openings was found very effective in upgrading the shear strength of RC deep beams. The strength gain caused by the CFRP sheets was in the range of 35–73%. A method of analysis for shear strength prediction of RC deep beams containing openings strengthened with CFRP sheets was studied and examined against test results.

Wen-Yao Lu [12] studied on "Shear Strength prediction for Steel Reinforced Concrete Deep Beams". In the paper the study on analytical method for determining the shear strengths of steel reinforced concrete deep beams under the failure mode of concrete crushing originally based on the softened strut-and-tie modal was carried out. By comparing the predictions of the proposed method with the available test results from the literature, it was found that the proposed method is capable of predicting the shear strengths for steel reinforced concrete deep beams with sufficient accuracy.

Aya G. Abdel-Nasser [13] studies on "A nonlinear strain compatibility model is considered to investigate the behavior of reinforced concrete deep beams. It is based on satisfying equilibrium of stresses and compatibility of strains at all layers of the beam cross-section. A VISUAL BASIC code is developed for this model. Strain distribution over the cross section depth in deep beams is different from shallow beams, and varies according to the case of loading, the span-to-depth ratio (L/h), and the structural system. The experimental values of strain over the cross-section depth for different cases for simply supported deep beams, are extracted from the available literature. Based on these values, simplified equations for strain profiles for each case is proposed to use them in the present model. A key feature of the model is the ability to illustrate the effect of shear deformation of the cross section. The model is validated by comparing predicted results with experimental ones from literature in terms of load-displacement

Khaled Elbadry [14] A series of nonlinear finite element (FE) analyses was performed to evaluate the different design approaches available in the literature for design of reinforced concrete deep beam with large opening. Three finite element models were developed and analyzed using the computer software ATENA. The three FE models of the deep beams were made for details based on three different design approaches: (Kong, F.K. and Sharp, G.R., Magazine of Concrete Res_30:89- 95, 1978), (Mansur, M. A., Design of reinforced concrete beams with web openings, 2006), and Strut and Tie method (STM) as per ACI 318-14 (ACI318 Committee, Building Code Requirements for Structural Concrete (ACI318-14), 2014). Results from the FE analyses were compared with the three approaches to evaluate the effect of different reinforcement details on he structural behavior of transfer deep beam with large opening.

III. CONCLUSIONS

From the previous review on experimental studies of reinforced concrete deep beams and their predecessors, it can noted that the researches aimed to investigate the behavior of deep beams and study several parameters that affect their capacity. From literature one can note the following prominent remarks concerning the effect of these parameters:

1. The ultimate strength and diagonal cracking capacity of deep beams are not significantly influenced by span to depth ratio (L/d). Where the ultimate shear strength is slightly decreases with increasing (L/d) ratio.

2. The ultimate strength and diagonal cracking capacity are significantly influenced by shear span to depth ratio (a/d) which is considered as one of the important parameters that govern failure of deep beams by shear mode or flexural mode. The increase in this ratio decreases the deep beam shear capacity.

3. Presence of steel fibers in construction of concrete deep beams is useful in increasing the shear capacity, improving the cracking behavior and decreasing the deformations.

4. The depth of deep beams has a significant influence on their shear capacity where it increases the cross section area and reduces the (a/d) ratio.

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