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Contribution of Steel Shear Reinforcement in Two-Way Shear Resistance of Flat Plates (Parametric Study)

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***Abstract* – The current research presents an experimental, analytical and finite element investigation to study shear enhancement of flat plates by shear heads. Experimental results of nine half-scale concrete flat plate specimens were tested. Three different column aspect ratio were tested in the current study as follows: 1:1, 2:1 and 4:1. Two different lengths of shear heads from column face equal to 2.00d and 2.60d were examined with change of column aspect ratios in which "d" is flat plate depth. Structural behaviors were evaluated in terms of overall load-deflection response, ultimate loading capacity and ductility. Failure patterns and strain distribution were also discussed. The research also presents parametric study through numerical analysis taken in to account most important variables which haven't been studied in the practical program. Different arrangement of shear head legs, changing cubic compressive strength of concrete were some of these variables. Several different lengths of shear heads were also studied. Experimental and numerical results were analyzed through regression analysis to propose a new formula to predict the ultimate punching shear capacity of flat plates with shear heads.**

***Keywords* – Flat plates; Shear heads; Column aspect ratio; Finite element investigation; Parametric study; Numerical analysis; Regression analysis**

INTRODUCTION

Punching shear is one of the most important criteria that control design of flat plates. There are many traditional ways to enhance punching shear resistance of flat plates such that using thick slab and large column or drop panel utilization with and without column heads. The ACI 318 and CSA (Canadian Standards) codes are based mainly on Moe's work (1961), while the BS 8110 (British Standard Institution) and EC 2 codes are based on Regan's work (1974). The present building code specifications for the shear strength of reinforced concrete slabs are based on the test results of plates made with relatively low compressive strengths, varying mostly from 14 to 40 MPa. The Kinnunen and Nylander concrete punching rational model (1960) still provides one of the best accounts of the punching behavior of concrete plates without shear reinforcement. Modern European codes of practice treat punching shear in terms of shear stresses calculated at control perimeters located at relatively large distance from the column or loaded area. In the CEB-FIP 1990 model code, at a distance is 2d. In BS 8110-97, it is 1.5d, but the peripheral has square corners as compared with CEB-FIP rounded corners.

In North American codes such as ACI 318 and CSA Canadian the control punching shear peripheral is only 0.5d away from the loaded column. Different European and North American codes and design guidelines allow the use of shear reinforcement for two-way slab plates. More recently, the American and the Canadian codes allows the use of shear studs developed by Ami Ghali and walter Dilger at Calgary University (1981). Also Punching shear reinforcement has become one of the approved methods in most codes of the Middle East countries such as Egyptian code of practice ECP 203(2017). Corley and Hawkins (1968) suggest details of a shear heads. This mechanism makes use of structural steel sections welded collectively to make a grid which can then be placed around or via a column. Their study shaped the basis of the shear head reinforcement design guidelines and recommendations in the American Code Institute design code ACI 318. The current research develops a new formula to predict contribution of shear heads in resisting punching shear of flat plates.

CONCLUSION

Flat slabs with shear heads enhanced the mode of failure to be semi brittle failure. The European code (EC2-2004) is the closest code for finding concrete contribution in punching shear resistance. The new proposed formula has an original contribution and a good agreement in prediction of punching shear capacity of flat slabs with shear heads. Shear heads with length equal to 2d, 2.5d, 3d, 3.5d enhanced punching shear capacity of flat slabs by 18, 22, 33 and 31.6 respectively for flat slabs with column aspect ratio 1:1, 2:1, 3:1 and 4:1. Punching shear capacity of flat slabs enhanced by 10, 19 and 27% when compressive strength of concrete changed to be 30, 35 and 40 MPa respectively.

Rates of improvement in punching shear force for specimens with the new arrangement (2,1) higher by (16.5, 10, 5 and 4%) compared to specimens with arrangement (1,1) at the same used lengths of shear heads (2d,2.5d,3d and 3.5d) respectively. The new arrangement of shear heads (2,0) showed its inability to increase the punching shear resistance of flat slabs with column aspect ratio (4:1) compared to the basic arrangement (1,1) at the same used lengths of shear heads (2d,2.5d,3d and 3.5d). To avoid slippage of steel shear heads in flat slabs, Minimum length of (2.00d) from column face is the preferred length for shear heads. Maximum optimum length of shear heads for flat slabs with column aspect ratio (1:1), (2:1), (3:1) and (4:1) is equal to (3.00d) from column face.

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