Imperial College London

ASSESSMENT OF PROPOSED PUNCHING SHEAR MODELS FOR INCORPORATION INTO 2018 REVISION OF EUROCODE 2

Luke Gardner Supervisor: Dr R Vollum

Department of Civil and Environmental Engineering, Imperial College London

Introduction

This project assesses the proposed punching shear models for incorporation into the 2018 update to Eurocode 2. Three methods for calculating the punching shear resistance are compared, these are the Siburg and Hegger modification of Eurocode 2, Critical Shear Crack Theory (CSCT) and Eurocode 2. Finite Element Analysis (FEA) is used to investigate the accuracy of the rotations and failure loads of Critical Shear Crack Theory on El Salakawy et al. (2000) slab XXX. The effects of openings and varied eccentricity and a continuous Sherif and Dilger (2000) slab S1-2 are also modelled.

Initial Modelling

CSCT is based on the relationship that the punching strength decreases with increasing rotation of the slab (Muttoni, 2008). Equation 1 expresses the rotation as a function of the applied load. The Siburg and Hegger approach is a modification of Eurocode 2, where the radius of the control perimeter is reduced from 2d to 0.5d and the value for β relies on the relationship between the load eccentricity and the diameter of the loaded area. The Eurocode initially gave the most accurate results for both with and without reinforcement, however CSCT needs investigating further using finite element analysis.

$$\psi = 1.5\frac{r_s}{d}\cdot\frac{f_y}{E_s}\cdot\left(\frac{V}{V_{flex}}\right)^{1.5} \qquad (1)$$

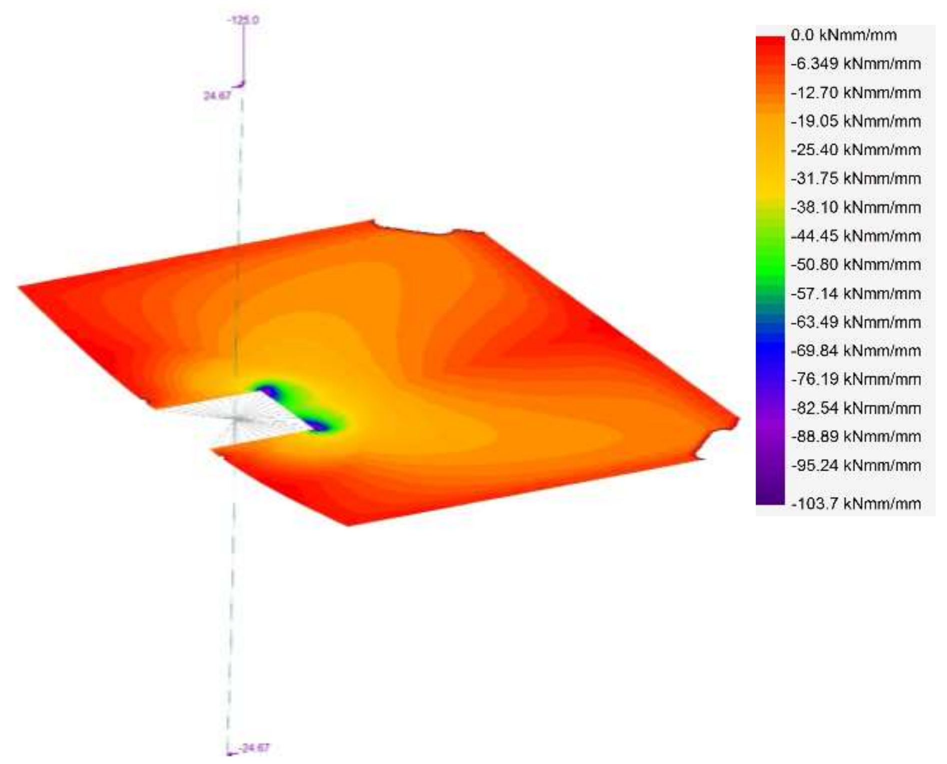
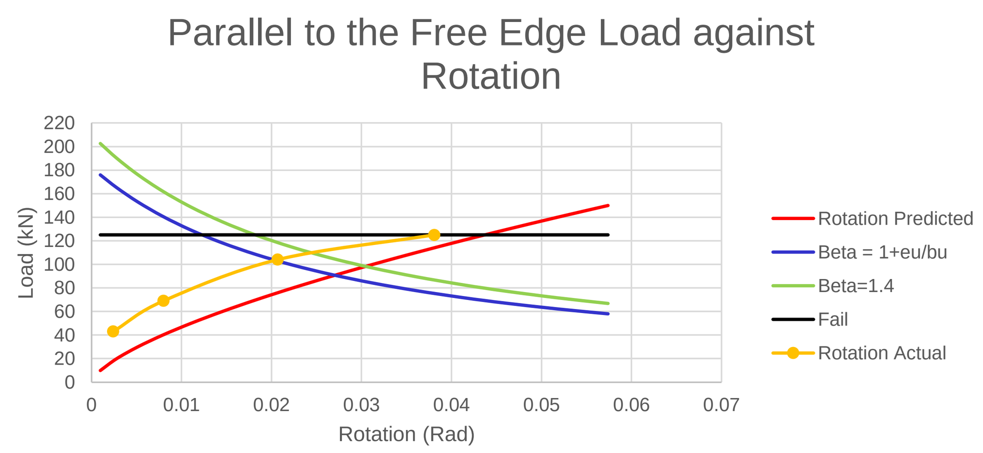
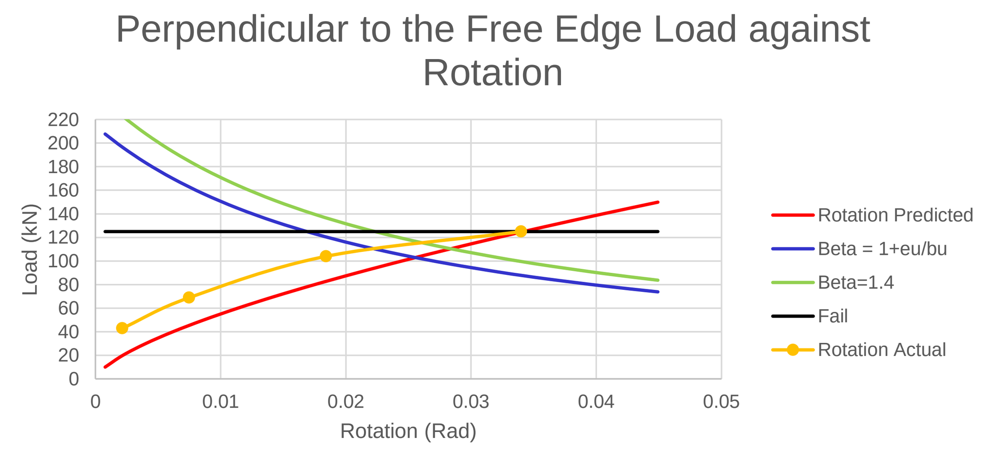


Fig 1: Applied Loading and Contour Plot for Slab XXX

El Salakawy et al. (2000) Test

Slab XXX was modelled in GSA because it had rotations and deflection profiles from the test data. Fig 1 shows contour plots used to measure the radius, r_s and obtain the moments on the support strip. The model gives a good approximation for the failure rotation and the resistance is underestimated in both directions. From GSA the side faces resist 51% of the shear and the front face 49% of the shear force. 66% of the moment is resisted by flexure which is close to the ACI approximation of 62%.





ACKNOWLEDGEMENTS

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Muttoni, A. (2008) Punching Shear Strength of Reinforced Concrete Slabs without Transverse Reinforcement. *Aci Structural Journal.* , 440.

Sherif, A. G. & Dilger, W. H. (2000) Tests of Full-Scale Continuous Reinforced Concrete Flat Slabs. *Aci Structural Journal.* 97 (3), 455.

Openings on the Slab

Fig 2 shows the slabs modelled in GSA with the openings. Individual elements were removed where the openings are located and the loading remained the same. For slab SF0 and CF0 the failure load is less than the test value and the rotation is estimated accurately in the y direction but underestimated in the x direction. The failure load is also underestimated for SE0 and the failure rotations accurately estimated in the x direction but underestimated in the y direction.

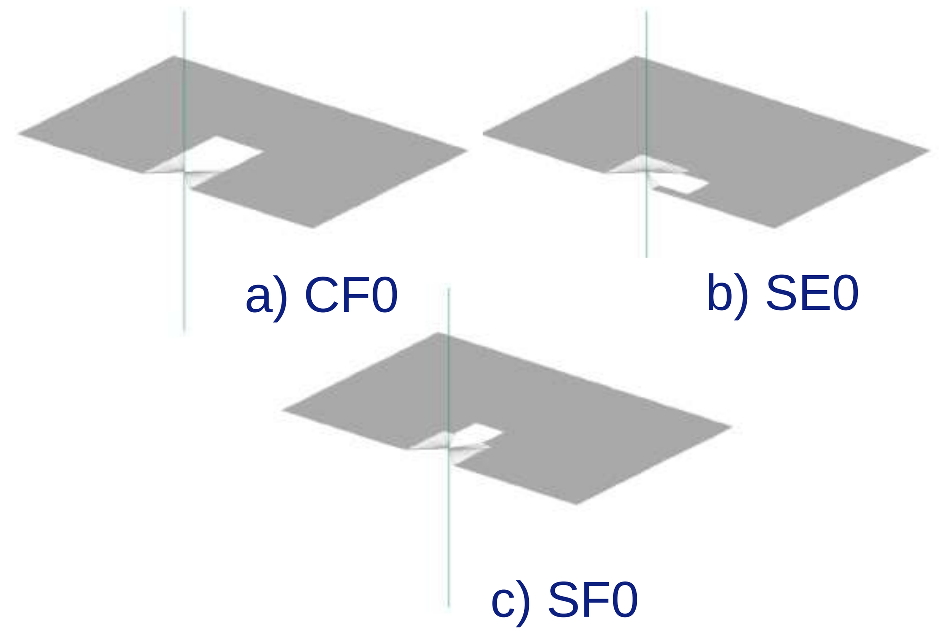
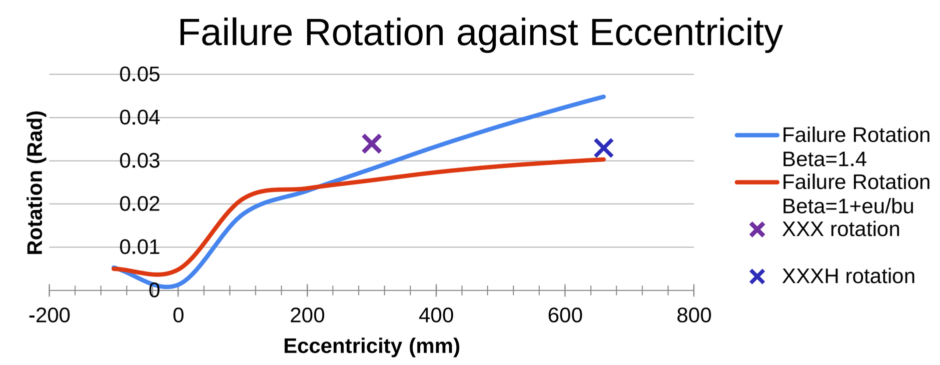
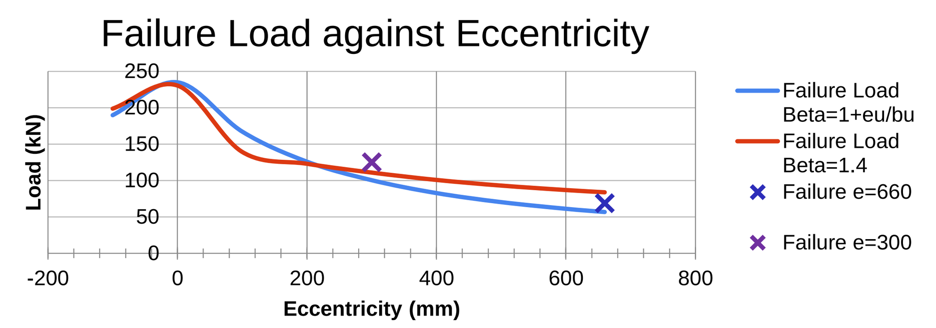


Fig 2: Openings of Slab in GSA

Varied Eccentricity of the Load

The eccentricity of the applied load was varied from -100 to 660mm and the results were compared to slabs HXXX and XXX. The resistance is greatest when the eccentricity is equal to 0mm. As the eccentricity increases the variable β underestimates the failure load and β 1.4 overestimates the failure load. The rotations are accurate for slab XXX but for slab HXXX, with higher eccentricity they are underestimated.





Continuous Slab

The slab S1-2 from Sherif and Dilger (2000) and its steel support frame was modelled in Oasys GSA. The slab was loaded with a full UDL including 5.12 kN/m^2 for self-weight. The model overestimates the edge column reaction, due to it being elastic. The values of r_s and the moment on the support strip are calculated from Fig 3. The validity of the rotations cannot be confirmed as deflection data is not available for this test. In the x direction the failure load was underestimated and in the y direction the failure load was accurately estimated.

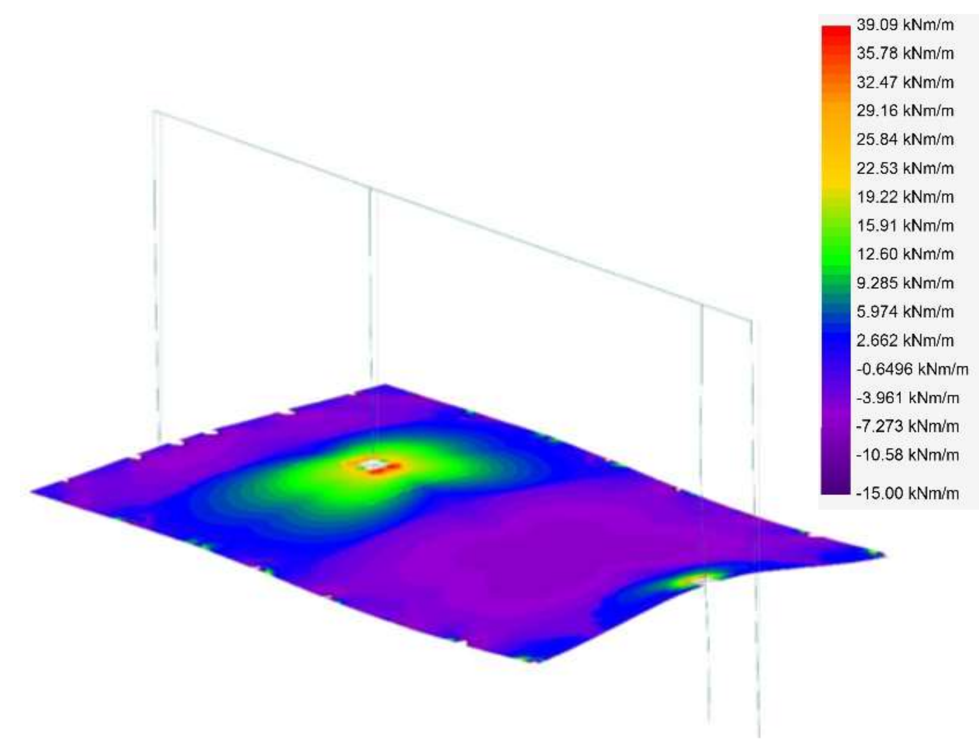


Fig 3: Contour Plot of S1-2

Conclusions

From the initial tests the Eurocode 2 method appeared to be the most accurate, however the Critical Shear Crack Theory relies on the rotations and failure load to be accurately predicted. The FEA model of slab XXX gave better estimates for rotations and resistance than the simplified rotation approach. However for smaller applied loads and large eccentricities the rotations were overestimated. If the opening is on the side face of the column it reduces the accuracy in the y direction and if the opening is on the front face it reduces the accuracy of the results in the x direction.