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FAILURE OF RC SLABS MODELLED USING AN EMBEDDED DISCONTINUITY APPROACH

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This paper investigates the collapse evolution process of reinforced concrete (RC) slabs subject to vertical loading. For the numerical model, concrete was discretized with hexahedral finite elements with embedded discontinuities with three degrees of freedom per node. Steel reinforcement was represented by 3D Bar elements, with also three degrees of freedom per node. Perfect bonding between steel bars and concrete was throughout assumed, as the failure of this type of slabs occurs mainly on flexure without evidence of debonding.

The constitutive model for the concrete considered a failure surface with different failure thresholds under tension and compression and included softening behaviour after reaching the failure surface. For the constitutive behaviour of the reinforcing steel, a von Mises yield surface considering hardening in the nonlinear interval was used.

The model of finite elements with embedded discontinuities and the assumed constitutive behaviour are validated by the numerical replication of the experimental results reported by [1]. The test specimen, shown in Figure 1a, was a square slab of sides 1.829 m long and a thickness 0.044 m. The vertical loads were applied at the top of the slab using four jacks with loading trees distributed to 16 load plates, as shown in Figure 1b. The mechanical properties for the concrete were: Young´s modulus $E_c=19.90$ *GPa*, Poisson ratio υ=0.2, ultimate tensile strength f_{tu}=3.1026 *MPa*, ultimate compressive strength $f_{uc}=31.026$ *MPa* and fracture energy density G_f=0.098 *N/mm* and for the reinforcing steel: Young´s modulus $E_s=206$ *GPa*, Poisson ratio $\upsilon=0.3$, yield stress $\sigma_y=330.95$ *MPa* and hardening modulus $H=2.871$*GPa*.

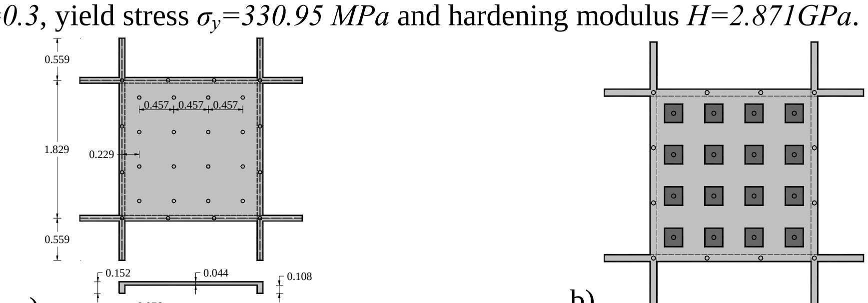


Figure 1. Experimental test: a) geometry and applied loads (adapted from [1]).

The load *vs*. displacement at the centre of the span curves are shown in Figure 2. These curves show numerical results congruent with the experimental reported by [1], both showing ultimate loading different to that calculated using the yield line theory.

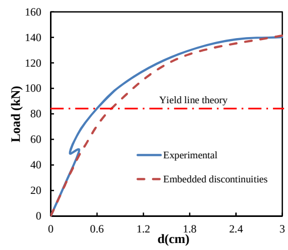


Figure 2. Comparison between experimental and numerical results.

Two other slabs of square and rectangular geometry, Figure 3, were also analyzed. Both were 10 cm thick and subjected to increasing uniform distributed loading. Two boundary conditions were considered: simply supported and fully fixed. As reinforcement, 3/8 in diameter steel bars spaced 20 cm in both orthogonal directions were used. For both slabs, the plots of distributed load intensity *vs.* displacements at the center of the spans are shown in Figure 4. Here, it may be observed that for equal displacements, the intensities of the distributed loading for the fixed slabs are approximately five times larger than for the simple supported slabs.

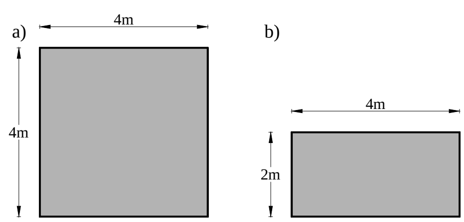
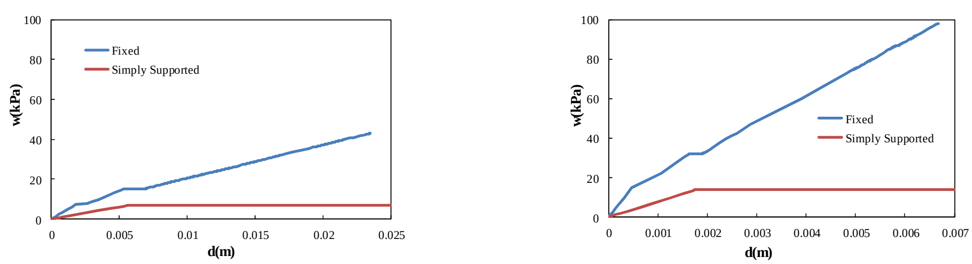


Figure 3. Geometry of slabs: a) square and rectangular



a) b)

Figure 4. Distributed load *vs.* displacement in: a) square slab and b) rectangular slab

REFERENCES

[1] A.G. Girolami, M.A. Sozen and W.L. Gamble, *Flexural strength of reinforced concrete slabs with externally applied in-plane forces*, Report to the Department of Defense, Illinois University, Urbana, Illinois, p. 176, 1970.

[2] J. Oliver, D.L. Linero, A.E. Huespe and O.L. Manzoli, Two-dimensional modelling of material failure in reinforced concrete by means of a continuum strong discontinuity approach. Comput. Method. Appl. M., Vol. 197(5), pp. 332-348, 2008.