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THE NEW MACRO-SCALE NUMERICAL MODEL FOR ANALYZING REINFORCED CONCRETE STRUCTURES

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ABSTRACT

The new macro-scale 3D numerical model for analysing reinforced and prestressed concrete structures is developed where the nonlinear behaviour of concrete is described by an elastoplastic material model which is based on the Mohr-Coulomb law for dominant compression stresses and the Rankine law for dominant tensile stresses. A multisurface presentation of the developed model (Figure 1) is implemented which permits the rapid convergence of the mathematical procedure.

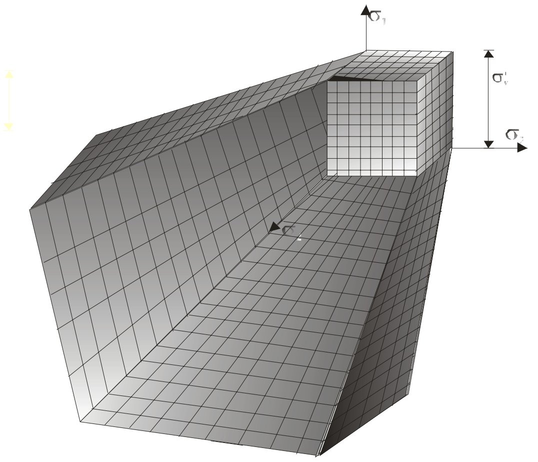
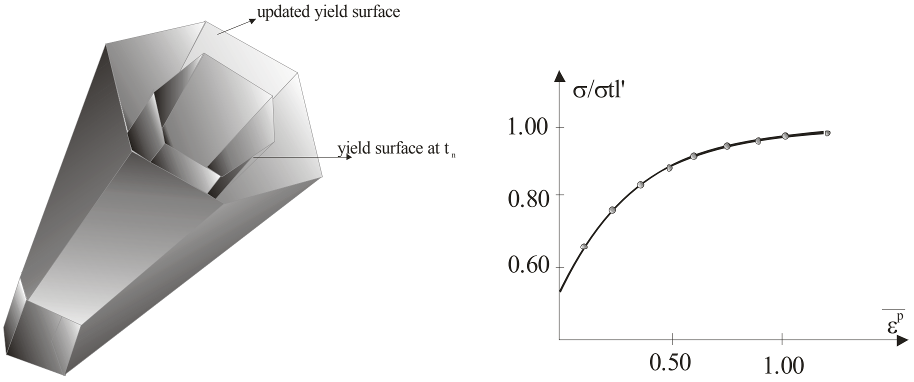


Figure 1. *Multisurface presentation of the proposed concrete model*

In this model [1], the nonlinear triaxial behaviour of concrete is considered, including all dominant influences in concrete: yielding in compression, cracking in tension, softening and hardening of concrete. Matrices of consistence are developed for each sextant separately for dominant compression stresses while the matrices of softened and cracked concrete are developed for dominant tensile stresses. Both, associated and non-associated flow-rules are considered. The strain hardening is implemented where the development of plastic strain is described by the function of cohesion. Hardening is defined by a segmental linear function with an arbitrary number of chosen points which is obtained by converting the function which defines the relationship between plastic strain and compressive strength in a one-dimensional test (Figure 2).



$$c = \frac{1-\sin\varphi}{2\cos\varphi}\sigma'_{tl}$$

Figure 2. *Development of yield surfaces defined by hardening law*

The model is defined by elementary material parameters (Young’s module, Poisson’s coefficient, maximal uniaxial tensile and compression stress, coefficient of tensile correction, maximal tensile and maximal compression strain) so that the very complex behaviour of reinforced and prestressed concrete structures is described simply and effectively but with a sufficiently accurate model.

The nonlinear behaviour of reinforcement bars and prestressed tendons is described by the one dimensional elasto-viscoplastic model [2]. The tendon element geometry is described by the second order space function which is determined by its projections. These elements make it possible to model arbitrarily curved reinforcing bars and prestressing tendons in space, thus they can be determined independently of the 3D concrete finite element mesh. This is very important in the case when the prestressing tendon can not be located in one plane.

The transfer of prestressing force on the concrete is modelled numerically. Among the losses which influence the decrease in the prestressing force it is possible to compute the losses caused by friction and the losses which result from the concrete deformation. The developed model makes it possible to compute prestressing structures in phases: before prestressing, during prestressing and after prestressing.

The described models for concrete and reinforcement are implemented in the computer programme for a 3D analysis of the reinforced and prestressed concrete structures where the structures are discretised by three-dimensional finite elements with an embedded one-dimensional element of reinforcing bars and prestressed tendons.

The analyses performed with this numerical program can be used as the numerical tests of the loaded structures until the failure. The obtained results show a very good agreement with experimental data.

REFERENCES

[1] M. Galić, Development of nonlinear numerical 3D model of reinforced and prestressed concrete structures, Ph.D. Thesis, University of Split, Faculty of Civil Engineering and Architecture, Split, 2006.

[2] P. Marović, Ž. Nikolić and M. Galić, “Some aspects of 2D and/or 3D numerical modelling of reinforced and prestressed concrete structures”, *Engng. Comput.*, Vol. **22**, pp. 684-710, (2005).