3D NUMERICAL MODELLING OF PRESTRESSED CONCRETE STRUCTURES

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Abstract: The paper presents a three-dimensional numerical model for describing nonlinear behaviour of prestressed concrete structures.

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 model is implemented which permits the rapid convergence of the mathematical procedure. Nonlinear triaxial behaviour of concrete is involved in the model, including all dominant influences in concrete: yielding in compression, cracking in tension, softening and hardening. The model is defined by elementary material parameters (Young's modulus, Poisson's coefficient, maximal uniaxial tensile and compression stresses, coefficient of tensile correction, maximal tensile and maximal compression strains) so that the very complex behaviour of prestressed concrete structures can be described simply and effectively but with a sufficiently accurate model.

The nonlinear behaviour of prestressed tendons is described by the one dimensional elasto-viscoplastic model. 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 prestressing tendons in space, thus they can be determined independently of the 3D finite element concrete 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 prestressed concrete structures where the structures are discretized by three-dimensional finite elements with an embedded one-dimensional element of prestressed tendons. The programme is tested on a few examples and the obtained results are compared with the known numerical and experimental ones.

Key words: Reinforced concrete, prestressing, non-linear analysis, numerical modelling, 3D composite finite element, material model of concrete.

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