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Modelling of tensile membrane action at very large displacements by use of DIANA

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ABSTRACT. Robustness of structures primary received significant attention 40 years ago following the famous collapse of the apartment building in Ronan Point (UK), and recent terrorist attacks at several locations were an unfortunate reminder of the potential fatal risks in case of initiation of progressive collapse.
In order to investigate the strength reserve in concrete slabs subjected to large deformations, an experimental large-scale test series was established involving the testing of continuous, longitudinally restrained, reinforced concrete slab strips exposed to a simulated accidental failure of the central support and subsequent vertical loading until collapse. In case a support of such a statically indeterminate concrete specimen is removed, tensile membrane forces can be activated at large deflections. This effect was found to increase the load-carrying capacity considerably compared to predictions obtained from small deformation theories neglecting membrane forces.
Further, the collapse of the specimens was ultimately induced by the tensile failure of the reinforcement bars in the cracked regions over the supports being exposed to a plastic rotation. It is well established that such non-linear effects are important as the development of plastic hinges influences the capacity of the structure to absorb energy and withstand extreme loads. The rotation of the sections over the supports created the necessary deformations to allow for the effect of tensile membrane action. As such, an appropriate modelling of the rotational capacity is of crucial importance when performing a failure analysis of concrete slabs subjected to tensile membrane action.
The finite element software DIANA is able to simulate the behaviour of concrete plates under these large deformations. Numerical FE analyses of the executed real-scale tests will be explained and compared with the experimental results.
Currently, however, different questions remain unsolved in order to properly assess the membrane actions, i.e. the influence of the constitutive laws which are implemented, the modelling of connectivity, fracture mechanical aspects under tensile membrane actions and large displacements, the influence of confinement on the concrete in the plastic hinges etc. Finally, the influence of reinforcement curtailment on the overall structural performance under tensile membrane action will be evaluated and compared with numerical simulations.