9th International DIANA Users Meeting
November 4th, 2014

Response of RC slab strips subjected to axial tension and transverse load

Beatrice Belletti*, Cecilia Damoni*, Max Hendriks#

* University of Parma, Parco Area delle Scienze 181/A 43124 Parma, Italy
# Delft University of Technology, Stevinweg 1, 2628CN Delft, The Netherlands

The structural response of RC slab strips subjected to axial tension and transverse load has been investigated by means of nonlinear finite element analyses (NLFEA) and analytical calculation, according to the current standards, mainly focusing on the influence of axial tension on the structural robustness.
The research fits into the experimental program driven by the Institute of Structural Engineering (IBK) of the Swiss Federal Institute of Technology (ETH)[1, 2]. Researchers were first invited to submit a blind prediction of the expected response. After this first step the numerical models carried out have been validated on the basis of experimental results. The experimental test comprised a total of 12 slab strips with different reinforcing ratios and arrangements, subjected to different tensile forces. The slab strips consisted of simply supported beams with a cantilever at one end of the specimen. A uniform load in the span was simulated by three point loads and an additional point load was applied at the end of the cantilever. The test specimens were suspended from the reaction structure at the two supports and connected to shear walls by means of a tie rod at the end of the cantilever. In a second loading phase the end of the cantilever was constraint and the only three point loads were increased up to failure. Four specimens, that differ in the axial tension level and in the transvers reinforcement ratio, were simulated for the prediction competition , using DIANA. A 2D modeling has been carried out following the main indication of the guidelines for non-linear finite element analyses published by the Dutch Ministry of Infrastructure [3]. A total strain rotating crack model was used to model mechanical nonlinearities. Due to the high slenderness of the slab strips the NLFEA have been carried out both taking into account and neglecting the effect of geometrical nonlinearities. According to the NLFEA results all slab strips failed in shear with developing of large shear cracks, showing a brittle behavior due to crushing of concrete as well as yielding of reinforcement. However all four tests proved to have residual capacity and therefore proved to be able to carry further loads after the failure of the slab strips themselves. This was probably due to the stiff tie-rod that could keep on carry transversal loads even after the collapse of the slab strips. Hence the local failure didn't coincide with the system failure. The results delivered by the four teams that joined the prediction competition highlighted the difficulties in the prediction of the failure mode and of the load bearing capacity of the specimens. In our case, even if the crack pattern at failure detected by NLFEA well matches with the observed experimental crack pattern, several difficulties arise in the prediction of the load carrying capacity, coupled with convergence problems during NLFEA. Furthermore the axial load level and the effect of geometrical nonlinearity proved to have a significant influence of the structural response. Both according to NLFEA and to experimental observation, the axial load proved to have a beneficial effect on the system capacity. The topic of RC specimen subjected to axial force and transverse load is slightly investigated in literature. Since it is of high practical relevance, further research is needed.

[1] Versuche an Plattenstreifen aus Stahlbeton unter Längszug und Querbelastung, Andreas Galmarini, Daniel Locher, Jonas Wyss, Peter Marti, IBK, ETH, Zürich, June 2013.
[2] Response of RC slab strips subjected to axial tension and transverse load, Prediction Competition. Andreas Galmarini, Daniel Locher, Peter Marti. Institute of Structural Engineering (IBK), ETH, Zürich, September 2013.
[3] Guidelines for Non-linear Finite Element Analyses of Concrete Structures. Rijkswaterstaat Technisch Document RTD:1016:2012, Utrecht: Rijkswaterstaat Centre for Infrastructure; 2012.