Summary

Flat slabs are commonly used in Switzerland but also in north America and in many European countries. Slab bridges are also a typical solution for crossing of motorways for example. In both cases, supporting a slab by columns is justified by the simplicity and the easyness of construction. When spans increase (larger than 8 to 10 m), the use of prestress becomes almost systematic. The deviation forces of prestressing lead the concrete to be subjected to normal forces, moment in the opposite way as those created by downward acting loads, and vertical components due to the geometry of prestressing tendons over the slab length. The zone in the vincinity of the column subjected to punching is thus also affected by various effects of the prestressing. The aim of this work is to investigate individually the influence of each of them on the punching shear strength.

To achieve this goal, various tests programmes were performed. The first one aimed at understandinng the influence of a moment acting in the opposite way as those generated by downward acting loads. The second one at understanding the influence of a normal force on punching shear strength. The third one gathered the two others by including prestressing tendons in the slabs, leading simultaneously to a moment and a normal force. It has been shown that each of the prestressing parameters has a significative influence on punching. The moment allows to increase punching shear strength and the deformation capacity tends to be reduced. The normal force tends also to increase punching shear strength but the deformation capacity is less affected as for the moment.

The main current design codes do not take into account all of these effects of prestress on the punching shear strength and do not deal generally with the influence of the prestressing induced moments. A formulation almost identical for Model Code (2010) and SIA 262 (2012) has been proposed allowing to consider every prestressing parameter. The tests series enable in particular to validate this new formulation.

Moreover the critical shear crack theory originally proposed by Muttoni and the failure criterion have been improved on the basis of a theoretical model taking into account the various effects of prestressing. The model is based on the kinematical behaviour of the slab measured on a specific test series performed during this work. A load-rotation law has been developped on the basis of the quadrilinear law initially proposed by Muttoni enabling to consider the influence of the moment and the normal force due to prestressing on the specimen behaviour. Finally, a simplified failure criterion has been proposed, extending the original criterion of Muttoni.

Key words :

punching, prestressing, reinforced concrete, prestressed concrete, flat slabs, slab bridges, load-roation law, codes, critical shear crack theory, failure criterion