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Strengthening Beams in the Shear Zone

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Summary

The paper consists of two parts. The first one presents the problem of strengthening the beams damaged in the shear zone in real industrial building. The analysis of serviceability and limit states was made and two ways of strengthening were design. Second part presents the experimental study on two reinforced concrete beams, underreinforced in the shear zone. One of them was strengthened by externally epoxy bonded steel plates, after loading of about 70% of its ultimate capacity.

1. Strengthening the concrete girders in the Textile Factory in Lodz

Two of all two-span box-girdes of the saw-tooth roof konstruction of the spinning mill building were significantly cracked, closed to the intermediate support. The roof consists of triangular concrete prefabricated frames supported on these girders and covered with bearing bush plates. The main beams have the cross-section dimensions of 1.00×1.35m and the spans of 18.0m. Their inner spaces are used to pull out air from the air-conditioning. Structural, statical and limit state analysis has been done, based on the investigation carried out in the building. There are few diagonal cracks on the side surfaces of the girders with the widths of 0.3 to 1.0mm, exceeding the limit values. The study of this case shows, that diagonal cross-section with the maximum crack width works in the worse conditions of the combined shear and bending. There are also effects of stresses due to shrinkage caused by the pull out air inside the girders and dry of the concrete. Ultimate shear capacity of the craced sections was calculated by the Polish Code method. The design shear resistance exceeds the shear force due to load, but with respect to serviceability limit state, two alternatives of strengthening the craced region were design as shown in fig. 1. Alternative b) represents the plate bonding technique and alternative a) is the traditional method of mechanical bonded externall stirrups.

2. Experimental tests

There were tests made in the laboratory of the Concrete Structures, Technical Univ. of Lodz, to check out shear behaviour of RC beam strengthened by epoxy resins bonded steel plates under repeated load (see fig. 2).

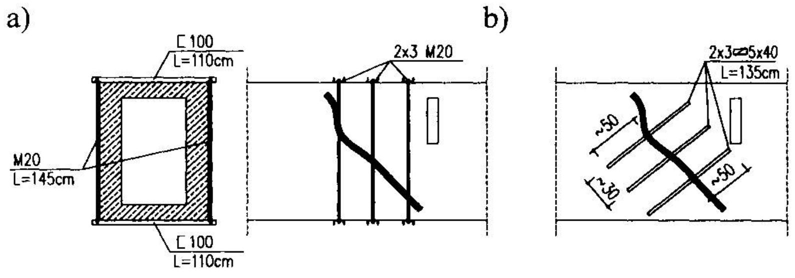

Fig. 1. Designed alternatives of strengthening

Two beams (b=0.20m, h=0.30m) were made as underreinforced in the shear zone. The control beam BS-0 was not repeired and the beam BS-2 was first preloaded to about 65% of its ultimate load and precraced. Next it was strengthened by steel plates 5×40mm, bonded and anchoraged to side faces in the support region using epoxy resins. Both beams failed as the result of diagonal tension cracking in the shear span regions. The effectiveness of the strengthening was 19 percent. The strengthened beam BS-2 failed prematuraly by tearing off the concrete and plates before yielding of the external reinforcement. The stresses in the steel plates at failure were only $0.19f_y$. Their full ultimate capacity was not developed. But the stirrups were significantly unloaded (about 70%) by the external reinforcement comparing with the control beam, short before failure - see fig 3. It apeared to be important problem how to design the strengthening to avoid the premature failure of the beam. The strength of repaired concrete should be high enough and the maximum shear and peeling stresses at the interface should not exceed the limiting values at which tearing of the concrete takes place.

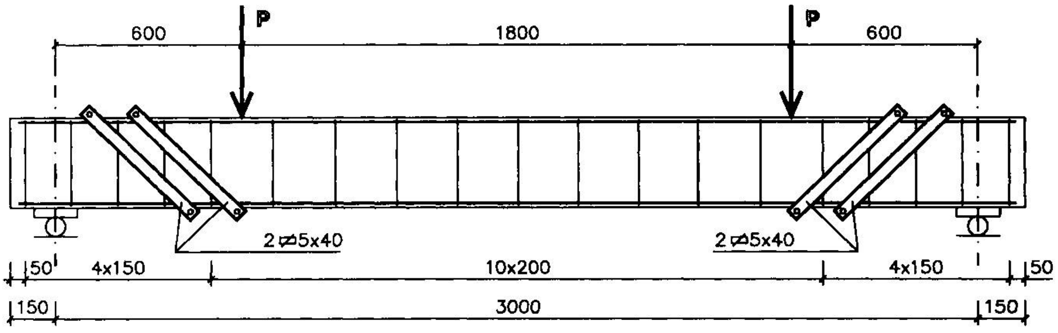

Fig. 2. Beam BS-2

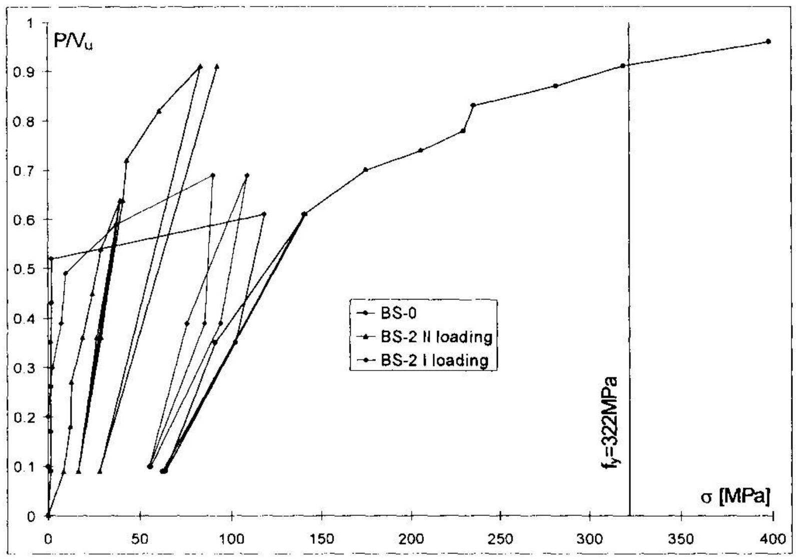

Fig. 3. Stresses in stirrups