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Tests of Reinforced Concrete Strengthened with CFRP Plates

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Summary

This paper presents the results of the research carried out on five beams strengthened with CFRP plates (Sika CarboDur - System). The model of failure of the beams was discussed and compared with an examination of strains and loading capacity of a section. The last one based on the nonlinearity of concrete, reinforcing steel and linear relationships σ-ε of the CFRP plates and the glue was in accordance with an experimental test. The ifluence of plates bonded to the both vertical sides of the beam in a support region on a load-bearing capacity was firstly considered.

1. Introduction

The investigations presented below were carried out in order to provide with data for verifying the assumed analytical model concerning the bending and also to test the influence of additional carbon plates attached to side surfaces of the element in its support zones for anchorage conditions of the plates.

2. Experimental investigations of the beams strengthened with the plates

Five single-span beams (dimensions and loading scheme shown in fig.1) have been tested. CFRP plates were attached to properly cleaned beam surface with CFK-Sikadur-30 adhesive, recommendations of applying given by the producer of the strengthening system were preciselly followed.

Basic information concerning the beams reinforcement and the mode of strengthening is presented in table 1.

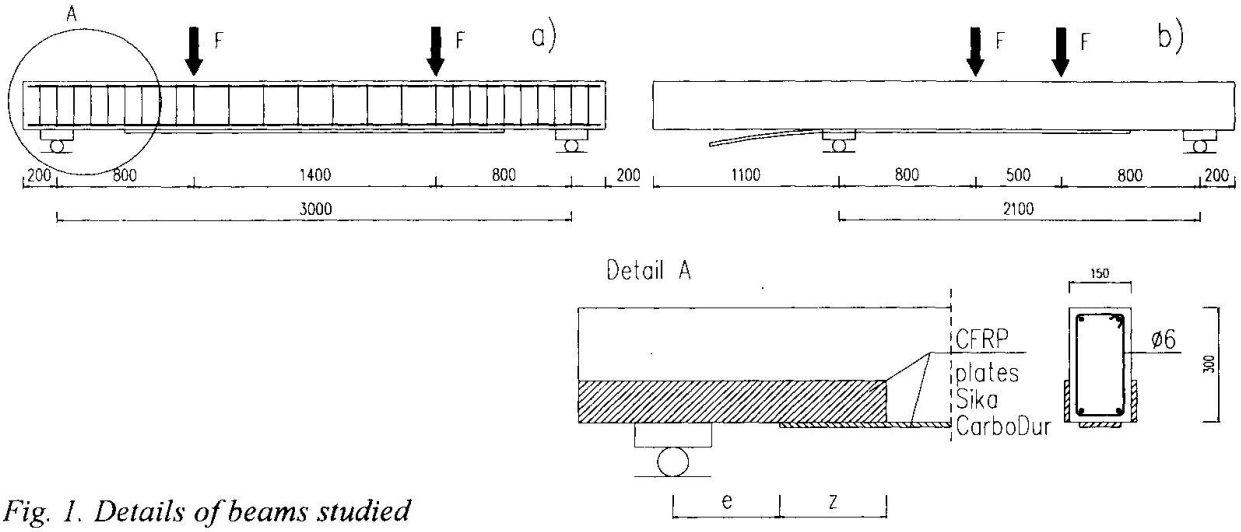

Fig. 1. Details of beams studied

Table 1. Details of test beams

Beam	Reinforcement ratio/bars	CFRP-plate (see Fig. 1)			Concrete strength[2], MPa				Ultimate load 2F, kN
		type	e, mm	z, mm	$f_{c,cube}$	f_c	$f_{ct,sp}$	E_c	
B-04/S1	0.0039 2#10	S	150 300	-	33.8	28.4	2.8	23400	120 90
B-04/S2			150[1]	-	51.3	36.6	3.2	29000	98
B-04/M		M	250	200 S and M	33.2	29.7	3.0	25000	120 (M) 120 (S)
B-06/S	0.0056 2#12	S	250 250	350 500	35.4	32.3	2.9	27400	140 145
B-08/S	0.0084 3#12	S	150	-	43.0	33.8	3.0	27300	180

1) half plate on both vertical sides of the beam
2) cubes 150×150×150mm, cylinders 150×300mm, E_c after DIN 1048

Conclusions

The investigations confirmed full cooperation within the pure bending zone of CFRP plate with the section strengthened in this manner. Thus it is reasonable to assume in the analysis the plane section principle. In the analysis as well material nonlinearity of the concrete and the tension stiffening pronciple were assumed. The proposal calculation model enables to evaluate the bending moment - curvature (or strain) relationship within the whole range of loading and thereby to estimate the value of cracking moment, reinforcement yielding moment and the ultimate moment resulted from limiting the strain of any of the materials in the section. It is also easy to estimate how much the load capacity of the plate may be used, if we know dimensions, the reinforcement ratio and material characteristics of the strengthening element.

Further investigations concerning anchorage zones of the plates are necessary. They are continued in Concrete Structures Department of Technical University in Lodz. Test on beams strengthened with CFRP plates and subjected to the cyclic load are foreseen to undertake soon.