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Repair and Strengthening of Slabs Using Bonded Concrete Overlays

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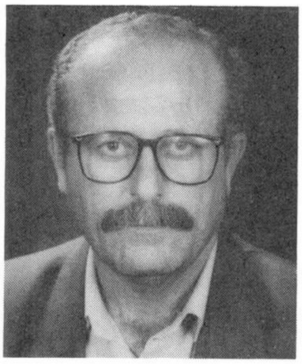

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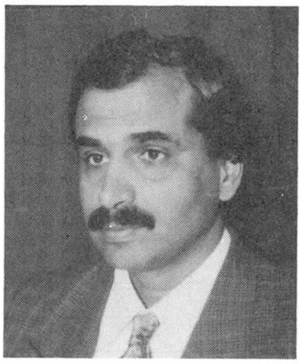

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Summary

Strengthening of slabs has been achieved by casting a new concrete overlay on top of original slabs. The inter-laminar shear failure has been prevented using expansion screws which provided positive anchorage between the two concrete parts. The test results on six slab types have indicated the adequacy of the proposed strengthening technique. The strengthened slabs have reached their full flexural behavior and acted as one unit. The strengthened slabs have achieved an increase in the load carrying capacity up to 310% compared to their original strength.

1. Introduction

Cracks may develop in concrete slabs of bridge decks because of the development of internal tensile stresses due to volumetric changes, applied loading conditions, and environmental effects. Large cracks may also develop in slabs due to incorrect design and detailing, or poor construction practice. Cracking has an important influence on deflection of slabs. In particular, long-term deflection may be large when compared to initial deflection as cracking progress with time. These adverse effects may reduce the load carrying capacity, and increase deflection of the cracked slabs. Such slabs need strengthening to enhance their load carrying capacity, to minimize their long-term deflection, and to enhance their durability.

2. Strengthening technique and test results

The proposed strengthening technique is based on the composite action between the original slab and a newly cast concrete overlay. The inter-laminar shear failure is prevented by using expansion screws which provide positive anchorage between the two concrete parts. The concrete overlay will protect against corrosion of reinforcement steel, reduce the long-term deflection and will result in the improvement of the serviceability and strength of the slabs. The concrete overlay may also be used to provide drainage slopes thus resulting in improving the durability of structures.

The test program has included six types of one-way slabs. The slabs were tested under single loading applied at mid-span up to failure. All slabs had an overall length of 1400 mm, effective span of 1300 mm and width of 400 mm. The original slabs Type O had a thickness of 60 mm, and effective depth of 48 mm. Slabs Type S were strengthened by casting a concrete overlay of thickness of 40 mm on top of the original slabs. The concrete compressive strength f_{cu} was 25 MPa. The reinforcement steel yielding strength f_y was 412 MPa. Expansion screws of 80 mm

MPa. The reinforcement steel yielding strength f_y was 412 MPa. Expansion screws of 80 mm length and 8 mm diameter were used for anchorage. The screws were tightened inside a 50 mm length hole drilled in the upper part of the original slab. The remaining lengths of the screws were embedded in the concrete overlay. The head of the screw was intended to act as an end plate to ensure the required anchorage. Each strengthened slab was provided with a total of 10 screws which were uniformly distributed in pairs along the length of the slabs. The test program also included nominally identical control slabs Type C. These slabs had the same overall dimensions and reinforcement as those used in the strengthened slabs and were included for comparison purposes. Two identical slabs were cast for each strengthened slab Type S. The details of the test program are shown in Table 1.

Table 1: Test details and results

Slab Type	Cross Section (mm X mm)			a/d*	A_s (mm^2)	ρ	P (kN)
	Original	Overlay	Overall				
O1	60 X 400	-	60 X 400	13.5	4 ϕ8	0.0105	12.9
C1	100 X 400	-	100 X 400	7.4	4 ϕ8	0.0055	34.0
S1	60 X 400	40 X 400	100 X 400	7.4	4 ϕ8	0.0055	31.3
O2	60 X 400	-	60 X 400	13.5	8 ϕ8	0.011	19.3
C2	100 X 400	-	100 X 400	7.4	8 ϕ8	0.021	57.4
S2	60 X 400	40 X 400	100 X 400	7.4	8 ϕ8	0.021	60.0

* (a/d) is the shear-span-to-depth ratio.

The values of total maximum applied load (P) obtained from the different slab types are shown in Table 1. Figs. 1 and 2 show the typical load-deflection curves and crack pattern for strengthened slab Types S1 and S2 with their corresponding control slab Types C1 and C2.

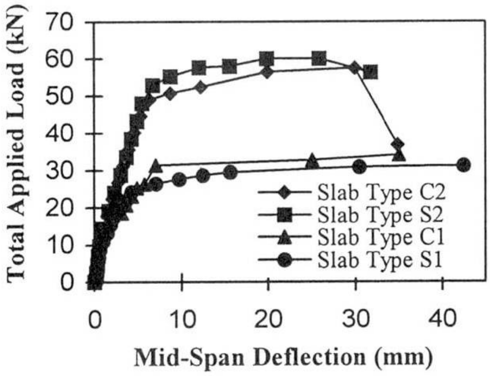

Fig. 1: Load deflection curves

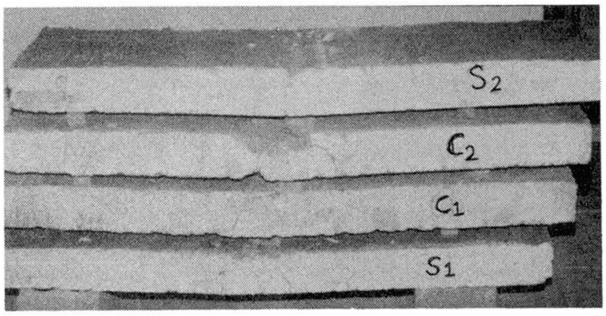

Fig. 2: Crack patterns for Types C1,S1,C2,S2

The test results and cracking patterns indicated that all test slabs were able to reach their full flexural behavior and failed in a ductile manner. The strengthened slab Types S1 and S2 acted as one unit under an increased loading. Their load carrying capacity, stiffness, ductility, and cracking patterns were similar to those obtained from the corresponding identical control slab Types C1 and C2 which were cast monolithically. Flexural cracks were developed in the lower part of the slabs. The flexural cracks widened and extended into the upper part under increasing loading. These cracks were extended in the strengthened slab Types S1 and S2 from the original slabs into the concrete overlay until they have been held in the compression zone. The test results have proved the adequacy of the expansion screws to provide the required positive anchorage between the two parts of the slabs; since no separation has occurred in any of the reported test slabs. The strengthened slab Types S1 and S2 were able to achieve up to 242% and 310% of their original strength compared to the original slab Types O1 and O2 respectively as indicated in Table 1.

It is concluded that the proposed strengthening technique can be easily adopted because of its simplicity in improving the structural behavior of slabs; especially in strengthening decks of existing bridges in order to increase their capacity to carry more demanding loading levels.