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Effect of Deviators in Long-Span Beams Strengthened by External Tendons

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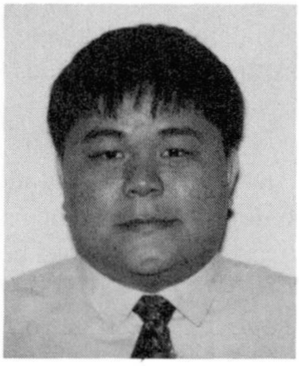

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Summary

Careful attention should be placed on the provision of deviators in the flexural strengthening of beams using external tendons, particularly where the beam has very large span-to-depth ratios and second-order effects due to eccentricity variations under load are dominant. In this study, nine prototype T-beams with span-to-effective depth ratios ranging from 7.5 to 30 were prepared and strengthened in flexure using external tendons, with or without deviators positioned at various locations along the span. The beams were loaded at third points to failure. The provision of a deviator at the mid-span section ensured satisfactory service and ultimate load behaviour of the strengthened beams with span-to-depth ratio of less than 20. For beams with higher span-to-depth ratios, two deviators each at the third-span sections are required to achieve the desired performance.

Test Programme

Nine prototype T-beams shown in Fig. 1 were prepared. No deviator was provided in T-0A and T-0B. In ST-1, ST-2, ST-3, ST-4 and ST-5, a 100 mm-wide deviator was provided at mid-span. ST-5A had two deviators at one-third span sections; and ST-5B had three deviators at quarter span sections. The span-to-effective depth ratios, L/d_{ps0}, were 7.5, 9.0, 15, 22.5 and 30.0 for ST-1, ST-2, ST-3, ST-4 and T-0A, and ST-5, T-0B, ST-5A and ST-5B, respectively. All beams were tested under third-point loads.

Test Results and Discussion

The load-deflection characteristics were largely the same for all beams provided with a deviator at mid-span. Beams without deviators showed no difference in deflection characteristics prior to cracking compared to beams provided with deviators (Fig. 2). However, after cracking has occurred, beams without deviators showed a greater reduction in stiffness and a smaller ultimate load. All beams showed ductile behaviour at ultimate. The smaller ultimate deflection registered by ST-5 was due to the failure occurring away from the mid-span at a section where the effective tendon depth was considerably lower due to second-order effects.

The maximum deflection under an assumed service load, defined as the ultimate load divided by a factor of 1.7, was in general less than 1/250 of the span. For beams with a span to depth ratio of less than 20, it is less than 1/350 of the span. All beams registered maximum crack width under the assumed service load of about 0.09 to 0.12 mm, except for ST-2 and ST-5B, for which the maximum crack widths were 0.16 mm and 0.2 mm respectively. These are all well below the allowable value of 0.2 mm for partially prestressed beams. Fig. 4 shows the appearance of four beams after failure.

From the study, it was concluded that one deviator at mid-span is adequate for beams with span-to-depth ratio of less than 20. Otherwise, two deviators should be provided, one at each third-span section, so as to ensure satisfactory service and ultimate load behaviour of the beam.

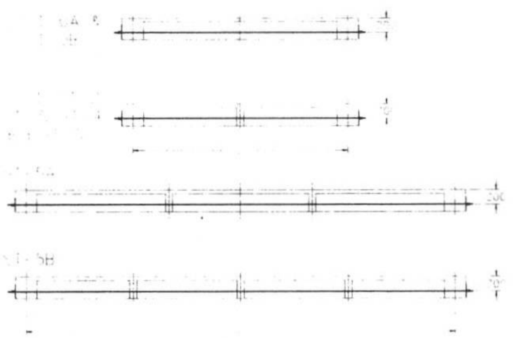

Fig. 1 External tendon and deviator configuration

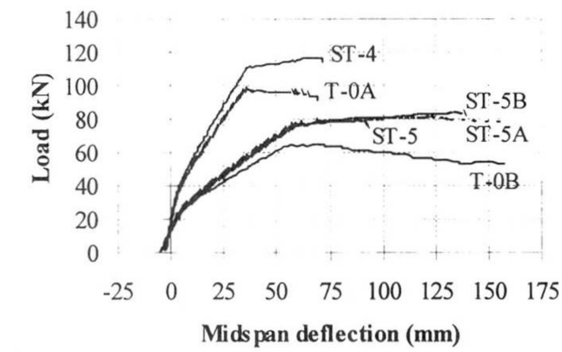

Fig. 2 Load-deflection curves

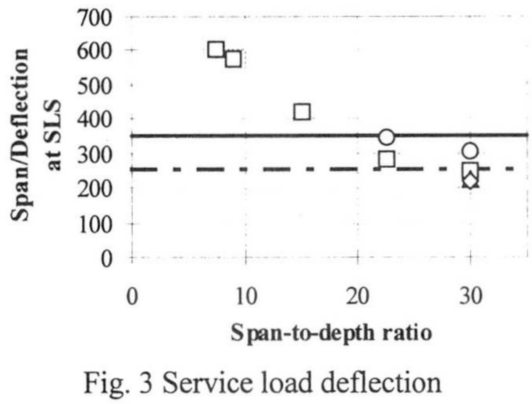

Fig. 3 Service load deflection

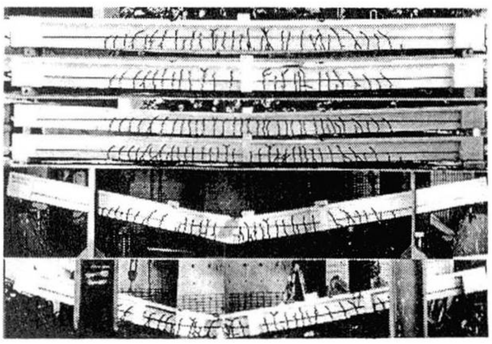

Fig. 4 Appearance of beams at failure