

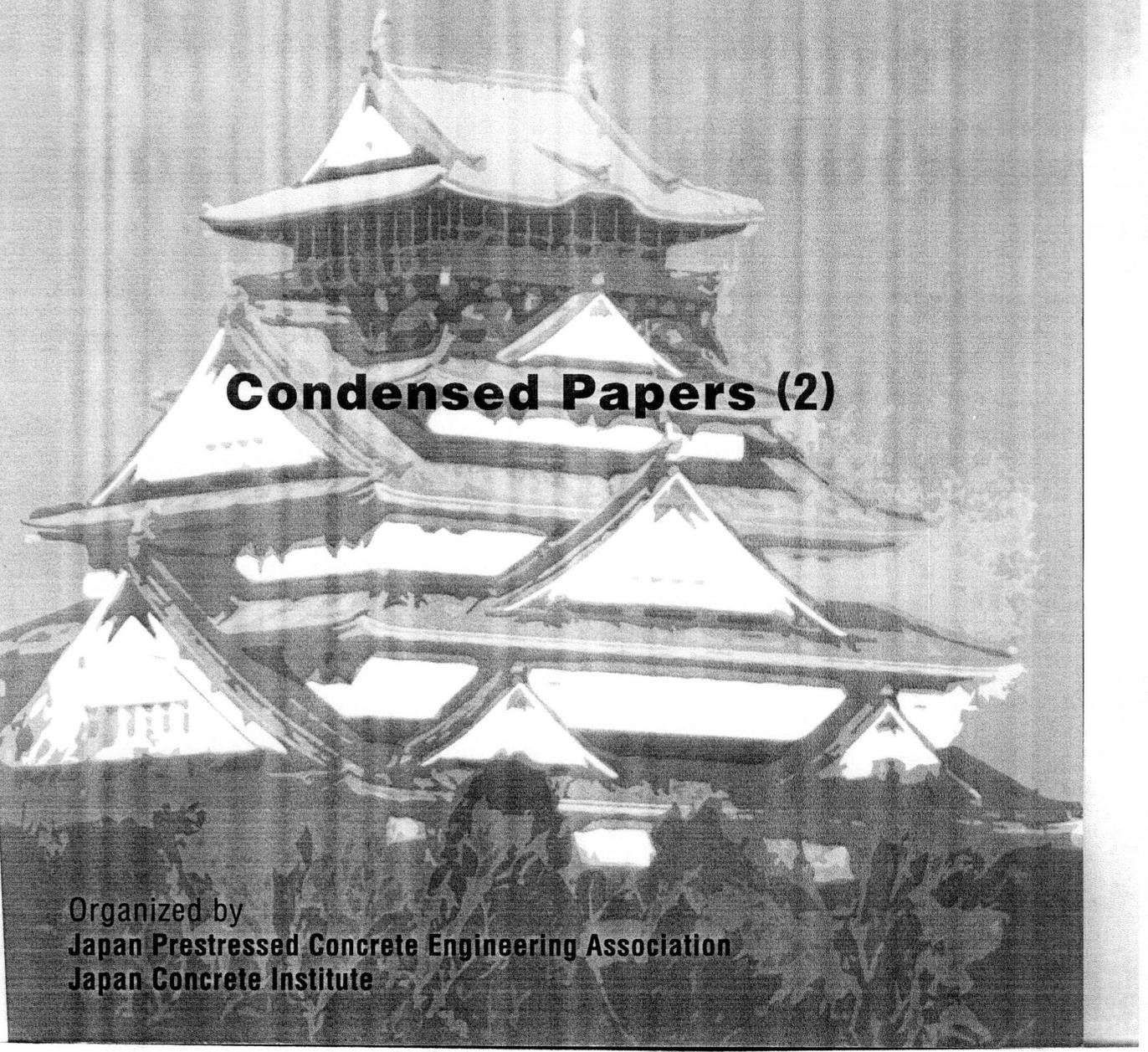
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PERFORMANCE OF REINFORCED CONCRETE BEAMS STRENGTHENED BY EXTERNAL PRESTRESSING TENDONS IN COMPARISON TO OTHER STRENGTHENING METHODS

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1 INTRODUCTION

This paper mainly focuses the experimental study conducted by ALMEIDA (2001) [1] in the analysis of strengthening methods with external prestressing tendons. A comparison of its results is made with those obtained by REIS (1998) [2] who analyzed strengthened reinforced concrete beams with addition of steel bars or plates and concrete on the tensioned face.

2 EXPERIMENTAL PROGRAM

The experimental program consisted of the strengthening and analysis of three reinforced concrete beams with a T-shape transversal section and 3 m span, as shown in Fig. 1.

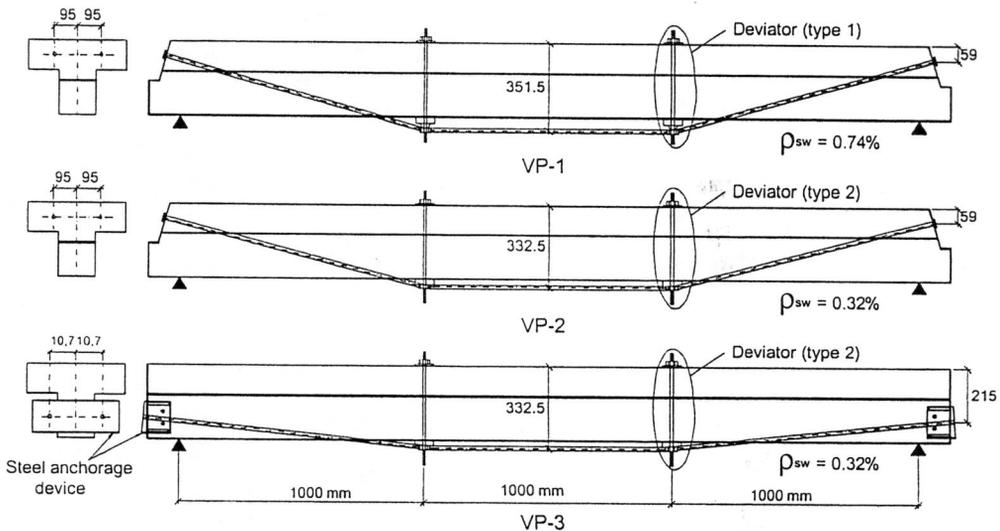


Fig. 1 Tendon profiles and shear reinforcement ratios

The parameters that changed during the tests were the shear reinforcement ratio and the profile of the external tendons.

3 TEST PROCEDURE

The tests consisted of three stages: pre-loading, prestressing of tendons and final loading up to collapse. In the first stage, an increasing loading was applied to the beam until a 40 kN force was achieved. In the second stage, the external force applied remained constant while the prestressing tendons were positioned and tensioned. The third stage began after the anchorage of the tendons, with increase of the applied force until the collapse of the beam. The flexural cracks appeared when the force was approximately 70 kN. Shear cracks appeared when the force was 130 kN for VP-1 and VP-2 and 115 kN for VP-3. The longitudinal reinforcement started yielding when the force reached 160 kN for the three tested beams.

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During the tests, the average value of the forces applied by the two hydraulic jacks was registered, and all the present results refer to this value. To allow the analysis and comparison of the behavior of the three tested beams, graphics were elaborated with the average values of the measurements: beam deflection at the mid span, longitudinal reinforcement strain, compression concrete strain, and stirrup strain.

4 COMPARISON TO BEAMS TESTED BY REIS (1998)

REIS (1998) [2] tested reinforced concrete beams with original section (before strengthening) and longitudinal and transversal reinforcements similar to the VP-1 beam. The VA series beams were strengthened by addition of regular steel bars to the tension zone. The additional bars were enveloped by a high-performance mortar that bonds the new reinforcement to the original beam. The VC series beams were strengthened by the attachment of a steel plate to their inferior face. The attachment of the plates was done by steel connectors and high-performance grout.

Diagrams in Fig. 2 illustrate the comparison among the beams tested by REIS [2] and by the present authors.

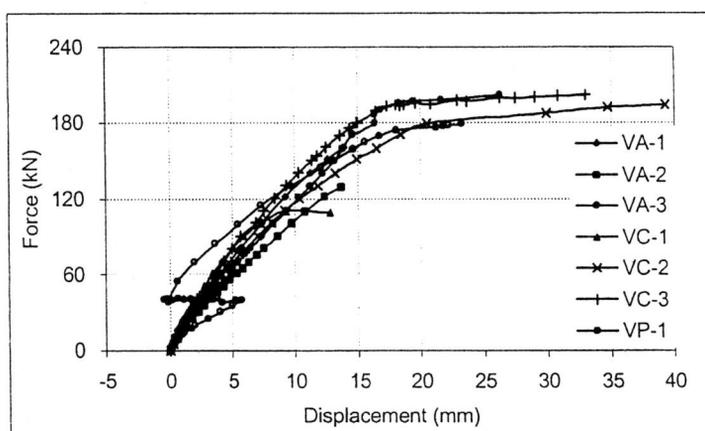


Fig. 2 Force versus deflection at mid span – comparison to REIS (1998) [2]

5 CONCLUSIONS

From the analysis of the results it is possible to conclude that external prestress highly contributes for the increase of the flexural and shear resistances, improving the service behavior through significant reduction of deflection and cracking. The tests showed that prestressing of external tendons when applied to beams under loading may lead to a total deflection recovering. Existent flexural cracks may be closed with prestressing of tendons.

It was observed that the tendon profile had no significant effect over the stiffness of the beams. The depth of the tendon in the mid span is the most effective characteristic for deflection control. Otherwise the shape of the external tendon has a great influence in the shear resistance. The shear cracking is significantly affected by the changes in the tendon geometry. For the tested beams, a larger deviation angle of the tendon led to a higher shear cracking resistance.

From the comparison between the strengthening methods it was possible to notice that despite its smaller stiffness, the beam strengthened with external tendons (VP-1) presented smaller deflections in service conditions. The favorable effect of prestress over the shear resistance was clearly observed. The strains in the stirrups in VP-1 were quite inferior than those found in the other beams until the collapse.

REFERENCES

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