V-457 INFLUENCE OF INTERNAL BONDED TENDONS ON STRENGTH AND DUCTILITY OF PRECAST SEGMENTAL PC BEAMS WITH EXTERNAL PRESTRESSING

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1. INTRODUCTION

There have been two big problems in precast segmental beams with external prestressing. One is that the flexural strength of such beams is generally smaller than that of PC beams with bonded tendons. The other is the lack of ductility compared to the usual PC beams. The use of combined prestressing consisting of external and bonded internal tendons may provide an alternative solution to the above problems. In addition, the ductility of prestressed concrete beams could be improved by confining the concrete in the compressive zone at the critical sections [1]. An attempt was made in this study to evaluate the influence of combined prestressing on the ultimate strength and ductility of beams with or without confinement reinforcements based on a parametric analysis.

2. EVALUATION METHODOLOGY

Based on a non-linear analytical methodology, a computer program was developed to predict the flexural behavior of beams with combined prestressing [2]. Using this program, the effect of combined prestressing on the ultimate behavior of beams was studied. For evaluation purposes, a simply supported beam having a span length of 5.2 m was used as shown in Fig. 1. The deviator distance was set at 3.0 m, with two point symmetrical loading at a distance of 0.9 m. The concrete strength (f'_c) was taken as 400 kgf/cm^2. The total area of prestressing tendon (A_{ps}) was kept constant as 220.4 mm^2. Three variables were considered in this study, namely, the ratio of internal to external tendons, the percentage of confined reinforcement and the percentage of initial prestressing stress to the ultimate strength of tendons, as shown in Table 1. The combination of the above three variables led to a total number of 99 cases that were evaluated in this study. For confined concrete the stress-strain relationship was based on the modified Kent and Park model shown in Fig. 2 [3].

Table 1 Summary of variable used for parametric evaluation

Description of variables	Range (%)	Increment (%)	No. of cases
1. Ratio of internal prestressing to total prestressing ($A_{ps(int.)}/A_{ps(tot.)}$)	0 - 100	10	11
2. Volumetric ratio of confinement (ρ_s)	0 - 2	1	3
3. Effective prestressing ratio (f_{pe}/f_{pu})	50 - 70	10	3
		Total	99

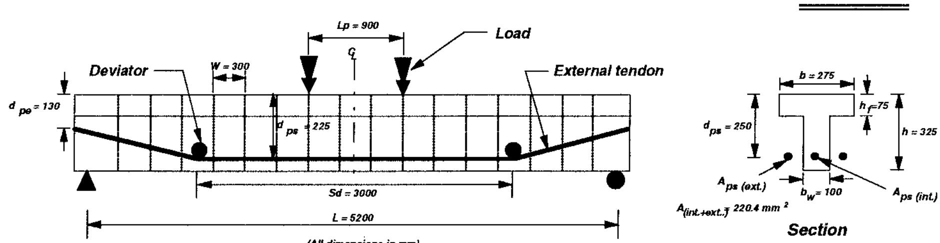

Fig. 1 Model of PC beam used in the parametric evaluation

3. INFLUENCE ON FLEXURAL PROPERTIES

Using the above evaluation methodology the load-displacement characteristics obtained for some cases are given in Fig. 3. The ultimate strength of the beam was greatly influenced by the presence of internal bonded tendons. The strength increase is proportional to the increase in percentage of bonded tendons. This is due to larger stress increase in the bonded tendons compared to the external ones. It can be seen from Fig. 4 that the percentage of initial prestressing had some influence in the ultimate strength, with higher percentages showing higher strength. This effect diminishes as the ratio of

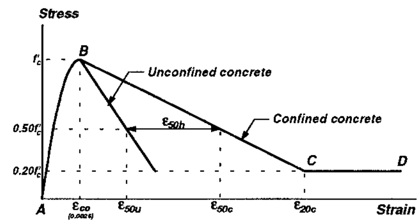

Fig. 2 Stress-strain curve for concrete confined by rectangular hoops

internal bonded tendons increases. The reason for this behavior is that with higher initial prestressing, the introduced prestress force is large though the total tendon area was the same. However, for higher internal tendon ratios, due to yielding of prestressing steel the ultimate stress approaches almost a constant value and thus the ultimate strength does not increase very much.

The ultimate deformation was obtained when the top most fiber at the critical section reached the ultimate compressive strain of concrete. The ultimate strain (ε_{cu}) was taken as the strain at which the compressive stress of concrete falls to 0.85 f'_c. This strain was considered as 0.0035 for unconfined concrete. For confined concrete, these values were computed as 0.0067 and 0.0125 for confinement ratios of 1% and 2% respectively, based on the modified Kent and Park model given in Fig. 2.

There is a significant difference in the ultimate deformation for beams with confined concrete compared to the unconfined ones as shown in Fig. 5. This difference is magnified exponentially as the ratio of confinement is increased. Also it is clear that with increase of internal tendons, the ultimate deflections are increased. However, as seen from Figs. 3 and 5, the rate of increase becomes high when the ratio of bonded prestressing is less than 50%. This is especially true for the unconfined case, where the ultimate deformation is almost constant for bonded tendon ratios above 50%. The ultimate deformation obtained with 100% internal bonded tendons could be achieved by using a combination of confinement reinforcement of 1% and bonded tendons of 20%. On the other hand, by using 2% confinement reinforcement with 20% bonded tendons, the deformations could be increased by about 80%. As such, it is deduced that a combination of internal bonded and external tendons together with confinement produces much better results than 100% internal bonded tendons.

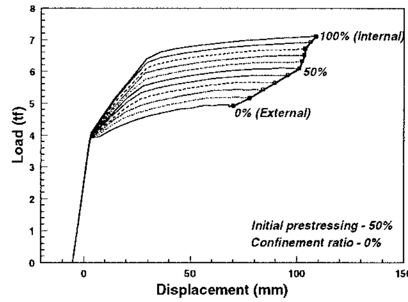

Fig. 3 Load deformation characteristics

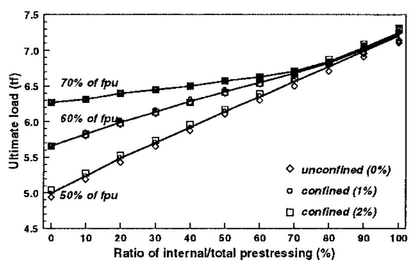

Fig. 4 Influence of bonded prestressing on the ultimate load

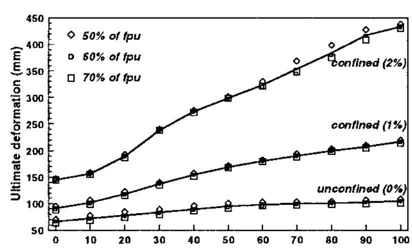

Fig. 5 Influence of bonded prestressing on the ultimate deformation

4. CONCLUDING REMARKS

A parametric evaluation was conducted to investigate the performance of combined prestressing together with confinement reinforcement compared to fully external prestressing. The following conclusions were drawn from this study.

- To maximize the ultimate strength the ratio of internal bonded tendons has to be increased. No apparent increase in strength was obtained by provision of confinements.
- The ductility behavior is improved significantly with confinements and bonded tendons. As such it is deduced that the provision of some of internal bonded prestressing together with confinement reinforcement could produce a better flexural performance in precast segmental beams.
- It is suggested that a detailed study should be carried out on the influence of other parameters and to obtain the optimum ratios for the best flexural behavior.

References

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