POST-PEAK DEFORMATION BEHAVIOUR OF CONFINED CONCRETE

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INTRODUCTION

A better understanding of stress- strain ($\sigma-\varepsilon$) behaviour of concrete is important as input to studies of rotation as well as earthquake behaviour of RC beams and colums. This work is part of a research on deformation of FRP-reinforced concrete flexural members. In this experiment the $\sigma-\varepsilon$ relation of concrete is investigated with special attention on the post-peak indicators: ultimate strain (ε_{ult}) and gradient of descending part (E_{des}). Varied parameters were thickness of cover concrete (t_v), type of confinement material and volume ratio of confinement (ρ_v) (Table 1).

Experiment Outline:

Compression tests were conducted on 62 column specimens (31x2 replications) of rectangular section with 400mm height and core section dimensions 80 x 180mm. The confinement ratio (ρ_v) was provided to the central 200mm portion of the specimen. Concrete strength was 40N/mm^2. Table 2 and Fig. 1 show FRP spiral properties and measured items.

RESULTS AND DISCUSSIONS

Post- peak Indicators Definitions:

ε_{ult} is strain at onset of failure. This can happen by rupture of spiral or by failure of core concrete. For ρ_v between 0 and 2.2% the later was usually the case. There was tendency of concrete strains (ε_c) increasing to large values at very low strength (approx. 20% σ_{max}). Fig 2 shows that spiral strains tended to flatten at high ε_c. Among all specimen only 3 had ruptured spirals. On the other hand, beyond 50%σ_{max} the damage to concrete is substancial and difficult to repair. Thus an arbitrary definition for ε_{ult} is adopted as strain at a point when stress drops to 50% of σ_{max}. E_{des} is slope of falling branch calculated using points ε_0 (strain at σ_{max}) and ε_{ult}. This definition conforms to the following $\sigma-\varepsilon$ model for descending part[1]: $\sigma_c = \sigma_{max} - E_{des}(\varepsilon_c - \varepsilon_0)$

Table 1: Test Variables

Series1: Effect of Cover Concrete

Variable	Levels
Thickness of cover, t_v (mm)	0, 8, 13, 25
Confinement Vol Ratio, ρ_v (%)	0, 0.8, 1.2, 1.6, 2.2

* Braided Aramid Spiral was used

Series2: Effect ρ_v, Ef and f_{sf}

Variable	Levels
Confinement Vol Ratio, ρ_v (%)	0.8, 1.2, 1.6, 2.2, 3.2
Type of confinement material	CFRP, AFRP, GFRP

Table 2: FRP spiral properties

	AFRP	CFRP	GFRP
Diam., mm	6	6	6
f_f, N/mm^2	1600	2570	1390
E_f kN/mm^2	64	152	44

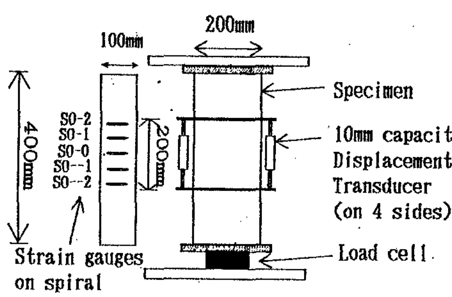

Fig 1: Test arrangement

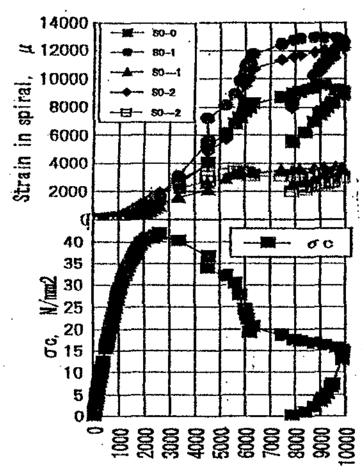

Fig 2: Spiral strains

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Effect of CoverConcrete:

The $\sigma-\varepsilon$ curves for the cover concrete were calculated by subtracting the load carried by core concrete from the total load. Fig 3 summerises results from series 1. It can be judged from the results that at high volume of confinement the maximum stress in cover concrete can decrease by over 10%. This is due to the following reasons: (1) interruption of the continuity of concrete by the spiral and (2) lateral tensile strain in the core being smaller than that in the cover, causes separation between the two and increase the risk of buckling of the cover. However, the shape of $\sigma-\varepsilon$ curve for the cover is similar to that of plain concrete and its ultimate strains, also, go slightly over 0.004.

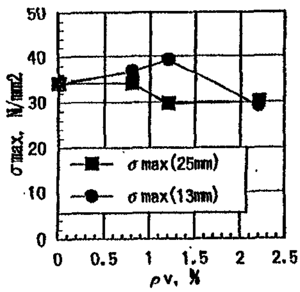

Fig 3: Effect of ρ_v on t_v and σ_{max} for cover concrete alone

Effect of ρ_v and type of confining material:

In this series influences of ρ_v, tensile strength (f_f), and modulus of elasticity of spiral (E_f) on ε_{ult} and E_{des} are discussed. Since FRP has no yield point, f_f can be considered to have no influence on $\sigma-\varepsilon$ behaviour when rupture of spiral does not occur. The development of lateral confining passive pressure in concrete depends on the ability of the confinement material to restrain the lateral expansion of the core concrete. This in turn depends on deformation stiffness of the spiral material: E_f, A and I . Fig. 4 shows the influence of ρ_v and E_f on E_{des} and ε_{ult}. Improvements in E_{des} and ε_{ult} due to the increase in ρ_v were up to 60% and 200% respectively. Reduced spacing associated with increasing ρ_v also contribute to the observed influence. Within the range considered, the influence of E_f was not observed. This shows that at low ρ_v, spacing is a critical factor in confinemet performance as it affects the ability of spiral to suport the concrete (Fig. 5).

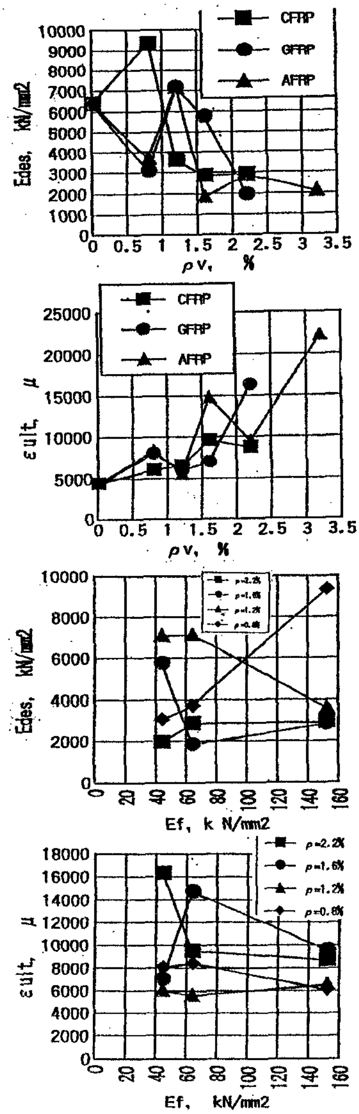

Fig 4: Effect of ρ_v and E_f on Edes and ε_{ult}

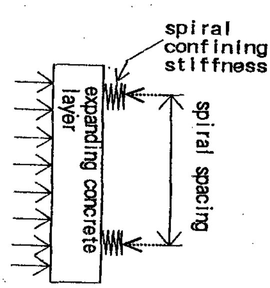

Fig 5: Effect of spacing

CONCLUSION

1. Cover concrete can be accounted for by adopting $\sigma-\varepsilon$ relation of equivalent plain concrete with an appropriate reduction of f_{cc}.
2. For $\rho_v < 2.2\%$ and $E_f > 40kN/mm^2$ E_f has negligible influence on E_{des} and ε_{ult}. ρ_v has greater influence.

REFERENCE (1) Hoshikuma J, Kawashima K, Nagaya K "A STRESS-STRAIN MODEL FOR RC COLUMNS CONFINED BY LATERAL REINFT" Conct. Library of JSCE No 27, June 1996, pp165-176