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BEHAVIOR OF CRACKED REINFORCED CONCRETE UNDER CYCLIC COMPRESSIVE LOADING

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1. INTRODUCTION

This paper describes an experimental investigation of the deformational behavior of cracked concrete under cyclic compressive loading at high strain rates. In order to study the effect of cracks on the overall behavior of concrete, a series of tests was carried out using hollow cylindrical reinforced concrete specimens to which predetermined tensile strains were introduced. Effect of cracks on compressive stiffness, strength, plasticity and cyclic response of concrete is discussed.

2. EXPERIMENTAL PROGRAM

2.1 Details of the specimen

The test specimens were reinforced concrete hollow cylinders, each having 300 mm height, 150 and 80 mm outer and inner diameters respectively. For the lateral reinforcement, D3 bars were used and reinforcement ratio adopted was 1% in all specimens. Details of a test specimen and mix proportion of concrete used are shown in Fig.1 and Table 1 respectively.

Table 1. Mix proportion of concrete

w/c %	s/a %	W kg/m³	C kg/m³	S kg/m³	M.S mm	Slump cm
47.4	56.5	220	465	840	10	7.5

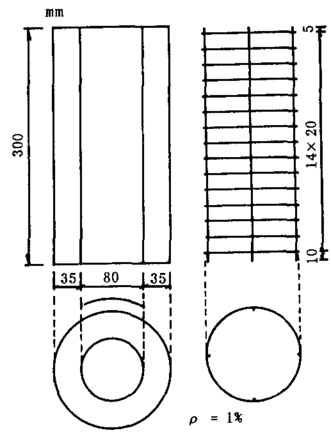

Fig.1 Details of the specimen

2.2 Testing Procedure

To generate tensile cracks in concrete in the direction parallel to longitudinal direction of the specimen, uniform pressure was applied radially by a pressure apparatus as shown in Fig.2. Average tensile strain "ε_t" in the transverse direction was calculated from the measurements of radial displacements at four points. After applying predetermined tensile strains in the transverse direction, the specimens were subjected to strain controlled uniaxial cyclic compressive loading.

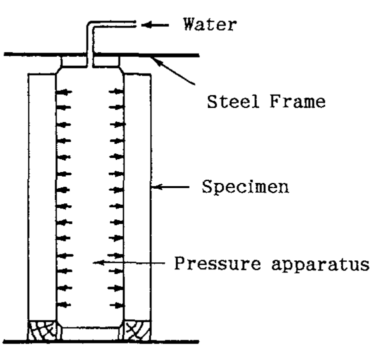

Fig.2 Setup for tensile cracking

Table 2. Summary of compressive strength, tensile strain and strain rate

SPECIMEN	f_c kg/cm³	ε_t micro	Strain rate %/sec
T_1	543	0	0.5
T_2	698	1333	0.5
T_3	698	3654	0.5
T_4	543	1671	2.5
T_5	543	4588	2.5
T_6	543	4758	2.5
T_7	543	0	5
T_8	698	1974	5
T_9	698	3649	5

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Applied load and the compressive strains in the longitudinal direction at mid sections of the specimens were measured. Table 2. summarizes the variables used in this series of tests.

3. OBSERVATIONS AND DISCUSSION

3.1 Comparison of the behavior of cracked and uncracked concrete

The envelop curves of uncracked and cracked specimens tested under same strain rate are shown in Fig.3. It can be seen that the existence of cracks reduces compressive stiffness and strength of concrete and this reduction increases with the increase of tensile strain normal to cracks. Similar behavior has been reported in reference[1]. The authors have defined the ratio of strength of cracked concrete to uncracked concrete as "K_t" and it is expressed as a function of average tensile strain "ε_t" as given in Eq.1.

$$K_t = \exp(-1650 \cdot \varepsilon_t) + 0.8 \qquad (1)$$
$$\leqq 1$$

In references [2] and [3] the strength reduction ratio is expressed as a function of the total tensile strain normal to cracks at the ultimate compressive strength. Even though the transverse tensile strain influences the stress-strain relationship of the envelop curve, there is no such influence seen in stress-strain relationship of the unloading and reloading paths. The Fig.4 shows the relationship between plastic strain "ε_p" and the maximum compressive strain of cracked and uncracked concrete and the results indicate that the plastic deformation in the longitudinal direction is not affected by the tensile strain in the lateral direction.

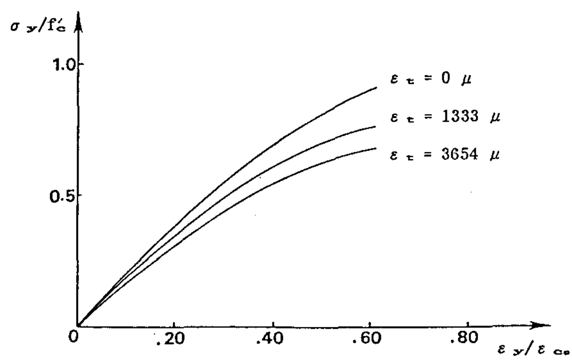

Fig.3 Normalized Stress-Strain relation

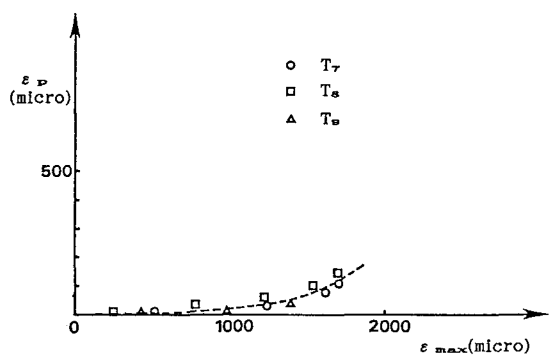

Fig. 4 ε_p versus ε_{max} diagram

4. CONCLUSIONS

In cracked concrete, strength and stiffness parallel to cracks are greatly reduced and the reduction can be uniquely expressed as a function of average tensile strain normal to crack direction. Stress-strain relationship of unloading, reloading and plasticity in the direction parallel to cracks are not affected by tensile strains in the normal direction.

REFERENCES

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