SHEAR TRANSFER BEHAVIOUR OF CRACKED CONCRETE UNDER FATIGUE LOADING

University of Tokyo, IIS Member of JSCE **Toshiharu KISHI
University of Tokyo, Graduate school Student Member of JSCE *Esayas Gebreyouhannes

1. INTRODUCTION

It is a well known fact that cracks in reinforced concrete structures can transfer a significant amount of shear stress. A number of researches, experimentally and analytically, has been done to understand and describe the behavior of cracked concrete subjected to shear loading. To date there are several constitutive models developed that can acceptably explain and predict the behavior for monotonic loading. On the contrary real structures are subjected to repeated loading with unpredictable sequences. Hence the above mentioned models have a short-hand in addressing the shear transfer behavior under repeated loading. Therefore in this study an experimental investigation on normal strength concrete was done to explain the degree of deterioration under single sided fatigue loading.

2. RESEARCH PROGRAM

Due to the highly nonlinear nature of the problem, the response under a given shear load is sensitive to the variation of boundary conditions. Therefore, in consideration of proximity to practical conditions and simplicity of experiment, tests with boundary conditions of finite lateral stiffness were carried out by providing two D22 steel bars passing through the holes,ϕ = 33 mm, in the specimen.

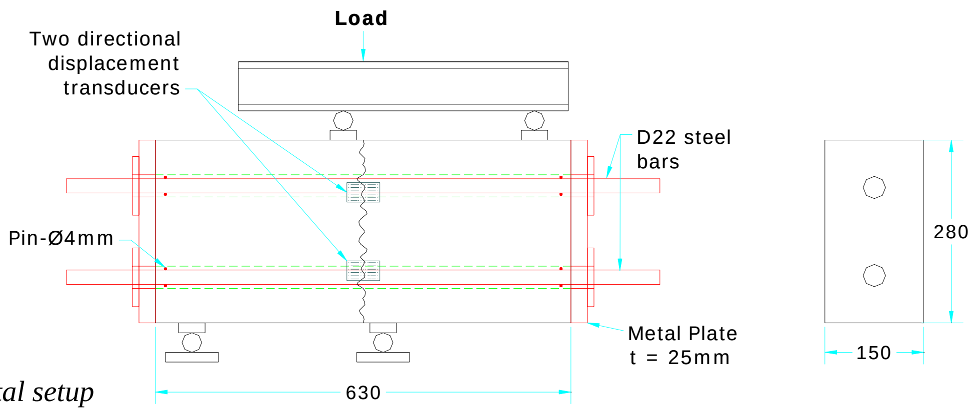

Fig.1.Experimental setup

Plain concrete specimens with dimensions 150 x 280 x 630 were used. During concreting two grooves, 5mm, deep were provided on each face of the specimen. Before shear loading a splitting crack was introduced by wedging the specimen. To exclude the effect of dowel action of the steel bars, pins of diameter 4mm were used at each end. The experimental set up and cross section of the specimen are schematically shown on Fig. 1. The maximum aggregate size and the elastic modulus of the steel used were, G_{max} = 20 mm, E_s=195.25 Gpa. Shear displacement and crack opening were continuously measured by two directional displacement transducers. And the shear force was measured by means of the load cell attached to the actuator while the confining stress was calculated by use of the steel strain gages attached to the steel bars.

3. LOADING

In this study a single sided fatigue loading with a constant amplitude level was considered. The three specimens, NSC_F1, NSC_F2 and NSC_F3, were subjected to constant maximum shear loads of 1.07, 2.79 and 2.26 Mpa respectively to represent low, moderate and high stress levels. The loading history of these specimens was achieved by varying the shear load between the respective minimum and maximum values described in Table 1. In all cases a sinusoidal load wave form at a frequency of 1.5 Hz was applied.

Table 1: Details of experiment

DESIGNATION	CYL.COMP. STRENGTH (MPA)	V_{MIN} (MPA)	V_{MAX} (MPA)	INITIAL CONDITIONS $\omega_0/\delta_o/\sigma_o$
NSC_F1	32.0	0.043	1.074	0.60/0.10/0.098
NSC_F2	32.6	0.172	2.792	0.53/0.11/0.037
NSC_F3	33.1	0.171	2.259	0.70/0.16/0.060

Note: compressive strength values presented are at the date of testing.

Keywords: Shear displacement, crack opening, damage, fatigue

* Graduate student, at the University of Tokyo, Graduate School
** Associate Prof. of concrete engineering, at the University of Tokyo, IIS.

4. EXPERIMENTAL RESULT AND DISCUSSION

As shown in Fig. 2, in each case, a considerable difference between the first and the subsequent cycles was observed, indicating that there is an irreversible damage occurring on the crack interface due to interlocking, fracturing, and crushing of asperities. As a result, the residual shear displacement is almost equal to the maximum value of shear slip corresponding to the peak shear load. Another common feature is that, the shear displacement increased in a decreasing manner for successive load repetition.

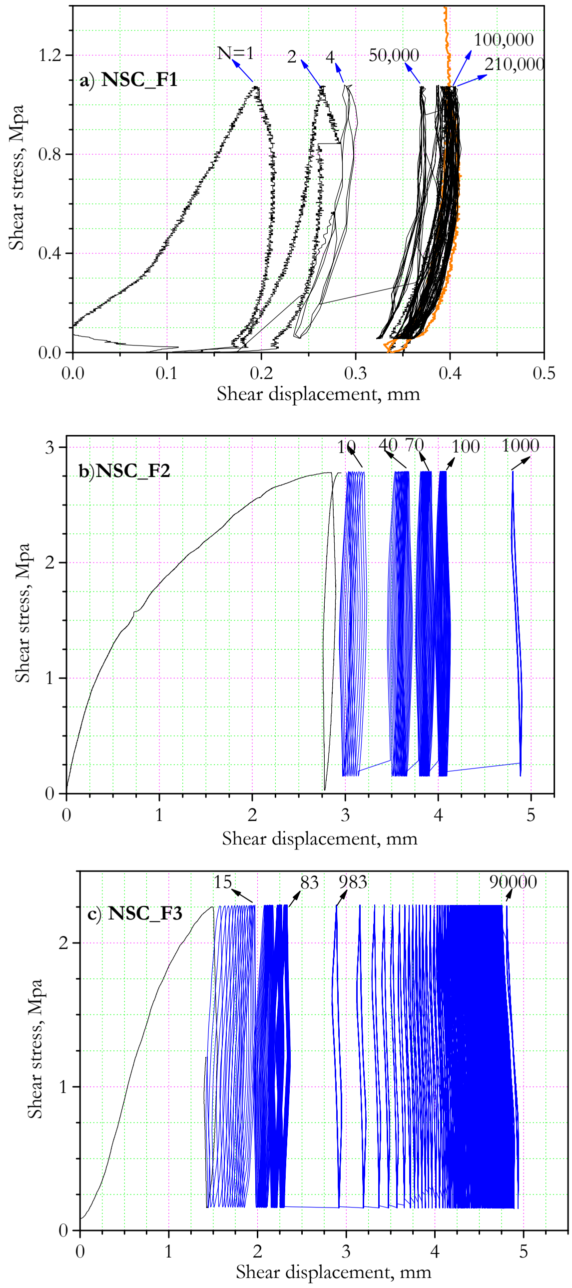

Fig.2. Shear stress vs shear displacement relation for the three specimens.

In the case of specimen, NSC_F1 damage was less significant. A stable situation was reached after 100,000 cycles, in which the increment of shear displacement and crack opening is extremely small for any further load cycle. Unlike NSC_F1 the damage in the case of NSC_F2 and NSC_F3 was significant. Besides, any new loading cycle led to further damage of the crack interface in steadily increasing values of shear displacement at peak shear load. In other words no stable situation was attained in the case of specimens NSC_F2 and NSC_F3. On the other hand the crack opening values (not shown here) in cases of specimens NSC_F2 and NSC_F3 increased until specific number of cycles (for NSC_F2 at N ≅100 and for NSC_F3 at N≅40,000) and then gradually decreased until the respective last cycles. This could be as a result of crushing of the cut off particles within the crack interface due to the presence of high local stresses. After the end of the shear loading the two blocks of the specimen were separated and observation on the interface showed that a small amount of powder was observed as a result of crushing.

5. CONCLUSION

- The behavior of cracked interfaces under shear loading is characterized by an irreversible damage, caused by fracturing and crushing of the asperities. As a result considerable decrease in hysteresis loop area between the first and second cycles were observed.
- Under repeated loading the Shear displacement increases in a decreasing manner. Indicating that majority of the interface deterioration occurs by the first few loading cycles.
- The rate of shear displacement increment is dependent on the load amplitude level and a stable situation can be attained in cases of low amplitude loading, for example τ_{max} = 1.074 Mpa in this study. However, a clear delineation of the minimum value of shear stress level in which a stable situation can be attained is necessary.
- As a result of smoothening of the crack interface the maximum crack opening per increment of shear displacement decreased significantly.
- It is expected that the damage in case of fully reversed cyclic loading could be more severe. This effect of loading pattern is under investigation and results will follow this paper.

6. REFERENCES

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