EXPERIMENTAL STUDY ON SHEAR FATIGUE BEHAVIOR THROUGH CRACKS OF LIGHT WEIGHT AGGREGATE EXPANSIVE CONCRETE

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1. Introduction

Life-time prediction of existing as well as newly constructed reinforced concrete (RC) structures catch engineers attentions for decades. In fact, cracks in RC structures is likely exists as the result of one or a combination of factors, such as drying shrinkage, thermal contraction, restraint (external or internal) to shortening, applied loads etc.. However, the occurrence of cracks does not mean that there is a total discontinuity in terms of stress-transfer, cracks still can transfer a substantial amount of stress due to aggregate interlocking, aggregate bridging and bond mechanisms.

LWAC, in recent years, becomes an important structural material and the demand for it is increasing because of practical advantages such as the lower density and higher insulating capacity, etc.[1].On the other hands, lightweight aggregate expansive concrete (LWAEC) can effectively eliminate the effect of autogenous shrinkage of concrete [2]. The shear transfer behavior of cracked concrete interfaces under shear fatigue loading was investigated [3], unfortunately, there has been little research about shear transfer behavior of LWAEC. This paper presents experimental study of shear fatigue behavior through cracks of LWAEC under reversed cyclic loading in wet condition.

2. Experimental program

2.1 Materials

The mix proportions of each specimen are shown in Table 1.

The properties of materials are shown in Table 2.

Table 1. Mix proportion

Series	W/B = 65%						
	C	EA	W	G	LA G	S	LA S
C0	280	-	180	962	-	937	-
CEA20LGS	260	20	180	-	484	-	638
CEA40LGS	240	40	180	-	484	-	638
CEA20LG	260	20	180	-	484	897	-
Remarks	LGS: lightweight coarse aggregate and lightweight sand						

Table 2. Material Properties

Materials	Symbo l	Type	Brand	Density (kg/cm3)
Normal Cement	C	Normal Portland	Sumito mo	3.15
Expansive Agent	EA	Power CSA	Denka	3.15
Sand	S	River Sand	-	2.63
Coarse Aggregate	G	Crushed limestone	-	2.60
Lightweight Aggregate	LWA	Expande d shale	Mesalite	1.42
Lightweight sand	LWS		Mesalite	1.87

2.2 Loading setup

In this study, 8 specimens with the dimensions 150 × 280 × 630 mm are considered. The experimental set-up is shown in Fig. 1.

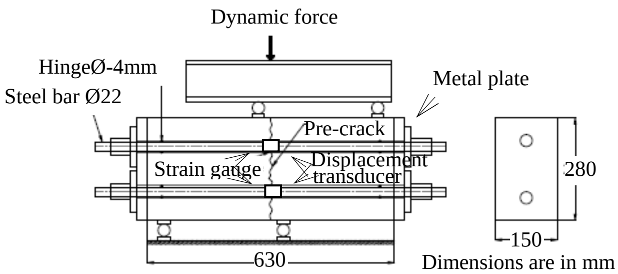

Fig 1. Experiment setup for dynamic loading

The specimens were cured in fully wrapped wet cloths and plastic sheets, and remove the cloths after 14days. The 5mm×5mm notch is adding in both side of specimens to induce more regular crack. Before the specimens were subjected to shear fatigue loading, cracks were introduced by splitting. The initial crack width for each specimen was maintained in the range of 0.3mm to 0.7mm. The two cracked halves were restrained by using un-bonded reinforcing steel bars passing through the longitudinal circular holes. The initial confining stress was kept very small, less than 0.01MPa. It is designed in such a way that the elements on the crack interface are in a pure shear state. All tests were load controlled and measurements of shear slip and crack opening were taken using two directional crack transducers, which are capable of measuring the shear slip and crack width simultaneously. The confining force was measured using strain gages attached to the steel bars.

Keywords: Lightweight aggregate expansive concrete, shear transfer, fatigue, reverse cyclic loading
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2.3 Loading pattern and amplitude

Cracks in bridge slabs are commonly exposed to rain. There fore water may influence the degree of deterioration of cracked interfaces. To examine and quantify the relative effect of water on shear transfer fatigue, all four case of reverse cyclic loading are carry out under wet condition. The detail of loading pattern and amplitude are shown in Table 3.

Table 3. Loading pattern and loading amplitude

Designation	Loading pattern	Concrete strength (MPa)	Stress level
C0-1	Static	32	Ultimate capacity (*P*)
CEA20LGS-1		13	
CEA40LGS-1		21	
CEA20LG-1		24	
C0-2	Reverse in wet condition	32	35%, 50% *P*
CEA20LGS-2		13	50% *P*
CEA40LGS-2		21	35% *P*
CEA20LG-2		24	35% *P*

3. Results and Discussions

The specimens are subjected to a monotonically increasing load with unloading and reloading ate some specified levels. Upon unloading the shear slip is almost irrecoverable indicating the behavior is mainly governed by frictional slip. However, there are slightly return can be seen in the low load level as a results of reduced friction.

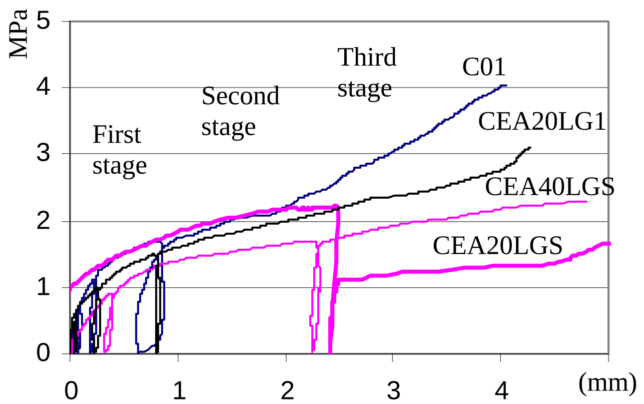

Fig 2. Relations between shear stress – shear slip

Although, the compressive strength of four series are different, but the shear response under static loading nearly the same in the first stage (contact area tends to increase, shear slip smaller than 0.5mm) and second stage (shear stiffness reduces gradually, shear slip smaller than 2.5mm). It is become different when they come to third stage (Flatter contact units get engaged, mainly governed by sliding and crushing), because of the type of aggregate, and the amount of expansive agent, Fig 3.

The response of CEA20LG and CEA40LGS under reverse cyclic loading with the stress level 35% of ultimate capacity is nearly the same, and the response is similar with the normal concrete case under the stress level 50%.

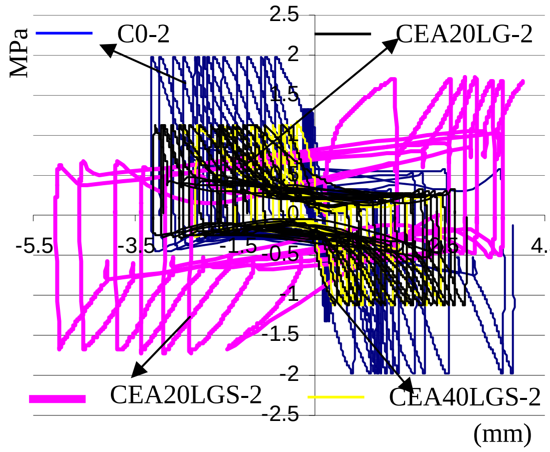

Fig 3. Relations between shear stress – shear slip under reverse cylic loading in wet condition

With the stress level 35%, normal concrete specimen shows very lightly change in shear slip. In case of, lightweight concrete CEA20LGS, under the stress level 50%, the response of specimen is just only 5 cycles compare with 15 cycles of normal concrete case (C0)

4. Conclusions

The shear behavior of LWAEC under static loading is similar with normal concrete in the shear slip range smaller than 2.5mm. The compressive strength tends to not a very importance factor in determine the shear fatigue response. Under reverse cyclic loading in wet condition, the response of LWAEC with the stress level 35% is similar with the response of normal concrete with the stress level 50%.

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