V-438 FATIGUE STRENGTH OF CONCRETE WITH CONSIDERATION OF CRACK GROWING MECHANISM

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1. INTRODUCTION

During the recent years, the static fracture process of concrete has become much better understood. On the other hand, the fatigue fracture process is less well understood. Only a few paper were found in the literatures, e.g. L.Elfgreen, et.al.[1] and Maruyama K.et.al [2] which have studied the fatigue of concrete with pull-out test of anchor bolt. Their discussions are limited to fatigue capacity only.

This paper discusses the crack growth and fracture process in concrete conducting the pull-test of anchor bolt under dynamic loading. The fatigue strength of concrete in shear and tension was compared with the formula which is proposed by Japan Society of Civil Engineers (JSCE) [3].

2. EXPERIMENT

The properties of bolt and concrete block are summarized in Table-1. In this study the bolt was placed before pouring concrete and frictional resistance between concrete and bolt was eliminated by wrapping vinyl tape on bolt shank.

The load level of dynamic test are shown in Table.-2. The load took a sine wave form and fluctuate between a constant Pmin = 0.1 and Pmax from the start until failure occur with frequency of 5 cycles per second (5Hz).

Table-1. The properties of Bolt and Concrete Block

Bolt Type	JIS G 4105 SCM(SCM3)	
1.Max Tensile Strength of Bolt	1059 MPa	
2.Diameter of Bolt	16 mm	20 mm
3.Embedment Length	30 mm	45 mm
Dimension of Block	400x400x250mm	
1.Nominal Compressive Strength	29.4 MPa	
2.Actual Compressive Strength	31.9 MPa	
3.Splitting Tensile Strength	2.60 MPa	

Table-2. Load level of dynamic loading

Embedment length, h		30 mm	45 mm
Ultimate load (ave.), Pu		13.73kN	29.81kN
Pmax/Pu	80%	10.98kN	23.85kN
	70%	9.61kN	20.87kN
	60%	8.24kN	17.89kN
Pmin/Pu	10%	1.37kN	2.98kN

Pmax: maximum load, Pmin : minimum load
Pu : static ultimate load (average)

3. TEST RESULTS AND DISCUSSIONS

3.1 MODELLING OF CRACK GROWTH MECHANISM

The crack growth mechanism was modelled on the following assumptions : (1) After the first cycle of load cracks initiate at the edge of bolt. The cracks continue to propagate at an angle of ϕ with a number of cycles of load. (2) At the tip of crack there act the tensile and bending stresses. The distribution of resistant stress is assumed to be a triangle as shown in Fig.-1.

When the cracks propagate under constant amplitude of dynamic load, the stress acting area increases and the tensile stress intensity at the crack tip decreases, but on the other hand the bending stress increases

because the diameter of conical shape of crack portion increases by propagation of crack as shown in Fig.-2

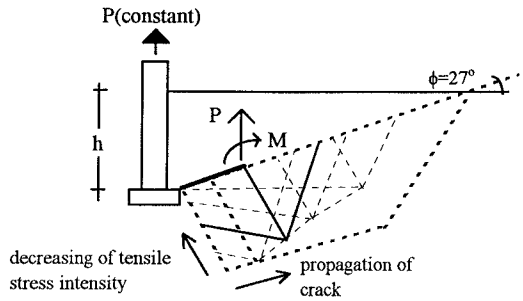

Fig.-1 Model of stress resistant mechanism

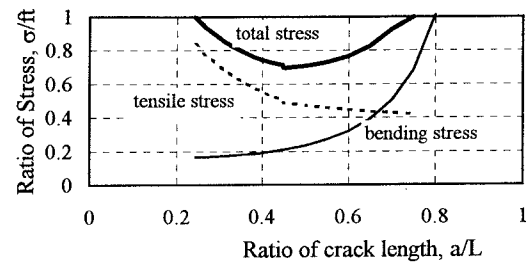

Fig.-2 Stress Intensity at crack tip

3 .2 COMPARISON OF CALCULATION WITH TEST

Fig.-3 shows the comparison of calculated and test results of crack growth as a function of cycles of load to cycles at failure. The calculated fatigue capacity by the model is compared with the formula of JSCE and the test results in Fig.-4.

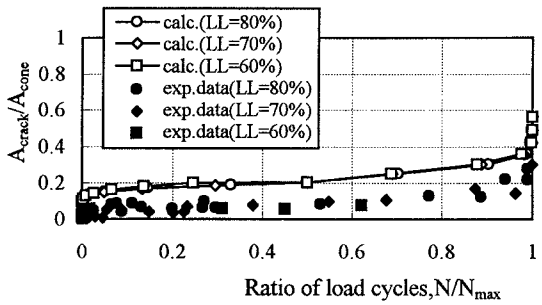

Fig.-3 Crack growth mechanism

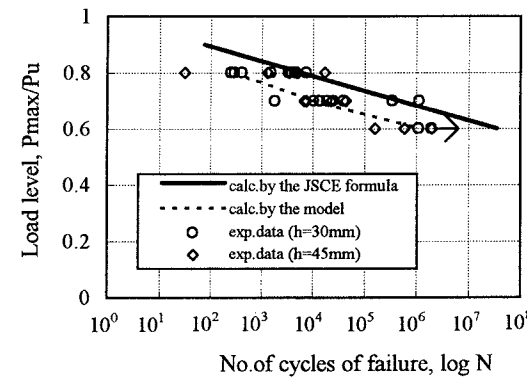

Fig.-4 Fatigue Strength of Concrete

Regardless the value of test data, the crack growth mechanism could be drawn with help of the model.

Judging from fig.-4, the calculated results by the JSCE formula are somewhat unsafe while those by the model show good agreement with test results.

4. CONCLUSSIONS

The crack growth mechanism model of concrete in the fatigue condition was introduced. The model can expressses the fatigue strength behavior of concrete fairly well.

REFERENCES

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3. JSCE,"Standard Specification for Design and Construction of Concrete Structures-1986,Part I (Design)",1986,p.244