UDC 666.974.6: 678.066
539.431.1.015

FATIGUE PROPERTIES OF RESIN CONCRETE UNDER REPEATED COMPRESSION LOADS

レジンコンクリートの圧縮疲労性状

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1. Foreword

The results of experimental studies of compression fatigue properties of resin concrete using unsaturated polyester resin are described in this paper.

A problem which arise in studying fatigue properties of resin concrete is that since the binder is synthetic resin, a phenomenon characteristic of visco-elastic bodies subjected to cyclic stresses is produced, that is, there is heat evolution due to phase lag of strain which causes specimen temperature to rise and reduce the strength of the concrete rendering it more prone to failure, thus making it difficult to grasp fatigue properties.

Another peculiarity of fatigue tests of resin concrete is that since compressive strengths are much more higher than for cement concrete—the strengths of resin concretes using polyester resins especially being about triple those of cement concrete in general—when the upper limit of dynamic loads is established based on compressive strength, even if the stress level is the same, the magnitude of stresses and strains produced in concrete due to dynamic loads are extremely large being approximately 3 times those for cement concrete. For example, in the compression fatigue tests reported in this paper, the upper limit of stress is 840 kg/cm^2 and the varying strain is $3{,}000 \times 10^{-6}$ for the case of a stress level of 60 percent.

Meanwhile, as the beforementioned heat evolution has an amplitude-dependent nature, the temperature rise of a specimen in a fatigue test producing such high stresses will be extremely great (Fig. 1). Therefore, in order to obtain an accurate picture of the fatigue properties of resin concrete, it is necessary to hold temperature rise of specimen to a minimum. In these experiments, specimens were made to be hollow and positive cooling of the specimens was carried using a room air-conditioner to blow chilled air directly against the specimens.

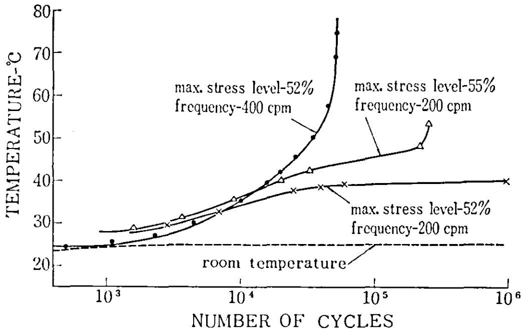

Fig. 1 Variation of temperature with number of cycles for resin concrete

2. Outline of Experiments

Table 1 indicates the materials used in resin concrete and the mix proportions. Of these

Table 1 Mix proportions of resin concrete

Material		Percent by weight
Liquid resin	Unsaturated polyester resin	11.25
Filler	Calcium carbonate	11.25
Aggregate	Crushed stone (10∼20 mm)	14.55
	Crushed stone (5∼10 mm)	14.55
	Coarse sand (1.2∼5 mm)	9.60
	Fine sand (∼1.2 mm)	38.80

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materials. aggregates and fine-particled filler were used at moisture contents of not more than 0.1 percent.

Specimens were thick-shelled hollow cylinders of outer diameter of 75 mm, inner diameter of 15 mm and height of 150 mm. After casting concrete, specimens were left standing for 24 hours at 20°C and 50 percent relative humidity upon which they were stripped and subjected to accelerated curing at 70°C for 15 hours.

The compressive strength, tensile strength, static modulus of elasticity and unit weight of resin concrete made in this manner were 1400 kg/cm^2, 110 kg/cm^2, 3×10^5 kg/cm^2 and 2300 kg/m^3 respectively.

Fatigue tests were conducted using a hydraulic-type fatigue testing machine of 50-ton capacity with the lower limit of load kept constant (approximately 3 percent by ratio to failure load) for one-way loading. The rate of repetition of load was set at 150 cycles per minute in consideration of temperature rise of specimens.

3. Test Results and Observations

Fig. 2 gives S-N curves of resin concrete according to which the stress level for withstanding 2 million cycles of loading, a number generally considered as a measure of fatigue strength of concrete, is about 59 percent and this is more or less the same for the case of cement concrete.

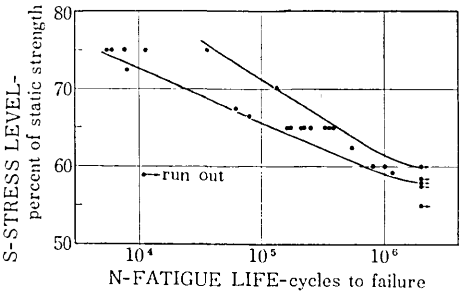

Fig. 2 S-N curve for resin concrete

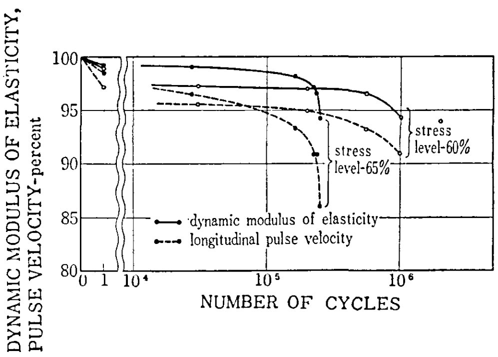

Fig. 3 Variations in dynamic modulus of elasticity and longitudinal pulse velocity with number of cycles for resin concrete

Fig. 3 shows the variations in dynamic modulus of elasticity and ultrasonic wave propagation velocity indicating that these are gradually lowered as the number of cycles producing fatigue failure is approached. This is thought to be due to growth of microcracks produced in the interior. Fig. 4 and 5 indicates respectively the variations in the form of the stress-strain curve and the variation in static modulus of elasticity in case up to approximately 2 million cycles of loading corresponding to 58 percent of static failure load is applied. In Fig. 4 a trend similar to the case of cement concrete is seen where the shape of the stress-strain curve initially convex in the upward direction gradually becomes convex in the downward accompanying increase in the number of cycles of loading. The curves in the figure represented by broken lines are for the case of cement concrete.

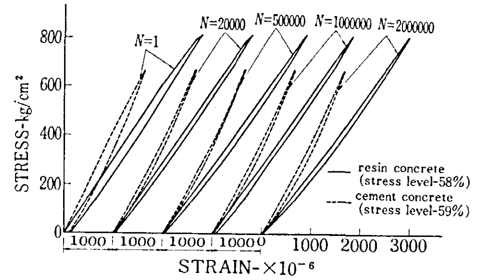

Fig. 4 Variation of stress-strain curve with number of cycles

Fig. 5 indicates stress-strain curves at various cycles only for when load was being applied which were plotted on the same coordinate axis showing clearly the decrease in gradients of stress-strain curves, in effect, the degree of reduction in the

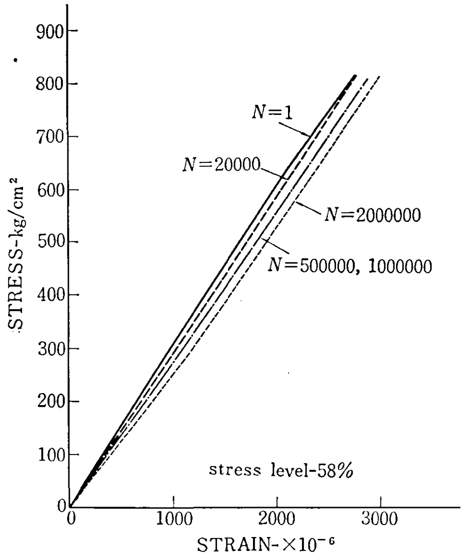

Fig. 5 Variation of stress-strain curve with number of cycles for resin concrete

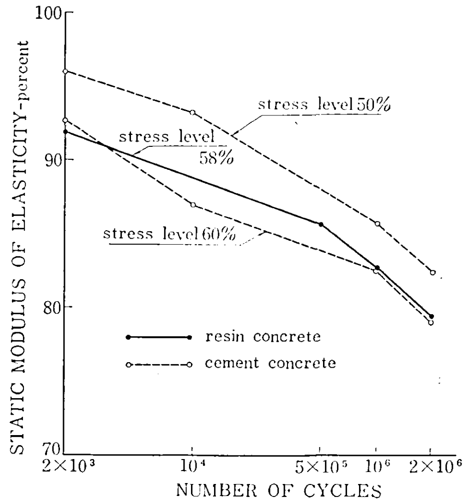

Fig. 6 Variations in static modulus of elasticity with number of cycles for resin concrete and cement concrete

static modulus of elasticity with increase in number of cycles of loading. In the case of this figure, static failure strength remains almost unchanged even if repetitive loads of stress level of 58 percent are applied 2 million times, but static modulus of elasticity is lowered by approximately 20 percent. That this rate of reduction is roughly the same as for the case of cement concrete may be judged from Fig. 6.

(manuscript received, December 25, 1973)

正　誤　表（2月号）

ページ	段	行	種　別	正	誤
5	左	図3	の横軸の式	${}_s\xi={}_s\varepsilon/{}_s\varepsilon_y$	${}_s\xi={}_s\varepsilon/{}_s\varepsilon_B$
5	右	図6		曲げモーメント M の矢印上向き↑	曲げモーメント M の矢印下向き↓
6	左	↓13	本文（式）	${}_s\tilde{N}=\sum_{j=1}^{m}{}_s\eta_j\cdot{}_s\tilde{a}_j \quad (6)$	${}_sN=\sum_{j=1}^{m}{}_s\eta_j\cdot{}_s\tilde{a}_j \quad (6)$