

論文

[2128] 応力及び温度履歴に依存するコンクリートの引張強度モデル

TEMPERATURE AND TENSILE STRESS PATH DEPENDENT MODELS FOR

TENSILE STRENGTH OF CONCRETE

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1. INTRODUCTION.

In the design of massive concrete structures nowadays, the precaution which gains much attention in designing procedures is the prevention of thermal crack initiation in concrete during the early period of construction. Cracking criterion of early age concrete, which is one of the important concerns in solving thermal cracking problems, was investigated in this study. In young concrete, hydration and sustained tensile stress history are two main factors affecting tensile strength. Hydration effect and sustained tensile stress history effect were separately clarified and mathematically modeled. Then, as the final step, the combined effects of the both were studied. Since temperature (directly affecting hydration) and sustained tensile stress in a concrete element in a structure keep varying in inconsistent manners, the models must be formulated by time i.e. having path dependent characteristics.

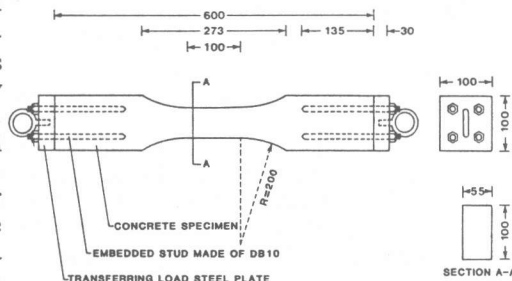


Fig.1 DIRECT TENSION SPECIMEN UNIT (mm)

2. EXPERIMENTS.

Splitting test was used to define tensile strength of concrete in the study of strength development due to hydration. Standard cylinders (10 x 20 cm) were adopted for the test. All splitting specimens were always kept in 100% relative humidity condition all along the curing period and during loading.

For the purpose of applying sustained tensile stress while hydration was under way in the study

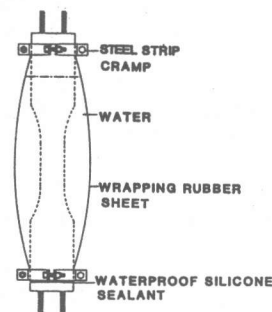


Fig.2 PREVENTION OF DRYING SHRINKAGE

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of combination of hydration and sustained tensile stress effects, direct tension test was utilized. Direct tension specimens of embedded-stud type (Fig. 1) were employed in the test. To prevent drying shrinkage, direct tension specimens tested at 20° c condition were coated with paraffin and those tested at 60° c condition were submerged in water utilizing the arrangement shown in Fig.2. Loading system used to apply sustained tensile stress is shown in Fig.3. The system is a sort of pulleys-cable system employing gravity load as source load.

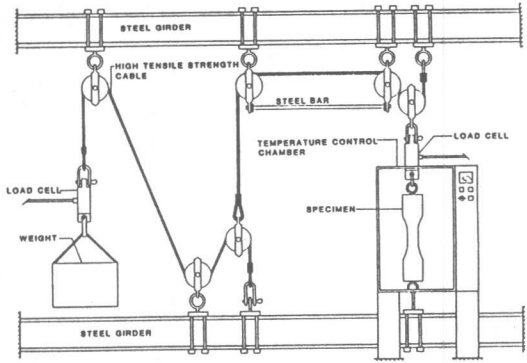


Fig.3 SUSTAINED TENSILE STRESS LOADING SYSTEM

### 3.GENERAL CONCEPTUAL MODEL.

Following are the basic assumptions for the conceptual model.

1. Concrete is composed of microscopic constituent elements aligned in parallel with the direction of tensile stress.

2. Number of elements in unit cross section of concrete is implied by "strength development ratio, N" defined as the ratio of tensile strength within strength development period, the period in which the concrete strength is still developing, to the tensile strength when hydration is supposed to complete (28-day strength is assumed as the tensile strength at this state).

3. Tensile strength of early age concrete depends on two parameters.

$$F_t = N \cdot F_i \text{-----(1)}$$

where,  $F_t$  = tensile strength of concrete during development period

$N$  = strength development ratio

$F_i$  = standard tensile strength of concrete when hydration completes (supposed to be 28-day strength).

4. Degree of severeness of applied tensile stress to young concrete is defined by

$$S_i = S/N \text{-----(2)}$$

in which,  $S$  = applied tensile stress

$S_i$  = normalized stress acting on hydrated compounds of concrete.

5. Hydration reaction increases strength development ratio while sustained tensile stress decreases it.

6. Concrete does not crack as long as the normalized stress  $S_i$  is less than ultimate strength  $F_i$  and crack initiates when  $S_i$  reaches  $F_i$ ; i.e.,

$$\begin{array}{l} \text{if } S_i < F_i \text{ no crack.} \\ \text{if } S_i = F_i \text{ crack occurs.} \end{array} \text{-----(3)}$$

This is the cracking criterion of early age concrete.

### 4.STRENGTH DEVELOPMENT MODELING.

#### 4.1 MODEL DEVELOPMENT.

The effects of the foregoing two parameters in Eq.1 on tensile strength were studied according to the following hypotheses.

1.Strength development ratio is not affected by the changing of temperature within the range of 20° c - 60° c.