CRD-C 71-80

STANDARD TEST METHOD FOR

OF CONCRETE

1. Scope

This method covers the determination of the ultimate tensile strain capacity of concrete subjected to static and sustained flexural loading. It is especially applicable to mass concrete and the specimen dimensions are such as to facilitate testing mass concrete.

2. Applicable Documents.

2.1 Handbook for Concrete and Cement.

CRD-C 4, Sampling Fresh Concrete.

CRD-C 20, Making and Curing Concrete Test Specimens in the Laboratory.

CRD-C 16, Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).

3. Significance and Use.

3.1 Cracking resulting from slow rates of stress development is of primary concern to the performance of mass concrete structures. The current practice of the U. S. Army Corps of Engineers for determining the tensile strain capacity of mass concrete is to perform rapid and slow flexure tests on concrete beams. Results of these tests are compared with tensile strains predicted by analytical methods for a given structure. These comparisons are the basis for development of temperature and construction control procedures for mass concrete projects.

3.2. When the purpose of the test is to compare the strain capacity potential of different concretes, loading should be started at 7 days age. When the complete strain capacity behavior of a given concrete is desired, start loading at 7 and 28 days age. When design conditions indicate the necessity of desirability, starting loading at 90 days and later ages should be evaluated.

4. Apparatus.

4.1 Molds. The rectangular steel molds shall be 12 by 12 inches (305 by 305 mm) in cross section. The length shall be at least 4 inches (102 mm) greater than five times the depth as tested. The inside surfaces of the molds shall be smooth and free from blemishes. The sides, bottom, and ends shall be at right angles to each other and shall be straight and true and free of warpage. Maximum variation from the nominal cross section shall not exceed 1/8 inch (3.2 mm). Provisions shall be made for positioning strain meters in the molds parallel to the top and bottom surfaces (as tested), 1-1/2 inches (38 mm) from those concrete surfaces, centered within the middle third of a 60-inch (1524-mm) simple span (Figure 1), prior to concrete placement.

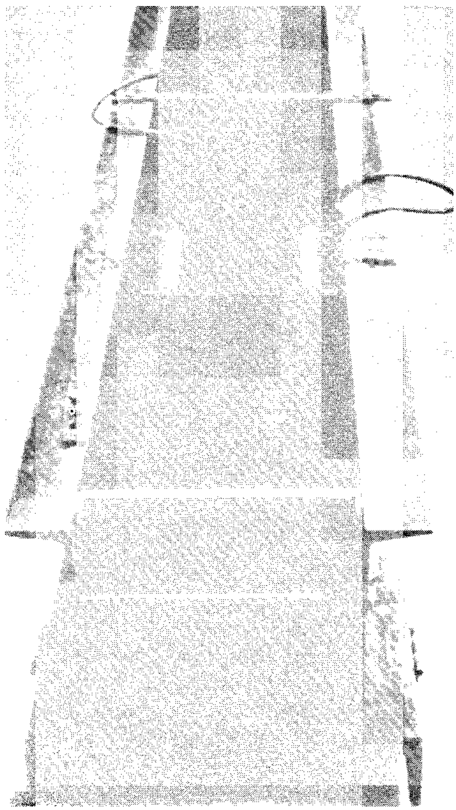

Fig. 1. Position of strain meters in beam mold

4.2 Loading Frame. The loading frame shall be capable of applying and maintaining the required third-point flexural load on the specimen, despite any change in the dimensions of the specimen. The apparatus should be capable of maintaining the specified span length and distances between loading and support rollers constant within ±0.1 inch (±2.5 mm). Reactions should be parallel to the direction of the applied forces. The testing machine may be of any type of sufficient capacity, and shall be capable of providing the rate of loading prescribed in 6.1. Sustained loads may be maintained using an oil reservoir under regulated high-pressure gas, springs, or deadweights. Hydraulic pressure gages or load cells shall be provided for measuring loads to the nearest 2 percent of the total applied load.

4.3 Strain Gages. Suitable surface strain gages or embedded strain meters shall be provided for the measurement of longitudinal compressive and tensile strain in the specimen to the nearest five millionths. Surface gages can effectively be used for rapid loading tests, but embedded strain meters should be used for sustained tests to avoid errors due to creep of surface-mounted gages. The effective length of embedded meters or series installed surface gages shall be at least three times the nominal maximum size of aggregate in the concrete. Strain meters for sustained load specimens shall be capable of measuring strains for at least six months without change in calibration.

Note-Carlson Model M-10 Strain Meters (10-inch gage) length have performed satisfactorily (Carlson Instruments, 1190-C Dell Avenue, Campbell, CA 95008).

5. Test Specimens.

5.1 Number of Specimens. A minimum of three beams shall be made.

5.2 Fabrication. Concrete mixing, placing, consolidation, and finishing shall be in accordance with applicable provisions of CRD-C 10. Mass concrete with maximum size aggregate in excess of 3 inches (76 mm) shall be wet-sieved through a 3-inch (76-mm) sieve in accordance with CRD-C 4, or laboratory mixtures reproportioned for 3 inches (76 mm) when maximum size aggregate is in excess of 3 inches (76 mm).

5.3 Curing and Storage. After finishing, specimens shall be moist cured in their molds at 73.4±3.0°F (23.0±1.7°C) for a period appropriate for satisfactory handling based on mix and age at loading. Beams will then be stripped, rotated 90 degrees, and sealed in a membrane to prevent drying during storage and testing. Beams shall be stored in the laboratory at a uniform temperature preferably in a range of 68 to 77°F (20 to 25°C) uniformly supported in a no-load condition until the time of test.

5.4 Surface Mounted Strain Gages. Three 6-inch (152.4-mm) gage length strain gages are mounted on the tension face and two on the compression face (Note 1). Gages are mounted in series centered in the middle third of the beam span. Gages are bonded to the beam surfaces with a rapid setting adhesive (Note 2). Gage mounting and testing must be accomplished at least one-half hour before moisture from the concrete returns to the dried area and delaminates and/or grounds out the strain gage. A satisfactory procedure is as follows:

a. On the day prior to test, the beam is removed from curing storage and enclosed in a plastic wrap (Note 3).

b. Openings, approximately 1 x 20 inches (25 x 508 mm) on the tension face and 1 x 14 inches (25 x 356 mm) on the compression face, are cut in the plastic wrap at locations for the strain gages.

c. The exposed concrete areas are thoroughly washed with alcohol to remove form oil.

d. On the day of the test, the exposed areas of the beam are thoroughly dried by spraying with alcohol and/or ether and blowing with compressed air.

e. Gages are bonded by applying the adhesive to the back of the gages, positioning the gages on the beam faces, covering the gages with a piece of wax paper, and applying pressure by means of wooden blocks spanning the installed strain gages and held in place by cross arm braces. The gage bonding operation and beam test must be completed within one-half hour to preclude return of moisture to the dried area causing delamination and/or grounding out of the paper backed strain gages.

Note 1-SR-4 Type A-9 Strain Gages, available from BLH Electronics, Inc., Waltham, MA 02154, have performed satisfactorily.

Note 2-Eastman Chemical Co. manufactures a cyanoacrylate adhesive called Eastman 910, which will set satisfactorily in five minutes.

Note 3-Bituthene, supplied by W. R. Grace Co., Cambridge, MA 02140, has been satisfactorily used for sealing sustained load beams. Saran plastic wrap has been used for sealing rapid load beams.

6. Procedure.

6.1 Loading of the beams shall be accomplished in accordance with applicable provisions of CRD-C 16. For each loading age, one beam shall be loaded to failure in third-point flexure using a rapid loading rate of 40 psi/min (0.28

MPa/min.) A continuous record of load and strain may be obtained throughout the test using an X-Y plotter, magnetic tape, etc., or strains may be recorded manually after each 500 lbf (2000-newton) increment of total load. A second beam shall be started in its slow-loading cycle (Figure 2) at the same age and the third beam stored under no load. In the slow-loading cycle, 25-psi (0.17-MPa) fiber stress shall be applied to the beam weekly until failure occurs. Take strain readings immediately before and after application of load increments. Intermediate readings may be taken if necessary. Measure the load prior to making each reading. If the load varies more than 2 percent from the correct value, it must be adjusted. Take weekly strain readings on stored specimens and plot strain versus time. At the time of failure in the second beam, test the third beam to failure using the 40-psi/min (0.28 MPa/min) loading range. After failure, measure the test specimen in accordance with CRD-C 16.

7. Calculations.

7.1 The modulus of rupture shall be calculated in accordance with CRD-C 16. If embedded strain meters are used, outside fiber strains are extrapolated from the strain readings assuming a linear strain distribution. Sustained load strain meter readings shall be corrected for autogenous volume change using the strain versus time plots for the stored specimens. Plot tensile stress versus tensile strain from data obtained from the test and take the tensile strain at 90 percent of the ultimate load as the ultimate tensile strain capacity.

8. Report.

8.1 The report shall include the following:

8.1.1 Identification number of each specimen.

8.1.2 Cement content, water-cement ratio, maximum aggregate size, slump, and air content of each batch.

8.1.3 Type and source of cement, aggregate, and admixture for each mixture.

8.1.4 Storage conditions prior to and subsequent to loading.

8.1.5 Age at time of loading and, in the slow-loading case, age at time of failure.

8.1.6 Type of strain gages and strain meters.

8.1.7 Average depth to the nearest 0.05 inch (1.3 mm) for each specimen.

8.1.8 Average width to the nearest 0.05 inch (1.3 mm) for each specimen.

8.1.9 Magnitude of total applied load and modulus of rupture for each specimen.

8.1.10 Plot tensile stress versus tensile strain data for each specimen.

8.1.11 Ultimate strain capacity for each test of three beams.

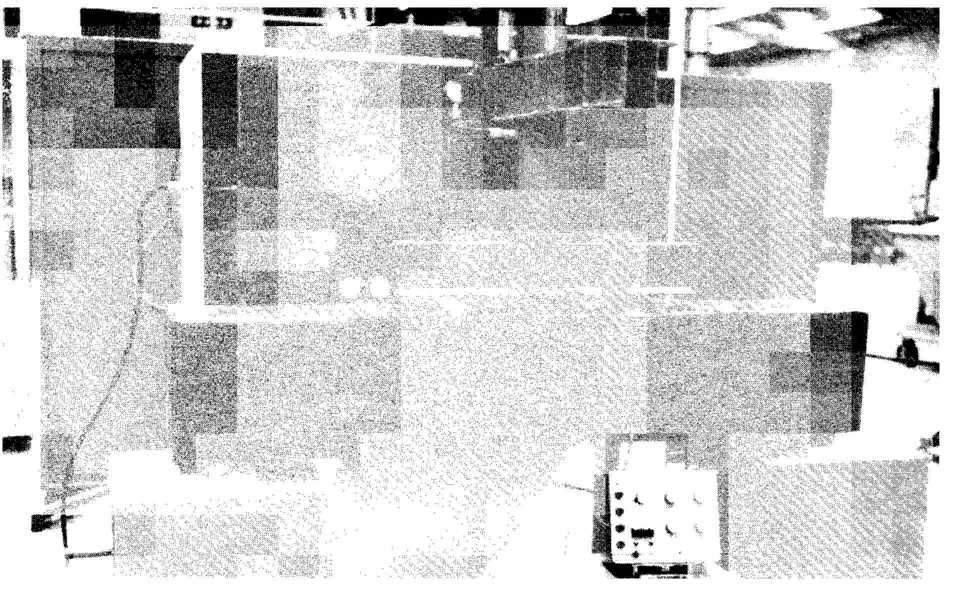

Fig. 2. Slow-loading test apparatus