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IS 9013 (1978): Method of making, curing and determining compressive strength of accelerated cured concrete test specimens [CED 2: Cement and Concrete]



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IS : 9013 -1978
(Reaffirmed 2008)

Indian Standard

METHOD OF MAKING, CURING AND DETER-
MINING COMPRESSIVE STRENGTH OF
ACCELERATED-CURED CONCRETE
TEST SPECIMENS

(Fourth Reprint DECEMBER 1998)
(Incorporating Amendment No.1)

UDC 666.97.035.5 ; 620.173

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Indian Standard

METHOD OF MAKING, CURING AND DETERMINING COMPRESSIVE STRENGTH OF ACCELERATED-CURED CONCRETE TEST SPECIMENS

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Indian Standard

METHOD OF MAKING, CURING AND DETERMINING COMPRESSIVE STRENGTH OF ACCELERATED-CURED CONCRETE TEST SPECIMENS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 30 November 1978, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 Traditionally, quality of concrete in construction works is calculated in terms of its 28 days compressive strength. This procedure requires 28 days of moist curing before testing, which is too long a period to be of any value for either concrete construction control or applying timely corrective measures. If after 28 days, the quality of concrete is found to be dubious, it would have considerably hardened by that time and also might have been buried by subsequent construction. Thus replacement of the concrete mass of questionable attributes becomes very difficult and often impractical. On the other hand, if the concrete is found to possess excessive strength than required, it would be too late to prevent wasteful use of cement on uneconomical mix proportioning. Hence, standard 28 days cube testing of concrete is not feasible for quality control.

0.3 What is essentially needed for assessing quality of controlled concrete is an acceptance test which can supply results, while the concrete is still accessible and sufficiently green to make its removal practicable, that is, within about 24 hours after casting. With the assistance of reliable test methods employing accelerated curing techniques, it is now possible to test the compressive strength of concrete within a short period and thereby to estimate whether it is likely to reach the specified strength at 28 days or not.

0.4 The need for having a reliable and fast method for evaluating controlled concrete in the field using accelerated curing technique was recognized by Cement and Concrete Sectional Committee and as a result, the Committee decided to evolve a standard method of determining

compressive strength of test specimens cured by accelerated curing methods.

0.5 This standard lays down the method of making, curing and testing in compression concrete specimens cured by two accelerated methods namely warm-water method and boiling-water method. The method laid down in this standard may be used for quality-control purposes, or for the prediction of normal strength of concrete at later ages, by the use of an appropriate correlation-curve obtained by testing normally-cured and accelerated cured concrete specimens of the mix proportion and materials to be used at the site. Such correlation-curves prepared on the basis of some case studies have been given in Appendix A. In this standard, the method of test has been so defined as to be readily applicable to the majority of test specimens made on construction sites and to give results of low variability.

0.6 High pressure steam curing is also used as an accelerated-curing method, but has not been covered due to its inherent limitations in application. However, this method may be useful for internal quality control purposes under special circumstances.

0.7 In the formulation of this standard, due weightage has been given to international coordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in the country. Assistance has also been rendered by the researches conducted by Cement Research Institute of India, New Delhi.

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard lays down the method for making, curing and testing in compression, specimens of concrete stored under conditions intended to accelerate the development of strength.

The following two methods of accelerated curing have been covered in this standard:

- a) Warm-water method, and
- b) Boiling-water method.

*Rules for rounding off numerical values (*revised*).

2. APPARATUS

2.1 Mould — The mould shall conform to IS : 516-1959*.

2.2 Mould Cover Plate — Each mould shall be provided with a flat steel cover plate, rigid enough so as to avoid distortion during use and of dimensions such that the plate completely covers the top edge of the mould.

2.3 Curing Tank

2.3.1 The curing tank shall be constructed from any material of suitable strength that will resist the effects of corrosion. The internal dimensions of the tank shall be adequate to accommodate the required number and size of the test specimens such that test specimens can be easily removed.

2.3.2 The tank shall contain sufficient water and be controlled so that the temperature of the water around the specimens immersed in the tank is maintained at the desired level at all times except for a period not exceeding 15 minutes immediately after the immersion of a freshly made specimen into the tank.

2.3.3 A typical diagrammatic layout of a tank suitable for accelerated curing of test specimens is given in Fig. 1.

3. PREPARATION OF TEST SPECIMENS

3.1 The preparation of test specimen including sampling of materials, preparation of materials, proportioning, weighing, mixing, testing for workability, choice of the size of test specimens, compacting, and capping of specimen shall be in accordance with IS: 516-1959*, if tests are intended to draw correlation curve between the results from compressive strength tests on specimens cured by normal curing method and accelerated curing method.

3.2 If the tests are intended for control purposes, sampling shall be done in accordance with IS : 1199-1959† and choice of the size of test specimens, compacting, and capping of specimen shall be in accordance with IS : 516-1959*.

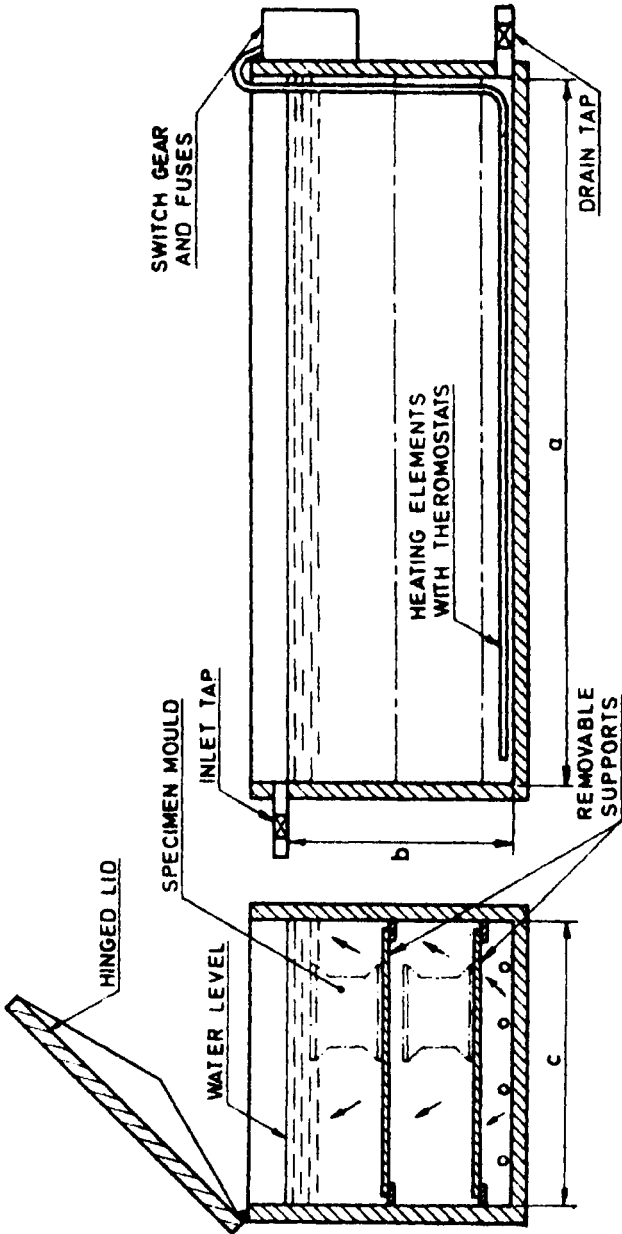
3.3 Immediately after moulding, each specimen shall be covered with a steel plate thinly coated with mould oil to prevent adhesion of concrete.

4. ACCELERATED CURING BY WARM WATER METHOD

4.1 After the specimens have been made, they shall be left to stand undisturbed in their moulds in a place free from vibration at a temperature

*Methods of tests for strength of concrete.

†Methods of sampling and analysis of concrete.



NOTE — The dimensions a , b and c of curing tank suitable for accommodating twelve, 150 mm cubes are 1.60 m, 0.50 m and 0.65 m respectively.

FIG. 1 DIAGRAMMATIC LAYOUT OF SUITABLE CURING TANK

of $27 \pm 2^\circ\text{C}$ for at least one hour, prior to immersion in the curing tank. The time between the addition of water to the ingredients and immersion of the test specimens in the curing tank shall be at least $1\frac{1}{2}$ hours but shall not exceed $3\frac{1}{2}$ hours.

4.2 The specimens in their moulds shall be gently lowered into the curing tank and shall remain totally immersed at $55 \pm 2^\circ\text{C}$ for a period of not less than 19 hours 50 minutes. The specimens shall then be removed from the water, marked for identification, removed from the moulds and immersed in the cooling tank at $27 \pm 2^\circ\text{C}$ before the completion of 20 hours 10 minutes from the start of immersion in the curing tank. They shall remain in the cooling tank for a period of not less than one hour.

NOTE— For control purposes, the above time tolerances may be relaxed and an appropriate correction factor applied.

5. ACCELERATED CURING BY BOILING WATER METHOD

5.1 After the specimens have been made, they shall be stored in a place free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of $27 \pm 2^\circ\text{C}$ for 23 hours \pm 15 minutes from the time of addition of water to the ingredients.

5.2 The specimens shall then be gently lowered into the curing tank and shall remain totally immersed for a period of $3\frac{1}{2}$ hours \pm 5 minutes. The temperature of the water in the curing tank shall be at boiling (100°C) at sea level. The temperature of water shall not drop more than 3°C after the specimens are placed and shall return to boiling within 15 minutes.

NOTE — In confined places the temperature of the water may be kept just below the boiling point to avoid excessive evaporation.

5.3 After curing for $3\frac{1}{2}$ hours \pm 5 minutes in the curing tank, the specimen shall be removed from the boiling water, removed from the moulds and cooled by immersing in cooling tank at $27 \pm 2^\circ\text{C}$ for 2 h.

6. TESTING

6.1 The specimens shall be tested in accordance with IS : 516-1959*.

6.2 In the warm water method specimens shall be tested while still wet, not more than 2 hours from the time of immersion in the cooling tank.

6.3 In the boiling water method, the age at the time of test shall be $28\frac{1}{2}$ hours \pm 20 minutes.

*Methods of tests for strength of concrete.

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7. CALCULATION

7.1 The calculation of compressive strength shall be done in accordance with IS : 516-1959*.

8. REPORT

8.1 The following information shall be included in the report on each test specimen :

- a) Identification mark (including the size and type) of test specimens and date of casting;
- b) Date and time of test and age of specimen;
- c) Particulars of concrete from which test specimen was made;
- d) Method of compaction;
- e) Size of specimen;
- f) Mass of specimen;
- g) Defects, if any, in specimen;
- h) Time of adding water to concrete materials;
- j) Time of making test specimen;
- k) Time of immersion of test specimen into curing tank;
- m) Time of removal of test specimen from curing tank;
- n) Time of immersion of test specimen into cooling tank;
- p) Time of removal of test specimen from cooling tank;
- q) Thermographic record of temperature of water in curing tank;
- r) Maximum load at crushing;
- s) Compressive strength; and
- t) Description of fractured face.

9. PRECAUTIONS

9.1 The following precautions shall be taken :

- a) The curing tank shall be cleaned and the water renewed periodically so as to prevent accumulation of detritus which may impair the heating or circulating system.
- b) The use of boiling water imposes the need for safety measures to prevent scalding or eye-burns, resulting from sudden escape of steam, upon opening the cover. Also care shall be exercised when immersing the specimens to avoid splashing of hot water.

*Methods of tests for strength of concrete.

- c) Strict attention shall be given to the protection and storage of the specimens during the initial period of curing.
- d) Suitable safety devices and indicators shall be provided with the set up. A separate panel or switch-board shall be provided incorporating the thermograph and related heating equipment controls.

10. INTERPRETATION OF RESULTS

10.1 Since strength requirements in existing specifications are not based upon accelerated curing, results from this method in checking the compliance of specified strengths at later ages shall be applied with great caution.

10.2 The results can be used in rapid assessment of variability for process control and signalling the need for indicated adjustments.

10.3 The magnitude of the strength values from strength tests is influenced by the specific combination of materials. Therefore the use of the results from either conventional tests at any arbitrary age or those from this method shall be supported by experience or correlations developed for the existing local conditions and materials (see Appendix A).

APPENDIX A

(*Clauses 0.5 and 10.3*)

CORRELATION OF RESULTS FROM COMPRESSIVE STRENGTH TESTS ON SPECIMENS CURED BY NORMAL AND ACCELERATED CURING METHODS

A-1. Accelerated curing of concrete hastens the process of hydration of cement and as a result, a substantial proportion of the strength to be attained in 28 days under normal curing conditions is achieved within a shorter time. The rate and extent of hydration of cement under a particular curing regime depend mainly upon the chemical composition of cement, water-cement ratio and mix proportions, which are considered to be important parameters in the correlation of results from compressive strength tests on specimens cured by accelerated curing method and normal curing method.

The accelerated curing regime, in itself, is another variable in that the higher temperature employed may alter the morphology of the hydration products apart from thermally activating the chemical reactions of hydration of cement.

A-2. The variability arising from the curing regime to be adopted, is eliminated by standardizing them, as is done in this standard. Figures 2 and 3 (see Note) show typical results on the correlation of compressive strength of concrete specimens normally cured and accelerated-cured by the Boiling Water Method and the Warm Water Method respectively. It is found that a correlation exists between the results obtained on concrete specimens, cured by accelerated method and cured by normal method, for mixes employing different materials and mix proportions. It is also found that the strength of concrete after accelerated curing (by either method) is of the order of 50 percent of that obtained on normally cured, 28 days old specimens. When results of concrete with specific ingredients and mix proportions are considered, the dispersion of results is considerably

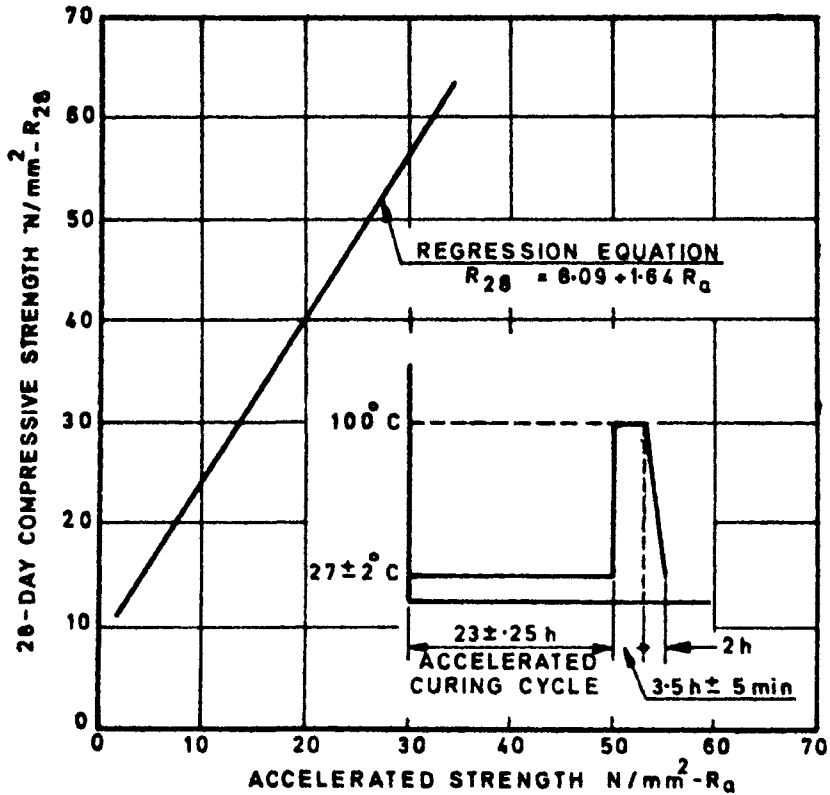


FIG. 2 TYPICAL RELATION BETWEEN ACCELERATED AND 28-DAY COMPRESSIVE STRENGTH OF CONCRETE (BOILING WATER METHOD)

reduced, and the coefficient of variation of results from accelerated curing methods may, in that case, be expected to be of the same order as obtained in normally cured, 28 days conventional tests. Although the tests have shown that the correlation between results from accelerated curing method and normally cured 28 days conventional tests is not materially affected by the chemical composition, fineness and strength of cements, the mix proportions or use of some indigenous admixtures, it is preferable to establish the actual correlation under site conditions for the specific materials and mix proportions to be adopted, for use in each case.

NOTE—The typical correlation curves given in Fig. 2 and 3 are based on a series of tests conducted at the Cement Research Institute of India, New Delhi.

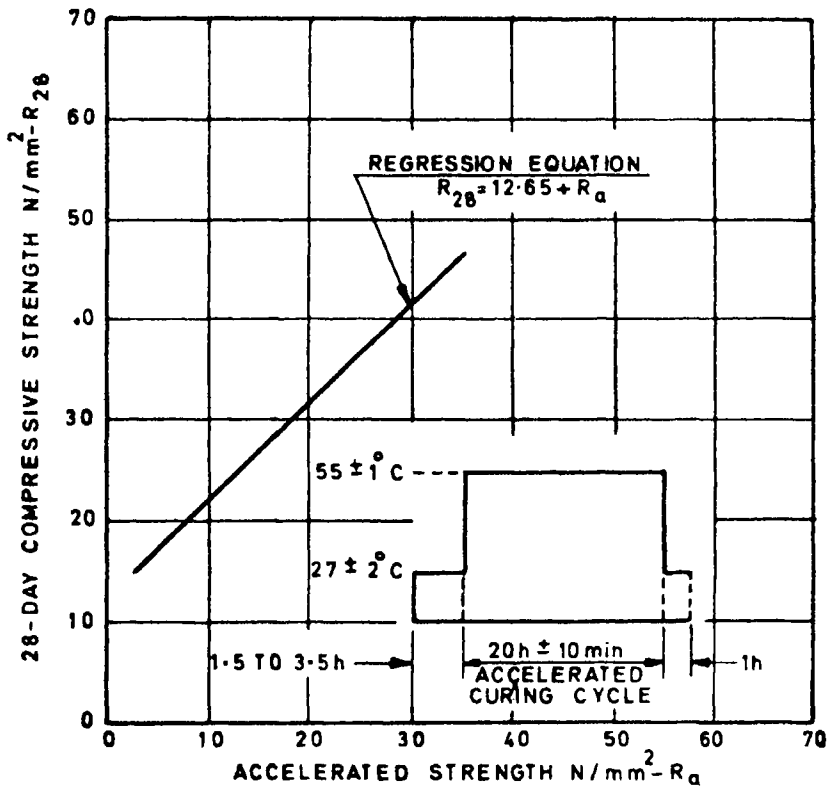


FIG. 3 TYPICAL RELATION BETWEEN ACCELERATED AND 28-DAY COMPRESSIVE STRENGTH OF CONCRETE (WARM WATER METHOD)

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