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RECOMMENDED PRACTICE FOR ACCELERATED STRENGTH TESTING AND EVALUATION OF CONCRETE FOR ROAD AND AIRFIELD CONSTRUCTIONS

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RECOMMENDED PRACTICE FOR ACCELERATED STRENGTH TESTING AND EVALUATION OF CONCRETE FOR ROAD AND AIRFIELD CONSTRUCTIONS

1. INTRODUCTION

1.1. The quality acceptance criteria of most cement concrete works including paving concrete works for roads and airfields are based on the strength of specimens tested at the age of 28 days after curing under standard moist conditions. An estimate of 28-day strength of concrete is sometimes done from the corresponding 7-day strength results for purposes of early quality control. In case of many constructions, the time lapse of even 7 days is too long for the strength results to serve any useful purpose from the point of either quality control or predicting the 28-day strength.

1.2. With a view to overcoming this problem, accelerated strength testing of concrete has been recommended in this document that would provide an early information, say in about a day, on the concrete strength likely to be developed at 28 days. Such an information may enable taking decision on removal of any defective concrete very early while it has still not hardened much, or before it is covered by subsequent layer. It will thus help achieve better control of concrete quality economically with greatly reduced chances of rejection.

1.3. For predicting the compressive and flexural strengths of concrete at 7 or 28 days, it will be desirable to obtain in advance in the laboratory along with the mix design of concrete, the correlations between the accelerated strength results and standard cured strength results at 7 or 28 days, using the material to be actually used in construction. For evaluation of 28-day compressive strength of concrete through accelerated testing, the Indian Standards Institution has already laid down detailed specifications in IS:9013-1978. The present Recommended Practice relates

particularly to the 7 and 28-day flexural strength evaluation of concrete through accelerated curing. Since flexural strength of concrete is of great importance to the paving engineers, this document will have particular significance in road and airfield constructions.

1.4. A draft for the Recommended Practice was approved by the Cement Concrete Road Surfacing Committee in their meeting held at Lucknow on the 28th January, 1980 (personnel given below). This was considered by the Specifications and Standards Committee in their meeting held on the 28th May, 1981, when a Working Group consisting of P.C. Bhasin (Convenor), Dr. R.K. Ghosh, one representative of I.S.I., one representative of Cement Research Institute of India and Member-Secretary, Specifications and Standards Committee was set up to review the draft in light of the discussion held during the meeting. The Working Group held its meeting at New Delhi on the 5th August, 1981 and modified the draft, and later it was approved by the Specifications and Standards Committee in their meeting held on the 11th October, 1982.

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This Recommended Practice was later approved by the Executive Committee and the Council in their meetings held on the 13th and 24th December, 1982 respectively.

2. SCOPE

2.1. This Recommended Practice covers procedure for accelerated curing, details of accelerated strength test under compression/flexure and evaluation therefrom of strength under standard curing for 7 or 28 days, and is recommended to be used when evaluation of 7 or 28-day flexural strength or both flexural and compressive strength is required from the accelerated strength tests.

2.2. For accelerated evaluation of 28-day compressive strength only, reference may be made to IS:9013-1978 "Method of Making, Curing and Determining Compressive Strength of Accelerated-cured Concrete Test Specimens", (para 5 -Accelerated curing by Boiling Water Method).

3. WORKING PRINCIPLE OF ACCELERATED CURING

The concrete specimens (cubes or beams) are cured in boiling water for 3.5 hours $\pm$ 5 min. after 23 $\pm$ $\frac{1}{4}$ hours of casting them. The specimens are tested after 2 hours of cooling in air under wet gunny bags. The total period elapsed between casting and testing is 28.5 hours.

4. APPARATUS FOR ACCELERATED CURING

4.1. Water Bath in the Laboratory

4.1.1. When it is desired to conduct accelerated strength test for both compression and flexure, the water bath which is to provide the accelerated curing conditions, shall consist of a galvanised steel tank of appropriate capacity and dimensions and shall have a detachable top cover. A tank should accommodate at a time 3 cubes and 3 beams encased in moulds. The plan of

placement of the moulds is shown in Fig. 1. The dimensions of the tank may be varied depending on the number, size and type of specimens to be accommodated in the tank.

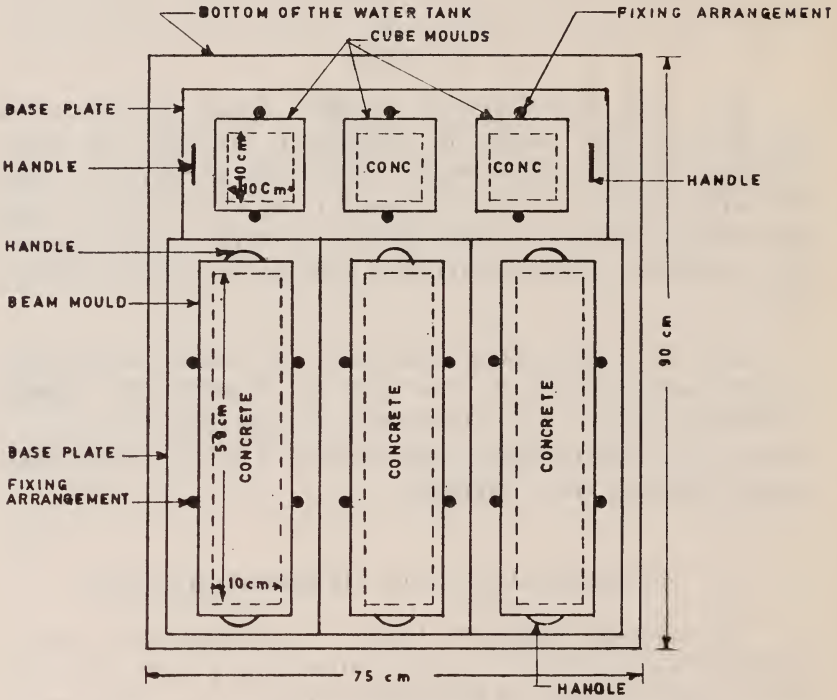

Fig. 1. Layout plan for 3 beams and 3 cubes inside the water tank

For 90 cm × 75 cm × 40 cm deep tank shown in Fig. 1, six immersion type heating elements (220V 1500W each) having a combined load of 9 kilo-watts are fitted horizontally at the side of the tank. These elements are distributed on the sides of the tank and located about 7 cm above the bottom of the tank. The tank is provided with a mild steel grid platform resting on 4 angle iron supports welded to the sides of the tank. The grid is placed about 10 cm above the bottom of the tank, Fig. 2. The cube and beam or only beam specimens together with their moulds are placed on the grid. The tank shall have an outlet at the bottom for emptying it, when required.

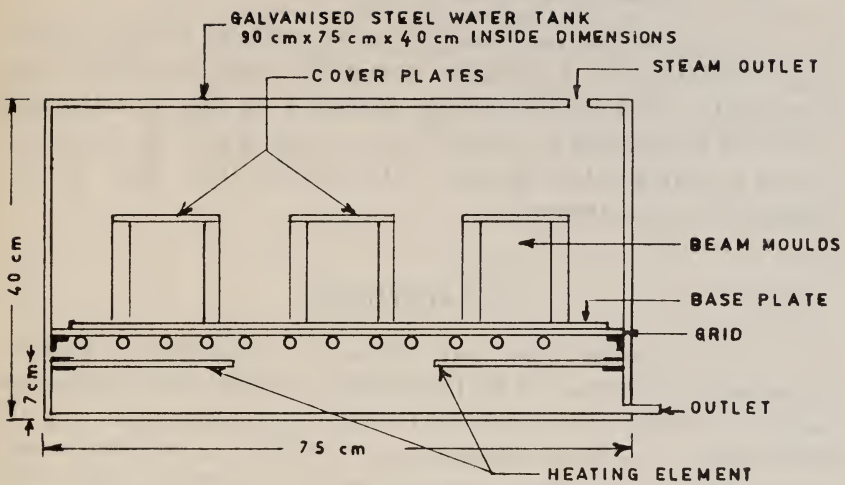

Fig. 2. Water tank showing position of heating elements, grid, base plate, mould, cover plate, etc.

4.1.2. The tank is to be filled with water to a depth of 25 cm for 90 cm × 75 cm × 40 cm deep tank so that when the specimens are placed in it, the water level rises to about 7 cm above the top of the moulds. This level of water is to be maintained during the heating period by adding small amount of water (as required) into the tank from time to time in order to maintain constant heat capacity of the curing medium. Depending on the ambient temperatures prevalent at the time of experimentation, about 60-75 minutes are required to raise the temperature of water in the tank to its boiling point near 100°C. The steam formed during heating is allowed to escape through an outlet provided in the tank cover, Fig. 2.

4 2. Water Bath in the Field

At construction sites in the field, where electrical power may not be available, water may be brought to boiling by means of heating through coal or firewood. The dimensions and other arrangements of the water bath should remain the same as described in para 4.1.

4.3. Mould for Concrete Specimens

The moulds for concrete specimens (cubes or beams) shall be as per IS:516-1959. In addition, 6 mm thick mild steel plate (with machined surface in contact with concrete) of size corresponding to that of the moulds is required to cover the specimens during the period of curing in boiling water. The moulds shall have suitable handles for easy removal.

5. PROCEDURE

5.1. Concrete cube and beam or only beam shall be prepared in accordance with IS:516-1959. The mould flanges are wiped clean after the concrete is trowelled level with the top of the mould. The specimens are cured for 23 $\pm$ $\frac{1}{4}$ hours under wet gunny bags at standard temperature (27 $\pm$ 2°C). After such curing, the specimens still in moulds shall be covered with cover plates (with machined surface in contact with concrete) and placed in boiling water in the tank. The temperature of water will drop slightly due to immersion of moulds but will regain the boiling temperature within 15 minutes.

5.2. The specimens shall be kept in the boiling water for 3.5 hours $\pm$ 5 min. After this period, these should be removed from the tank with hooks having wooden handles, demoulded and left to cool in air for two hours under wet gunny bags. Immediately after 2 hours of cooling of the specimens, these shall be tested for compressive/flexural strength as per IS:516-1959.

6. EVALUATION OF 7 OR 28-DAY STRENGTH

6.1. Ordinarily, the correlation between the accelerated strength results as per procedure described in para 5 and standard cured strength results at 7 or 28 days shall be obtained in the laboratory along with the mix design of concrete, using the materials to be actually used in the construction. These correlations should be supplied to the site engineer along with the mix design.

6.2. Where such correlations are not made available from the laboratory, general guidance may be had from the correlations given in Figs. 3 and 4. While Fig. 3 gives the statistical correlations between accelerated and 7-day standard-cured compressive strength, Fig. 4 shows the same between accelerated and 7 or 28-day standard-cured flexural strength. In as much as the correlations between accelerated and 28-day standard-cured compressive strength are concerned, Fig. 2 of IS:9013-1978 may be followed. The correlations shown in Fig. 3 and 4 relate to concrete mixes using ordinary portland cements having widely different physical and chemical properties i.e., 3-day compressive strength varying between 160 and 235 kg/cm^2 and 7-day compressive strength varying between 225 and 330 kg/cm^2, specific surface varying between 3150 and 3720 cm^2 per gm (*Blaine's*), C_3S content varying between 28.4 per cent and 45.5 per cent and C_2S content varying between 41.5 per cent and 31.5 per cent, and different aggregates comprising Delhi quarzite, dense variety blast furnace slag from Bhilai and natural river gravel from Hardwar.

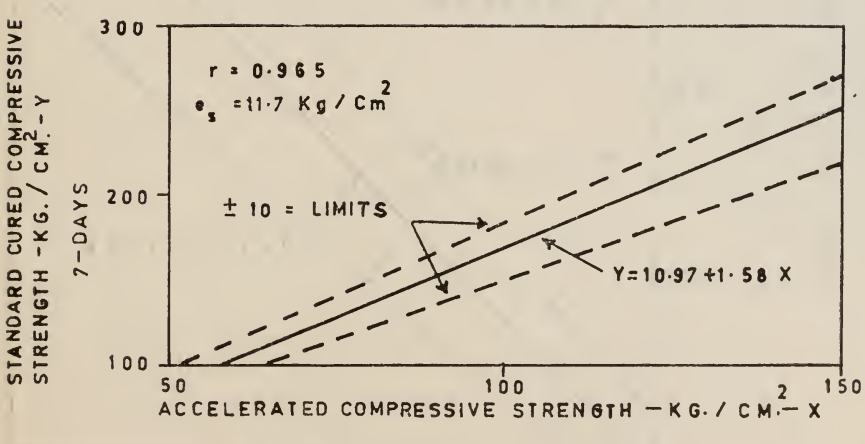

Fig. 3. Statistical relationship between accelerated and standard cured compressive strength

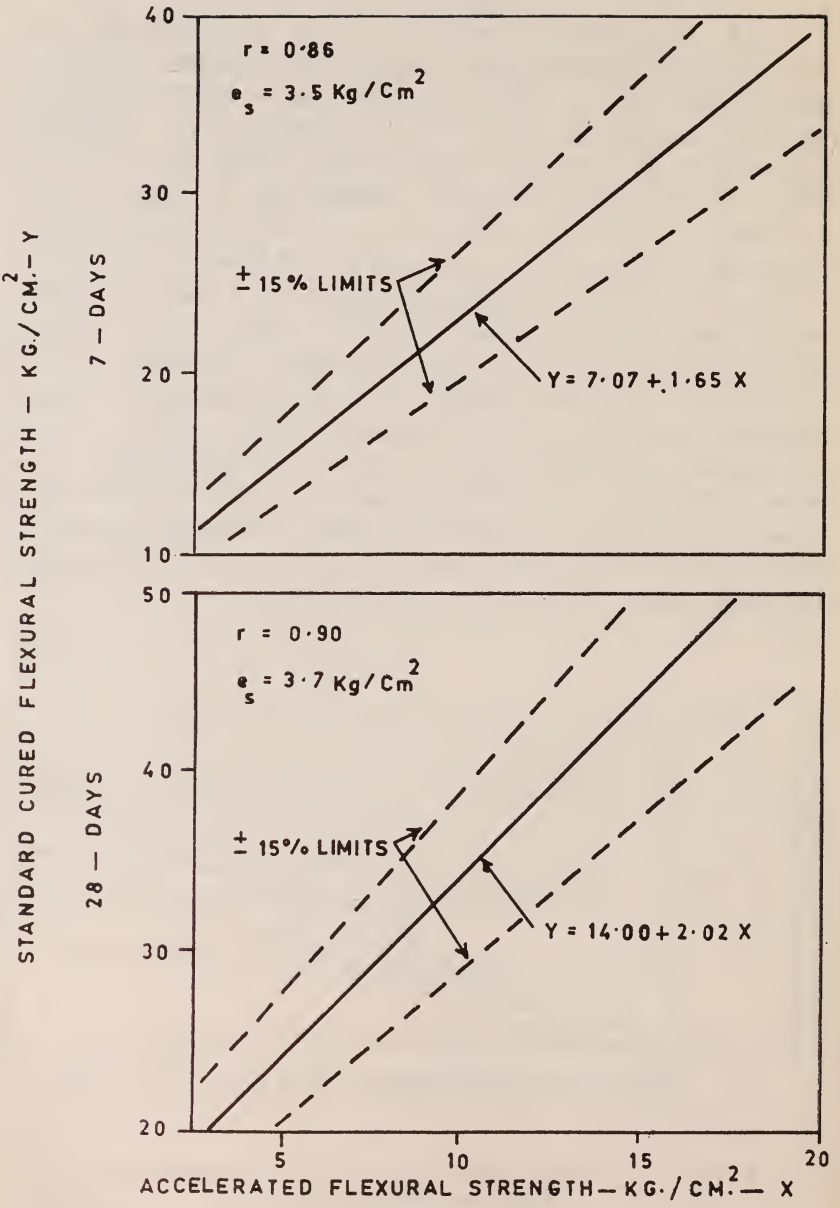

Fig. 4. Statistical relationships between accelerated and standard cured flexural strength

r = coefficient of correlation

e_s = standard error of estimate

29. P.K. Nagarkar	Chief Engineer & Director, Maharashtra Engineering Research Institute
30. Lt. Gen. T.B. Nanda	Master General of the Ordnance, Army Headquarters
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52. M.C. Vakil	Superintending Engineer, H.P. PWD
53. The Director (B.D. Jayaraman)	Highways Research Station, Madras
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