RECOMMENDED DESIGN CRITERIA FOR THE USE OF CEMENT-MODIFIED SOIL IN ROAD CONSTRUCTION

(First Reprint)

THE INDIAN ROADS CONGRESS

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Published by
THE INDIAN ROADS CONGRESS,
Jamnagar House, Shahjahan Road,
New Delhi-110011
1978

IRC : 50—1973

First published in June, 1973

Reprinted April, 1978

Printed at Sagar Printers & Publishers ,New Delhi-3 Phone : 618484

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1. INTRODUCTION

1.1. Addition of cement to soils has been tried successfully to improve their resistance to softening action of water, and other behavioural properties. As such, stabilisation with cement has been used extensively in road construction. The technique commends itself for adoption especially in areas where the cost of conventional road aggregates may be high.

1.2. Recommendations in this Standard cover the use of 'cement-modified soil' for sub-bases, as distinct from 'soil-cement' which is a stronger material, reserved usually for base courses.

1.3. This standard was initially prepared by the Soil Engineering Committee (personnel given below). It was processed and approved by the Specifications and Standards Committee in their meeting held on the 29th and 30th September 1972. Later this was finally approved by the Executive Committee in their meeting held on the 11th March 1973 and by the Council in their 81st meeting held at Cochin on the 26th April 1973.

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2. SCOPE

2.1. The extent to which soil properties get modified by cement action depends greatly on the concentration of cement. With cement in the range of 7 to 10 per cent, depending on other factors the mixture may develop considerable compressive strength. The strength could be around 17.5 kg/cm^2 or more when tested on cylindrical specimens after curing for 7 days. A material of this nature is known as "soil-cement" and has found wide usage in many countries for base course construction. Soil-cement is usually designed on the basis of unconfined compressive strength, or wet and dry durability test, limits for which have been laid down in specifications from these countries.

2.2. On the other hand, considerable advantage could be gained by the limited improvement of soil as a result of addition of smaller quantities of cement, without necessarily improving the soil to the level of soil cement. A soil processed with these objectives is known as cement-modified soil. Considerable amount of work, in the laboratory as well as in the field, has been carried out in India on the utilisation of this material. It has been shown that even with small concentrations of cement, of the order of 2 to 3 per cent, a soil could develop adequate strength to satisfy the requirements of a road sub-base. As an illustration, the strength developed by a typical soil with different concentrations of cement is indicated in the *Annexure*.

2.3. Recommendations in the Standard are restricted to the use of cement-modified soil. It is presupposed that the work will be carried out fully according to construction specifications with requisite site supervision over the quality of materials and process of construction.

3. DESIGN CONSIDERATIONS

3.1. Soil Type

3.1.1. Generally, granular soils free of high concentrations of organic matter or deleterious salts are suitable for cement-stabilisation. For checking the suitability of soil, it would be advantageous to keep the following criteria in view :

(i) Plasticity modulus, expressed as the product of PI of soil and per cent fraction passing 425 micron sieve, should not exceed 250 and

(ii) Uniformity coefficient of soil should be greater than 5 and preferably greater than 10.

3.1.2. Soils not suitable for cement-stabilisation are :

(i) Heavy clays including black cotton soil having a PI greater than 30

(ii) Soils having organic content higher than 2 per cent

(iii) Highly micaceous soils, and

(iv) Soils with soluble sulphate or carbonate concentration greater than 0.2 per cent.

3.3. Concentration of Cement

3.3.1. The amount of cement will depend on the type of soil, design requirements, and overall economic considerations. Because of difficulties of uniform mixing, however, cement content of even 2 per cent may be necessary in the case of hand mixing.

3.3.2. In every case, cement concentration must be expressed as per cent by weight of the dry soil.

3.4. Degree of Pulverisation

3.4.1. For effective stabilisation, it is necessary that the soil must be in a well pulverised state before cement is added. The degree of pulverisation should be such that at least 80 per cent of soil passes through 4.75 micron sieve and there are no lumps larger than 25 mm.

3.5. Strength Criteria

3.5.1. Cement-modified soil mixes should be designed on the basis of their soaked CBR value.

3.5.2. For design purposes, field CBR should be regarded only as 45 to 60 per cent of that obtained in the laboratory, depending on the efficiency of mixing, placing, curing and other related factors.

3.6. Mix Design

3.6.1. The proporations for cement-modified soil mix should be determined in the laboratory. The following procedure may be adopted for this :

(i) The soil should be tested for PI, sand fraction, sulphate/carbonate concentration, and organic content, in order to assess its suitability for stabilisation (vide para 3.1.);

(ii) Moisture-density relationship for the soil should be established as per IS : 2720 (Part VII)—1974;

(iii) After pulverising the soil to the degree indicated in para. 3.4, CBR specimens with varying percentages of cement should be prepared at maximum dry density and optimum moisture content corresponding to IS : 2720 (Part VII)—1974. The specimens should be initially cured for 3 days followed by soaking in water for 4 days prior to their testing as per IS : 2720 (Part XVI)—1965. At least 3 specimens should be tested for each cement concentration; and

(iv) On the basis of strength results, the design mix should be chosen keeping in view the criteria set out in paras 3.3. and 3.5.

Annexure

LABORATORY TEST RESULTS FOR A TYPICAL SOIL STABILISED WITH DIFFERENT PERCENTAGES OF CEMENT

Cement content (per cent by wt. of dry soil)		*CBR value of specimens compacted at proctor density*
0	...	8**
1	...	20*
2	...	43*
2.5	...	60*
3	...	65*
4	...	85*

** Soaked in water for 4 days prior to testing.

* Cured for 6 days and thereafter soaked in water for 4 days before testing

NB: These results are for a soil with PI ranging between 5 and 10 and fraction coarser than 75 micron sieve of not less than 50 per cent.