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To

The Chief Engineers dealing with Roads of
All the States/Union Territories

Subject : Interim Technial Memorandum on the Specifications for construction of roads and embankments in expansive soil areas

The Ministry has launched a research scheme designated R-9 for development of specifications for construction of roads in expansive clay areas. The results of the study are expected to be available after a period of 3 years. Meanwhile, these interim guidelines are circulated for the guidance of engineers engaged in the construction of roads in expansive soil areas.

INTERIM TECHNICAL MEMORANDUM ON THE SPECIFICATIONS FOR CONSTRUCTION OF ROADS IN EXPANSIVE SOIL AREAS

1. *Introduction*

1.1. Expansive soils commonly known as black cotton soils are spread over an area of about 300,000 sq. km. in India. They are predominantly found in the States of Andhra Pradesh, Karnataka, Gujarat, Madhya Pradesh, Maharashtra and Tamil Nadu. These soils are formed from the reathering of igneous and metamorphic rocks. They contain montmorillonite and other secondary minerals which give rise to the expansive and shrinkage properties, which are peculiar to the B.C. Soils.

1.2. Experience on highway construction in these areas has often been unsatisfactory both economy and performance-wise. This may be due to the lack of understanding with regard to the identification, properties, awareness of the problems associated with the expansive soil and the measures to tackle the same. The object of this memorandum is to bring out all relevant points with regard to the construction of roads and embankments in expansive soil areas leading to recommendations which would serve as tentative gudielines to the practising engineers.

2. *Identifications*

2.1. The identification of expansive soil depends on the fundamental properties like Atterberg's limits, percentage clay fraction (Activity), free swell; max. dry density O.M.C. relationship, etc. The table below gives physical properties of expansive soils.

Liquid Limit	53.0 - 90.0 (%)
Plastic Limit	26.0 - 50.0 (%)
P.I.	18.0 - 53.0
Shrinkage Limit	7.0 - 13.0 (%)
Sp. gravity	2.7 - 2.9
Clay content	32.0 - 70.0 (%)
Silt content	17.0 - 43.0 (%)
Sand content	1.0 - 26.0 (%)
Gravel content	0.0 - 8.0 (%)
Dry density (standard Proctor)	1.30 - 1.35 gm/cm^3
O.M.C.	25.0 - 35.0 (%)
Swell pressure at a dry density of 1.3 gm/cc under no volume change condition	0.5 -10 kg/cm^2

2.2. In order to know whether a soil is of expansive type, the following procedure may be adopted. About 100 gms dry soil is placed in a 200 c.c. graduated jar and its volume is noted. Then 100 c.c. of distilled water is added to it and they are vigorously mixed by closing the open end with the palm and shaking the mixture up and down. Then it is allowed to rest for about 24-48 hours and the volume occupied by the soil is noted. If there is 50% or more increase over the initial volume, the soil may be considered as expansive. For all practical purposes, this precedure should lead to reasonable identification of swelling clays.

3. *Basic Data*

3.1. If the soil in the area where the road is to be constructed is identified as expansive soil, the following basic data should be collected.

(i) Depth of water table and its fluctuation over the year;

(ii) Engineering properties of the soil (Atterberg) Limits, laboratory soaked, CBR, optimum moisture content and Proctor density),

(iii) If stabilization with lime is proposed, the optimum lime requirement for stabilisation should be determined (IRC : 51-1973).

Where high embankments are involved, special investigations should be carried out as per guidelines for the Design of high Embankments (IRC : 75-1979).

4. *Awareness of Problems Associated with Construction*

4.1. It is essential that the field engineer should be aware of problems that are likely to arise before, during and after construction so that suitable precautions can be taken at the appropriate time to ensure longer life, economy and satisfactory performance. Some of these are :—

(i) Difficulties in pulverization of soil

(ii) Failure of pavement due to swelling of subgrade soil

(iii) Sloughing of side slopes

(iv) Problems of surface and subsurface drainage

(iv) Difficulties in maintenance of berms

4.2. The various steps to be taken to overcome the problem are set out in the succeeding paragraphs.

5. *Ground Preparation*

The route along which the alignment is proposed should be cleared off vegetation. It is then levelled and rolled to form a firm ground.

6. *Pulverization*

In as much as the expansive soil lumps from the borrow-pits would be upto 30 to 40 cm in size, it is difficult to achieve the desired compaction. Under the roller, the lumps may not break completely and remain separate with open voids in between. Further, the moisture content within the clods can be very much on the wetter or the drier side of O.M.C. It is, therefore, essential that the soil lumps should be pulverized to less than 5 cm size for effective compaction, so that the clods are kneaded and coalesced into a homogenous whole. The pulverization can be achieved using a disc harrow or rotavator or manually. Where lime stablished sub bases are contempleted, 50% of design lime content may be added to contemplated, 50% of design lime content may be added to partially broken clods to aid pulverization (IRC : 49-1973).

7. *Compaction*

7.1. In the laboratory, O.M.C. is determined using Standard Proctor test. The normal practice in the field is to compact the clays at about 3% wet of laboratory O.M.C. But in the case of expansive soils, it is observed that plates of soil stick to the roller and heaving up is noticed on either side of the roller as it is moved. The dry density obtained will also be low. Evidently, the O.M.C. so obtained from the laboratory tests is very much on the wetter side. It is, therefore, suggested that a more realistic approach should be followed by actually conducting a field test to obtain field O.M.C. This is got from a field compaction curve by noting field densities at different moisture contents under the same number of passes of the roller. The field O.M.C. is found to be generally less than laboratory O.M.C. and more or less the same as that obtained from the modified AASHO test in the laboratory.

7.2. The equipment used for compaction in the field is a smooth-wheeled roller or a sheeps footroller. For clayay soils, sheepsfoot roller is best suited for compaction especially in view of the big lumps brought from borrowpits. Therefore these rollers are preferable to smooth wheel rollers. But in our country, use of smooth wheeled roller is common thereby necessitating pulverisation of lumps preceding the compaction.

7.3. Compaction is generally done in layers of 25 cm loose soil compacted to 15 cm so as to attain minimum of 95% standard proctor density. Sometimes, when compaction is done in the field at about 2% wet of laboratory optimum, the required density is not achieved and is apt to create problems. In such cases, the field O.M.C. described earlier should be resorted to.

8. *Drainage*

8.1. Normal camber of 1 in 40 for the black top surface and a cross slope of 1 in 20 for the berm should be provided to shed off surface run-off

8.2. No standing water should be allowed on either side of the embankment.

8.3. A minimum free board of 1 m should be ensured (The free board is defined as the distance between the bottom of the pavement crust and the highest water-table in the vicinity).

9. *Pavement Design*

9.1. A soaked CBR value found on the basis of laboratory tests should be taken as the design criterion for expansive soils.

9.2. Traffic survey should be conducted and a suitable curve on the CBR chart chosen keeping in view the future traffic demands (IRC : 37-1970)

9.3. *Blanket course*

9.3.1. A blanket course of 23 cm in thickness is necessary for the pavement crust and it should extend beyond the carriageway for the full width of the formation. The blanket course should be placed above the subgrade and below the pavement

9.3.2. The blanket course could be either sand/quarry spoils moorum (natural as mechanically stabilised or lime stabilised soil, based on local conditions and economy.

9.3.3. In places where drainage and free board conditions are likely to fall short of requirements, sand or moorum blanket courses should be preferred to lime stabilized soil blanket courses. Wherever moorum is plastic in nature, it should be treated with lime to bring down its P.I. to less than 5. The quantity of lime added will be determined on the basis of laboratory tests. About 2-3% lime of 25% purity is normally sufficient. Sand in suitable proportion can also be added to bring down the P.I. of moorum wherever economical. In the case of sand blanket courses, sand should be compacted with a plate vibrator. Alternatively, the sand layer can be rolled with a smooth wheel roller after wetting it sufficiently.

9.3.4. For the lime stabilised soil blanket courses, the following procedure should be strictly followed :—

(i) The percentage of lime to be added to the soil to obtain a particular CBR should be determined in the laboratory on the basis of percentage purity of lime

(ii) In the field, about 1% excess lime should be added to take care of wind transportation losses, wastage and improper mixing.

(iii) Mixing should be done with a rotavator, discharrow. Manual means may be adopted only where no mixing equipments are available.

(iv) Scarifying should be done whenever a new layer is laid for proper bond.

(v) Rolling should be completed within 3 hours of mixing

(vi) 7 days curing should be followed.

(vii) A field CBR test in a pit soaked for 4 days should be done to check the strength achieved in the field.

9.4. *Sub Base/Base*

9.4.1. Wherever stone is used over the blanket course as the sub-base, oversize metal should be used and its voids filled and rolled.

9.4.2. W.B.M. layer should be laid as per IRC Standards.

10. *Berms*

10.1. Berms should be preferably of lime-stabilised soil not only to provide an impermeable barrier but also to provide some rigidity to take care of occasional wheel loads.

10.2. At places where lime stabilised berms cannot be had, berms can be of compacted brick metal, soil aggregate or graded gravel.

10.3. Berms made up of permeable granular materials, like sand, moorum, quarry rubbish, etc. are not preferable. Where lime stabilished sub bases exist, rain water is found to percolate from these permeable berms into the pavement crust and stagnate because of the impermeable lime-stabilised soil barrier. Thus pavement flooding occurs leading to faster deterioration.

10.4. Berms should be atleast 1.5 m wide and 15 cm. in thickness.

11. *Embankment Slopes*

11.1. A slope of 2 horizontal to 1 vertical is found to be satisfactory for embankment made up of black cotton soil

11.2. Embankment slopes should be turfed. Where turfing is not possible, the side slopes can be provided with a non-expansive soil cover of 50 cm thick.

11.3. Gully formation on the side slopes is not uncommon following the monsoon but they should be brought back to original shape-through periodical maintenance.