IRC : 34-1970

RECOMMENDATIONS FOR ROAD CONSTRUCTION IN WATERLOGGED AREAS

THE INDIAN ROADS CONGRESS

1996

RECOMMENDATIONS FOR ROAD CONSTRUCTION IN WATERLOGGED AREAS

Published by

THE INDIAN ROADS CONGERSS
Jamnagar House, Shahjahan Road,
New Delhi-110011
1996

Price Rs. 24.00
(Plus Packing & Postage)

First Published : January, 1970
Reprinted : May, 1974
Reprinted : May, 1980
Reprinted : August, 1996

Printed at Sagar Printers and Publishers, New Delhi-110003
(1000 copies)

RECOMMENDATIONS FOR ROAD CONSTRUCTION IN WATERLOGGED AREAS

1. INTRODUCTION

A Panel Discussion* on the subject of construction of roads in waterlogged areas was held during the Hyderabad session of the Indian Roads Congress in January 1959. As a result of this discussion, the Soil Research Commitee (personnel given below) took upon itself the task of framing recommendations for road construction in these areas:

B.D Mathur	*Convenor*
Dr. H.L. Uppal	*Member-Secretary*

MEMBERS

N. Amanullah	J.S. Marya
K. Basanna	Prof. S.R. Mehra
Lt. Col. Harish Chandra	H.V. Mirchandani
S.N. Gupta	A. Muthukumaraswamy
Dr. R.K. Katti	A. R. Satyanarayana Rao
Kewal Krishan	S.N. Sinha
Mahabir Prasad	J.M. Trehan
H.C. Malhotra	Dr. I.S. Uppal
M.R. Malya	

Director General (Road Development) &
Addl. Secy. to the Government of India.
(*Ex-Officio*)

The recomendations drafted by the Committee were subsequently reviewed by the Specifications and Standards Committee (personnel given on inside front cover) and after approval of the Council at their 72nd meeting held on the 4th October, 1969 are now suggested for general adoption in the country.

2. SCOPE

The recommendations deal with the problem of road construction in waterlogged areas, including those subject in addition to flooding and/or infested with detrimental salts like the sulphates and carbonates. The recommendations relate both to the construction of new roads and to the remedial measures to be adopted in the case of existing constructions.

*The background note for the Panel Discussion is published in the Journal of the Indian Roads Congress, Volume XXIII-part 2 and discussion in the Volume XXIII-part 4.

For the purpose of these recommendations, waterlogged areas are considered to be those where the level of subsoil or standing water is such that for prolonged periods the subgrade immediately below the pavement is well within the capillary fringe of the water-table, i.e., within about 1.5 metres.

3. THE PROBLEM

3.1. Due to Waterlogging

As a result of migration of water by capillarity from the high water-table, the soil immediately below the pavement gets more and more wet and this leads to a gradual loss in its bearing value.

3.2. Due to Flooding

Where flooding for continuously long periods also takes place side by side with waterlogging, the progressive deformation of the subgrade, as well as of the pavement, is accentuated by ingress of water from the top of the wearing surface comprising usually of a thin bituminous treatment. The already inadequate waterproofness of the surface is impaired further by stripping of the binder due to prolonged contact with water. Infiltration of flood waters through the shoulders is another factor aggravating the situation.

3.3. Due to Presence of Detrimental Salts

The problem is made still more complicated if in addition to waterlogging, and/or flooding, injurious salts like sulphates of sodium, calcium or magnesium and sodium carbonate are present either in the subgrade soil or in the ground water. Damage to crust from injurious salts can be in two ways—due to physical effect or chemical.

3.3.1. **Physical effect of the injurious salts:** In waterlogged areas infested with detrimental salts, the salts keep on moving up with capillary moisture. During subsequent evaporation of the salt-laden water the salts are left behind and they get concentrated in the surface layers. The salts increase many times in volume upon hydration under suitable humidity and temperature conditions*. Alternate hydration and dehydration results in repeated formation of salt crystals occupying much more volume than the amorphous salts lodged in the voids. In due course these repeated volume changes break up the structure of the pavement, working from the top downwards.

*As a result of research carried out in India, it has been demonstrated that crystallisation of sodium sulphate takes place when temperature is below 32°C and relative humidity above 80 per cent. In northen parts of the country these conditions exist generally during the period of winter rains.

3.3.2. **Chemical effect of the injurious salts:** The damage due to chemical action is mainly on account af sulphates of calcium, magnesium and sodium. Constructions specially vulnerable to this type of attack are those containing cement like the cement concrete pavements and soil-cement base/sub-base course.

Cement concrete

The sulphates present in the subsoil which migrate to the top by capillarity react with the free lime liberated from cement resulting in the formation of gypsum. This reaction is accompanied by a considerable increase in the volume of the solids which is known to lead to the destruction of the hydrated cement matrix. After gypsum has been formed, or if calcium sulphate itself is found in the soil or ground water, tricalcium aluminate in the hydrated cement combines with gypsum to form needle-shaped crystals of double salts like calcium sulpho-aluminate which give rise to further expansion of volume and damage. Apart from the formation of gypsum and calcium sulpho-aluminate, the decomposition of hydrated calcium silicate by sulphate solution is an additional factor affecting the durability of concrete. However, this would occur normally only in the case of magnesium sulphate solution which is found generally in waterlogged areas near the sea.

Dissolved carbon dioxide and bicarbonate salts present in certain marshy and rice growing areas also take part in the leaching of lime liberated from cement and slowly attacking the cementitious calcium silicate hydrates formed. Such solutions are characterised by pH value in the acidic range, usually below 5.

Concrete is not directly attacked by solid sulphate salts, but only by their solutions in water, so that it is the amount of salts dissolved in the ground water that determines the rate of attack. As a result of chemical action of sulphates, the cement concrete pavements suffer internal disintegration and gradual spalling from the underside. The process described is, however, slow.

Soil cement

Presence of sulphates in waterlogged areas has a detrimental effect on soil cement mixtures akin to that in the case of cement concrete pavements.

Bituminous constructions

It does not appear that these salts, in the concentration they normally occur in soil, ground water or sea-water, have any detrimental chemical effect on bituminous constructions.

Water-bound macadam

Salts do not directly affect unsurfaced water-bound macadam constructions provided the filler material used in them is inert and free of injurious constituents.

4. RECOMMENDATIONS ON METHODS OF ROAD CONSTRUCTION IN WATERLOGGED AREAS

4.1. The recommendations are divided into the following three groups:

(a) Road construction in areas where the problem is one of waterlogging alone and is not tied up with flooding or salt infestation.

(b) Road construction in areas where in addition to waterlogging flooding for prolonged periods is also expected.

(c) Road construction in areas where in addition to waterlogging injurious salts are present in the suboil or ground water.

4.2. Different treatments are suggested under each group. Some of these can be made use of only on new constructions, and others on old, while some hold good for both. Broad guidance about these is provided at the beginning of each section.

5. RECOMMENDATIONS FOR ROAD CONSTRUCTION IN AREAS WHERE THE PROBLEM IS ONE OF WATERLOGGING ALONE AND IS NOT TIED UP WITH FLOODING OR SALT INFESTATION

The remedial measures recommended under paras 5.1, 5.2 and 5.4 could be utilised both on new constructions and existing roads. However, the capillary cutoff technique described under para 5.3 will be found economical only on new roads.

5.1. Depressing the Level of Subsoil Water by Drainage Measures

Satisfactory results could be achieved by providing 5 to 6 ft deep drainage channels as close to the road bank as possible and connecting these by suitable outfalls to either channels of irrigation system or natural drainage. Alternatively, buried drains of suitable design such as French drains could be provided at the edges of the pavement for the lowering of water-table. Either of these measures will help

in keeping the top of the subgrade above the capillary fringe.

The method of drainage is applicable to all types of road construction (whether rigid or flexible), and should be preferred wherever economically feasible.

5.2. Raising of the Embankment

Where it is too expensive to provide deep drainage channels as specified in para 5.1, it is recommended that subject to a careful examination of the economics of the case, an embankment, of such height may be provided that the bottom of the pavement remains at least 1.5 metres above the highest water-table.

5.3. Capillary Cutoff

As an alternative to the recommendations contained in paras 5.1 and 5.2, a capillary cutoff could be provided to arrest the capillary rise of water. Provision of capillary cutoffs could, however, prove to be expensive and may be justified only in special circumstances.

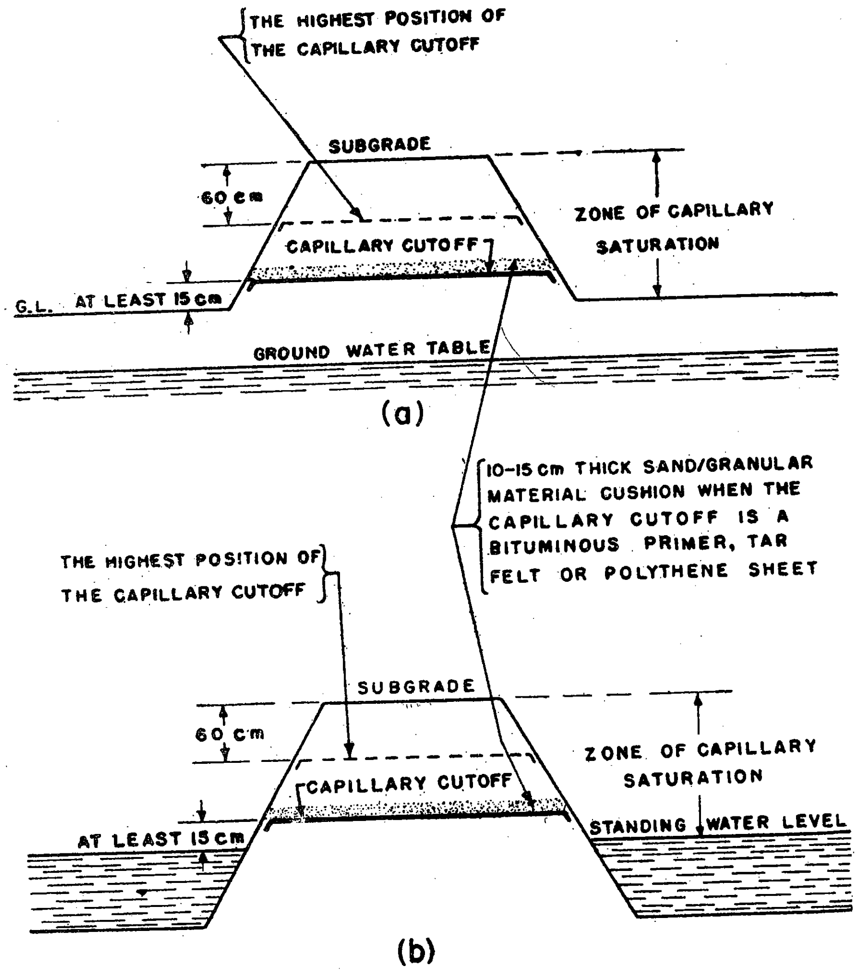
The cutoff should be placed at least 15 cm above the ground level or the standing water level, whichever be higher, as illustrated in figure on page 6. But in no case should it be positioned higher than 60 cm below the top of the subgrade. When provided, the cutoff medium should extend under the berms as well.

Suitable types of capillary cutoffs are listed under Section 8. When the cutoff medium selected is of the type bituminous primer, tar felt or polythene envelope, it will be advisable to cover it with a 10 to 15 cm thick layer of granular material like sand for the dual purpose of acting as a drainage course for water infiltrating from the top and of protecting the envelope during construction against rupture by sharp particles in the fill material.

5.4. Providing Sufficient Thickness of the Pavement to be Adequate for Saturated Subgrade Conditions

In case neither drains nor sufficiently high embankment nor capillary cutoff can be provided on an existing road, the thickness of the pavement should be determined on the basis of strength of the subgrade soil at saturation and strengthening carried out accordingly.

This measure can be adopted in the case of new constructions as well. In that event, at least 10 cm thickness of sub-base should be made up of such material as stabilised soil, which will be stable when wet, so that it is not possible for the soft subgrade soil in saturated condition to work up into the voids.



SKETCHES ILLUSTRATING DESIRED POSITION OF THE CAPILLARY CUTOFF FOR PREVENTING THE RISE OF CAPILLARY MOISTURE

6. RECOMMENDATIONS FOR ROAD CONSTRUCTION IN AREAS WHERE IN ADDITION TO WATERLOGGING FLOODING FOR PROLONGED PERIODS IS ALSO EXPECTED

In the case of roads subject to flooding in addition to waterlogging, the following measures may have to be taken over and above those recommended in Section 5 against waterlogging. The three treatments suggested could be applied equally on new constructions as well as old.

6.1. Raising of the Embankment

In areas subject to frequent floods where the highest flood level is not too much above the natural ground level, it is recommended that the embankment should be raised so that the top of the subgrade is at least 30 cm above the highest recorded flood level.

6.2. Provision of Cement/Asphaltic Concrete Surfacing

Where for any reason whatsoever it is considered inevitable to let flood waters pass over the road, and also traffic is heavy and flooding expected for prolonged periods, cement/asphaltic concrete surfacing of appropriate thickness should be provided for at least two lanes of traffic. The cement concrete pavement, when provided, should have a cement/lime soil base 15 cm thick underneath the slab and permanent stakes on the carriageway edges for demarcating the travelled way. When asphaltic concrete is selected as the surfacing, the mix should be dense graded and resistant to flood conditions.

Where formation level of the road is well above the surrounding ground level, side drop walls and guide uprights must also be provided. In addition, the banks should be protected against erosion.

6.3. Provision of a Thin Bituminous Surfacing with Seal Coat

Where traffic is very light and the provision of a cement/asphaltic concrete surface is considered unjustified on economic grounds, a tolerable solution will be to provide a thin bituminous surfacing with seal coat over at least two lane width, using suitable anti-stripping agents and supplemented by guide uprights and side drop walls as necessary.

7. RECOMMENDATIONS FOR ROAD CONSTRUCTION IN AREAS WHERE IN ADDITION TO WATERLOGGING DETRIMENTAL SALTS ARE PRESENT IN THE SUBSOIL OR GROUND WATER

The following recommendations apply generally to construction of new roads. On existing roads, measures outlined in paras 5.1, 5.2 and 5.4 may be adopted for relief.

7.1. No special measures are considered necessary from the standpoint of physical/chemical action of injurious salts except those stated in Sections 5 and 6 if the concentration of sulphates in the subgrade soil is below 0.2 per cent (as sulphur trioxide) while also below 0.03 per cent (as sulphur trioxide) in ground water. Similarly, sodium carbonate concentrations of upto 0.2 per cent in subgrade soil and 0.02 per cent in the ground water are considered unharmful. Salt concentrations may be determined in accordance with the procedure laid down in relevant I.S.I. Standards—IS : 2720, part XXIII —1966 "Methods of Test for Soils : Determination of Calcium Carbonate", and IS : 2720, part XXVII—"Methods of Test for Soils : Determination of Total Sulphate".

No damage is expected from dissolved carbon dioxide or bicarbonate salt solutions (met with in certain marshy areas) provided the pH value of the solutions is higher than 5.

Where the concentration of these salts is in excess of the safe limits specified above, special measures as indicated below are recommended as a guide for road construction. These measures are in addition to those recommended in Section 5.

7.2. **Flexible Pavements**

7.2.1. **Water-bound macadam roads with or without bituminous surfacing:** Even if concentration of salts in the subgrade or ground water is higher than the safe limits prescribed in para 7.1, no special measures other than those set forth in Section 5 are considered necessary for water-bound macadam roads with or without bituminous surfacing except that the filler used in water-bound macadam and soling should be inert and free from injurious salts.

7.2.2. **Stabilised Soil Constructions:**

(a) **Mechanical stabilisation**

(b) **Cement and lime stabilisation**

(c) **Bituminous stabilisation**

If the above constructions are contemplated in waterlogged areas infested with salts, the soil used for stabilisation should not contain more than 0.2 per cent of total soluble sulphates and carbonates.

Besides this, to prevent the injurious salts in the subgrade or ground water from coming into contact with stabilised soil courses, a suitable capillary cutoff out of those described in Section 8 should be provided underneath the pavement extending across the full width of the roadway, treating it as an essential measure.

7.3. **Rigid Pavements**

When sulphates are in excess of the safe limits prescribed in para 7.1, the following additional measures are recommended during the construction of cement concrete pavements over and above the provisions of paras 5.1 and 5.2.

7.3.1. Since all types of concrete, irrespective of the type of cement used, are more vulnerable to salt attack during the initial period of hardening than when fully set, it is of importance to prevent contact between the ground water and concrete in the early stages. For this purpose, applying a light coat of bitumen to the underside of precast units, protecting cast-in-situ concrete by a thin bituminised coating on the base just below the slab, or provision of one of the capillary cutoffs mentioned in Section 8, are some of the measures recommended for adoption under relatively mild conditions of exposures to sulphate attack, viz., when sulphate concentration in soil is upto about 0.5 per cent.

Under more severe conditions, i.e. when sulphates are in excess of 0.5 per cent, the bituminous coatings used should be thicker* as they are known to possess higher durability.

7.3.2. Furthermore, the following measures are suggested as suitable for minimising adverse chemical effect of the sulphates on concrete:

(i) Designing a dense, well-compacted, high quality concrete which will have low permeability aginst ingress of sulphate solution. (This is recommended even when SO_3 in water is above 0.02 per cent).

(ii) Use of special sulphate resistant cement, puzzolanic cement or super-sulphated blast furnace slag cement, depending on availability and economy (when sulphate content is more than 0.3 per cent in soil and more than 0.03 per cent in ground water).

7.3.3. In areas where there is danger of damage from dissolved carbon dioxide or bicarbonate salts as evidenced by pH values of below 5, the provision of a waterproof layer below the concrete pavement, such as heavy duty bituminised paper or polythene sheet, and use of a dense, well-compacted, high quality concrete are the measures recommended for adoption.

*For the purposes of this specification, thin coats are considered to be those in which the rate of application of straight-run bitumen is 12 kg per 10 m^2 and thick coats are those in which the rate of application is 20 kg per 10 m^2.

8. SUITABLE CAPILLARY CUTOFFS

8.1. Provision of Sand Blanket

Sand blanket of adequate thickness over the full width of embankment is recommended as an effective capillary cutoff. The thickness of the sand blanket needed to intercept capillarity depends on the particle size of the sand and may be determined from the following formula*:

$$t = \frac{(8)^{0.92}}{d}$$

where t = thickness of sand layer in cm

$d = \frac{2d_1 \times d_2}{d_1 + d_2}$

= mean particle diameter in mm

d_1 = aperture size of sieve (mm) through which the fraction passes

d_2 = aperture size of sieve (mm) on which the fraction is retained.

The sand shall be compacted after adding sufficient moisture to permit easy rolling. Alternatively, it might be compacted dry if the facility of vibratory roller was available.

8.2. Some of the Other Capillary Cutoffs**

8.2.1. **Bituminous impregnation using primer treatment:** 50 per cent straight-run bitumen (80-100) with 50 per cent high speed diesel oil or its equivalent in two applications of 10 kg per 10 m^2 each, allowing the first application to penetrate before applying the second one.

8.2.2. **Heavy duty tar felt:** Providing an envelope with heavy duty tar felt.

8.2.3. **Polythene envelope:** Providing an envelope with polythene sheets of at least 400 gauge.

8.2.4. **Bituminous stabilised soil:** Providing bituminous stabilised soil in a thickness of at least 4 cm.

---

*This formula was proposed initially by the Public Roads Administration and is published in Highway Research Board Proceedings, Vol. 21, 1941, page 452.

**Experience on the successful performance of capillary cutoffs suggested in para 8.2 is, however, limited.