EFFECT OF WATER STORAGE TANKS AND IRRIGATION WATER CARRYING STRUCTURES ON ROADS

Mahesh Kumar
Engineer-in-Chief, Haryana PWD (B&E) Branch, Chandigarh
(Vice President, IRC)

1. Introduction

The site of water storage tanks, channels for water and other such irrigation structures is normally selected adjacent to existing roads not only that it suits the comfort and conveniences of staff working but also it is preferred from the point of view of construction, inspection and maintenance. In some cases, percolation losses are allowed and in other cases, the percolation of water keeps taking place in view of lining being damaged or structure being unplanned. Such type of percolation losses prove highly detrimental to roads. The roads become very soft for which heavy periodical repairs have to be carried out.

The failure of roads in such type of cases is mainly because of failure of sub-grade. The investigations of failure in the foundation of roads, highlight the need of coordination required between Highways, Public Health and Irrigation Engineers for site selection of such structures. These investigations also reveal new problems of interest both to the maintenance engineer and research workers.

2. Scope of Paper

In this Paper only two locations in Hisar district of Haryana have been selected where the roads have failed due to change in moisture content of sub-grade for an in depth study. These are:

(i) A road joining Delhi-Hissar road (NH-10) with Hansi-Jind Road (State Highway) and in its vicinity i.e. at 20 m from the centre line of road, water storage tanks of Public Health Department were constructed.

(ii) The second, at km 123 of NH-10 where a Sander Sub Branch is crossing. Also on both sides of National Highway, water courses are running within 20m of centre line of road.

Certain difficulties were encountered in investigating causes of failure of roads is the absence of information relating to the characteristics of sub grade during the time when the road was constructed. This difficulty has been overcome to some extent by comparing the characteristics of sub-grades of sound sections of road with that section of the road where crust had failed. The procedure adopted has been found to be successful to a great extent in determining the various factors responsible for failure of the road crust.

3. Causes of Moisture Content Changes in Subgrade

It is well known that the performance of roads would be better only if soil foundations remain in a relatively dry condition. The loss in strength of soil consequent upon an increase in moisture content have been established...
fully. There are several ways by which change of moisture content of subgrade of a road takes place. To name a few factors responsible for bringing changes in the moisture content of subgrade are the rise or fall in the level of water table, by the transfer of moisture from or to lower soil layers, by the transfer of moisture either to or from soil in the voids as a result of differences in moisture content, by the percolation of water through surface of road and by seepage of water into the subgrade from higher ground adjacent to road.

4. Investigation Into Causes of Uneveness, Settlement and Disintegration on a Link Road.

4.1 This is a very important link road which joins Delhi-Hosar-Sisar road (NH 110) to Hansi-Barwala Hansi link road, both State Highways. The traffic intensity on this road is 1143 PCE's per day. In view of its nature as link road, it appears to be unimportant but almost entire traffic leading to Delhi from Pandas via Barwala Toh and traffic from Hosar Hansi to Pandas uses this link road. Hansi market of Hansi is also located on this road. The length of this link road is 7.8 km only. The water storage tank of Public Health Dept. is located in vicinity of toy. This bituminous road, 5.5 m wide has shown severe settlement accompanied at many places by disintegration along the full width of road. This section of road had been a source of trouble for a considerable period and a heavy recurring annual expenditure is being made in order to improve its performance.

4.2 Percolation and Evaporation Losses

A storage and sedimentation tank of capacity 2,37,93,280 gallons was constructed along the length of this road. Its design provides for 25% of losses in form of percolation and evaporation. If maximum losses take place per design criteria, the losses become enormous quantify.

4.3 Study of Road Pavement

4.3.1 Unevenness index: Smooth pavements allow desired speeds to be maintained in conformity with geometric standards. Pavement unevenness affects operation cost, comfort and safety. Higher the unevenness, pavement, higher would be fuel consumption, operational cost like wear and tear of tyres and other moving parts.

The unevenness index of reach of road which have settled and have disintegrated and is located in vicinity of storage and sedimentation tank was 475.6. The unevenness index of the reach of the road nearly one km away from above mentioned site where performance of road is better was found to be 47.6. The extent of damage can be judged by difference of unevenness index. It was further noticed that initially road had turned wavy, undulating for a smaller length but later on, the waviness tended to increase for a larger length.

4.3.2 Soil investigations: The studies were carried out by sampling the soil investigations of reach where have settled and disintegrated and road about one km away from that area reach, whose performance was satisfactory.

The subgrade soil consisted of clayey clayey medium clayey (Table 4.2 gives the characteristics of soil at four locations of reach in where road has settled and disintegrated and 4 location where road is satisfactory). Whereas the water table in the affected reach is around 1.5 m and in the reach behaving properly, it was not available till 2.5m. The moisture content of soil is also seen to be quite high in affected reaches as compared to reach which is satisfactory. In addition, CBR value of soil is also quite low in reaches where the road has settled and disintegrated.
4.4 Reasons for Failure

The main factors contributing to failure was seepage of water from sedimentation and storage tank of water. If the failure would have been for the reason of insufficient thickness of crust then some other reaches would also have failed, which has not been the case. The percolation/seepage of water of storage and sedimentation tanks was thus mainly responsible for failure of road crust.

4.5 Proposed Action for Improvement

At first, it was considered to provide a drain which would have been located deeper and the drain trench back to ground level with permeable material so as to trap the run off. But in view of recurring expenditure in the intenance of drain and also in view of site conditions, this proposal was not pursued and subsequently dropped. Finally a proposal of execution of following items was decided and work was executed accordingly.

(i) Scarifying the existing road crust.
(ii) Earth work in embankment ht. of one m average in 9.75 width at top with side slope 3:1.
(iii) 200 mm thick GSB as per MORTH specifications.
(iv) 115 mm thick stone soilig (63 to 45 mm) with brick on end edging in 5.50m width.
(v) 102 mm thick stone metal wearing coat (53 to 22.4 mm).
(vi) 20 mm thick premix carpet with seal coat.

The raising of road helped in providing a dry sub-grade to the road crust thereby resulting in satisfactory performance.
5. Investigation into Causes of Unevenness. Settlement and Disintegration of road between Haig and Rohtak at Km 122 to Km 125 of NH-10

5.1 The traffic intensity of this road normally is 17,878 PCU per day. Sometimes the traffic intensity becomes abnormal when the defence vehicular movement takes place. In km. 123, the road is crossing a lined Sunder S Branch which is running on a high embankment. There is large seepage as lining is damaged at many places. The road level is almost equal to ground level. The water courses are also running parallel to National Highway with 20m of centre line of road. These had resulted into unevenness, settlement and disintegration of road at certain places from km 122 to 125 along full width of 7.5m. A heavy recurring annual expenditure was being done in or out to improve it.

5.2 Study of Test Reach

5.2.1 Unevenness index: Unevenness index of the affected reaches between km 122 to 125 was found to be 7100mm per km. The unevenness of the same reaches was again measured after 7 days of repairing of road and was found to be 6050mm per km. The unevenness index at km 127 where the performance of road was satisfactory was found to be 3400 mm/km. It was further noticed that initially road had turned wavy/undulating for a smaller length but later on the waviness tends to increase for a larger length.

5.2.2 Soil investigation: The studies were carried out by comparing the soil investigation of the reach from km 122 to 125 which have settled, disintegrated and the road in km 127 whose performance is satisfactory.

Sub-grade soil consisted of silty clay. The results of soil at four sites (2 in affected reach and 2 where road satisfactory) are given in Table 2.

<table>
<thead>
<tr>
<th>Site No</th>
<th>Depth (Metre)</th>
<th>Liquid Limit</th>
<th>Plastic Limit</th>
<th>Plasticity Index</th>
<th>Sand Content</th>
<th>Soil Classification</th>
<th>Depth of Water Table (Metre)</th>
<th>Dry Density (gm/cc)</th>
<th>Moisture Content %</th>
<th>CBR</th>
<th>Shear Strength Parameter</th>
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<tbody>
<tr>
<td>1</td>
<td>0.30</td>
<td>27</td>
<td>18</td>
<td>9</td>
<td>19</td>
<td>CL</td>
<td>1.20m (Silty)</td>
<td>1.561</td>
<td>24.2</td>
<td>2.2</td>
<td>859</td>
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<td></td>
<td>1.20</td>
<td>28</td>
<td>18</td>
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<td>6.2</td>
<td>-do-</td>
<td>-do-</td>
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<td>18</td>
<td>9</td>
<td>24</td>
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<td>16</td>
<td>-do-</td>
<td>-do-</td>
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<td>5.9</td>
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<td>2.9</td>
</tr>
<tr>
<td></td>
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<td>35</td>
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<td>-do-</td>
<td>1.676</td>
<td>7.2</td>
<td>19.2</td>
<td>3.4</td>
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</table>

Site 1 and 2 are on the opposite sides of N.H.-10 at R.D. 122,900, which is an affected reach. Site 3 and 4 are on the opposite sides of N.H.-10 at RD 126,900, whose performance is satisfactory.
Study of results shows that the water table in affected reach is around 1.20m and in the reach behaving properly it was not available till 3m. Similarly the moisture content in the soil in the effected reaches is 5-6 times higher than in the satisfactory reaches. It is further observed that the values of CBR are abnormally low in the effected reaches as compared to satisfactory reaches.

5.3 Reasons for Failure

Investigations showed that there was an insufficient crust thickness on the road. However, if the road had ailed on account of insufficient crust then it should have failed in the other reaches as well. Therefore, heavy percolation from Sunder Sub Branch and from the water courses was mainly responsible for failure of road crust.

5.4 Proposed Action of Improvement

It was decided that the formation will be raised by 1.30m average with tibba stand which is available in km 112. Finally the work was executed with the following provisions.

(i) 20 mm thick GSB as per MORTH specifications.
(ii) Water bound Macadam Grade-1 (90mm-45mm) in 2 layer of 100mm thick compacted thickness.
(iii) Water bound macadam Grade-3 (53mm-22.4mm) in two layers of 75mm thick compacted thickness.
(iv) One coat of surface dressing.
(v) 75mm built up surface grout.
(vi) Levelling coarse @ 10 percent of surface area with 20mm thick premix carpet.
(vii) Mix seal surfacing type B.

The raising of road helped in providing a dry sub-grade to the road crust and thereby resulting in good performance of the road.

6. Few more sites

The study of only two test reaches has been carried out in detail. However, in Hissar District itself there are many more such sites where road crust has failed on these lines. Few of them in addition to above are.

(i) At Bhiwani-Jind Road (State Highway) km. 35 to 36.060 also same type of situation existed. One Sunder Sorkhi link Channel is crossing the State Highway. This was unlined, continuous percolation losses took place resulting into waviness and subsequently disintegration of road. The road was also not satisfying the requirement of being one meter above H.F.L. or 1.5 m above highest sub-soil water level.

(ii) At Hissar Barwala Tohana Road (State Highway), between Surewala Chowk to Tohana at village Samain, a big village earthen pond existed adjacent to State Highway, resulting into rise of water table. It resulted into waviness of road and ultimately disintegration of road.

(iii) On National Highway No. 10, Delhi Hissar Sirsa road between km 225.300 to km 239, the road was not constructed as per minimum requirements of embankment and as such flood water used to cross thereby resulting in failure of road crust. Ultimately remedial measure had to be taken on above lines.

(iv) In all above cases the waviness first existed only on small length of road and subsequently the waviness of road increased to larger lengths.
7. Conclusions

In most of failed reaches, it is found that failure is on account of change in moisture content of subsoil which is again because of not keeping embankment one meter above NSL or HFL or 1.5m above sub-soil table. Failure to take correct technical decision at initial stage results in unevenness, settlement and disintegration of road which causes inconvenience to road users. Ultimately when remedial actions are taken then it involves substantial investment. It should be ensured that unevenness once developed in the small reach of road in attended immediately in order to prevent if from further aggravation. Site selection of the water storage sedimentation tanks need to be done after proper technical discussion between Highway Engineer and Water Engineers. Due care has to be taken to minimize losses in these tanks and in no way it should be allowed constructed near the highways or roads. Irrigation Engineers need to take steps for making lining more effective in this regard it has to be ensured by irrigation Engineers that lining of channels/minors have to be so done that certain length (half km or one km) depending upon importance of road in upstream and downstream of reach y road crosses channels or minor, the percolation losses should be minimal. Similarly, care will have to be taken by Public Health/ Irrigation Engineers to design and actually implement the construction of water storage tanks zero percolation losses. For this, even if they have to go in for richer specification of lining, they should opt for specifications. Such steps will go a long way in protecting the sub-grade of crust from ingress of moisture, ensuring longer life for the pavement.

References