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RESEARCH ARTICLE

REPEATED DAMAGE OF FULBARI BY-PASS ROAD: CAUSES AND MEASURES FOR RESTORATION

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ABSTRACT

The Fulbari by-pass road is a service road running parallel with Tista-Mahananda canal of West Bengal, India. The road has been damaged repeatedly for the last few years. There are huge depressions on the road surface and it now look like a sine curve. Field investigation, field tests indicate huge seepage is flowing under the road throughout the year, ultimately leading to piping and consequent soil loss. The adjoining canal lining is severely damaged leading to huge seepage. Field and laboratory tests suggest that the sub-grade soil is poor, un-compacted heterogeneous sub-soil of very loose compactness and thus unfit to act as a sub-grade material under severe traffic load. A combination of these factors is jointly responsible for the damage of the road, even after repairing every year. Two alternative suggestions have been given by the author. Either construct rigid pavement on supporting piers founded on a firm-soil. Also absolute leak proofing of the adjoining canal was suggested to be mandatory. Or search for a new location, where there will be no seepage effect. A new flexible pavement could be constructed, which might be cheaper than the first suggestion and keep the aforesaid road to serve just like a service road.

INTRODUCTION

The site under investigation is the Fulbari by-pass road running by the side of the Tista-Mahananda canal. Firstly, it is to be noticed that this road is a typical Service Road which is constructed for the inspection of the adjoining canal and communication to the remote areas. Generally this type of road cannot withstand heavy vehicular traffic load. Here, the entire road surface looks like a sine curve with a number of huge depressions of the order of 1m to 1.5m depth, below the existing ground level. Though a few pot holes have also been observed on the road surface at different places, but they are not of major importance regarding the repeated damage of the Fulbari by-pass road. The sub-grade of the road is mainly loosely compacted granular soil. In a few boreholes, soft cohesive deposits in small layers have also been encountered.

Detection of the causes of Damage

- It has been observed that there is continuous seepage flow below the aforesaid road from countryside to Tista-Mahananda canal in non-monsoon period. On the other hand, the direction of flow is reversed, during monsoon, indicating landward hydraulic gradient. This has been established by excavating a trench on the country side during monsoon. Huge quantity of seepage flow and consequent sloughing of the saturated side of the trench have been observed. It clearly indicates that there is strong seepage flow running below the road from the adjoining canal to the country side during monsoon period. Hence, seepage flow is continuing under the road throughout the year, only with varying magnitude of seepage pressure $i.z.\gamma_w$, where i is the hydraulic gradient, z is the depth at which seepage pressure is computed and γ_w is the unit weight of water. This pressure is softening the sub-soil and is ultimately leading to 'Piping'.
- For sub-soil investigation, five bore holes (B.H.1, B.H.2, B.H.3, B.H.4, and B.H.5) whose Reduced levels (R.Ls) are 99.44m, 99.35m, 99.45m, 99.45m and 99.45m respectively, have been done at five locations at the site.[Top of the Dowla has been chosen as arbitrary datum and R.L of the top of Dowla is taken as 100.00m]

a) In B.H-1, the Standard Penetration Value ('N value') [IS: 2131: 1981], at a depth of 2.5m below R.L-99.44m, is 2 i.e. N = 2.
b) In B.H-2, N values at a depth of both 1m and 2m below R.L-99.35m is 4 i.e. N = 4.
c) In B.H-3, N value at a depth of 2m below R.L-99.45m is 2 i.e. N = 2.
d) In B.H-4, N value at a depth of 3m below R.L-99.45m is 3 i.e. N = 3.
e) In B.H-5, N value at a depth of 5m below R.L-99.45m is 3 i.e. N = 3.

From the above points, it can be concluded that Piping is occurring in all the Boreholes where the N values are too low indicating very loose compactness of the sub grade materials [If 'N' is lying between 0-4, indicates very loose compactness-Table-17.3- V.N.S Murthy-1992] . These weak planes are very much prone to Piping.

- It has been informed by the representative of Irrigation Department that some openings are kept on the river side slope of road for releasing pore-water pressure. Hence, initially the sub-grade of the road was prone to seepage flow through it and under such conditions soil loss from sub-grade is expected to occur.
- It may be pointed out that dislodging of sub-grade soil and subsequent removal of the same, due to seepage pressure, is going on for a long time. This 'Piping' is partly responsible for the development of huge depression of the road surface, under heavy traffic load.
- During soil investigation, it has been found that the sub-grade is basically, filling layers of heterogeneous materials, laid layer by layer and un-compacted which cannot be considered to be a suitable material for sub-grade. No virgin soil has been encountered throughout the depth of exploration.
- It has also been detected that all the layer of sub-grade are almost un-compacted. 'N' values at different depths and in different Boreholes indicate very loose compactness of the sub-grade. At the same time, very low value of dry densities of the

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order of 1.59gm/cc, 1.62 gm/cc etc. have been found in different boreholes, which were obtained by Modified Proctor Test [As per IS:2720(Part-8)-1983], done in the laboratory. Also, from Laboratory Soaked C.B.R Test [IS:2720(Part-16)-1979], it has been found that C.B.R values in all the Boreholes are also poor, as low as 1.84%, 1.90% up to a maximum value of 3.21% (In B.H-1 only) under heavy compaction. From the above technical discussion, it can be concluded that the sub-grade soil is very poor and also loosely compacted, during construction of the canal side embankment and thereby totally unfit as a sub-grade material for the road carrying huge traffic load every day. This is another cause of the damage of the road mentioned before.

- Basically Fulbari By-pass road from Fulbari to Goultuli is a service road, which is mainly constructed for canal inspection, communication to the remote areas etc. Hence, the present huge traffic loads are creating repeated damage to the road.

Combination of all the factors mentioned above is responsible for the repeated damage of the Fulbari Bypass road.

DISCUSSION

Observing the field sub-soil condition, continuous seepage flow through it, field and laboratory testing of the sub-grade soil, it may be concluded that flexible pavement cannot be constructed for such heavy traffic load. Removal of the soil up to a depth of 10m below R.L-99.44m and for a length of 13km and subsequently filling it with well compacted Sand is an impossible task and appears to be a myth. Moreover, this removal of soil will lead to the damage of the road side slope of the Tista-Mahananda canal. Hence, there are two alternative solutions followed by the primary but compulsory technical requirement.

Suggestions for permanent restoration of the road

1. Absolute Leak Proofing of the adjoining Tista-Mahananda canal is mandatory

2. i) From the above discussion, it is concluded that provision of rigid pavement is mandatory here. Since the rigid pavement cannot be founded on such un-compacted heterogeneous low quality sub-grade soil, hence it is suggested that the rigid pavement should be constructed on supporting piers span wise up to a length of 13km, the foundation of which will rest at a depth of 10m below R.L-99.44m.

ii) Strip footing throughout the length of the pier is suggested. But, before construction, Plate Load Test [IS 1888: 1982] is suggested under the base of the footing, at least one test per km length of the road.

a) If it is found that the strip footing at that depth is unable to withstand the severe vehicular traffic load, then deep foundation in the form of D.M.C bored Pile in a group is suggested. Pile Load Test is also suggested on three test piles before construction.

b) The spans between peer to peer of the rigid pavement should be selected in such a way that there will not be any overlapping of stresses beneath the footings, if strip footings are provided.

3. i) Alternatively, The Fulbari Bypass road can be kept as a normal service road, only after moderate repairing of the damaged road surface, where only the light vehicles may be allowed to move over it for inspection of canal and communication to remote areas.

ii) A new location of the road may be searched for, which is away from the canal, where there will not be any seepage effect.

iii) The new embankment is suggested to be constructed by high quality, well compacted sub-grade soil having relative compaction ranging between 0.95 to 0.98.

iv) Then Soaked C.B.R tests (heavy compaction) at a moisture content equal to the O.M.C of the sub-grade soil could be carried out.

v) From the values of Soaked C.B.R test (heavy compaction) and antecedent traffic load, a new flexible pavement may be designed.

Some of representative Field and Laboratory test results and graphs are furnished here under.

BORELOG DATA SHEET

B.H-1

--0.0 (R.L-99.44m)

Top soil consists of gravel, sand, stone dust and various heterogeneous foreign materials

---0.70 m

Greyish Sand with a few gravels and high % of fines

---1.50 m

Silvery grey sand with traces of mica.

---1.80 m

Greyish Clayey Silty sand

---3.35 m

Multi-colored Sandy Gravel with traces of mica along with a few Cobbles.

---4.25 m

Greyish/Brownish grey Clayey Silty Sand with Mica

---4.70 m

Silvery grey/ Blackish grey Sand with a few Gravels and traces of mica.

--7.25m

Greyish/ Silvery grey Sandy Gravel/Gravelly Sand With mica

---9.25 m

Multi-colored Gravelly Sand

---10 .00m

NOTE: BORELOG IS NOT TO SCALE

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APPENDIX

Table 1: Estimated Physical properties of soil.
Sample Calculation

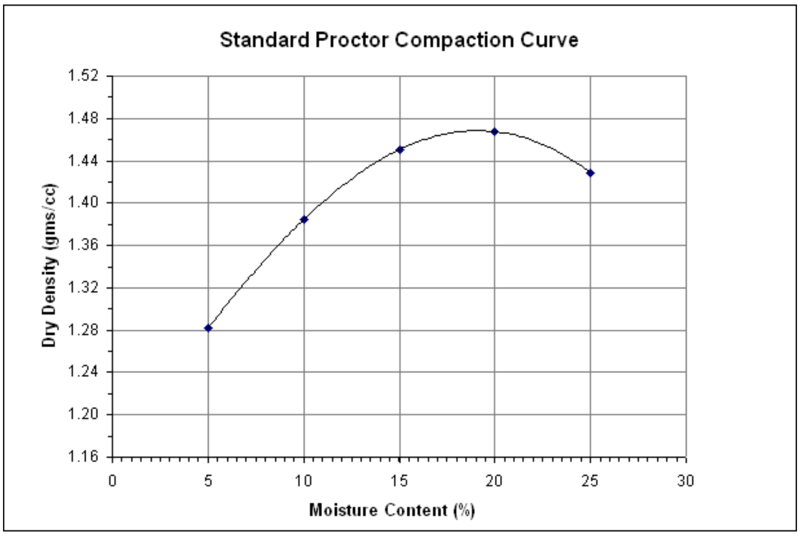
Location	Depth (m)	Field density (gm/cc)	w_n(%)	G	Grain Size Distribution [%]					Soil Type
					Gravel	Sand			Silt & lay	
						C	M	F		
B.H-1	0.70-1.15	1.32	14.82	-	2.4	1.0	28.2	50.2	18.2	Greyish Sand with a few gravels and considerable % of Fines.
	1.60	-	4.56	2.63	2.6	1.0	23.6	69.4	3.4	Silvery Grey Sand with traces of mica.
	2.00	1.51	32.27-	2.66	0.0	0.0	0.0	57.8	42.2	Greyish Clayey Silty Sand.
	4.25-4.70	-	37.66	-	0.0	0.0	0.0	65.8	34.2	Greyish Clayey Silty Sand with mica.
	5.50-6.00	-	30.86	-	10	30.0	50.4	8.4	1.2	Blackish Grey Sand with a few gravels.
	9.45-10.00	-	-	-	0.0	0.0	41.4	58.0	0.60	Multi-colored Gravelly Sand

Table 2: Estimating Physical Properties of Soil

Borehole No:	Depth below R.L-99.45m(m)	Modified Proctor Test		Modified CBR (%)	Remarks (for CBR only)
		O.M.C (%)	MDD (gm/cc)		
B.H-1	2.0	19.00	1.47	3.21	
B.H-2	2.0	14.10	1.75	1.90	1.Type of Compaction- Heavy
B.H-3	2.0	15.50	1.72	3.14	2.Seating Load-4 Kg 3.Surcharge Load- 5 Kg
B.H-4	3.0	10.75	1.68	1.96	
B.H-5	5.0	18.44	1.62	1.84	4. Period of Soaking- 96 hours

A Sample of the Modified Proctor Test
B-H-1
DEPTH-2.0m
Location: Fulbari Bypass Road
Modified Proctor Test Result

Wt. of the mould	Wt. of the mould with wet soil	Volume of the mould	Bulk density	Moisure Content	Dry density
gms	gms	c.c	gms/cc	%	gms/cc
3854	5200	1000	1.346	5.00	1.282
3854	5377	1000	1.523	10.00	1.385
3854	5522	1000	1.668	15.00	1.450
3854	5615	1000	1.761	20.00	1.468
3854	5640	1000	1.786	25.00	1.429



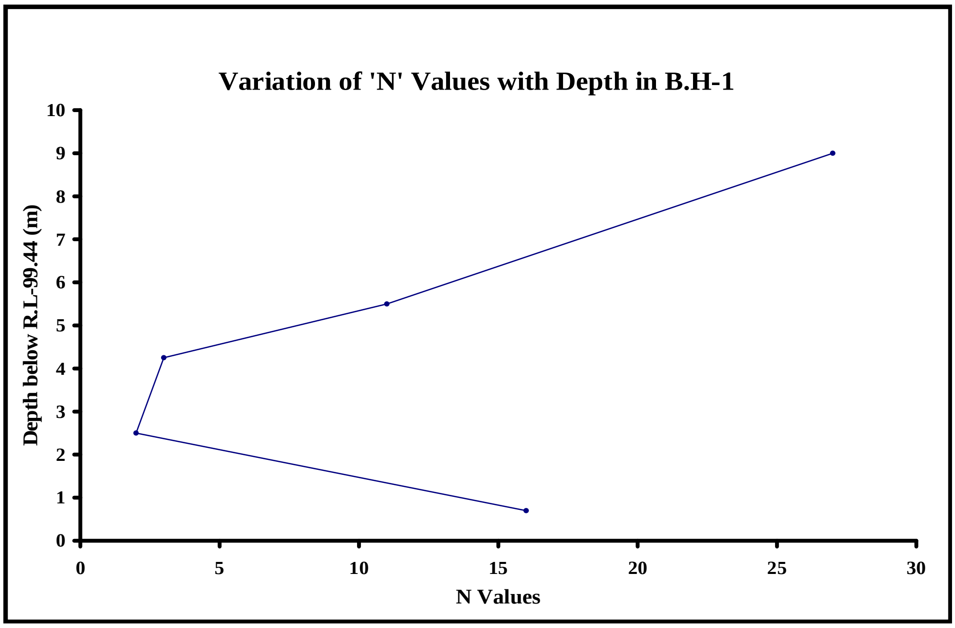
O.M.C = 19.00%
M.D.D = 1.47 gm/cc

APPENDIX

Table 3: SPT Values at different depths

Borehole	Depth below R.L 99.44m	Observed 'N' value	Corrected 'N' value
	0.70-1.15	18	16
	2.50-2.95	2	2
B.H-1	4.25-4.70	3	3
	5.50-6.00	11	11
	9.00-9.45	39	27

Sample Figure



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