EFFECT OF LIME-FLYASH STABILIZED SUBGRADE ROADS AND ITS PERFORMANCE

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ABSTRACT: The City of Surat situated at South Gujarat region in India having majority of top soil as black cotton soil. This soil being expansive required special attention for road construction as well as pavement design. The study by Jigisha shows the average soaked CBR for typical South Gujarat undisturbed or compacted soil as 2.0 %, the study also describes some ambiguity in results due to uneven moisture distribution within the soaked test specimen. The IRC: 37-2001 Annexure – 4 suggest 0.6 to 1.0 m thick non-expansive cohesive soil cushion on the expansive soil for road construction. Alternatively insitu Lime - Flyash stabilized soil layer has been prepared as subgrade. SMC (Surat Municipal Corporation) constructing the kilometers of roads with in Surat City was working with the design of pavement having rubble at sub-base layer which suffered severe damage after rains – floods. SMC decided to generalize type road design for different categories of roads with soil stabilization technique. The aim behind modified design was to reduce the annual maintenance expenditure for flexible pavement & standardized design for city roads. Typical pavement designs for different category of roads were developed by authors with Lime – Flyash stabilization technique to improve the subgrade CBR. The design achieved the reduced annual maintenance expenditure with more durable road subgrade.

1 INTRODUCTION

The Surat City situated in South Gujarat area of India having top layer of black cotton soil. Fig. 1 - Map of soil deposits in Gujarat State shows that the majority of South Gujarat area having black cottons soil as top layer. This soil being expansive required special attention for road construction as well as pavement design. The study by Jigisha shows the average soaked CBR for typical South Gujarat undisturbed or compacted soil as 2.0 %. The study also describes some ambiguity in results due to uneven moisture distribution within the soaked test specimen. Also study carried out by Yogendra shows the similar type of observation for the South Gujarat region soil. Table – 1 shows the Geotechnical Properties of Black cotton soil as observed by Yogendra. It shows that soil is having high free swell index of 70 % which leads to cyclical swelling – shrinking phenomenon of the black cotton soil.

Table – 1: Geotechnical Properties of Black Cotton Soil

Property		Values
Grain Size	Gravel (%)	1
	Sand (%)	12
	Silt + Clay (%)	87
Atterberg's Limit	Liquid Limit (%)	55
	Plasticity Index (%)	27
Compaction Test	MDD (kN/m^3)	15.50
	OMC (%)	21.75
Swelling Test	Free Swell Index (%)	70
CBR (%)		1.77
UCS (kN/m^2)		59
Permeability (m/s)		8.75 x 10^{-9}

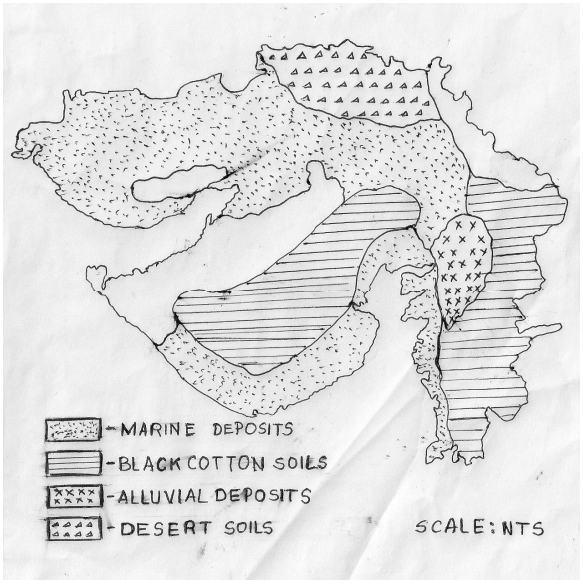

Fig. 1- Map of soil deposits in Gujarat State.

The IRC: 37-2001 Annexure – 4 suggest 0.6 to 1.0 m thick non-expansive cohesive soil cushion on the expansive soil for road construction. Alternatively insitu Lime - Flyash stabilized soil layer has been prepared as subgrade. Surat is the one of fastest growing city situated at South Gujarat with top soil as black cotton soil. The Surat Municipal Corporation (SMC) looking after the road construction and maintenance work has to handle

six zones (before 2006) within the Surat City limit. As per there earlier approach new design were developed for each new road construction. The typical design adopted by SMC is shown in Fig. 2. It shows rubble soiling as sub-base layer, above which the aggregate layer provided as base layer and the bituminous macadam layer with seal coat act as top surfacing. The use of rubble as sub-base layer created lots of problems by sinking in subgrade soil due to impact of traffic and dead load, which caused mud pumping during monsoon. It led to the failure of pavement, formation of potholes, ruts etc. The roads were badly damaged after the every monsoon and the maintenance cost were also higher.

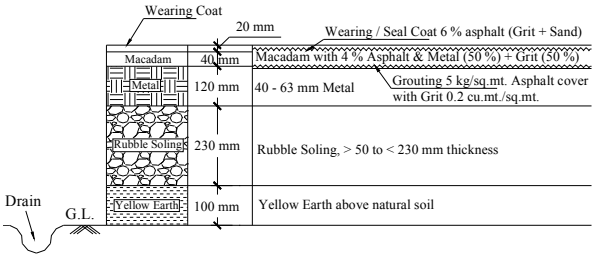

Fig.2- Sketch showing the typical pavement composition executed by SMC pre 1995.

To overcome the recurring maintenance cost problems, during the year 2002 the SMC has decided to form a committee with aim of standardizing the road design for different categories of Urban roads. The committee members are experts from academic institutes as well as industry, working in the area of road design. The committee has decided to develop the standardized road design for specified categories of urban roads for city limits. The roads are categorized as,

a) Residential Streets, having width less than 12.19 mt (< 40'),
b) Collector Streets, having width 12.19 to 24.39 mt, Excluding 24.39 mt (40'–80', Excluding 80'),
c) Sub Arterial Roads, having width 24.39 to 36.58 mt, Excluding 36.58 mt (80'–120', Excluding 120') &
d) Arterial Roads, having width 36.58 to 60.97 mt (120' to 200').

The above four categories are common for all the zones & all zones have to follow the common design for each category of the road. This provides uniform pavement thickness, its composition etc. for specified category of roads within different zones of the city. The pavement design with Lime-Flyash stabilized sub-grade, excluding the top surfacing was entrusted to author[2]. The top surfacing for different category of the road was decided by the other committee members and it has to be followed while designing new pavement composition. In this paper the standardized pavement design for sub arterial roads and arterial roads are discussed. The practice of pavement construction before monsoon and laying top bituminous surfacing after year was also considered in design.

2 SOIL SUBGRADE IMPROVEMENT

The City of Surat having the most of the region covered with top black cotton soil. This soil is highly plastic clay (CH group) with high expansive potential / shrinkage potential. The study carried out by Yogendra shows the high free swell index of 70 % for South Gujarat soil. Nos. of tests was carried out to get the CBR value of existing subgrade layer. The average value observed was Soaked CBR of 1 to 2 %. The recent study by Jigisha (2008) & Yogendra (2008) also shows the Soaked CBR value for South Gujarat region as 1.0 to 2.0 %. The IRC:37-2001 Annexure – 4 suggest 0.6 to 1.0 m thick non-expansive cohesive soil (CNS) cushion on the expansive soil for road construction. The old city area & drainage of frequently occurring flood did not permit raising the formation level of roads. Hence as per the new road design it has decided to go for insitu soil stabilization with Lime and Flyash. The stabilization has to be done in following steps. (1) Disk harrowing the existing top 100 to 150 mm soil. (2) Apply 10 kg of slaked lime (CaOH, as per clause 402.2.2 of MoRT&H) per sq.m. area. (3) Apply 50 kg Flyash per sq.m. (4) Thoroughly mix the Lime – Flyash with pulverized soil by disk harrowing. (5) Cure the mixed material for 24 hrs with 60 to 70 liter water per sq.m. (6) Compact the cured surface at OMC with 8 T static / vibratory rollers as per guidelines of IRC: 37 – 2001. This stabilized subgrade has the minimum CBR value of 4 %. Hence the subgrade CBR = 4% is adopted for all categories road design. The width of stabilization has to be 1 m more than proposed road width for better performance. However when the pavement is in cutting, this additional 1 m width can be dropped, which would mostly found in SMC case. Also the drainage on roadsides is assumed as well planned. Thus drain will not soak subgrade during the rains and a random check on CBR with tolerance + 5 % has suggested for better quality control.

3 DESIGN TRAFFIC

The vehicle count survey was carried out at different locations to get the existing traffic condition for each category of the roads. Looking to the observed traffic composition, lane distribution and future growth of the city common design traffic of 60 msa is considered for the design of sub arterial roads and arterial roads.

4 PAVEMENT THICKNESSES AND ITS COMPOSITION

Using the CBR = 4 % and the design traffic 60 msa common for both categories of the roads the detailed design was carried out referring IRC: 37 – 2001. Fig. 3 shows the pavement thickness with its detailed composition and material specification for Common design of sub arterial roads and arterial roads. The design was inaction from year 2004 or so and showed the better performance with reference to earlier roads.

5 PERFORMANCE OBSERVATIONS

The annual maintenance expenditure data for roads within Surat city limit is shown in Table – 2. This shows the reduction in the maintenance expenditure inspite of the continuous rise of 10 % in SOR (Schedule Of Rate) for various work. Fig. 4 gives the graphical presentation for the same and it seems that the design is performing well with reduction in annual maintenance expenditure for flexible pavement roads. Also from the local experience and general observation now a days the private developers are also using the same standardized design for internal society roads etc.

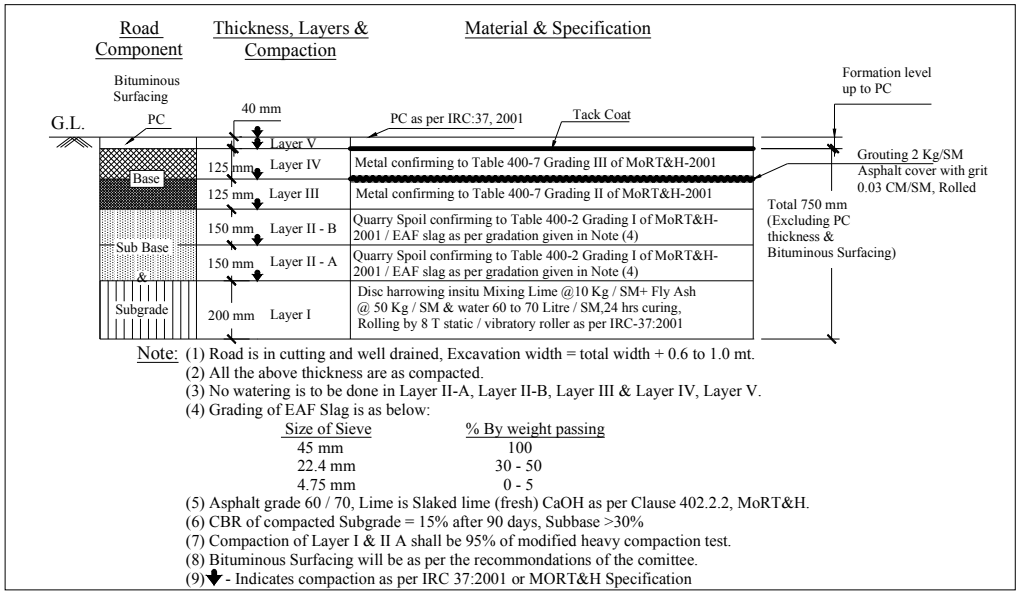

Fig.3 - Sketch showing the various layers of Roads having width 24.39 mt. & above, Sub-arterial roads and Arterial roads, Surat City Limit.

Table – 2: Annual maintenance expenditure for road in SMC limit

Year	Total Flexible Pavement Road Length in km	Total Maintenance Expenditure in Crores	Maintenance Expenditure in Lakh / km
2002-03	1033.65	15.98	1.55
2003-04	1097.03	22.26	2.03
2004-05	1133.37	25.54	2.25
2005-06	1233.10	33.20	2.69
2006-07	1608.50	36.09	2.24
2007-08	1723.99	36.88	2.14

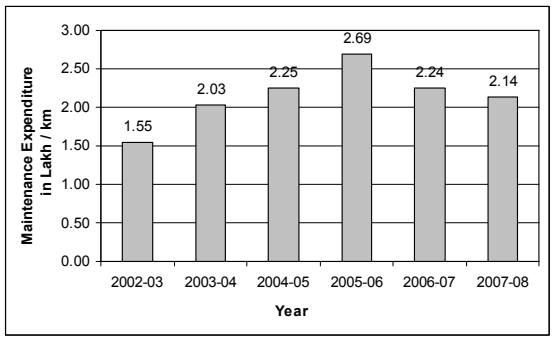

Fig.4- Graph showing the annual maintenance expenditure per km length of the flexible pavement road in SMC limit.

In addition to reduction in cost of maintenance, open excavation of 1 to 2 years old road works were inspected. Lime – Flyash stabilized zone of subgrade showed definite improved CBR with time of one to two years. The sectors where repairs, laying of drains etc were executed without providing treated subgrade surface, damaged post monsoon were a common site.

6 CONCLUSION

The Surat city road performance with Lime-Flyash stabilization for black cotton expansive soil shows better performance as indicated by reduction in annual maintenance cost per km road length. Simultaneously the standardization of road width for various categories of the urban roads has helped a lot for the financial management of the SMC with uniform design and cost for all the zones. It provides the uniformity form the tendering stage to execution and maintenance stage also. The similar approach can help a lot to optimize the financial sources of the governing authority of any urban area.

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