

A Study of Cement Treated Base and Sub Base in Flexible Pavement

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Abstract - Countries all over the world are developing rapidly and infrastructure sector plays a vital role in the development of nations. Transportation is the main constituent of infrastructure sector. Most of the countries are dependent on the roads and highways for transportation of all kinds, as compare to waterways, railways, airways etc. In many developing countries, crushed rock and murrum is used as a base material for road pavement. These materials are required in large quantities and are not easily available in many regions. Government of India is concentrating on the development of National Highways and State Highways for the fast transportation and conveyance. Hence the requirement of the construction materials is very huge. The material used for base layers in pavements is costly as it requires production cost i.e. drilling, blasting, crushing, transportation etc. Although this material is fails under heavy traffic load as well as heavy rainfall. Also it is not easily available in city areas. This report consists of the study of reasons of failure of the flexible pavements, the materials used for the pavement construction in traditional method, the problems associated with these materials. This study explains the mechanism of Cement Treated Base and Sub-base. The quantity of the cementitious material required to be added for stabilization process. The requirements of cement treated base/sub-base are also studied in this report. The construction process is explained in details. This material is beneficial because it minimizes the crust thickness and hence saves the material required for construction. The cement treated base and sub-base is tested for the unconfined compressive strength and the results are obtained. It proves that, this material gives better strength as per requirement and performance also better as compare to the traditional materials. The construction cost, quantity of material, transportation charges for material, machine requirement, machinery fuel cost are analyzed and compared for the cement treated sub-base and traditional material. The result shows the saving in the construction cost for CTB and CTSB method is more. This report shows how it is beneficial to use cement treated base and sub-base to replace the traditional base material used for construction of highways.

Key Words: Cement Treated Sub base (CTSB), Cement Treated Base (CTB), Flexible pavement, Performance Analysis

1. INTRODUCTION

Today India is the fastest growing country in the world. Transportation plays a very important role in the development of the country. Interconnectivity of Capitals, Ports, Industrial areas etc. should be well-connected to

ensure the fastest transportation of all goods, materials as well as peoples. Transportation sector includes Highways, railways, waterways etc. In India highways plays vital role for all kinds of transportation.

Today, many big highway projects are going on all over country and in future it will increase. The Government of India has planned Rs. 5.35 Lakh Crore of road projects under the Bharatmala Pariyojna to meet the target of 83,677 Km highway construction in the period of 2017 to 2022. This Bharatmala will significantly boost highway infrastructure. It raises the 6 NC corridors to 50 corridors, 40% freight to 80% freight on National Highways, it also raises district connectivity from 300 district to 550 district connected by minimum 4 lane. The Government of Maharashtra also planned the most prestigious road project i.e. Samruddhi expressway it will connect 700 km long going through ten districts with the whopping budget of 48,000 corer. This sector contributes 6% of total GDP out of which 70% shares comes from the road sector. The construction of road pavement costs about 50% of the total cost of construction of the road. Now with these two big ambitious projects the material requirement for construction of pavement is very high. Cost of the required material should be within budget and should be easily available. If the material required will be not available locally then it requires to be borrowed from the other site it will affect the cost of project.

Also the material requirement for construction of pavement using the conventional method i.e. GSB & WMM as base layer is very high and it also increases the material as well as total project cost. For reducing the pavement thickness the alternate base layer should be used so it will minimize the material consumption and saves the money. For achieving this the cement treated base and sub base used as alternate in the flexible pavement without compromising with the strength.

Flexible pavement is the ones which are having low or negligible flexural strength. They are flexible in their structure under loads but if the lower layer gets undulated the entire pavement gets disturbed. The load is transferred from grain to grain action and maximum compressive stress will be on the pavement surface, so it is necessary to provide a strong layer at the top. In this thesis the concept of CTB and CTSB should be study for making strong base.

1.1 NEED OF STUDY

Taking into the account the current speed of highway construction and coming big projects like Bharatmala pariyojna and Samruddhi Expressway the material required for construction if roads is very high. The better & sustainable highway design is the need of future generation. So new pavement design shall fulfill the requirement of less material requirement, more strength and also the future costs like maintenance cost, rehabilitation cost etc. To overcome the above said problem the use of cement treated base and sub base in the flexible pavement is the most suitable method.

1.2 OBJECTIVE

- A. To Study the Concept of Cement Treated Base (CTB) and Cement treated Sub-base (CTSB) of flexible pavement.
- B. To Study the reason of failure of flexible pavement.
- C. Design of flexible pavement by using empirical-mechanistic method.
- D. To study the performance of the CTB and CTSB with conventional method.
- E. To compare overall cost analysis of for CTB and CTSB with conventional method.

2. FAILURE OF FLEXIBLE PAVEMENT

The major flexible pavement failures are fatigue cracking, rutting, and thermal cracking. The fatigue cracking of flexible pavement is due to horizontal tensile strain at the bottom of the asphaltic concrete. The failure criterion relates allowable number of load repetitions to tensile strain and this relation can be determined in the laboratory fatigue test on asphaltic concrete specimens. Rutting occurs only on flexible pavements as indicated by permanent deformation or rut depth along wheel load path. Two design methods have been used to control rutting: one to limit the vertical compressive strain on the top of sub-grade and other to limit to tolerable amount (12 mm normally). Thermal cracking includes both low-temperature cracking and thermal fatigue cracking. Also the potholes, undulation in pavements, failure of the shoulders seen many times. These failure patterns arises due to the weak sub-base layers and the poor water drainage through the sub-base layers.

3. DESIGN OF FLEXIBLE PAVEMENT

The flexible pavement design is done by using the Empirical-Mechanistic method. The pavement design basically aims at determining the total thickness of the pavement structure as well as the individual thickness of structural components for carrying the estimated traffic loading under the prevailing climatic conditions with satisfactory performance of the pavement.

The following six main steps have been followed in designing the flexible pavement:

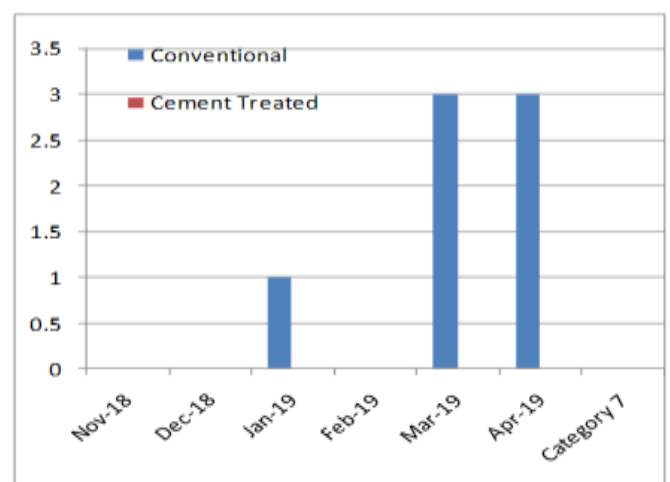
- Estimating the volume of traffic and the cumulative number (in million) of equivalent standard axles (CMSA) that will use the road over the selected design life.
- Traffic growth rate during the design life in percentage.
- Design life in number of years.
- Spectrum of axle loads.
- Vehicle Damage Factor (VDF).
- Lane Distribution of Traffic.

For this purpose the guidelines given in the IRC-37-2012 was followed to design the flexible pavement. And pavement design done for both pavement type for 150 MSA.

4. PERFORMANCE ANALYSIS OF PAVEMENT

The performance analysis of the pavement with using CTB and CTSB was done with the pavement with conventional crust. For this purpose the pavement condition survey was done as per the guidelines by IRC-115-2014. The pavement evaluation and the data collection for the both type of the pavements was done at NH-4B. For the pavement evaluation of CTB and CTSB method the stretch from Km. 21.200 to Km. 22.200 in D to E section of the project and for the conventional method the stretch from km. 1.100 to Km. 2.100 in D to G Section selected. In this selected stretch for both type of pavements the stretch is divided into the 10 parts. Each part of 100 m length and 9 m width. In this stretch the pavement condition measured for the various type of distress such as cracking, rutting, raveling, potholes and patching. For this the detailed observation and record was kept for six months from the day of traffic diverted on the said stretches. The observations made of the pavements for both types at the regular interval of the 15 days for the six months. Following fig shows the comparison between pavement with CTB and CTSB to the Conventional one. It shows the percentage of the distress observed in the Pavement.

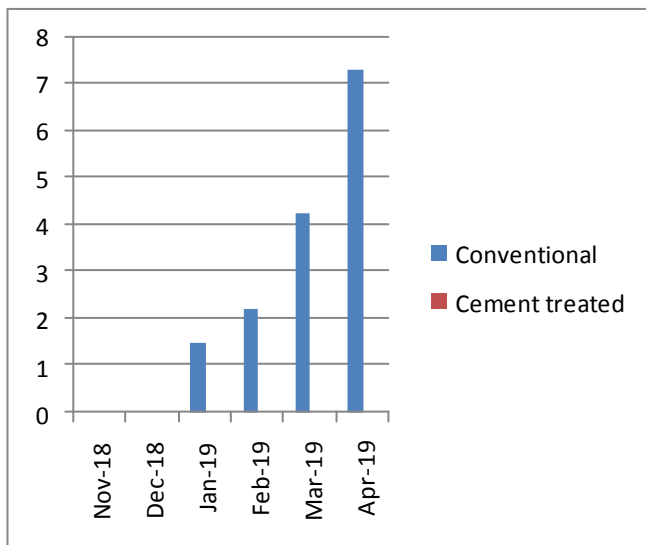
A. Cracking :-



In this graph on the X-axis the period is plotted and on the y-axis the percentage of cracking is plotted. From this it is clearly seen that the cracking are observed in the conventional pavement and no cracking in the CTB and CTSB pavement.

B. Rutting :-

The rutting graph also plotted for both the pavements. In this graph also on X-axis the period is plotted and on the y-axis the rutting observed in mm is plotted. From this it is clearly seen that the rutting are observed in the conventional pavement and no rutting in the CTB and CTSB pavement.



There is severe rutting found in the flexible pavement with conventional method which indicates that the failure of the one of sub base layers of pavement.

5. OVERALL COST ANALYSIS OF PAVEMENT

Overall construction cost of flexible pavement with CTSB/CTB method is less than the traditional material, because the saving in material, required machineries, fuel consumption and material transportation charges etc.

For Example, we consider a patch of 1 Km (1000 m) length and 9 m width for both methods. The quantity and cost of materials required for Main Carriageway will be as follows:

Table 5.1: Required Quantities of Material

Quantities for Pavement with CTB/CTSB Material				
Layer	Length (m)	Width (m)	Depth (m)	Quantity in Cum
BC	1000	9	0.05	450
DBM	1080	9	0.05	450
WMM	1000	9	0.100	900
CTB	1000	9	0.110	990
CTSB	1000	9	0.250	2250
SG	1000	9	0.500	4500
Total				1060

Quantities for Pavement with Conventional Material				
Layer	Length (m)	Width (m)	Depth (m)	Quantity in Cum
BC	1000	9	0.05	450
DBM	1000	9	0.120	1080
WMM	1000	9	0.250	2250
GSB	1000	9	0.200	1800
SG	1000	9	0.500	4500
Total			1120	

From above tables of it is seen that pavement with CTB/CTSB has total crust thickness is 1060 mm where as the pavement with conventional method the total thickness is 1160 mm. Hence by using the CTB/CTSB method the pavement thickness can be reduced up to 100 mm which results in the saving of the aggregate required for pavement construction.

Table 5.2: BOQ Rates of the material

Layers	Cost (Rs)
Bituminous Course (BC)	8084
Dense Bituminous Macadam (DBM)	7702
Wet Mix Macadam (WMM)	1542
Cement Treated Base (CTB)	1667
Cement Treated Sub Base (CTSB)	1291
Granular Sub Base (GSB)	1046
Sub-Grade (SG)	527

The total construction cost for the both type of the pavement for the 1 km is calculated is shown below :

Table 5.3: OVERALL CONSTRUCTION COST

CONSTRUCTION FOR CTB/CTSB METHOD			
LAYERS	QUANTY IN CUM	RATE IN RS	AMOUNT IN RS
BC	450	8084	3637800
DBM	450	7702	3465900
WMM	900	1542	1387800
CTB	990	1667	1650330
CTSB	2250	1291	2904750
SG	4500	527	2371500
TOTAL AMOUNT			1,54,18,080/-

CONSTRUCTION FOR CONVENTIONAL METHOD			
LAYERS	QUANTY IN CUM	RATE IN RS	AMOUNT IN RS
BC	450	8084	3637800
DBM	1080	7702	8318160
WMM	2250	1542	3469500
GSB	1800	1046	1882800
SG	4500	527	2371500
TOTAL AMOUNT			1,96,79,760/-

From the above tables it is seen that the construction cost for CTB/CTSB method for the 1 km is 1,54,18,080/- and that is for the conventional method the construction cost for the 1 km is 1,96,79,760/-. The difference in the Amount =1,96,79,760-1,54,18,080=42,61,680/-. The 42,61,680/- is saved per km by using the CTB/CTSB method over conventional method.

6. CONCLUSIONS:

The use of CTB and CTSB saves the material required for the construction of flexible pavement. The transportation charges, fuel consumption, machineries required is less for CTB and CTSB method than the traditional method. Hence the initial cost of construction is less for CTB and CTSB method. The CTB and CTSB is having more strength as compare to the traditional material. So the maintenance work required for CTB and CTSB will be less. It will save the maintenance cost and affects the life cycle cost of the project.

CTB and CTSB method gives better results than the traditional method of construction of flexible pavement. It is seen that the pavement with conventional crust fails for the distresses such as cracking, and rutting. But the CTB and CTSB better fatigue and rutting resistant. Hence it is recommended that to use this material for the construction of Base for road pavement. As it reduces the material requirement, minimizes the initial cost of construction, gives better strength than the traditional materials and reduces the maintenance work of the project which affects the life cycle cost of the entire project.

Also by using CTB/CTSB we create strong rigid sub base so that the reduction in the bitumen consumption. The pavement thickness is reduced up to 100 mm by using the CTB/CTSB method. It has longer life of the pavements than that of the conventional pavement.

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