Comparative Analysis of Innovative Material Used in Pavement Construction - A case study

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***Abstract*— Highway play a vital role in the overall economic development of the country and the pavements are an important part of the road. So that it is important that the road pavements should be well designed and constructed so that they can allow the heavy movement of traffic through them. A road pavement structure is made of multiple layers of processed and compacted materials, in different thicknesses and in both unbound and bound forms, which together form a structure that primarily supports vehicle loads as well as providing a smooth riding quality. But the major problem faced by many developing countries is the durability of pavement is less and requires more maintenance. The selection of highway construction materials is based on the type of roadway, identified and predictable traffic volume and the climatic conditions of the region. Nowadays transportation engineers have a more scientific approach; they use eco-friendly methods to construct roads.**

***Key Words*— GSB, WMM, BC, DBM, White Topping, Geogrid, Innovative Material.**

I. INTRODUCTION

India is one of the fastest developing countries in the world. The future development of our country depends on the development of its infrastructure and efficient delivery of its services. Highway play a vital role in the overall economic development of the country and the pavements are an important part of the road. So that it is important that the road pavements should be well designed and constructed so that they can allow the heavy movement of traffic through them. Road is the most important structure that decides the economic growth of a country. The road structure is to be constructed based on the traffic requirements, climatic conditions of the area, terrain, etc. The road structure has to withstand abrasion loads and climatic and terrain conditions without failure. A road pavement structure is made of multiple layers of processed and compacted materials, in different thicknesses and in both unbound and bound forms, which together form a structure that primarily supports vehicle loads as well as providing a smooth riding quality.

Various factors can degrade the road pavement such as climatic conditions, frequency of usage, and the weight of the vehicular traffic. Here, we will explore the whole concept of the road pavement.

- The road pavements are constructed to transmit the heavy load of the movement of vehicular traffic.
- It provides a smooth surface for the movement of the traffic.
- It does not allow rainwater to accumulate on the surface.
- Road pavements help in the effective transportation of vehicles.

But the major problem faced by many developing countries is the durability of pavement is less and requires more maintenance. The selection of highway construction materials is based on the type of roadway, identified and predictable traffic volume and the climatic conditions of the region. Nowadays transportation engineers have a more scientific approach; they use eco-friendly methods to construct roads. The highways are designed to stand up to the different stresses of heavy traffic, and they should support traffic during the different weather conditions.

The conventional layered flexible pavement is constructed in a layered system that consists of

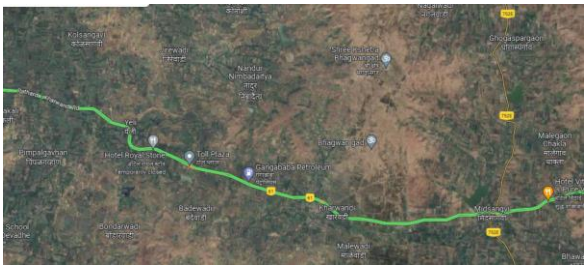
Subgrade, Granular Subbase (GSB), WMM, DBM and BC etc. During the construction of the conventional layered flexible pavement, the high-graded materials are placed at the topmost part of the pavement and the low-graded materials are placed at the bottom layers.

The innovative materials used in the pavement such as CTSB (cement Treated Sub Base) and CTB (cement Treated Base), Geogrid, Stone matrix asphalt (SMA), White Topping etc.

II. STUDY AREA LOCATION

This current research is limited to explore the concept of Innovative Materials used in Pavement Construction of the project of two lane stretches with paved shoulder of NH-222 (New NH-61)

1. From Malshej Ghat (Km 101/000) to Ane Ghat (Km 161/000),
2. From end of Ane Ghat (Km 161/000) to Start of Ahmednagar Bypass (Km 211/000), and
3. From Bhutetakli (Km 284/000) to Junction of NH-211 (Km 337/000) in the state of Maharashtra as a case study. (Total Length – 153 Km)



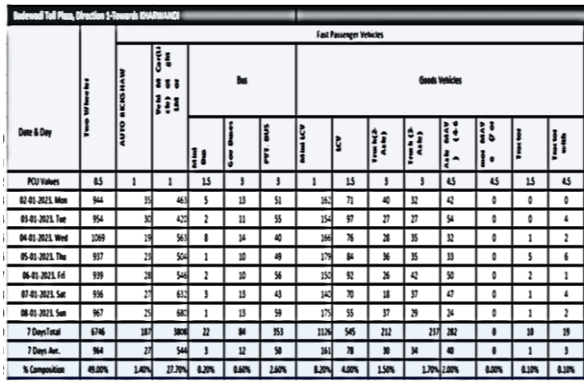
III. DATA COLLECTION

The main data will be acquired from the literature, while the secondary data will consist of Falling Weight Deflectometer (FWD) data, traffic counts, and existing pavement details.

The FWD measures the deflection of the pavement under the impact of a falling weight, providing valuable data to determine the load-bearing capacity, resilience, and overall integrity of the pavement. Such assessments help in making informed decisions about pavement maintenance, rehabilitation, and design, ensuring safe and durable road.

The traffic counts, combined with data on axle loads and repetitions, are used in pavement thickness design methods. These design methods ensure that the pavement has sufficient thickness to distribute the traffic loads and avoid excessive stresses on the underlying layers.

Table I: Traffic Data Analysis



1. New material used in pavement

Govt. of India is promoting use of cost effective new/alternative material and innovative technology in highway construction and maintenance.

Accordingly, Contractor/ Concessionaire has freedom to use any type of pavement for the project, subjected to satisfy the

Design Traffic load (MSA) on the road (Present with projected for design life)

2. Innovative Materials

Table II:- List of Innovative Materials

Sr. No	New/ Alternate material / Innovative technology	Applications
1	Cement Treated Granular Layer	In base (CTB) and subbase course (CTSB)
2	Geo Synthetics (Geogrid)	In Subbase, Filtration Layer
3	SMA (Stone Matrix Asphalt)	Wearing Coat
4	Thin White Topping	Wearing Coat

This material used to active

- Increasing the speed of construction without compromising quality
- Reducing the cost of Construction and maintenance
- Improving asset durability
- Enhance safety
- Lowest life cycle cost
- Design Life of Project is increased upto 10 years

3. PAVEMENT DESIGN

Table III: CONVENTIONAL TYPE FLEXIBLE PAVEMENT

CRUST	Thickness (mm)
Subbase	500
GSB	200
WMM	250
DBM	100
Total	1090

Table IV: CTSB, CTB, DBM, BC

CRUST	Thickness (mm)
Subbase	500
CTSB	200
CTB	130
DBM	60
Total	930

Table V: - GSB, WMM, DMB SMA

CRUST	Thickness (mm)
Subbase	500
GSB	150
WMM	150
DBM	60
Total	910

Table VI: GSB, GEOGRID, WMM, DBM**, BC**

CRUST	Thickness (mm)
Subbase	500
GSB	150
WMM	150
Total	900

Table VII: GSB, WMM, DLC, WHITE TOPPING

CRUST	Thickness (mm)
Subbase	500
GSB	150
DLC	150
WHITE TOPPING	100
Total	900

IV.CONCULSION

The main purpose of the study is the is to compare these new crust materials with conventional materials used in crust of the pavement for the private developer and the authority among various alternatives investigated for the development of road project. Accordingly, find out most economical crust materials to be used for the pavement crust.

The aim of the Comparative Analysis of Innovative Materials is to determine the most cost-effective pavement crust option. This analysis involves evaluating FWD data, traffic studies, pavement design, and conducting financial calculations for the road pavement. The results are presented in Table VIII and Table IX, which showcase the results of the pavement assessment and the financial analysis, respectively.

Table VIII:

Alternative no.	Details	Construction cost Cr.	Annual Routine Maintenance cost Cr	Periodic Maintenance cost Cr
1	CONVENTIONAL TYPE FLEXIBLE PAVEMENT	431.75	11.55	215.48
2	CTSB, CTB, DBM, BC	473.30	9.55	175.79
3	GSB, WMM, DMB,SMA	345.16	8.55	174.79
4	GSB, GEOGRID, WMM, DBM, BC	313.20	7.55	175.84
5	White Topping\	381.53	9.77	77.33

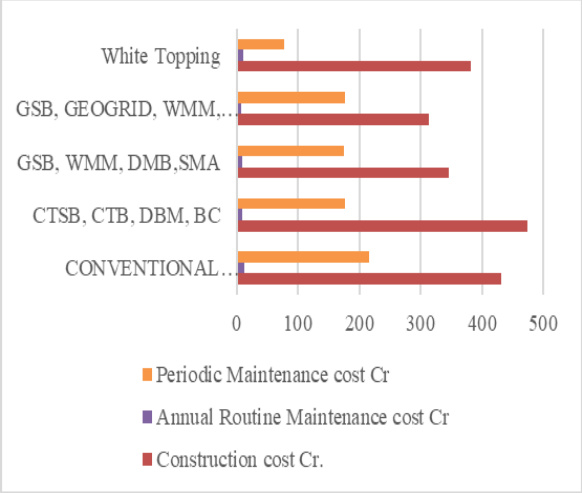
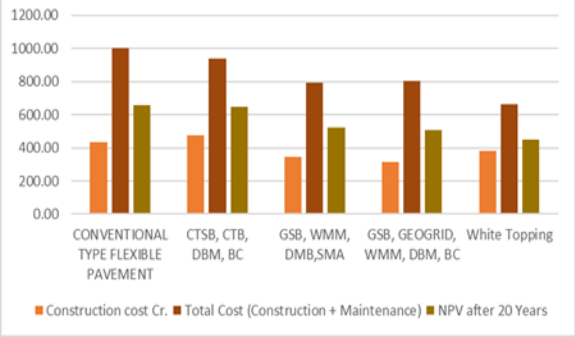


Table IX: -

Alternative no.	Details	Total Cost (Construction + Maintenance)	NPV after 20 Years
1	CONVENTIONAL TYPE FLEXIBLE PAVEMENT	1070.61	686.93
2	CTSB, CTB, DBM, BC	996.78	672.22

3	GSB, WMM, DMB,SMA	848.63	545.17
4	GSB, GEOGRID, WMM, DBM, BC	800.77	507.81
5	White Topping	664.26	450.51



To determine the optimal crust thickness for road, pavement design, a cost analysis is conducted, including the calculation of the Net Present Value (NPV) to justify the selected thickness and material. Furthermore, the assessment reveals that utilizing innovative materials not only proves cost-effective for the government but also enhances the durability and performance for road users.

After analyzing different models, it becomes evident that each model has its advantages and disadvantages. However, when compared to the other options, the White Topping model proves to be the most cost-effective choice. To arrive at this conclusion, we conducted a Net Present Value (NPV) analysis, considering the net cash flows (Income - Expenses) for each model. The GSB, White Topping model demonstrated the highest net cash flow (adjusted NPV) of INR 450.51 Crore, surpassing the performance of other models significantly.

The findings of the Innovative analysis reveal that the construction costs of GSB, GEOGRID, WMM, DBM, and BC models are the lowest compared to other options. However, it is noteworthy that white topping model stands out with the least maintenance cost among all the alternatives.

Therefore, the study concludes that the Project road can be constructed by using white topping. This crust composition is beneficial to Government.

V. ACKNOWLEDGEMENT

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