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CURRENT PERPETUAL PAVEMENT EFFORTS IN INDIA - A CASE STUDY AND DESIGN WITH COMPARISON OF DIFFERENT PAVEMENT LAYER OPTIONS IN PERPETUAL PAVEMENT

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Abstract - The construction of perpetual pavement has just recently started in India, and the design limitations of tensile strain at the base of the asphalt and compressive strain at the top of the subgrade are checked for 80 and 200 micro-strains, respectively. With SMA - 50 mm, DBM - 250 mm, WMM - 150 mm, GSB - 200 mm, and Subgrade - 500 mm pavement layers, the Delhi Vadodara Expressway Project (8 lanes divided carriageway) is constructed in the country's first perpetual pavement. As it is seen that the proposed perpetual pavement crust in India is of higher construction cost due to use of conventional pavement layers. Hence, this study identifies the cost-effective alternative crust for perpetual pavement. In India the road transportation has gradually increased over the years with improvement in connectivity between cities, towns and villages in the country. Considering the financial impact on Nation the Ministry of Road Transport & Highways has published the circular vide MoRT&H (GOI) RW/NH-33044/18/2020-S&R(P&B) Dated: 14th Dec 2020 regarding cost effective new / alternative Material and Technology in highway construction to reduce construction cost.
However, this study deals with to find out the alternate option for the Perpetual Pavement versus current implementation in India for upcoming Expressway / Highway in India.

***Key Words*:** Perpetual pavement, Expressway, Environment effects, construction cost, current implementation

1. INTRODUCTION

An asphalt pavement that is intended to survive for more than 50 years without having extensive structural repair or reconstruction is known as a perpetual pavement. Instead, it just needs periodic surface replacement to address problems that are limited to the top of the pavement.

In India, conventional pavement is intended to last for 15-20 years, but it is typically discovered that rehabilitation is needed after 5-7 years or sooner, and early failure happens after construction due to the use of subpar materials, overloading, permitting vehicles before all pavement layers have been completed, and a lack of sufficient quality control throughout the building of the pavement layers. According to Indian codal provisions, the corresponding limiting strains may be considered as 80 and 200 micro strains, respectively, given the climatic conditions present in India's plains, where the average annual pavement temperature may be near to 35^0C. In order to keep the horizontal tensile strain and vertical compressive strain within the previously indicated limiting strain values corresponding to endurance conditions, long-life pavement design entails choosing an appropriate pavement layer mix. Only the surface course of the long-lasting pavement's many layers has to be developed and built in such a way that it may occasionally be replaced.

2. LITERATURE REVIEW

A report on Perpetual Pavement: Way Forward from Design to Quality Construction (nbmcw.com) Atasi Das, Assistant Vice President, G R Infraprojects - Delhi Vadodara Expressway (8 Lane Divided Carriageway)

This study presents the Perpetual Pavement idea and its practical use in the construction of expressways in India while taking into account the special layers, materials, and thicknesses that are pertinent to Indian circumstances and are in accordance with the regulations of the Indian Road Congress.

For mix design of asphalt mix, layer thickness, grading, and performance testing for perpetual pavement, there are no established guidelines. It has been determined that the maximum size of aggregate to be utilized is 25 mm, and 26.5 mm for Indian grading consideration, based on previous work done abroad. In India, aggregates with a size of 37.5 mm are used for DBM 1, however using bigger aggregate sizes has the drawback of trapping water in the mixture, which produces vapour in the summer heat and fractures or segregates aggregates from bitumen, causing pavement discomfort. It is advised that DBM Grade 1 be avoided in perpetual pavement as a result. The usage of stone matrix asphalt (SMA) was chosen to resist both rutting and durability issues for the renewable surface layer in order to accomplish the target of a 20-year surface life. SMA is a very rut-resistant bituminous course that has been successfully employed by many nations across the world as both a binder (intermediate) course and a wearing course, particularly for heavy traffic loads. SMA was developed in Germany in the middle of the 1960s. For efficient weight transfer, it is a gap-graded bituminous mix with stone-on-stone contact.

Guidelines for the Design of Flexible Pavements IRC:37-2018 (Fourth Revision) (Published by Indian Road Congress)

According to IRC:37-2018, a pavement is referred to as long-life or perpetual if its lifespan is fifty years or longer. Pavements with design traffic of 300 msa or more may be created as long-life pavements in the Indian environment. According to Asphalt Institute, MS-4, 7th edition [39], the bituminous layer would never break if the tensile strain brought on by traffic in the layer is less than 70 micro strain (considered to be the endurance limit of the material). Similar to this, there won't be any rutting in the subgrade if the vertical subgrade strain is less than 200 micro strain. The comparable limiting strains for the climate on the Indian plains, where the average annual pavement temperature may be near to 350C, may be taken as 80 and 200 micro strains, respectively. In order to maintain the horizontal tensile strain and vertical compressive strain within the previously indicated limiting strain values corresponding to endurance condition, long-life pavement design entails choosing an appropriate pavement layer mix. Only the surface course of the long-lasting pavement's many layers has to be developed and built in such a way that it may occasionally be replaced.

A Synthesis on Perpetual Pavement by Dr. David Newcomb of the National Asphalt Pavement Association for the Asphalt Pavement Alliance (APA).

This document was prepared for the Asphalt Pavement Alliance (APA), a coalition of the National Asphalt Pavement Association (NAPA), Asphalt Institute (AI), and State Asphalt Pavement Associations (SAPA).

The effectiveness of well-built, thick asphalt pavements has developed the idea of the perpetual pavement. Deep-strength and full-depth asphalt sections have been demonstrated to restrict distresses to the upper pavement layers, while being meant to function similarly to more traditional flexible pavements. This lowers the expense of rehabilitation and the inconvenience to users by allowing for routine removal of the surface layer and replacement with an HMA overlay. Recycling the pavement material that has been removed from the surface helps to preserve natural resources. There is a limit beyond which increasing HMA thicknesses yield very little return on investment, hence a different design strategy is required. Mechanistic approaches provide a way to determine the ideal pavement structure that won't need to be rebuilt for a certain material combination by calculating the stresses in pavement constructions. Distinct mixing characteristics need the development of different design criteria. In Illinois, California, and the United Kingdom, work on this has already started.

A method for designing pavements with a long lifespan has been proposed by the Transport Research Laboratory in the UK. The creation of national policies and processes should come next, giving pavement engineers the resources, they need to properly plan and build perpetual pavements. Along with new or reconstructed pavements, these recommendations should cover the rehabilitation of rigid and flexible pavements.

Review on the importance of perpetual pavement in future pavement networks (Mithil Mazumder, Hyunhwan Kim, Soon-Jae Lee - Journal of Advanced Construction Materials, Vol.19 (1), 2015)

The significance of perpetual pavement in upcoming pavement networks is discussed in this research. Perpetual pavement is defined, along with its mechanistic-empirical design principles and distinctions from ordinary pavement. There are offered specific layer uses and distresses. Future research recommendations are made in order to get the best asphalt perpetual pavement design. Due of their sustainability, perpetual pavements are becoming increasingly well-liked and accepted. Although users of perpetual pavement benefit from increased safety and lower user delay costs owing to less maintenance operations, there are also issues with the design technique being changed, economic applicability, and material limitations. For a better grasp of how to apply the ideal asphalt perpetual pavement design, fruitful research is required. It is necessary to do more study and construct a numerical model that replicates the deterioration of perpetual pavement based on wheel movement, freeze-thaw cycles, stochastic approaches, and partial or complete debonding.

In order to build high modulus asphalt pavement with a reduced overall thickness and lower material consumption, study is required to determine the best mix design. Based on the actual traffic section, it is necessary to invest in updating the fatigue endurance limit by creating a correlation between the laboratory fatigue endurance limit and field observed strain. Additionally, research is required to determine the causes, modes of failure, and optimum methods of compaction for top-down cracking. Understanding pavement layer bonding is crucial from an execution aspect since structural layers strengthen over time rather than deteriorate. Additionally, it is necessary to research how to transform the current pavement into the best permanent pavement.

It has been proven that perpetual pavement is more cost-effective than standard pavement when user delay costs are taken into account. Therefore, life cycle cost analyses may be done on several types of everlasting pavement. Perpetual pavement's high initial construction costs are primarily due to how much asphalt it consumes. So, a cost-effective strategy would involve utilizing less asphalt to produce it while still guaranteeing its definition. A sustainable optimum everlasting pavement design is unavoidable for future roadway networks because to the rising cost of aggregates and other pavement materials.

3. OBJECTIVE OF STUDY

This study deals with to find out the alternate option for the Perpetual Pavement versus current implementation in India. The main objective of this study is designing a perpetual pavement strategy that will be more cost - effective and efficient and feasible than existing attempts to build expressways and highways in India. In this study, the thicknesses of the Perpetual Pavement are analyzed using “IITPAVE” software.

4. APPROACH & METHODOLOGY OF STUDY

The process for choosing the best methodological approaches to achieving the suggested strategic objectives is outlined below.

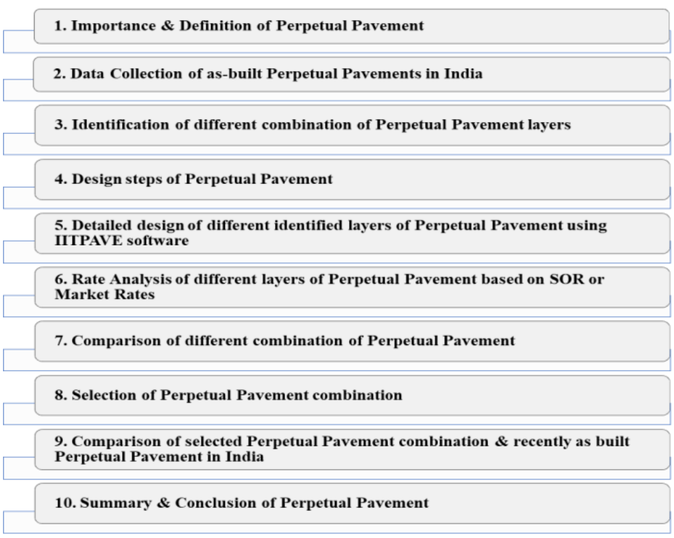

Fig -1: Flow Chart of Methodology

5. FUTURE SCOPE OF STUDY

India has the second-largest road network in the world, spanning a total of 6.3 million kms. The huge network of Expressways & National Highways is currently under implementation in India. Also, most of the Expressways & National Highways are upcoming in India.

The objective of selection of this topic is to introduce option of Perpetual Pavement which is cost effective, less environment effects than current efforts & less time required for Construction.

In India the first Perpetual Pavement is constructed in the Delhi Vadodara Expressway with thicknesses are wearing course as (SMA) - 50 mm, bituminous binder course (DBM) - 250 mm, granular base course (WMM) - 150 mm, granular subbase course (GSB) - 200 mm & Subgrade - 500 mm. Also, the most of the upcoming expressway / highways are also are proposed as perpetual pavement.

The Ministry of Roads & Transport Highway are published the circular MoRT&H (GOI) RW/NH-33044/18/2020-S&R(P&B) Dated: 14th Dec 2020 regarding cost effective new / alternative Material and Technology in highway construction to reduce construction cost. In this regard we have to think on the alternative combination of perpetual pavement to reduce the construction cost & other benefits of it.

Accordingly, the future scope of study is mainly to identify option of perpetual pavement which is cost effective, less environment effects than current efforts & less time required for construction. This study will be most helping in the reduction of the cost & less environmental impact of perpetual pavement for the upcoming expressway in India.

6. CONCLUSION / OUTCOMES OF THE STUDY

The outcomes of this study will be as follows:

1. The detailed design of perpetual pavement of options given in table below of for 15% effective CBR will be carried out. The design of below options of Perpetual Pavement using IITPAVE software for 15% effective CBR will be ready to use.

Table -1: Proposed Perpetual Pavement alternatives

Sr.	Options	Layers
1.	Option A	SMA + DBM + WMM + GSB + Subgrade
2.	Option B	SMA + DBM + AIL + CTB + CTSB + Subgrade
3.	Option C	SMA + DBM + SAMI + CTB + CTSB + Subgrade
4.	Option D	SMA + DBM + RAP + CTSB + Subgrade
5.	Option E	SMA + DBM + AIL + CTB + GSB + Subgrade
6.	Option F	SMA + DBM + WMM + CTSB + Subgrade
7.	Option G	SMA + DBM + Geogrid reinforced WMM + Geogrid reinforced GSB + Subgrade
8.	Option H	PQC + DLC + GSB + Subgrade

* SMA - Stone Matrix Asphalt, DBM - Dense Bituminous Macadam, WMM - Wet Mix Macadam, GSB - Granular Sub base, AIL - Aggregate Interlayer, CTB - Cement Treated Base, CTSB - Cement Treated Sub base, SAMI - Stress Absorbing Membrane Interlayer, RAP - Reclaimed Asphalt Pavement, Geogrid Reinforced WMM - Geogrid Reinforced Wet Mix Macadam, Geogrid Reinforced GSB - Geogrid Reinforced Granular Sub base, PQC - Pavement Quality Concrete, DLC - Dry Lean Concrete

2. This study will be assisted in understanding the basis for the selection of pavement crust option for perpetual pavement.
3. The cost comparison for the Perpetual Pavement will be ready to use to selection of pavement configuration as per availability of material.
4. This research study discovers and designs a perpetual pavement strategy that will be more cost - effective and efficient and feasible than existing attempts to build expressways and highways in India.
5. This study discovers the perpetual pavement option from above alternatives which is cost effective, less environmental effects than current efforts & less time required for construction.

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