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Analysis of Highway Construction and Execution Process with Reference to NH4

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Abstract: ***Road transport system acts as an essential constituent of the infrastructure of India which contributes to economic development and connectivity. National highways, although forming only a small portion of the entire network of roads, handle a significant amount of vehicular traffic. This paper discusses a case study on the construction practices and methodology of flexible pavement construction on NH4 (currently known as NH48) from Kolhapur to Mumbai. The case study has been conducted based on site observation along with conventional construction methodologies such as preparation of sub-grade layer, granular sub-base (GSB), wet mix macadam (WMM), dense bituminous macadam (DBM), and bituminous concrete (BC). Special attention will be paid to material requirements and construction process. The results will also provide comparison of current practice with IRC and MORTH standards.***

Keywords: Highway Construction, NH4, Bitumen, Pavement Layers, WMM

I. INTRODUCTION

The transportation infrastructure plays a major role in determining the overall economy and social structure of a country. In the context of India roads are a widely utilized mode for transporting both passenger and freight. National Highways is an extremely significant part of this system because they connect all major cities, industry regions, ports and other important locations of the country and despite making up for a very small proportion of total road length, a large proportion of total passenger and freight is transported over them. Design and construction thus play a vital role in the performance of NHs.

NH4 which has now been renumbered as NH48 is an important corridor between two high traffic load and economy dependent region of Kolhapur and Mumbai. Given the immense utilization of this highway by both passenger and goods vehicles, the construction methods adopted in them and the management of performance of the pavement becomes an important factor, given the constant traffic and varying environmental conditions it has to withstand.

Flexible pavements are one among the types of highway pavements that are widely used as they are able to adapt to conditions of stress and are economical. Also, they can be relatively easily repaired. A flexible pavement structure consists of several layers where each layer performs a function for distributing the traffic loads on to the sub-grade and providing structural capacity. In the case of flexible pavements typically there is the presence of sub-grade, granular sub-base, wet mix macadam, dense bituminous macadam and the bituminous concrete layer.

The performance of flexible pavements not only depends on its design but on the quality with which the construction methods are adopted. Aspects like compaction, temperature control and moisture control during the time of construction can affect the overall quality of pavement layer. However, even with standard guides followed, the conditions at the field level can result in varying outcomes. This paper presents the case study of highway construction on NH4 between Kolhapur and Mumbai which studies the process, materials involved and the quality control during the construction of the flexible pavement. It also includes a comparison of construction practice with the standards provided by the IRC and the MORTH. The paper aims at creating a picture on the construction of highway construction practices at the site and how an adequate construction can lead to a sustainable pavement structure.

Flexible pavement systems are generally preferred on high ways because it is a flexible system and can resist different traffic load conditions and environment. These pavements are laid in various layers, so as to transmit the wheel load evenly to the sub grade. Load bearing capacity not only depends upon the design, but it is also depends on construction aspects.

In practical fields of highways loading on highways are continuously varying due to movement of vehicle. Also load is subjected to constant temperature and moisture fluctuations which, if not properly executed while construction will deteriorate the future performance of pavement. It will be beneficial to study the actual construction practice at site and compare it with the code provision.

This study is based on the construction practices of NH4 (NH48) between Kolhapur and Mumbai, considering standard guidelines and typical execution methods. The aim is to understand how flexible pavement construction is carried out in real-world conditions.

II. OBJECTIVES

The objectives of this project are listed as:

1) To explore the whole construction process of the flexible pavement starting from the subgrade to the top bituminous layer.
2) To gain the knowledge of the performance of various pavement layers such as GSB, WMM, DBM, BC.
3) To learn about the materials used in highway construction. These includes the various types of soils, aggregates and bitumen used in highway constructions.
4) To learn about the sequence of operation involved in the construction of the highway.
5) To study the various methods adopted for construction and the quality control adopted for construction of highway.
6) To correlate theoretical study and practical construction.
7) To analyse the highway construction using the information gathered using NH4 (Kolhapur- Mumbai stretch).

III. LITERATURE REVIEW

1) The construction of highways and pavement design have been a extensively researched topics by many researchers working in the field of civil engineering. IRC:37(2018) provides design methods for flexible pavement design on basis of traffic loading and subgrade characteristics and MORTH (2013) provides comprehensive specifications for construction practices, materials and quality control activities.
2) Huang (2004) discusses the behaviour of layered pavement system and load distribution mechanisms of pavement. Roberts et al. (2009) also covers properties of bituminous materials and performance of pavement in different temperature. Brown (1996) also underlines the significance of soil properties in pavement design and performance.
3) Kadiyali (2013) and Khanna and Justo (2011) present comprehensive detailed discussion regarding highway engineering practices.

Most of the research is based on analytical and laboratory studies but this study is based on actual case study on highway construction work which represents the execution of design.

IV. METHODOLOGY

This study is based on a case study approach and does not involve experimental testing. The methodology includes:

1) This study is about the construction methodology practices being followed for the flexible pavement on NH4 (Kolhapur-Mumbai stretch) using the case study methodology. This work was done by field observation of the construction process, and then comparing the results with that with standard road construction practices.
2) The work included, site investigation, excavation, embankment construction, preparation of subgrade, laying of different layers of pavement such as GSB, WBM, DBM and BC. The materials involved, such as, soil, aggregates, and bitumen were also checked to know the effect of the quality on the road.
3) Comparison of the construction procedure being performed with standard practices of construction as laid down by the Indian Road Congress (IRC) and Ministry of Road Transport and Highways (MORTH) was also made and also found out factors which play a vital role.

V. CONSTRUCTION PROCESS

1) Site Investigation: The site investigation was conducted to know about soil and ground water characteristics of the area. For the assessment of soil characteristics disturbed and undisturbed samples were studied.
2) Excavation and Embankment: Excavation was done as per alignment and levels. Embankment was done layer by layer, with adequate compaction and maintenance of moisture content.
3) Subgrade Preparation: The subgrade was compacted with adequate compaction to achieve specified strength and stability with appropriate moisture content. Carefully preparing subgrade is needed as it represents the entire structure from the bottom. It must have good performance, otherwise the performance of upper layers will be weakened.
4) Granular Sub-Base (GSB): GSB was constructed with well graded aggregate, watered and compacted with rollers to attain specified density.

5) Wet Mix Macadam (WMM): The WMM was prepared at a mixing plant and spread through paver. Gradation and compaction was maintained to get strength.
6) Dense Bituminous Macadam (DBM): DBM was prepared at a desired temperature and transported carefully without allowing it to cool down, it was then spread over the required surface. Compaction was provided as per specifications.
7) Bituminous Concrete (BC): Bituminous concrete was provided as the top layer; the required compaction was done to get smoothness and durability. Control over temperature was maintained during laying.

VI. HIGHWAYS CONSTRUCTION EQUIPMENT

During the construction of highway different types of equipment are being used to conduct the operations appropriately and with the required quality.

A. Excavator

An excavator is utilized at the beginning of construction to carryout the excavation process for road formation and helps to cut, dig out the soil with the proper level and alignment of the road. It is helpful to clean the site and makes preparation for other construction activities. It helps the earth work at the faster and the appropriate level compared to manual process.

B. Dump trucks

A dump truck is used to convey the materials like excavated soil, aggregate and others from one point to another. At each stage of construction it require to transport materials to various places continuously and thus the process will go in uninterrupted with the help of the dump trucks.

C. Roller (Compactor)

A roller or compactor is used to compact different layers like subgrade, GSB, WMM etc. Compaction improves the density and strength of the material and reduced the air voids. A good compaction is very essential for proper load carrying capacity of pavement layers.

D. Paver Machine

A paver machine is used to lay the pavement layers like WMM, DBM and BC. It spreads the material on the roads properly at consistent thickness and alignment.

VII. MATERIALS USE

Properties and types of materials used for highway construction are very important for strength and durability of pavement structure. The performance of the pavement structure depends on using right material and testing the material properties.

A. Soil

Soil provides the base for pavement structure, and it constitutes the subgrade layer. Its strength and stability depend on type of soil, moisture content, degree of compaction. If the soil is weak or not compacted enough it deforms.

B. Aggregate

Aggregates are used for layer like GSB and WMM. Aggregates used should be of a good strength and durable for the loads applied by traffic. These are required to be properly graded for good compaction and good load transfer from upper layer.

C. Bitumen

Bitumen is used as binder in DBM and BC layer, holding the aggregate material together creating a smooth and hard surface. Performance of bitumen depends on the temperature of mixing and viscosity, etc.

VIII. QUALITY CONTROL MEASURE

1) Density tests for compaction
2) Moisture control during construction
3) Temperature control in bituminous layers
4) Visual inspection of layers

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IX. RESULT AND DISCUSSION

It is concluded that sound implementation of construction procedure is essential in governing performance of flexible pavement. Out of all other parameters, compaction was one of the most significant factors that affect the pavement layer stability and strength. Failure in implementing correct procedure may result in deformation and settlement of pavement layer due to traffic load.

Moisture control was also noted to be extremely important in preparation of subgrade and WMM construction. Controlling moisture close to optimum moisture content could lead to increased density and higher load bearing characteristics of the layer. Likewise, control of temperature during placement of bituminous layer viz. DBM, BC, etc. Was required to gain proper bond and compaction.

It is finally concluded that any deviation from the specified construction practices may lead to pavement distress like cracking, rutting, surface distortion etc., therefore construction as per IRC and MORTH specifications is required to achieve durable pavement.

Additional to the points mentioned above, continuous inspection during the construction was also considered to be important in ensuring the quality of construction. Inadequate supervision can lead to non-uniform compaction and incorrect layer thickness; thus, can shorten pavement life. Skilled supervision and construction in accordance with standards are required for durability of pavement.

Fig. Typical Cross Section of Flexible Pavement

X. CONCLUSION

This particular case study shows that construction of highway needs proper planning, selection of material and construction method. NH4 project indicates that IRC and MORTH standards need to be followed for good performance of the pavement and importance of compaction, moisture control and temperature during construction.

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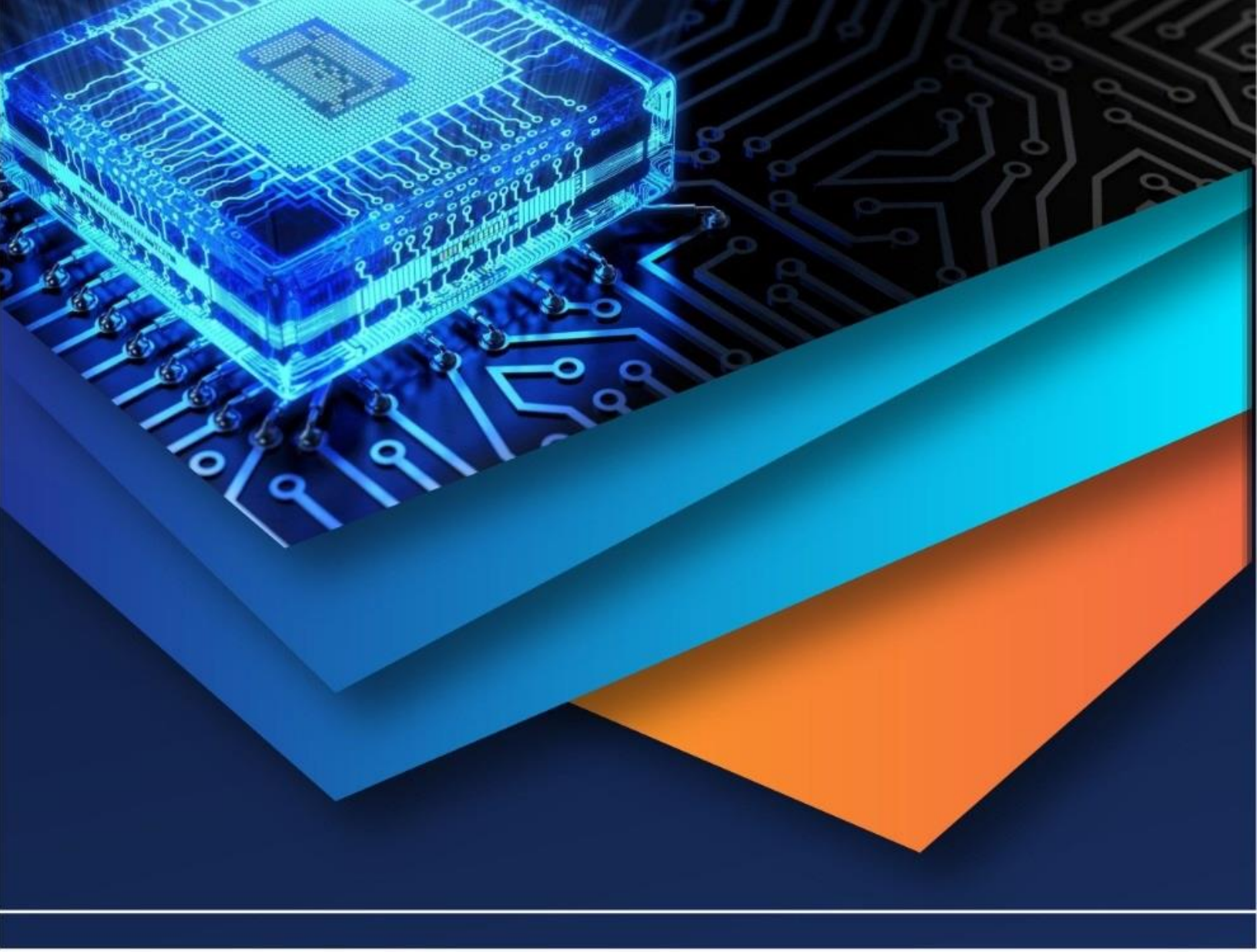

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