

Bridge Load Rating and Analysis Using MIDAS Civil

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Abstract- The present effort focuses on improving the technique for analyzing and designing flexible pavement by taking into account the wide range of materials that will be utilized in the various pavement layers and the real field's environmental conditions. In order to understand how different loading conditions and material qualities affect performance parameters, the 2D axis symmetric finite element approach is used. The horizontal and vertical limits of the mesh are established after assuming and validating the planned pavement sections from the relevant codes. Subgrade soils were categorized according to their strength parameters by field study and laboratory examination. This research analyzes the impact of various waste products, both singly and in combination, on the physical characteristics, rutting, and fatigue behavior of pavement in a controlled laboratory setting. Structural models make use of a wide variety of input data, such as traffic characteristics, moduli of paving materials, etc. Distress models employ structural model outputs such as strains, stresses, and deflection, and their results are compared to fatigue and rutting requirements from the design handbook of flexible pavement (IRC37-2012). By comparing the estimated strains at the key sites with the allowed limits, the thicknesses of hypothetical circumstances created under different combinations of different materials and varied thicknesses may be determined. The majority of India's flexible pavement is showing signs of early deterioration, much before the end of its expected lifespan. The results of an analysis of the relationship between overloading and inflated pressure show that the former is likely a contributing factor to the premature degradation of pavement. Overloading has a greater impact on pavements built on poor subgrade soils; hence, this problem must be addressed at the pavement design phase. Back-calculated elastic moduli bituminous mix designs, as suggested by temperature analysis, are likely to have the best possible depth, making them more cost-effective. The proposed design charts are more realistic and optimal since they take into account a number of aspects of diverse nature; these charts may be used to replace an existing pavement section in a way that is both environmentally friendly and fiscally responsible.

Keywords: Bituminous Cement, Crumb rubber, Tensile Strength ratio, Bulk Density, Air voids, Air voids, Rutting, Marshall Stability, flexible pavement.

I. INTRODUCTION

Any nation's progress is tied to the quality of its road system. As a result, several large-scale development initiatives are currently under way in emerging economies like India. The most common causes of traffic mishaps are the building of new roads and the neglect or poor maintenance of existing roads, which results in cracks, potholes, and an uneven surface due to rutting. The World Health Organization (WHO) has already designated the current decade as the decade of action for road safety because of the staggering number of lives lost and people permanently disabled every year due to traffic collisions. There were 1,51,417 fatalities and 4,69,418

accidents on India's roads in 2018, according to preliminary data released by the government, placing India at the top of a list submitted to the World Health Organization (WHO) on the topic of global road safety. The Road Transport and Safety Bill has previously been introduced by the Ministry of Road Transport and Highways (MORT&H) [1] to increase nationwide road safety and facilitate travel.

Many developing countries, like India, need to expand its infrastructure to keep up with the expansion of industrial development and to lessen the traffic density on existing transportation systems, both of which contribute to fewer accidents. Overloaded vehicles and other changes in the static

and dynamic features of traffic on these highways necessitate the provision of these additional infrastructural elements. Pavement problems including potholes, cracks, undulations, raveling, rutting, and so on in the bituminous layer are brought on by a combination of these variables. Knowing the impact of these overloaded cars may be mitigated with the use of instrumented pavement, but due to their widespread dispersion across the country, implementing this solution is a time-consuming and laborious operation.

To solve this problem, a comprehensive design approach should be developed alongside appropriate design charts that reflect current needs [2]. The present design recommendations were developed for choosing the pavement material based on the knowledge, experience, and engineering judgements of specialists in the area. The major shortcoming of the Indian Road Congress ..2 (IRC) and American Association of State Highway Officials (AASHTO) [3] codes is that the experiences are based on particular local conditions regardless of regions and different climatic conditions. It is crucial to have a custom tool that can estimate the performance of a new flexible before it is built, for a variety of material and thickness combinations. Using a combination of reclaimed asphalt pavement (RAP) base treated with foamed bitumen/bitumen emulsion, cementitious subbase having Wet Mix Macadam (WMM), base, and bituminous surfacing, as well as the availability of conventional and alternative materials, it is possible to achieve a more durable and stronger composition and a cost-effective approach with bituminous surfacing.

Raveling, undulations, rutting, cracking, bleeding, and potholing are all early signs of strain in bituminous surfacing, which has been accelerated by an increase in traffic, overloaded vehicles, and considerable fluctuations in daily and seasonal pavement temperatures. The necessity for an affordable alternative in the form of an analytical tool that can handle the specifics of the complicated pavement system emerges because a successful pavement design is one that offers the required performance with suitable economic consideration [4]. There is an immediate requirement to produce

an appropriate mix of design procedure/charts that are realistically applicable for any combination of material and environmental condition in order to limit the number of road accidents caused by poor road conditions. Pavement performance may be predicted in advance of construction, saving both time and money compared to traditional methods such as laboratory or on-site testing.

In this regard, the design of flexible pavement using the adaptable finite element method (FEM) is a sure bet. This paper discusses the application of finite element analysis (FEA) in two dimensions to probe the parametric research of flexible pavement. After doing a thorough literature analysis, we conduct the gap research for the present work. As and when necessary, reports have been made detailing the analysis and appraisal of findings from diverse design techniques and approaches pertaining to flexible pavement from across the world. The list of literature referred to is appended at the conclusion of the thesis. The failure of pavement before its design life causes a huge loss for maintenance and construction for this deteriorated pavement structure, which is especially problematic in developing countries like India, where infrastructure facilities are crucial to development.

II. RESEARCH METHODOLOGY

Foreword:

Over the years, experts from a wide variety of countries have created a wide variety of methods for the design of flexible pavement, from single-layer to multi-layer elastic theories and finite element models. In this section, we elaborate on the work done and the methods used in the present study. Beginning with an overview of the finite element method and its key components, this chapter moves on to formulating and evaluating equations to determine results. The final results of the studied scenarios and the selected pavement section using the finite element method are provided. Utilizing Flexible Software for Two-Dimensional Finite Element Modeling

Anslys:

Allows to undertake tedious analysis using two-dimensional finite element analysis for the parametric study of pavement. Analysis is performed by discretizing the playing field into smaller and smaller components, then applying the governing equations and material characteristics to the nodes of those elements. By imposing conditions on the issue, we are able to build equations whose solutions reveal the continuum's reaction to those conditions or restrictions [47]. As can be shown in Figure 3.1, the poison's ratio and moduli of pavement materials in different levels of pavement section are crucial input parameters for structural models used in the design of flexible pavement.

Values of crucial parameters at critical places, which were generated by the structural model, were input into the distress model. We compared the distress model's results with the criteria for failure. If the distress model's output is higher than allowable levels, the pavement portion is unsafe and must be modified by adjusting its thickness and material. When fed into a distress model, structural model outputs like strains, stresses, and deflection yield an output of cumulative standard axles in the form of the number of repetitions. The aforementioned study was performed following preliminary laboratory testing of various waste items. The research is then continued for all trials that were eliminated due to overloading and inflated tyre pressure, and a conclusion is produced based on the analysis performed.

FEM and Hypotheses Vital Considerations:

In the finite element solution approach, there are three primary phases through which an analysis must traverse. According to Zienkiewicz et al. [48], these foundational procedures include: research prior to system idealization; formulation of equations to provide solutions for stated phenomena; evaluation of structure response; and, finally, final design. The steps involved in a finite element analysis are outlined below. 3.3.1 The system idealized: Creating an idealization of the issue or domain being studied is the first step in any FEA. The concept of "finite elements" comes from the need to break down a complicated field into its constituent pieces. There

are several FEA kinds available in the element library. The choice between 2D, 3D, and infinite elements, among others, depends on the nature of the analysis being performed. For 2D elements, the plain stress strain and axis symmetric analysis can yield better findings, whereas for 3D elements, the depth and detail of the continuum can be better analyzed. Infinite element systems, as the name suggests, can be utilized for either 2D or 3D elements if the horizontal and vertical bounds of the considered section are infinite.

III. FIELD AND LABORATORY INVESTIGATION

Foreword:

In growing nations like India, rapid industrialization and the upgrading of infrastructural facilities generate a wide variety of trash, posing a serious challenge in terms of collection, sorting, and disposal. Reclaimed asphalt pavement (RAP), Crumb Rubber (CR), etc., are examples of waste materials that have been recycled, and many industrialized nations have made strides in recycling these materials and created criteria for utilizing them in pavement. However, due to a lack of research on their local environment, people in underdeveloped countries like India are not as knowledgeable about the potential uses of these various wastes. India has the second-longest road system in the world, with a total length of almost 5.5 million kilometers.

Ninety percent of the nation's road system is made up of pavements that can be easily bent or reshaped, and these are the roadways that will benefit most from the different government programs, such as the National Highway Development Programme (NHDP). In order to meet development program deadlines, India is constructing 40 kilometers of new pavement every day, resulting in a massive volume of recycled asphalt pavement (RAP) from previously dug pavement layers [57]. Excavated debris has been piled up along freshly paved roadways or soil filled in the region without any additional treatment for decades. A lot of power is needed so that the plant can make asphalt mix.

Thousands of tons of aggregates are needed annually in the creation of new pavements, and the manufacturing of Hot Mix Asphalt (HMA) for 1 tonne of aggregates (heating and drying) needs around 6-7 liters of gasoline. The manufacture of HMA also results in a significant amount of greenhouse gas emissions due to the heating of aggregates and bituminous binder.

When excellent resources (aggregates, binders) are in short supply in close proximity to building sites, construction costs rise, and pollution is produced by the transportation of supplies from farther away. By substituting acceptable alternatives from readily accessible waste materials like RAP and CR for aggregate and asphalt (binder) in pavement, environmental protection, energy conservation, and, ultimately, cost savings can be realized [43]. Figures 4.1, 4.2, and 4.3 demonstrate how the flexible pavements built in the area of the chosen site in Satara. 52 District are degrading far before the end of their planned life.

The current study seeks to examine the viability of various locally accessible waste materials that may be utilized in pavement construction (such as aggregates, RAP binder, CRMB, etc.) as an eco-friendly and environmental solution to this problem. The study's goal is to experimentally and analytically determine the optimal mix of RAP aggregates and CRMB to fulfill pavement performance in terms of fatigue and rutting life. 4.2.1 Soil samples and the California Bearing Ratio Test: Accurate values of material characteristics, obtained from experimental work, are crucial input parameters for the analytical study; hence, it is crucial to get these values. Since the load from the pavement surface is transferred to the soil under the subgrade layer, the strength of the subgrade soil appears to be the most critical input element in determining the optimal thickness of any pavement section.

Soil types and the local geology were used to create several zones in the immediate neighborhood of the research location. Soil samples were taken from various zones so that a California Bearing Ratio (CBR) test could be conducted, and the results of this test were used to categorize the soils. Three tests were

conducted at each site, and the average value was used to get the CBR value that would be used to categorize the soil based on its strength characteristics. The CBR test method was used to evaluate the soil strength of samples taken from various locations within the research region.

IV. RESULTS AND DISCUSSION

This study involves the analytical and experimental examination of reclaimed asphalt pavement aggregate with conventional aggregates replaced in part by crumb rubber and with bitumen content replaced by crumb rubber. Tables 4.1 and 4.2 provide the most fundamental physical characteristics of all the materials studied, and it is clear that they are all well-suited for use in road building. From the preliminary inquiry as indicated in Table 4.1, it is found that, forgetting the slight differences in the physical characteristics of crumb rubber, no considerable change is seen.

The optimal partial replacement of conventional aggregates with RAP is evaluated through experimental work on RAP samples obtained from diverse sites using the Marshall Stability Test. Similarly, experimental and analytical methods are used to determine whether or not crumb rubber is being used to its full potential. Optimal bitumen content, optimal crumb rubber mix, and optimum RAP aggregate mix are determined by experimental evaluation of Marshall Stability (kN), flow value (mm), bulk density (gm/cc), percentage air voids, and percentage V.M.A. The data are analyzed, and then charts and graphs are used to illustrate the findings.

Results illustrating the effect of changing the bitumen component of the crumb rubber mix on the mix's bulk density is graphically represented in Figure 4.6. Density in bulk can be anything from 2.23 to 2.35 grams per cubic centimeter. From Figure 4.6 through Figure 4.10, it can be shown that the 9% crumb rubber mix outperforms the control mix with 5.5% bitumen content in terms of Marshall Stability (kN), flow value (mm), bulk density (gm/cc), percentage of air voids, and percentage of V.M.A.

V. CONCLUSION

An extra 500mm modified subgrade layer is advised for sandy soil based on the study's findings for employing the RAP aggregates with CB, which would make it safe against important factors like fatigue and rutting. The criterion (Fatigue and Rutting) can be met with a minimum DBM layer thickness of 100 mm and a minimum base layer thickness of 525 mm when working with strong subgrade soils like clay and gravel. It is not possible to suggest a design chart from any tried and true combination for poor strength subgrade soils such as silt and silty sand.

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