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STRUCTURAL EVALUATION OF RIGID PAVEMENT: A Review

Mr. Sujit Ambagade[1], Mr. Laxmikant Vairagade[2]

[1]*PG Student, Dept. of Civil Engineering, G. H. Raisoni Academy of Engineering & Technology, Nagpur – 16, India, Email: ajay.patre3@gmail.com*

[2]*Assistant Professor, Dept. of Civil Engineering, G. H. Raisoni Academy of Engineering & Technology, Nagpur – 16, India*

Abstract

Pavements are the important part of the infrastructure for the development of country. Flexible pavement are widely use and maximum road network is of flexible pavement. But now a days the construction of rigid pavement is increasing due to there own benefits and it is necessary to study the rigid pavement property and behavior under loading. Analysis of the rigid pavement is necessary to study and evaluate the pavement for improve the design procedure in the traditional design method. Rigid pavement is studied for to find out the weaker portion, causes of distress such as deflection, tensile stresses, temperature stresses, stresses at joints, edge and at corner of the pavement. Stress pattern are plotted for the same. Finite-element analysis is not new to the pavement analysis and research community. Two-dimensional finite-element programs have been in use for the past two decades to analyze rigid pavement response. In recent years three dimensional finite-element analyses emerged as a powerful tool capable of capturing pavement response. The study of effect of temperature effect, stress pattern for various condition of pavement using ANSYS software is presented. Theses study result are compared with traditional design method and required improvement in design are suggested. It is observed that temperature caused stresses in long slab. And heavy load caused critical stress at joint, edge and corner of the slab.

Index Terms: *Rigid Pavement; ANSYS; Finite Element Method; Stress pattern; Temperature stresses.*

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INTRODUCTION

In recent years, cement concrete pavements are being adopted in many new road projects in India in view of their longer services lives, lesser maintenance requirements and smoother riding surface. The current practice of constructing concrete pavement on Indian highways is to provide a granular sub-base over the sub-grade to be followed by Dry lean concrete base with the concrete slab on top which is called rigid pavement. Rigid pavements are those which possess flexural strength & flexural rigidity. The stresses are not transferred from grain to grain to the lower layer as in the case of flexible pavement layers. The rigid pavement are made of Portland cement concrete either plain, reinforced or pre-stressed concrete. The plain cement concrete slabs are expected to take up about 40kg/cm2 flexural stress. Tensile stress are developed due to the bending of the slab under wheel loads & temperature variation.

Finite-element analysis is not new to the pavement design and research community. Two-dimensional finite-element programs have been in use for the past two decades to analyze rigid pavement response. In recent years three dimensional finite-element analyses emerged as a powerful tool capable of capturing pavement response.

ANSYS software is used for the modeling and analysis of the rigid pavement. In this study 3 dimensional finite element model for concrete pavement is developed. For this analysis of the pavement ANSYS software used.3 dimensional SOLID 185 element having 8 nodes with three degree of freedom element is used for modeling in the software.

The main objectives of analysis to determine the effect of temperature stresses and to study the stress pattern at the different position of the pavement. Modeling is done with the different thickness of the slab to get different result for different thickness. This number of modeling for different properties of the pavement gives effective slab model which can be used for further design purpose. Design of the weaker part of the slab is done by IRC:58 2002.

REVIEW

Mechanistic Analysis of Rigid Pavement for Temperature Stresses Using Ansys" By **Mohd. Imran Khan**In this study author presented the effect of temperature variation on concrete pavement using ANSYS software was presented. ANSYS is finite element method based software. Analysis for temperature stresses has been done using both linear and non-linear temperature gradient between top and bottom of pavement slab. The results obtained using the linear temperature gradient has shown reasonable agreement with the results obtained from the three other mechanistic models: given by software KENSLABS, ILLI-SLAB and JSLAB. The result also matches with

the analytical solution proposed by Bradbury. The model was used to perform parametric studies involving effect of slab length and thickness on curling stresses. High curling stresses were not only observed for long slab but also for the short slab that has a thickness of 30cm. Frictional stress value obtained by ANSYS showed reasonable agreement with the stress value given by the software package ABAQUS, and but its value was less than that given by Westergaard's solution. The temperature stresses obtained for non-linear temperature gradient were compared with the linear temperature distribution. Non-linear temperature distribution cause higher stresses as compared with the linear temperature distribution.

"Evaluation of Temperature Reponses in Concrete Pavement" By **Kamyar C. Mahboub** This study showed that, Field data from a section of heavily instrumented concrete pavement on the Gene Snyder Freeway, Louisville, Kentucky were closely examined. To predict the mechanical behavior of the rigid pavement, a three-dimensional 3D finite element pavement model was developed using the *ANSYS* program. The 3D finite element model was successfully implemented for predicting the stresses and strains in the concrete slabs. An important conclusion of this study was that temperature-induced pavement responses were more significant than traffic-induced responses. This is a very important finding, and can potentially have serious design implications. Applications of this work may include the development of a more scientifically based rigid pavement design and analysis systems for Kentucky conditions. Results of this study will serve as background information for the implementation of new pavement design procedures in Kentucky.

"Structural Response of Concrete Pavements under Moving Truck Loads" by **Mostafa Yousefi Darestani** There has been a great deal of research conducted on concrete pavement performance and deterioration under static loads, only very limited research has been carried out on its dynamic response. Furthermore, opinions differ as to which type of loading results in greater values of slab deflection or flexural stress. In the present study, a test section consisting of two jointed reinforced concrete pavement and two jointed plain _unreinforced_ concrete pavement was constructed and tested under both quasi static and dynamic truck loads. Truck load was allowed to wander at predetermined locations on the instrumented pavement at speeds from 5 to 55 km/h. Strain gauges and displacement transducers were installed along the test section to monitor the pavement responses. Time history responses of the test section were recorded and used to validate a finite-element model developed in the ANSYS platform for further sensitivity study on those parameters affecting the dynamic response of concrete pavements. Results indicate the significance of dynamic amplification in concrete pavement design.

"Finite Element Modeling For Rigid Pavement Joints" By **Michael I. Hammons** The contribution of a cement-stabilized base course to the strength of the rigid pavement structure is poorly understood. The objective of this research was to obtain data on the response of the rigid pavement slab-joint-foundation system by conducting laboratory-scale experiments on jointed rigid pavement models and to develop a comprehensive three-dimensional (3D) finite element model of the rigid pavement slab-joint-foundation system that can be implemented in the advanced pavement design concepts currently under development by the Federal Aviation Administration. Evidence from experiments conducted on six laboratory-scale jointed rigid pavement models suggests that the joint efficiency depends upon the presence and condition of a stabilized base. The presence of cracking in the base and the degree of bonding between the slabs and the stabilized base course influence the structural capacity and load transfer capability of the rigid pavement structure. The finite element model developed in this research indicates that a comprehensive 3D finite element modeling technique provides a rational approach to modeling the structural response of the jointed rigid airport pavement system. Modeling features which are required include explicit 3D modeling of the slab continua, load transfer capability at the joint (modeled springs between the slabs), explicit 3D modeling of the base course continua, aggregate interlock capability across the cracks in the base course (again, modeled by springs across the crack), and contact interaction between the slabs and base course. The contact interaction model feature must allow gaps to open between the slab and base. Furthermore, where the slabs and base are in contact, transfer of shear stresses across the interface via friction should be modeled.

"*Effect of Dynamic Load on Rigid Pavement"* By **Belekar Yuvaraj** There is growing interest in the construction of concrete pavements in India due to their high strength, durability, better serviceability and overall economy in long run. The structural adequacy of a rigid or concrete pavement can normally be predicted based on its structural response to the applied loads. While considerable knowledge of pavement behaviour under static loads is available word-wide, only very limited number of studies have been carried out in the past to determine the effect of dynamic loads on rigid pavement deteriorations. Some software studies show that the effect of the moving load on the concrete pavement much important. Hence, opinions differ as to which type of load (static or dynamic) results in greater values of

base deflection or flexural stress. The need for modern transportation system together with the high demand for sustainable pavements under applied loads has led to a great deal of research on concrete pavement worldwide. Progressive knowledge of concrete pavement behavior under applied loads, concrete pavement still suffer from deterioration due to crack initiation and propagation, indicating the need for further research. Cracks can be related to fatigue of the concrete or erosion of material in sub-layer. Although longitudinal, mid edge and corner cracks are the most common damage mode in concrete pavement. Present review study includes the behavior study and compared it with dynamic analysis results.

"*Experimental Study On Structural Response Of Rigid Pavements Under Moving Truck Load"* By **M. Y. Darestani** The structural adequacy of a rigid pavement can normally be predicted based on its structural response to the applied loads. While considerable knowledge of pavement behaviour under static loads is available word-wide, only very limited number of studies have been carried out in the past to determine the effect of dynamic loads on rigid pavement deteriorations. Hence, opinions differ as to which type of load (static or dynamic) results in greater values of base deflection or flexural stress. In the present study, a rigid pavement test section consisting of two jointed reinforced concrete pavements and two jointed plain (unreinforced) concrete pavements was constructed and tested under both quasi-static and dynamic truck loads. Truck load was allowed to wander at predetermined locations on top of the instrumented pavement. Nominal speeds from 5 km/h to 55 km/h were used in the study. Various devices including strain gauges, displacement transducers, vertical accelerometers and thermocouples were installed at different depths along the test section. A total of 5184 time history responses of the test section were recorded. Results indicate the importance of dynamic analysis in rigid pavement design.

"Finite Element Investigation of the Deterioration of Doweled Rigid Pavements" By **Ziad Ghauch** This study investigates the failure of concrete around dowel bars in jointed rigid pavements, and the resulting effect on the pavement performance. In fact, under repetitive vehicle loading, concrete in contact with the dowel bar deteriorates, particularly at the joint face. The degradation of concrete around the dowel negatively affects the latter's performance in terms of transferring wheel loads through vertical shear action. In this context, a nonlinear 3D Finite Element (FE) analysis was performed using the commercial FE code ABAQUS (v-6.11). The 3D FE model includes friction interfaces, infinite boundary elements, and 3D beam model for dowel bars. The obtained numerical results were validated with classical analytical solutions of shear and moment along the dowel. A concrete damaged plasticity model was used for the concrete slab to model the degradation of concrete matrix around the dowels under incremental loading. Results obtained show, among other things, that the degradation of concrete around dowel bars was found to initiate at the face of the joint and propagate towards the interior of the dowel. Also, the central dowels under the wheel load lost a significant portion of their load-transfer capacity as the concrete matrix around them deteriorated, while dowels farther away from the wheel load became more engaged in load transfer. Finally, it was confirmed that the overall vertical load transferred by all the dowels across the joint decreases as the concrete matrix deteriorates.

SCOPE

- Stress pattern for various loading can be helpful for finalize the thickness of pavement.
- Effect of the environmental forces on the pavement design and after design can be evaluated.
- Relation between subgrade modulus and thickness of slab gives effective design.
- This analysis is also helpful in evaluating and designing of sub base and sub grade of the pavement.

CONCLUSION

Above literature study shows the following conclusions

- In temperature stresses analysis non-linear analysis gives maximum stresses then linear analysis.
- Relation of the stress to thickness are shown that as thickness increases the stresses of the pavement reduces.
- Single axle wheel may gives less stresses the tandem axel wheel load in analysis.
- Temperature stresses can give maximum at edge and corner stresses.
- Comparison of Ansys and Analytical calculation is performed and shows the variations in results which are acceptable.
- Modulus of subgrade reaction seen more for at the load location at the interior of the slab or near the free edge

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