ASSESSING DISTRESS IN ROADS, IDENTIFYING CAUSES AND PREDICTING ITS FINANCIAL IMPLICATIONS USING FINITE ELEMENT

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***Abstract*— This paper will visual observation and appraise the flexible pavement failures for maintenance and recommend better way to minimize and hope fully eliminate the cause of failure of flexible pavement. Road constructions are generally excepted to give trouble free service throughout its intended the design life. However the expectations are not realized in many constructions in the project study area Pavement failure is decreasing serviceability caused by development of cracks. An concentrated field work was carried out on the existing pavement condition of rural road. It was found that most of damaged pavement section suffered from severe cracking, deterioration and deformation. By using the finite element model, simulation to predict the fatigue failure of the pavement using abaqus. The comparison between simulation model and field condition is used to calculate the loss of useful service life of pavement due to poor design use of interior materials and workmanship. The damage could be describe to improper soil investigation, inadequate design, follow the same and design type of soil. Its cost implication can be easily calculated by extrapolating this study for all rural roads in our country.**

Keywords — failures, evaluation, finite element model.

1. INTRODUCTION

Road transport is movement of people, animals and goods from one location to another. Road and motor transport act as a feeder to the other modes of transport such as railway, marine and airway. Pavement design is the process of developing the most economical combination of pavement layers (in relation to both thickness and type of material) to suit the soil type and the cumulative traffic to be carried during the design life.

Pavement deterioration start very slowly and over time is accelerates at faster rates. To minimize deterioration by use the best practice method in planning, design, construction and maintenance of the road. This can be achieved by examining pavement failed prematurely on determining the causes of failure; it can be prevented in the future.

Pavement design consists of mainly two parts: (i) design of the material mixture, to be used in each pavement component layer; (ii) design lf pavement structure (design of thickness and type of different component layers).The main factors to be considered in the pavement design are: traffic; climate; road geometry; and position ,soil and drainage. Road maintenance is one of the important components of the entire road system. Preventive maintenance is much more cost effective than performing major repairs.

The developing countries have lost precious infrastructures worth billions of dollars through deterioration of their roads. Poor drainage can lead to premature aging of the roadway surface and sub-grade. Pay special attention to the drainage of roadway sections when planning maintenance activities. The cost of restoring these deteriorated is going to much higher than excepted for the timely effective maintenance. Pavement deterioration on the other hand is very common in developing countries. Detailed investigations could be valuable in reducing the costs associated with pavement failures in the future.

1.1 OBJECTIVE OF THE STUDY

The objective of this paper identify the different kinds of distress, pattern, possible causes in roads and experimental investigation as a case study in particular region and create the similar model in abaqus software and apply the cyclic loading simulation for finite element packing the sampled load condition.

2. PAVEMENT EVALUATION GUIDELINES

The objective of this paper is to establish guidelines describing systematic method for inspection and evaluation of pavement failures and to find out the possible causes of these failures using finite element model. The proposed method has some basic steps as follows:

i. Inspection and Appraisal plan
ii. Documents and literature review
iii. Pavement condition study
iv. Experimental work
v. Determine possible causes of failure
vi .Finite element model.
vii. Selection of the best maintenance option
viii. Report on outcomes.

2.1 Inspection and Appraisal plan

Planning is valuable to ensure that inspection and appraisal of pavement failures were carried out their engaged tasks within time.

When planning the evaluation program, a general review of the problem should first be conducted, along with the possible scope of inspection and maintenance work that may need to be carried out.

2.2 Documents and literature review

Analyzing documents and literature may involve the inspection of plans, pavement drainage design, pavement materials details and specifications, previous materials tests results, construction and previous maintenance records, testing methods, traffic volumes. These collected data are very important for both the field survey task and the evaluation of pavement failures.

2.3 Pavement condition study

The pavement condition survey may include visual examination of pavement failures, other details soil of the surrounding areas may also be of importance in determining the causes of the pavement failure. An effective visual survey of pavement failures is essential, to ensure that the cause of the failure can be diagnosed efficiently. Distress surveying should be carried out on failed pavement sections to find out the type, and condition or severity level of distress, as well as the condition or effectiveness of any previously applied distress treatments.

2.4 Experimental work

The experimental work includes filed and laboratory testing. Field test visual examination of pavement layers. Laboratory testing should be conducted on representative samples taken from pavement layers to determine physical characteristics of the soils and the plasticity limit,liquid limit,density and specific gravity California Bearing Ratio (CBR) tests.

2.5 Determine possible causes of failure

It is important to find out the possible causes of the pavement failure being investigated. The possible causes are normally one or multiple factor involved in failure. The first stage in determining the failure causes is the investigative combination, where all the information gathered is listed. From this listed information, it is then necessary to determine which information supports each of the possible failure assumption. This may be initially done by considering general failure causes, such as those related to construction, materials, design,traffic volume or the environment. It is more required that specific causes of the failure be considered. This is achieved by going through possible failure causes for the failure type. Once this has been done, it is necessary to determine the probable causes of the failure.

2.6 Finite element models

Creating the road layers similar to the existing road size. Experimental test results size of road created, assembled the road layer by binding tool. Cyclic load is applied on the assembled layers . simulation study estimates the failure of the first crack.Which indicates that the approximate duration required for first remedial repair.The comparison between simulation model and field condition is used to calculate the loss of useful service life of pavement.

2.7 Selection of the best maintenance option

To select the best maintenance option, it is necessary to list a variety of alternatives that may be feasible, from an initial examination of the conditions. These possible alternatives can then be subjected to much more detailed examination of economic, design and construction factors. Other factors to consider include whether the treatment is accepted local practice, and whether a long lasting or simply an economical short-term treatment is required. Once these questions are answered, a list of possible maintenance options could be selected for further study by finding those treatments that satisfy the above criteria. Treatments may include surface treatments, overlays, in-situ stabilization, or any other maintenance treatments.

2.8 Report on outcomes

A report on the outcomes of the pavement evaluation should be produced, as this enables others to learn from the failures, and should help reduce the chances of similar failures in the future. Information that should be included a general description of the project and its location, a description of any testing carried out, the possible causes of failures expected, how it could be prevented in the future, and possible maintenance options.

3. CASE STUDY

The study was concentrated on Reddirapatti and Gobinayakanpatti roads in T.Kallupatti road in madurai. This rural road is single carriageway.The road length and width are 2.4 km and 3m respectively.

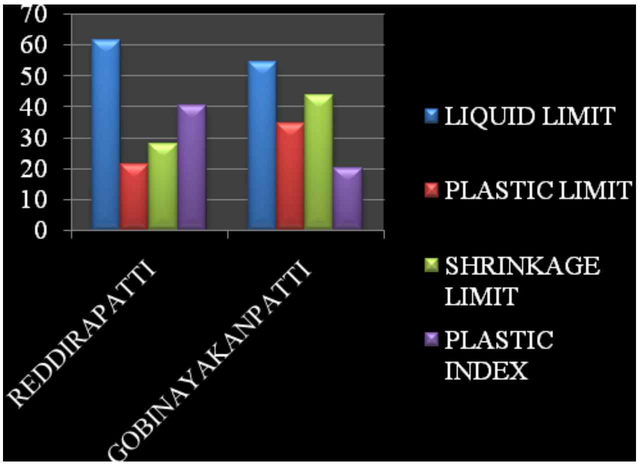
Reddirapatti and Gobinayakanpatti road was maintained several times still suffered from severe distresses. The last rehabilitation of this road was carried out in 2015 by widening and strengthening the pavement. The road much severs from serious problems that may decrease its efficiency and safety. These problems include inadequate drainage system and damaged pavement surface. The edges of the road suffers from a series of distresses and the pavement surface is not comfortable for riding. The distresses and defects on pavement may be due to deficiency in design, material and construction. The failures occurring were beginning to reach unacceptable levels, since the failed pavement surface prevented water from flowing off the pavement during rainfall, leading to further deterioration.

Table 1: soil properties of Reddirapatti

PARTICULARS	RESULTS
Liquid limit (%)	54.5
Shrinkage limit (%)	43.97
Plastic limit (%)	34.5
Plastic index (%)	20
Specific gravity	1.38
Max dry density (gm / cm3)	2.21

Table 1: soil properties of Gobinayaganpatti

PARTICULARS	RESULTS
Liquid limit (%)	61.66
Shrinkage limit (%)	28.07
Plastic limit (%)	21.3
Plastic index (%)	40.36
Specific gravity	1.35
Max dry density (gm / cm3)	2.01



EXICITING ROAD SIZE

Refilled soil = 1300 mm
Granular sub base = 250 mm
Base course = 150 mm
Surface course = 50 mm
Bitumen top = 20 mm

4. FINITE ELEMENT MODEL

4.1 CREATING PAVEMENT

Finite element simulation to predict the fatigue life of pavement using abaqus.

The layers in the road were modeled as soli blocks as shown in figure

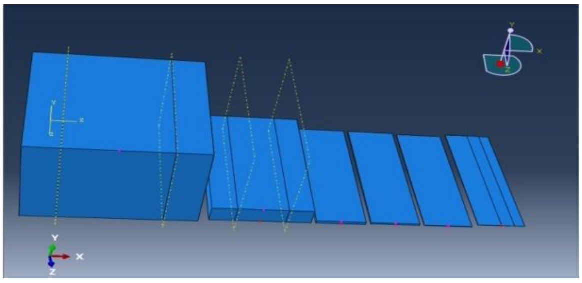


Figure 1: Pavement layers

4.2 BINDED WITH PAVEMENT LAYERS

These block were stacked and connected with each other using tie constrain in the assembly module.

The material characteristics for all the layers were obtained by conducting field tests.

Summarize the test results in tables and the values of E and M used in each layer.

The modeled system was discretized using C3D8 Mesh elements.

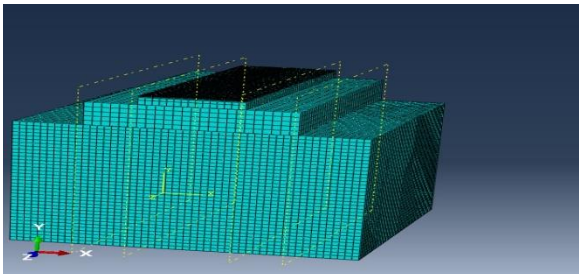


Figure 2: Meshed the pavement layers

4.3 STRESS DISTRIBUTION ON PAVEMENT

The stress distribution predicted using FEM simulation correlates well with the stress intensity

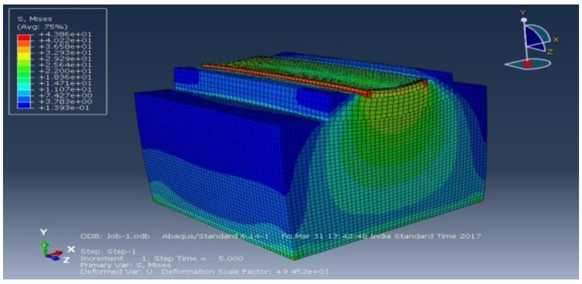


Figure 3: Stress distribution on pavement

4.4 COMPARISON OF STRESS DISTRIBUTION

We compared the simulation obtained from Abaqus a finite element software and standard stress distribution.

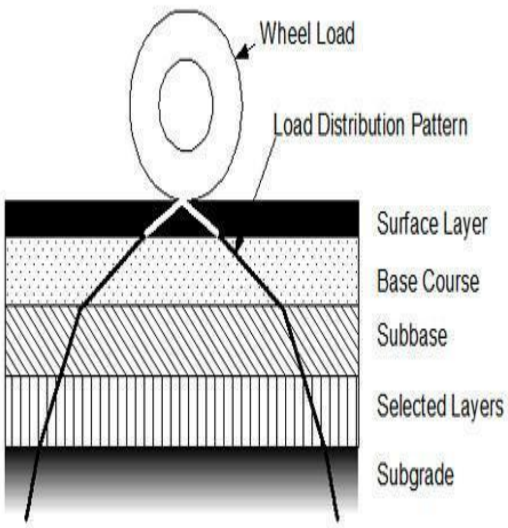


Figure 4: Standard stress distribution

4.5 CYCLIC LOADING

The model was set up for analysis using cyclic loading capability in abaqus.

The number of cycles to cause initiation of visible cracks on the pavement surface was observed and is shown in figure 5

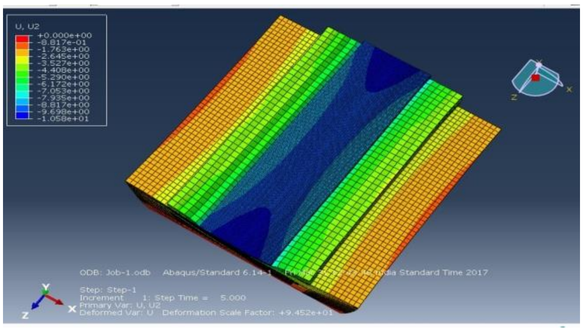


Figure 5: Cyclic loading on pavement

4.6 SETTLEMENT OF FAILURES

Crack was initiated at the center of bitumen top.
The crack was propagated as settlement of layers as in figure 6.
From the simulation obtained the measurements of settlement can be found.

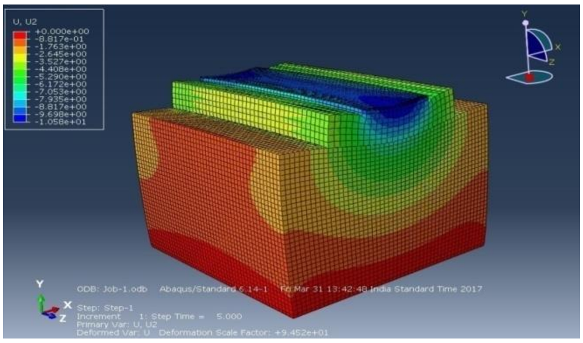


Figure 6: Settlement of failure on pavement

5. RESULTS AND DISCUSSION

The above simulation study estimates the failure to initiate after 50000 cycles of loading. On an average 32 heavy duty vehicles cross the road. Which indicates that the approximate duration required for first remedial repair is 50000/32. That is 4.2 years. However the T.Kalupatti roads have got un repair ably damaged in 1 year.

6. CONCLUSION

This study has been undertaken to investigate the pavement failures and propose a method for inspection and evaluation of failed pavement.

Road failure on existing road cost Preventive maintenance is much more cost effective than performing major repairs.

The comparison between simulation model and field condition is used to calculate the loss of useful service life of pavement due to poor design, use of interior materials and workmanship.
Its cost implications can be easily calculated by extrapolating this study for all the rural roads in our country.

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