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Comparative Study of Flexible and Rigid Pavement Subjected To Static and Transient Loading In Ansys

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Abstract: *The analysis of flexible and rigid pavement is a difficult, because of the pavement system is multilayered and three dimensional. To provide accurate displacement, strain and Stresses, the system must consider the different characteristics of each layers. In this project work represent that behavior of the flexible and rigid pavement under static pressure and transient loading by using finite element analysis. Both the pavement have been analyzed by taking section properties of length 25m width 7.75m and total thickness for flexible pavement is 0.665m and total thickness for rigid pavement is 0.6m. In flexible pavement we have taken sub base course, base course and asphalt surface course and for rigid pavement base course and concrete layer. After that assigning the suitable material properties and support condition analysis is done. This study shows that effect of increase of pressure with time on deflection, stress and strain in both rigid and flexible pavement.*

Keywords: *Finite element analysis, ANSYS, flexible pavement, rigid pavement, stresses, strain, displacement.*

1. Introduction

A) Flexible pavement: Generally flexible pavement consist of four components i) soil subgrade ii) sub-base course iii) base course iv) Asphalt surface course. The flexible pavement layer transmit the vertical or compressive stresses to the lower layers by grain to grain transfer through the points of contact in the granular structure. A well compacted granular structure consisting of strong graded aggregate can transfer the compressive stresses through a wider area and thus forms a good flexible pavement layer.

B) Rigid pavement: Rigid pavements are those which possess note worthy flexural strength or flexural rigidity. The rigid pavement consist of three components i) soil subgrade ii) base course iii) cement concrete slab. The rigid pavement has the slab action and is capable of transmitting the wheel load stresses through wider area.

Objectives

1. To compare flexible pavement and rigid pavement under combined bending and shear for static pressure and transient loading.
2. To check total deformation and deformation along Y direction for shear for static pressure and transient loading.
3. To check stresses and strain developed in both flexible and rigid pavement under shear for static pressure and transient loading.

2. Literature Review

Aurea Silva de Holanda (2003): In this paper Finite element modelling of flexible pavements, Federal University of Ceará – Department of Transportation Engineering Campus do Pici, Bl. 703, 60455-760, Fortaleza, Ceará, Brazil. In this study well-known that the analysis of flexible pavements is a difficult task, since the pavement system is multilayered and three-dimensional. To provide accurate displacements, strains and stresses, the system must consider the different characteristics of each layer. Granular layers, for example, present complex nonlinear stress-strain relationship, while the surface (asphalt) layer displays a time-dependent viscoelastic behaviour. Furthermore, cracks and fatigue are some of the problems that the surface layer may present. This paper addresses techniques used in the finite element modeling of flexible pavements. Therefore, appropriate constitutive models and numerical algorithms to represent the nonlinear resilient behaviour of the unbound layers and the viscoelastic characteristics of the HMA layer are thoroughly discussed. These techniques are implemented in a computer system developed using an Object-Oriented Programming (OOP) approach. Both axisymmetric and three-dimensional models are included. Several numerical examples will be analysed in order to validate the implementation and assess the importance of the consideration of the nonlinear and time-dependent effects. The obtained results will be compared with available analytical and computational solutions

Aleksander Szwed, Aleksander Szwed (2015): This paper presents "Mitigation of low-temperature cracking in asphalt pavement by selection of material stiffness" In this research, A simple model dedicated to prevention or mitigation of low-temperature cracking in asphalt pavement is discussed in this paper. Having defined minimum temperature distribution in asphalt concrete pavement qualitative considerations on distribution of material stiffness are performed. As a result closed-form mathematical formulas allowing to reduce tensile stresses due to temperature drop are proposed in this approach.

Dilip et.al (2013) This paper discuss the uncertainty in material properties and traffic characterization in the design of flexible pavements. This has led to significant efforts in recent years to incorporate reliability methods and probabilistic design procedures for the design, rehabilitation, and maintenance of pavements.

3. Methodology

System Development: ANSYS is useful to final element simulations for pavement we use SOLID 186 for pavement, CONTA 174 And TARGE 173 to define contact between them. Following are the elements are used for the simulation of pavement.

i) SOLID186 Element Description:

SOLID186 is a higher order 3-D 20-node solid element that exhibits quadratic displacement behavior. The element is defined by 20 nodes having three degrees of freedom per node: translations in the nodal x, y, and z directions. The element supports plasticity, hyper elasticity, creep, stress stiffening, large deflection, and large strain capabilities. It also has mixed formulation capability for simulating deformations of nearly incompressible elastoplastic materials, and fully incompressible hyper elastic materials.

ii) CONTA174 and TARGE170:

The 3-D contact surface elements (CONTA173 and CONTA174) are associated with the 3-D target segment elements (TARGE170) via a shared real constant set. ANSYS looks for contact only between surfaces with the same real constant set. For either rigid-flexible or flexible-flexible contact, one of the deformable surfaces must be represented by a contact surface.

If more than one target surface will make contact with the same boundary of solid elements, you must define several contact elements that share the same geometry but relate to separate targets (targets which have different real constant numbers), or you must combine two target surfaces into one (targets that share the same real constant numbers).

Real constant R1 is used only to define the radius if the associated target shape (TARGE170) is a cylinder, cone, or sphere. Real constant R2 is used to define the radius of a cone end at the second node.

iii) Analytical work

In this paper we take one problem for work having length 25m, width 7.75m and thickness for flexible pavement is 0.665m and rigid pavement 0.6m. For flexible pavement gives three layers sub base layer (0.4m), base layer (0.2m) and asphalt surface layer (0.065m). Then we give the properties of materials like young's modulus, poison's ratio and density. Rigid pavement gives two layers base course (0.4m) and concrete slab (0.2m).

Materials properties used for sub base course are young's modulus, poison's ratio and density are 5Mpa, 0.45 and 2000kg/m3 respectively. For base course are young's modulus, poison's ratio and density are 350Mpa, 0.2 and 1800kg/m3 respectively. For asphalt surface course are young's modulus, poison's ratio and density are 3500Mpa, 0.3 and 2243kg/m3 respectively. For concrete slab are young's modulus, poison's ratio and density are 3000Mpa, 0.18 and 2300kg/m3 respectively.

iv) Loading applied

a) Static loading

In static loading we applied 5pa to 45 pa pressure for 10 sec. and check behavior of flexible and rigid pavement.

b) Transient loading

In this paper a moving load of 39 kN is passing through flexible and rigid pavement having five equal sections for a time period of 2.4 seconds. Hence the time interval is taken as 0.48 seconds for each step.

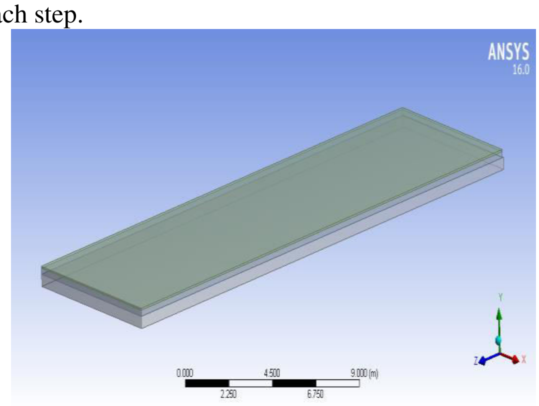

Fig.1 Model of flexible pavement

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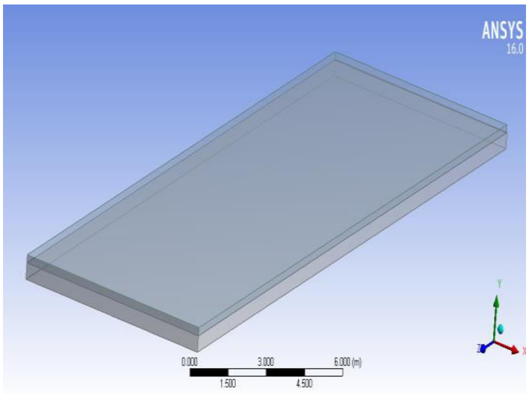
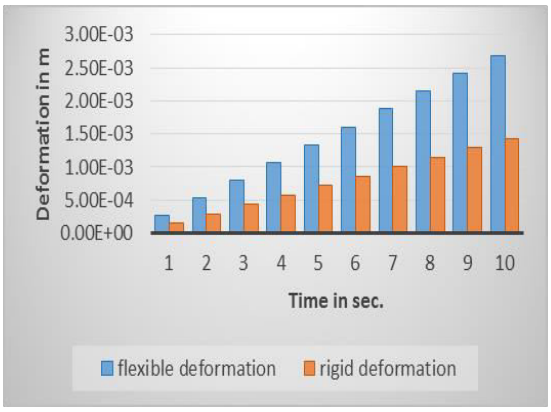


Fig.2 Model of rigid pavement

4. Result and Dissection

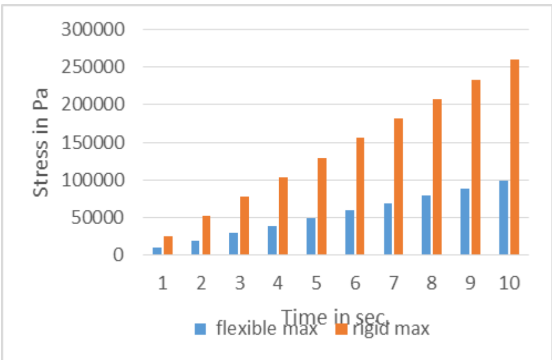
1) Static pressure apply on flexible and rigid pavement:

A) Total deformation of flexible and rigid pavement



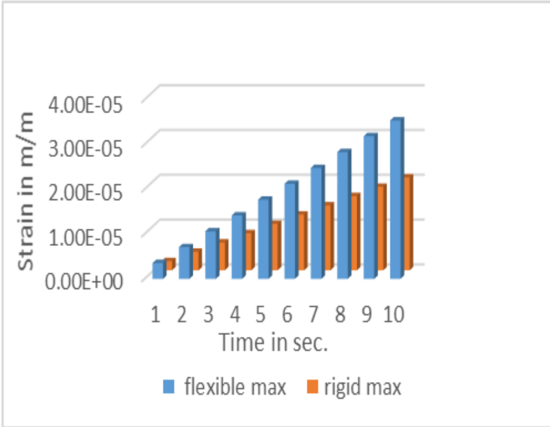
Graph 1 - Deformation of flexible and rigid pavement.

B) Stress formation in flexible and rigid pavement:



Graph 2 – Stresses in flexible and rigid pavement.

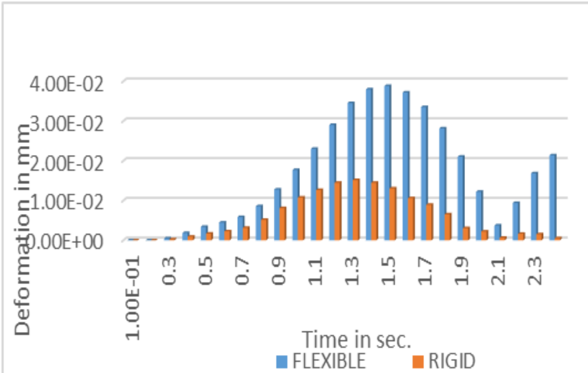
C) Strain formation in flexible and rigid pavement:



Graph 3 – Strain in flexible and rigid pavement.

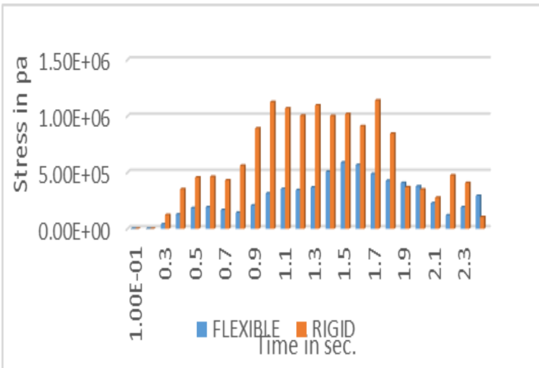
2) Transient loading applied on flexible and rigid pavement:

A) Total deformation of flexible and rigid pavement



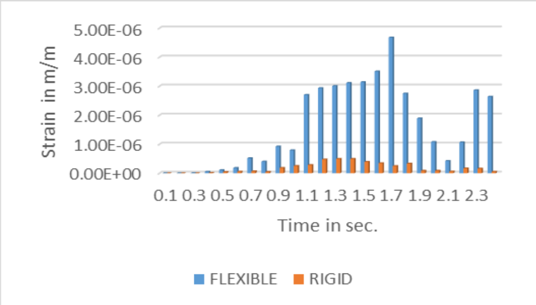
Graph 4 - Deformation of flexible and rigid pavement.

B) Stress formation in flexible and rigid pavement:



Graph 5 – Stresses in flexible and rigid pavement.

C) Strain formation in flexible and rigid pavement:



Graph 6 – Strain in flexible and rigid pavement.

5. Conclusion

1) Static pressure applied on flexible and rigid pavement

1) The deformation in flexible pavement is 50-60% more than rigid pavement due to applied pressure.
2) When pressure is applied on both the pavement i.e rigid and flexible pavement it has been observed that the stresses generated in rigid pavement is 30-35% greater than flexible pavement.
3) Strain developed in flexible pavement is 50-55% more than rigid pavement due to applied pressure.

2) Transient loading applied on flexible and rigid pavement

1) The deformation in flexible pavement is 55-65% more than rigid pavement under transient loading.
2) When transient loading is applied on both the pavement it is been observed that the stresses in rigid pavement is 65-75% greater than flexible pavement.
3) Strain developed in flexible pavement is 80-85% more than rigid pavement under transient loading.

6. References

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