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A FEM Modeling of the Concrete Pavement Made of the Recycling Material

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Abstract. Paper is a brief review of the research focused on formulation an numerical model for the concrete pavement which is made by the recycling material. For numerical modeling the finite element model (FEM) and the 3D finite element model were applied. The software EverFE 2.25, was used. The results of FEM analysis is in a chapter shape showing move value change, strees and deflections for all layers a construction road model. In the next phase of the research was provided by FEM software with appropriate general purpose non-linear models, which allows the analysis of the real behavior of solid pavement under load.

1 Introduction

The concrete pavement consists of four layers, including a subgrade. The first layer is concrete pavement, the second layer is made of crushed stone with fraction 0/31.5, and third layer is made of crushed stone 0/63. Each layer takes over the load and transmits it to the subgrade. The goal of this study is to find out maximal/minimal principal stress values per slab. We used a bus, very frequent on that section of the road. The model is carried out with the software EverFE 2.25 which gives us the model results with 3D FE element [1-11].

2 3D fe analaysis

To model a stress notation of the special systems 3D solid FE are used as the most complex and ensure the most precise approximation. Applying these FE we get models with high degree of freedom, therefore their application is limited to analysis of specific construction systems [1].

The software Ever FE version 2.25, has been used for modeling. The software is equipped with the qualitative tools for creating 3D FE models. The first step in creating a model of the concrete pavement is to determine its dimensions and to define the number of layers. Each layer has a specific modulus of elasticity (E), Poisson`s ratio (ν) and layer thickness (d) [2]. All the values are presented in Table 1.

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Table 1. Pavement structure with characteristic data

Layers	Layers thickness (cm)	Modulus of elasticity (MPa)	Poisson's ratio
Concrete pavement layer	24	33000	0.35
Crushed stone road-base 0/31.5 (base)	15	480	0.35
Crushed stone road-base 0/63 (sub-base)	25	400	0.35
Clay subgrade	10	50	0.45

Ever FE is equipped to allow the user to specify a wide range of realistic loads that may be applied to a solid pavement through a vehicle's tire.

The first step in selecting a load is to choose the type of tire contact which can be rectangular or circular. After selecting the type of tire contact, the user must define the rest of the load parameters. The wheel type can be selected as single or dual. The axle type can be selected as single or tandem.

The test bus station has tree concrete pavements that are made of recycling material and they have 15 dowels. The dowels durations are 600mm and diameters are 22mm. For testing load was used the bus which has 120kN on front axle and 120kN on rear axle (Fig 1, 2).

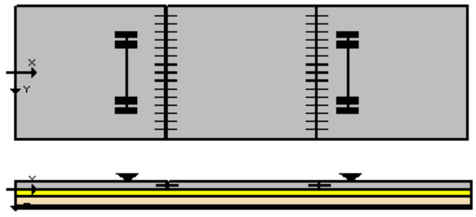

Fig. 1. Bus load scheme.

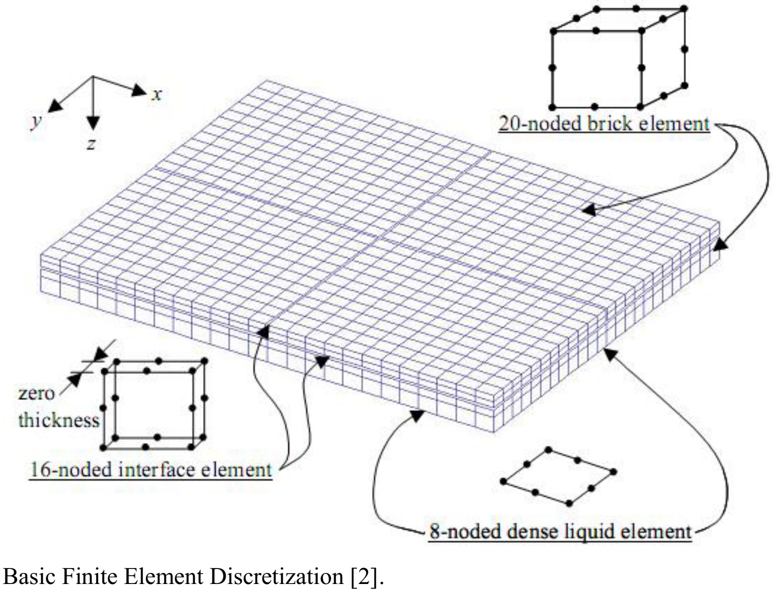

Fig. 2. The Basic Finite Element Discretization [2].

3 Research results and discussion

After defining the parameters the above menitoned, the research results are obtained. EverFE allows the results of the finite-element analysis to be presented using any of four options available from the visualization menu: Stresses (Maximal Principal, Minimal Principal, Stresses in the x-x plane, y-y plane, z-z plane, x-y plane, y-z plane and z-x plane), Displacements, Results for Points, and Results for Dowels [2].

Displaced shapes of slabs and the base layer can be viewed for any project for which a solution exists. The results for this points are showing the maximum and minimum principal stresses and their locations in the corresponding slab; the red text show the highest principal stress on the slab.

Selecting dowels from the Visualize menu show all moments for any selected dowel. The five force components that can be viewed: Nq (axial force), the shears Fr and Fs, and the moments Mr and Ms. The subscripts q, r and s refer to the dowel local coordinate system, and correspond to the global model (x,y,z) axes [2]. The maximum values of shear and moment are displayed for the currently selected dowel at the bottom of the dowel results panel. These maximum values are computed as the magnitude of the "r" and "s" components, which is appropriate for a dowel with a circular cross-section. The following charts present the characteristic cross-sections of the stresses, displacements, results for points and results for dowels. (Fig. 3)

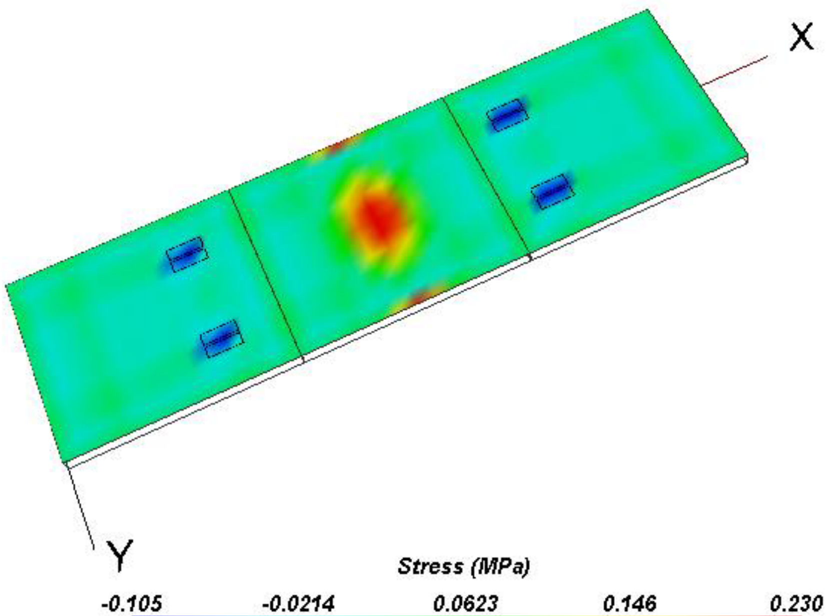

Fig. 3. Maximal Principal.

The maximal principal stress is in the center concrete pavement, so the major impact is noticeable in the upper layers (Fig. 4).

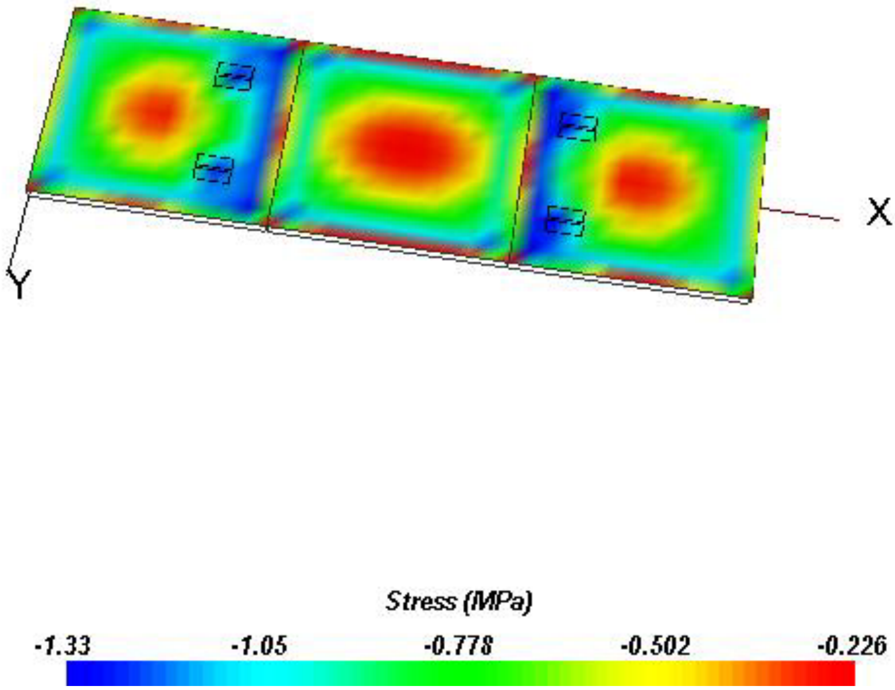

Fig. 4. Minimal Principal.

The minimal principal stress is in the end of the first pavement and the start of the third pavement. (Fig. 5)

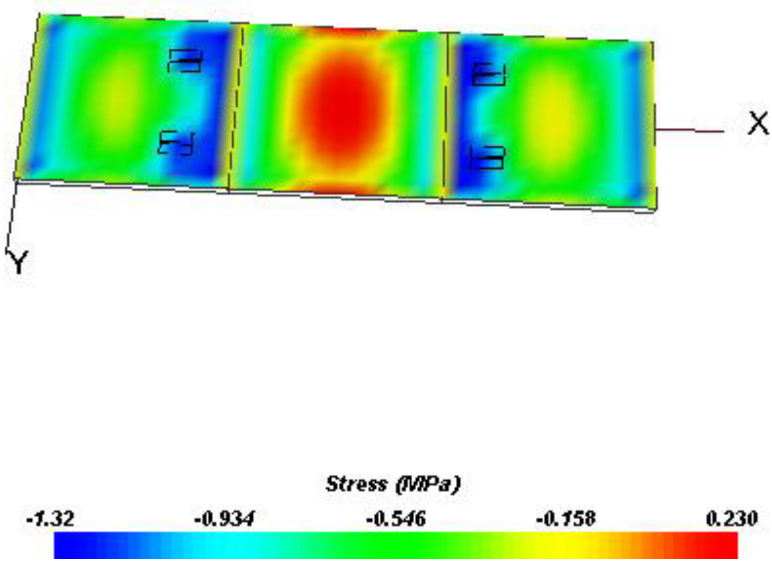

Fig. 5. Stress in the x-x plane.

The maximal stress is in the center of middle concrete pavement, and the minimum is in the end of the first pavement and the start of the third pavement (Fig. 6, 7).

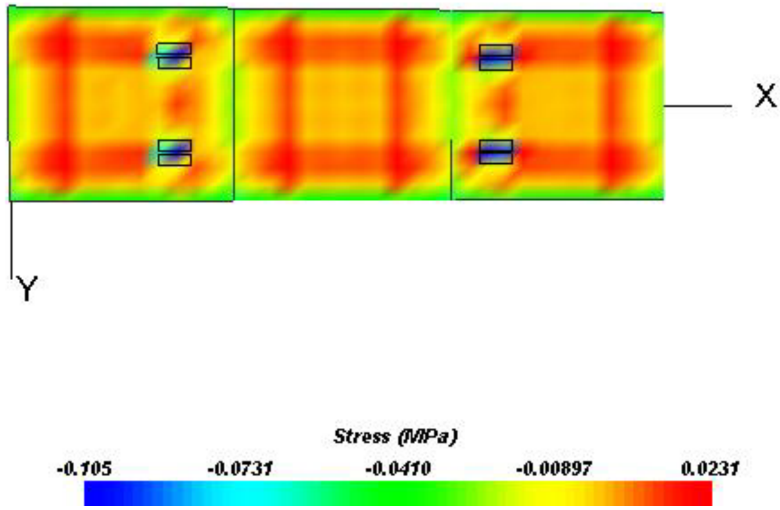

Fig 6. Stress in the z-z plane.

The maximal stress is in the all slabs, but the minimum is under the wheels.

Fig. 7. Deflections of the all slabs and the base.

All slabs are deflected, even thought the loads are placed on first and third slab, because it has dowels that link all slabs and loads.

MAX: 1.22587MPa X: 3666.63mm Y: -1458.29mm Z: -119.99mm MIN: -1.72333MPa X: 1666.68mm Y: 2.27374e-013mm Z: -0.01mm	MAX: 1.22607MPa X: 7679.32mm Y: -1458.29mm Z: -119.99mm MIN: -2.2094MPa X: 6012.7mm Y: 2.27374e-013mm Z: -0.01mm	MAX: 1.22691MPa X: 8358.77mm Y: -1458.29mm Z: -119.99mm MIN: -1.80472MPa X: 10025.4mm Y: 2.27374e-013mm Z: -0.01mm

Fig. 8. Maximal/Minimal Principal Stress Values per Slab.

The numbers in each rectangle shows the maximum and minimum principal stresses and their locations in the corresponding slab; the red text show the highest principal stress on the slab (Table. 2).

Table 2. Maximal moment and maximal shear for dowels

slab	Dowel	Max.Moment (Nmm)	Max.Shear (N)	slab	Dowel	Max.Moment (Nmm)	Max.Shear (N)
First and second slabs, link with dowels	1	48200.800	1165.410	Second and third slabs, link with dowels	**16**	**48895.200**	**1294.790**
	2	45975.100	1051.580		17	46927.500	1193.800
	3	44134.201	957.750		18	45292.000	1109.750
	4	42560.701	878.386		19	43801.500	1034.140
	5	41339.901	816.631		20	42556.501	971.100
	6	40385.001	768.949		21	41486.401	917.526
	7	39776.300	738.882		22	40761.700	881.268
	8	39494.200	725.150		23	40428.600	864.761
	9	39774.000	738.758		24	40763.600	881.366
	10	40385.301	768.965		25	41486.101	917.513
	11	41342.801	816.785		26	42554.101	970.977
	12	42556.501	878.163		27	43805.100	1034.310
	13	44132.301	957.647		28	45293.600	1109.830
	14	45975.600	1051.610		29	46927.000	1193.780
	15	**48203.600**	**1165.560**		30	48892.700	1294.670

The bold text values maximal moments both on first and second slabs and second and third slabs. Fig. 9-12.

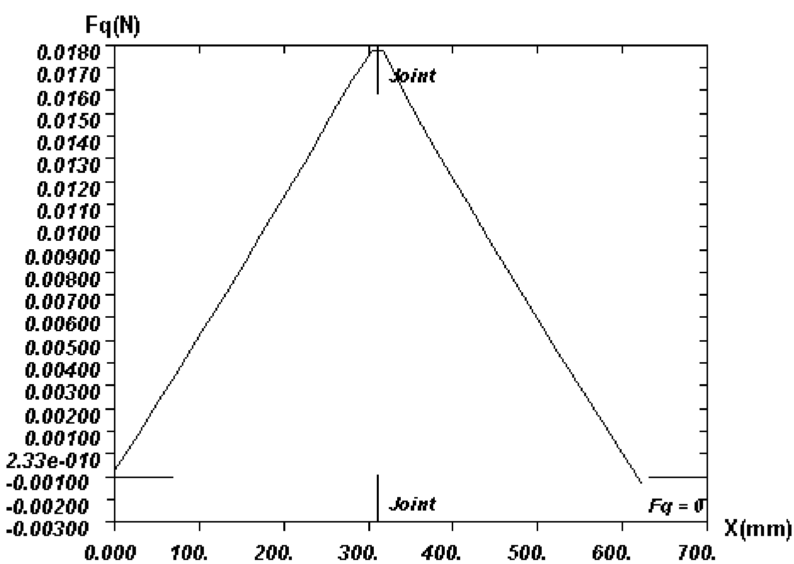

Fig. 9. Axial Forces (Nq).

They have an upward linear dependence on the end of second pavement and another linear decreasing dependence at the beginning of third pavement.

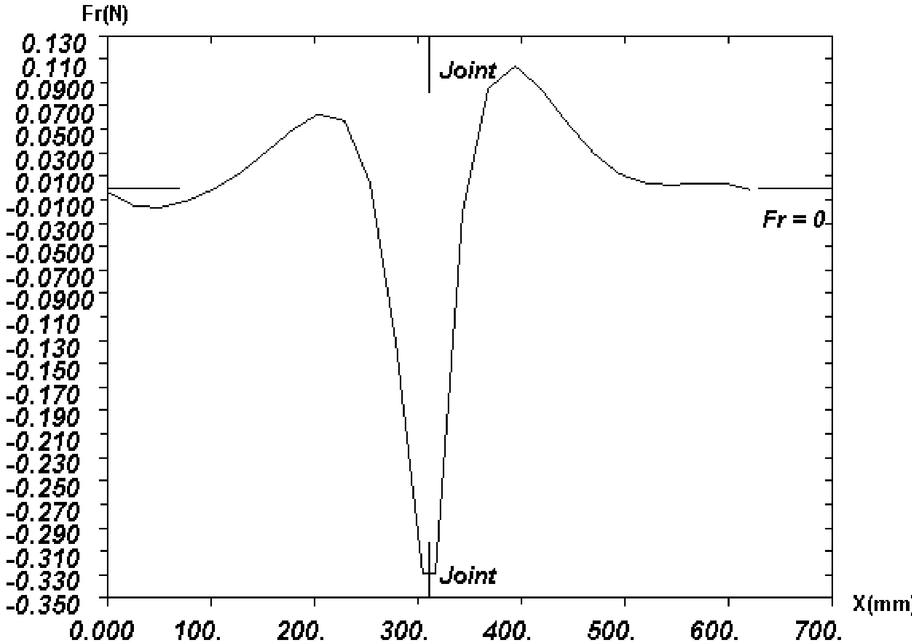

Fig. 10. Shear Forces (Fr).

Between second and third concrete pavement there are big leaps for Shear Forces (Fr).

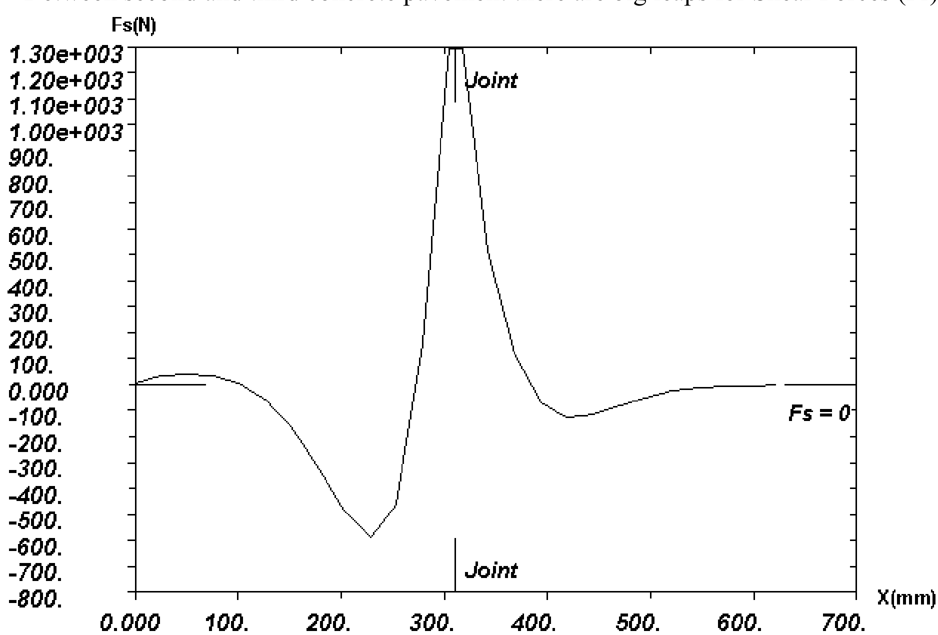

Fig. 11. Shear Forces (Fs).

Between second and third concrete pavement there are big leaps for Shear Forces (Fs).

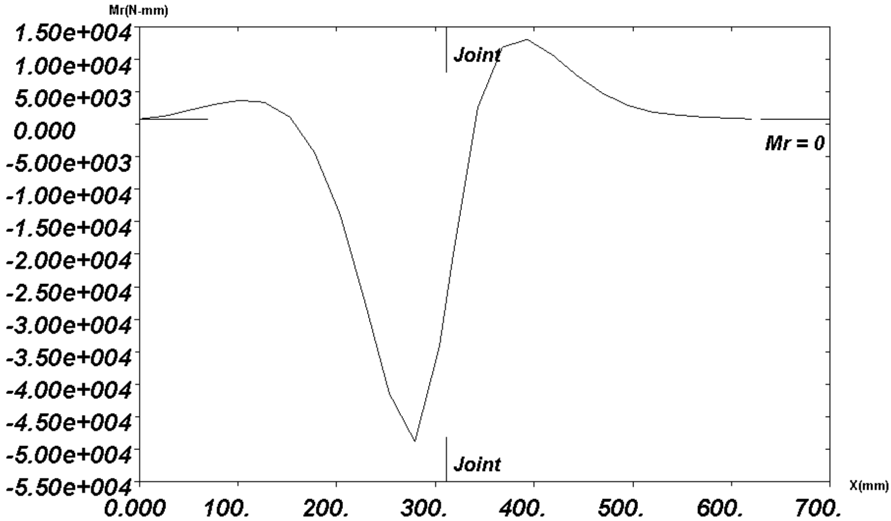

Fig. 12. Moment of dowel (Mr).

Between second and third concrete pavement there are big leaps for Moment (Mr).

4 Conclusion

After the research was carried out, we have got the results in the form of a model and graphics which ensure an insight in all their changes and deviations. The conclusions of the study are following:

- there are substantial deviations in the stresses, displacement and results for dowels. The cause of these changes is the traffic loading,
- the loads are changeable in all three concrete pavements.
- The direction of further research:
- test influence to use reinforce concrete pavement,
- testing joints with the big diameter at the ends of the concrete pavement,
- test influence with angle on the first and the final pavement.

5 Acknowledgements

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