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EXPERIMENT OF TIRE-CROWN FOR COMPUTATIONAL MODELING OF TIRE

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1.Introduction

The vehicle tire can be generally understood as long-fiber composite material [1] where there is an interaction of the elastomeric matrix with metallic as well as non-metallic reinforcements. The composite structures used in tire with the different cord-angle, material of cords, numbers of layer (single-layer or multi-layer) are:

- textile tire carcass;
- overlap textile belt;
- steel-cord belt.

From the aspect of the material composition, construction as well as geometry, there is a continuous development of the radial tires because of increasing requirements as well as higher construction speeds regarding to the passenger cars [2]. The mentioned development is mostly based on advanced methods including computational modeling while the given methods are commonly verified by conventional experimental tests or procedures. The combination of the computational modeling with conventional testing methods is not closely connected only with verification or confirmation of the results obtained from the calculation but it also leads to acquisition of the required and important materials parametres. The created computational model has to be precisely described with help of the mentioned parametres because this is the accurate way to obtain the adequate computational results.

In relation to the computational modeling, it is necessary to pay attention to the materials as well as geometric input data from the complex aspect in order to make precise characteristics standing for composite – tire casing system. The mentioned fact is closely connected with the accurate determination of materials parametres as the input data used for creation of the computational model. Moreover, there is the effort to find the precise but simple specification of the approach referring to the most suitable description of the tire casing for the computational analysis while the stress-strain behavior, deformation characteristics and stiffness parametres are kept. The given fact can be connected with the replacement of the whole steel-cord reinforcement by only one homogeneous material with the orthotropic character of the behavior in order to make stress-strain analysis [3]. If the immediate response in the short computational time is required during the application of the finite element method, it is necessary to find compromise between the discretization of the computational tire casing model and required accuracy of the results but it has to be pointed out that it is significantly influenced by suitable selection of material description for the tire casing.

2.The input data for the computational models

In relation to the tires, the important input data for computational modeling are divided to geometric and materials parametres obtained in an experimental way and furthermore, there are also specifications on tire inflation obtained from producers and all important parametres describing interaction of tire casing with the surrounding environment including the specification of the critical states.

For creations of computational models, it is necessary to have a good knowledge about [4]:

- structure of tire-casing as a whole;
- steel-belt which is used into tires;
- construction and material of cords in tire;
- material parameters of elastomeric matrixes and cords as reinforcements;
- microstructure of bond between cords and elastomeric matrixes with detailed information on geometry.

The given scheme shows the connections between computational input parametres as well as outputs based on the given input parametres and it is closely connected with the performance of the sensitivity analyses in order to obtain information about the noticeable influence on the output data when the changes of some input parametres are carried out. According to the fact hereinbefore, the detailed attention has to be paid mainly to the mentioned influencing input parametres and these parametres has to be designated as “sensitive” from the aspect of their precise specification. The “sensitive” parameters include mainly materials parametres which are needed to be specified in an experimental way. The geometric configuration of the reinforcements is the main factor for the specification of the materials parametres which would be used for description of the whole steel-cord belt or the whole area of casing under the tread.

3.The construction of the selected tire casing

The main purpose of the research was to determine the required materials parametres for the reinforcing layers in relation to selected casing R18. The given tire casing was cut by help of water jet in longitudinal and transverse direction in order to obtain the specimens from the whole under-tread reinforcing area of the casing (Fig. 1).

The specimens were prepared with different width and it was 10, 15 and 20 mm. The static tensile tests and bend tests were performed for the specimens in agreement with standard specifications and it was with the aim to obtain moduli of elasticity for different directions of configuration of specimens.

The conditions of the tensile tests were:

- starting value of length between clamps of test machine was 100 mm,
- elongation measured on the same length,
- loading speed was 10 mm/min.

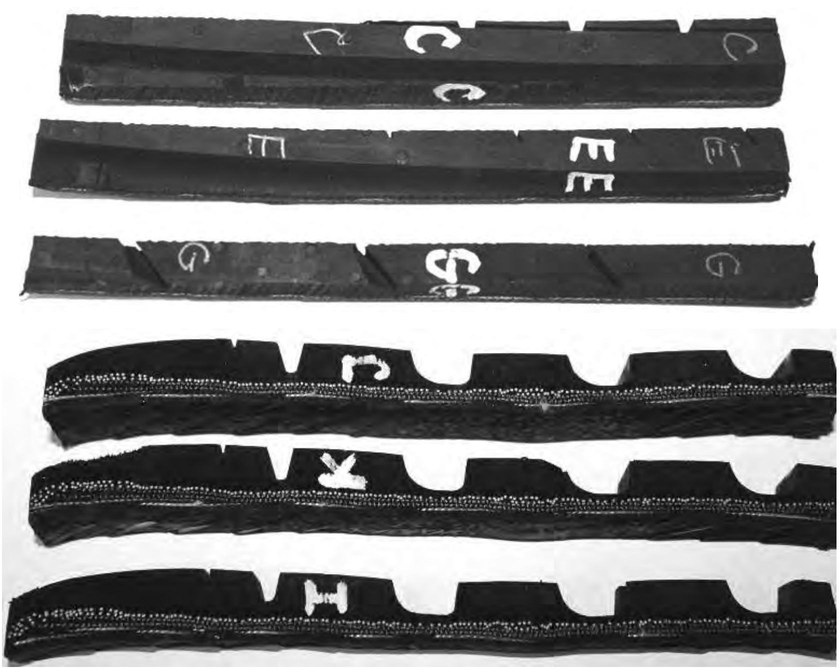

***Fig. 1** Specimens – cuttings in longitudinal direction (top) and transverse direction with different width, prepared for performance of the tensile and bend tests*

The conditions of the bend tests (Fig. 2) were:

- the value of distance between outside points was 50 mm,
- the loading speed was 5 mm/min.

Fig. 2 *Specimens in radial direction with tread after bending loading*

The specimen in transverse direction with width of 10 mm and without tread was not measured because small bending forces were obtained during measurement.

Furthermore, the photographic documentation showing the geometric configuration of reinforcing cords in steel-cord belts and tire-crown was supplied (Fig. 3) in order to obtain accurate geometric data which were needed for computational modeling of the given steel-cord belt.

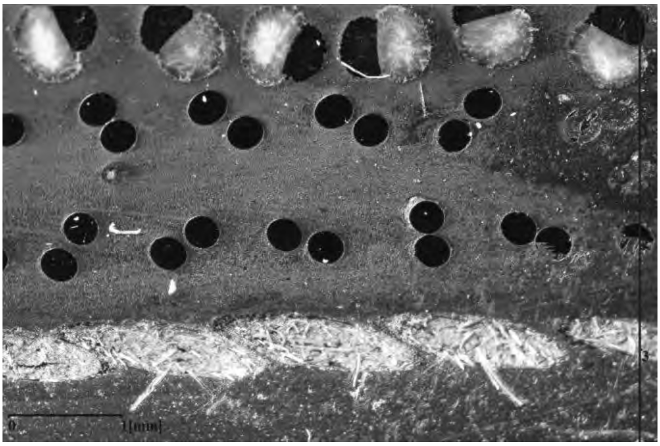

Fig. 3 *Detail of cord structure in the tire-crown*

4.Experimental results

Outputs based on tensile experiments for selected specimens are presented in Fig. 4 where the stress-strain dependencies can be seen.

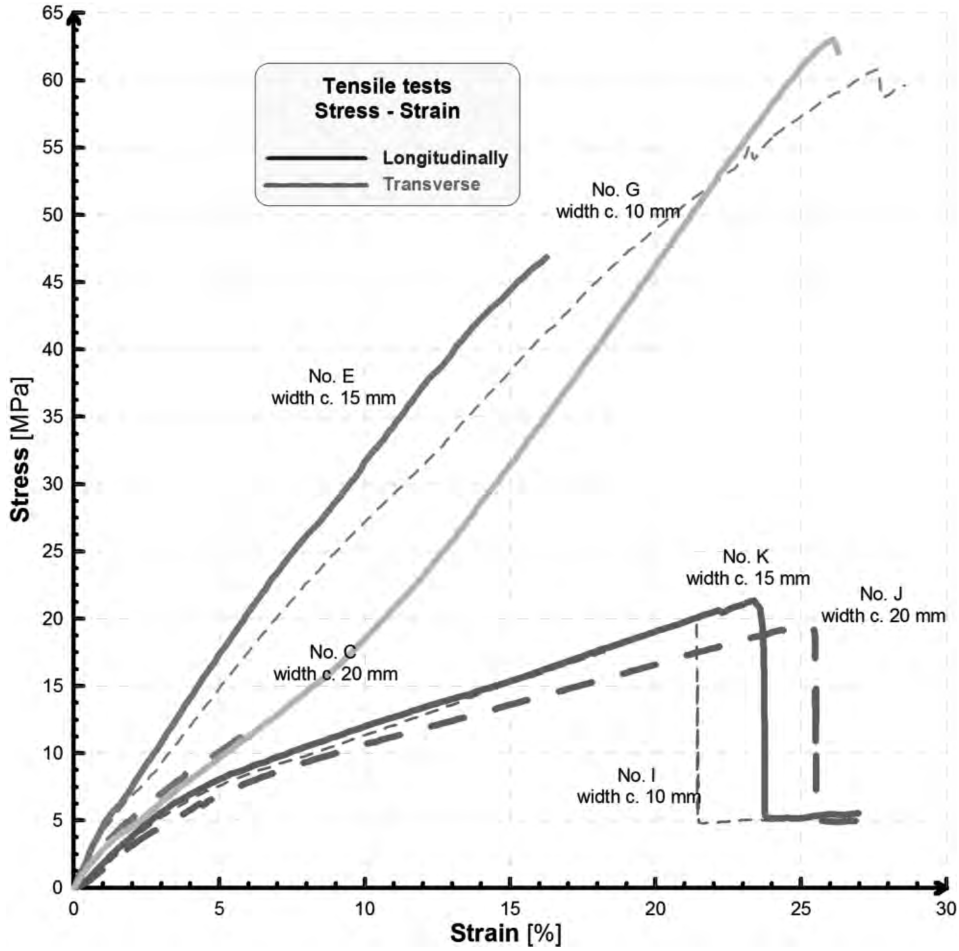

Fig. 4 *Stress-strain dependencies from the tensile tests for tire-crown specimens with different width [5]*

Table 1 *Moduli of elasticity ([1] moduli of elasticity from tensile tests, [2] moduli of elasticity from bend tests)*

Modulus of elasticity [MPa]		Specimen width		
		10 mm	15 mm	20 mm
Loading in direction	Longitudinal [1]	380	400	285
	Transverse [1]	200	205	185
	Radial [2]	90-110 for specimens which were cut in longitudinal direction		

In Tab. 1, there are the moduli of elasticity and they represent the outputs from tensile experiments and they are subsequently used as input data to make the computational models. Moduli of elasticity were obtained by tangent method at the start of the stress-strain dependence [6].

Outputs from bending tests for selected specimens are presented in Fig. 5.

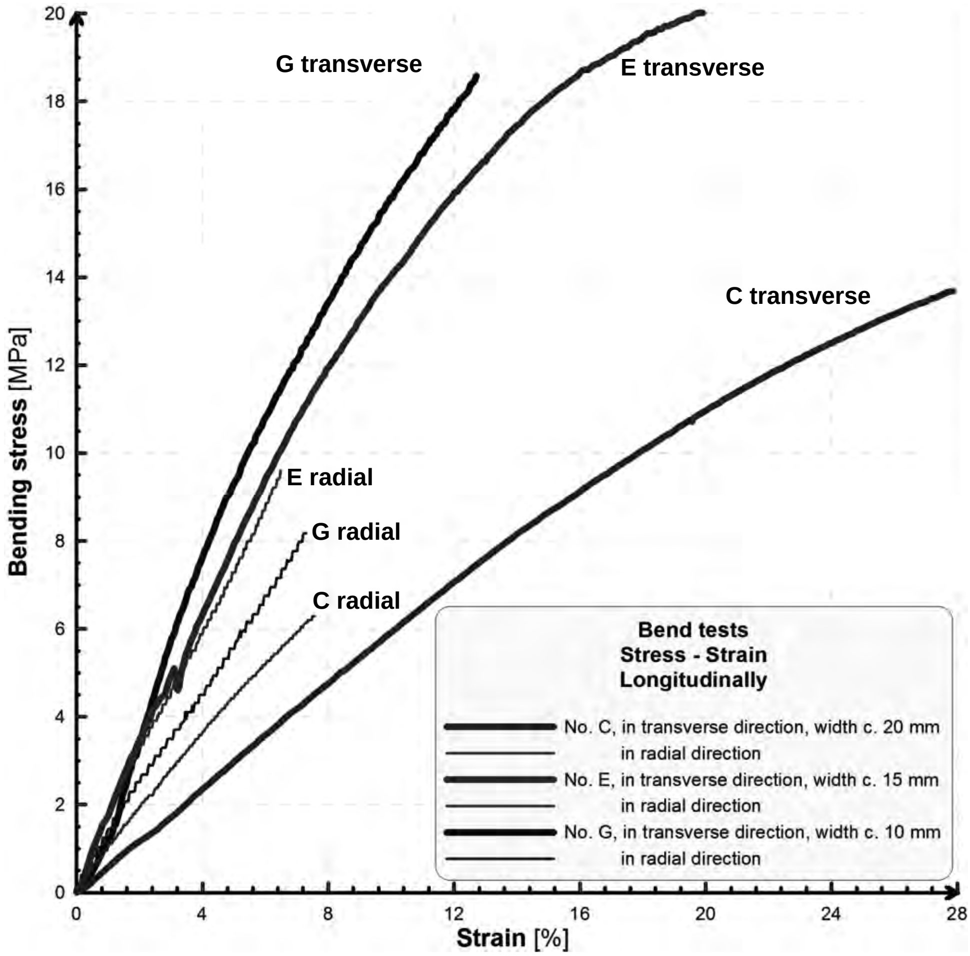

Fig. 5 *Stress-strain dependencies from bend tests for the tire-crown specimens in longitudinal direction without tread and with different width*

The geometric configuration of the reinforcing cords is shown in the Fig. 6 and it results from the facts presented in the Fig. 3. The construction of steel-cords is 2x0.30.

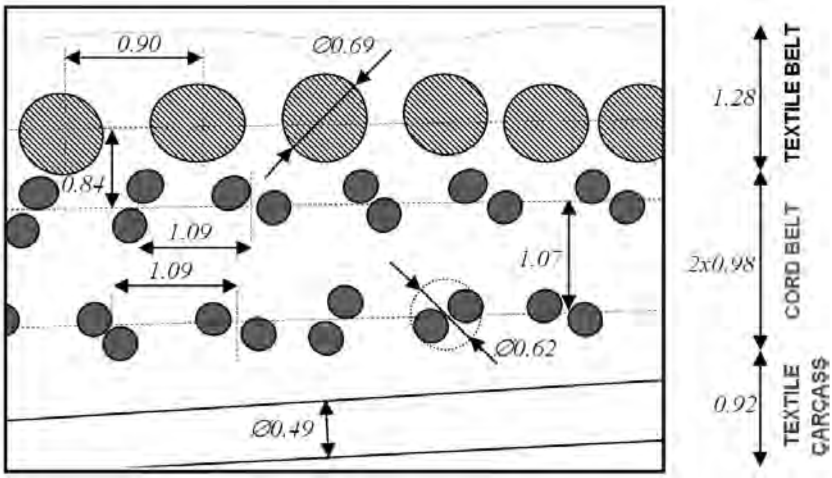

Fig. 6 *Structure of the geometry in the tire-crown – it is for the given radial tire with detailed view of steel-cord*

5.Conclusions

The results of the experiments can be used as verification data for comparison with results from computational modeling with experimental data.

The obtained information on geometric arrangement of reinforcements can be used also for optimization of arrangement of cords in the tire casing in order to gain better stiffness parametres standing for individual directions.

The authors will be continuing in this research area.

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Summary

Experiment of tire-crown for computational modeling of tire

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The paper deals with all of important materials parameters which are required for computational modeling in relation to the specific composites where the matrix is represented by elastomeric material. In the given paper, the mentioned materials parametres have to be used as input data to make the computational model of the radial car tire. The composite structures in the car tire are required to be described by help of appropriate parametres while the given parametres include geometric arrangement of reinforcements in the elastomeric matrix. The main attention is paid to the steel-cord belt. There are some ways how to replace the steel-cord belt. In this paper, the authors pay their attention to the orthotropic material which is often used as a replacement of steel-cord belt because the given orthotropic material has quite good response to the surrounding environment. After the determination of the input parametres, it is necessary to perform some experimental tests which has to be completed by microscopic observation and by this way, the more detailed information can be obtained in relation to the arrangement of the reinforcements in the area under the tread.