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MAŁGORZATA URBANEK, ALEKSANDRA PAWLAK-BURAKOWSKA*

COMPARISON OF EXPERIMENTAL AND NUMERICAL MODELS OF LONGASF RAILWAY FOUNDATION

WERYFIKACJA ZGODNOŚCI MODELU LABORATORYJNEGO Z MODELEM NUMERYCZNYM NAWIERZCHNI KOLEJOWEJ LONGASF

A b s t r a c t

This paper outlines the innovative concept of unconventional railway track on longitudinal sleepers and asphalt track bed. The authors presented a method for LONGASF numerical modeling. This paper describes the creation of the numerical model at the macro scale according to the behavior and interaction of analyzed laboratory sample in a micro scale.

Keywords: numerical modeling of railway track, LONGASF, unconventional railway track, model rescaling

S t r e s z c z e n i e

W artykule przedstawiono zarys koncepcji innowacyjnej niekonwencjonalnej nawierzchni kolejowej na podkładach wzdłużnych i podłożu asfaltowym. Autorzy zaprezentowali metodę modelowania numerycznego nawierzchni LONGASF. W niniejszej pracy opisano stworzenie numerycznego modelu w skali makro analizowanej nawierzchni uwzględniając zachowania i pracę nawierzchni w skali mik ro.

Słowa kluczowe: modelowanie numeryczne nawierzchni kolejowej, LONGASF, niekonwencjonalna nawierzchnia kolejowa, przeskalowanie modelu

* M.Sc. Eng. Małgorzata Urbanek, M.Sc. Eng. Aleksandra Pawlak-Burakowska, Faculty of Civil Engineering, Cracow University of Technology.

1. Introduction

Designing the railway track requires consideration of a large-size construction and repeatability of its components (slippers, fastening system, rail). The implementation of new methods for railway tracks for ballasted as well as slab track requires numerous experiments including numerical modeling as a basis for further design [4]. In such a case the problem of the transition between the size of laboratory sample occurs, as in laboratory conditions it must be short and the actual dimensions of the railroad truck is considerably longer. An important element in the design of a new rail track is numerical modeling.

This paper presents the implementation of finite element method for numerical analysis of the rail road. Such surveys were also performed by other researchers [5–10]. Numerical analyss and experimental tests of the compressed concrete slippers were carried out. In the next stage of experiments the slippers are stressed firstly in the laboratory and later on an experimental track. The set of aforementioned tests are called multilayer approach.

In order to develop a new method for design of the railway substructure using a multilayer approach, a set of Finite Element Models have been developed. To evaluate the accordance of the models with the real construction [11], a set of experiments were performed using a laboratory LONGASF construction sample. Bearing capacity of the construction was assessed and compared with the values obtained from numerical simulation. This method allows the transition from micro to macro scale. It also enables the designers to carry out additional simulations that require considerable distance along the track such as braking test.

Unconventional railway track called LONGASF, described in this paper, is designed on the foundation typical for roads. The mechanically stabilized aggregate layer is located on the ballast with sufficient capacity. At the top of it a layer of asphalt concrete without wear layer is placed. LONGASF construction consists of longitudinal slippers. The width of slippers is selected so that the load transferred to the surface of the asphalt is no higher than the heaviest load unit cars. Due to the fact that it is not possible to obtain higher accuracy of positioning the asphalt than ± 1 cm, the use of balancing layer was provided under the longitudinal slippers. Longitudinal slippers are connected transversely with steel fasteners and longitudinal elastic layers (Fig. 1).

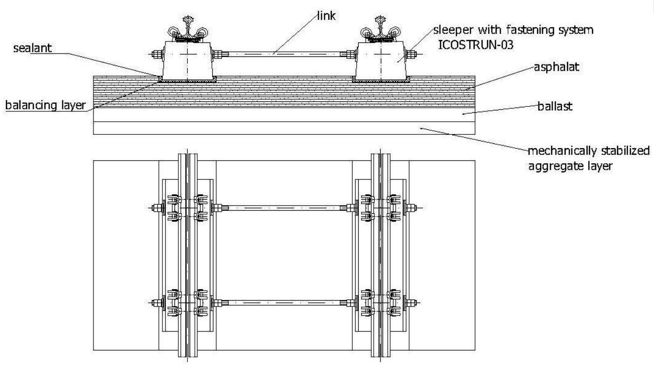

Fig. 1. General diagram of LONGASF railroad track [1]

2. Laboratory tests of the LONGASF sample

Laboratory tests (Fig. 2, 3) were carried out on the small size sample in relation to the dimensions of the actual railway structure. The dimensions of the asphalt surface were limited to the length of 1.5 meters and the width of 3.0 meters [1]. During the tests the vertical displacement of the rail has been measured.

Studies of the LONGASF railroad track with the fastening system ICOSTRUN-03 were carried out according to the standard PN- EN 13481-5:2004 Railway applications – Track – Performance requirements for fastening systems – Part 5 [2].

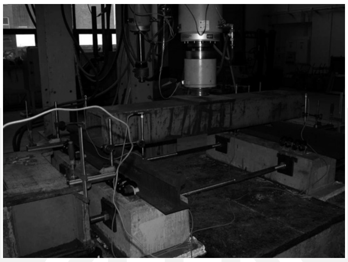

Fig. 2. LONGASF sample with ICOSTRUN 03 during stiffness tests [1]

Fig. 3. Sample with forcing element and measuring system during vertical stiffness test

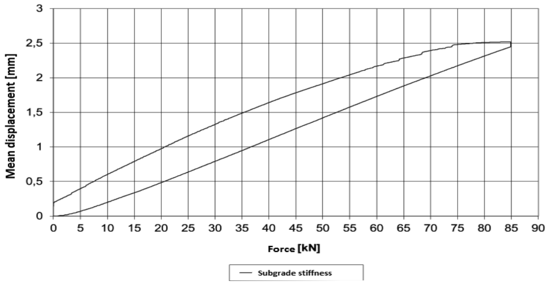

Fig. 4. Rail vertical displacement graph

The tests have shown that the maximum vertical displacement of the rail is 2.5 mm (Fig. 4). The results of preliminary laboratory tests, in which a ride on the curves was simulated, made it possible to carry out further computer simulations. This test shown that the maximum horizontal displacement of rail was about 4.6 mm. Such high value of displacement was caused by the lack of influence of neighboring fastenings.

3. Development and calculations of numerical sample

The three-dimensional model of the rail track LONGASF was created using Autodesk Simulation Multiphysics based on the laboratory model. It consists of a 3D placeholder (brick) and actuator, which were used in order to fix the fastening system as shown in Fig. 5.

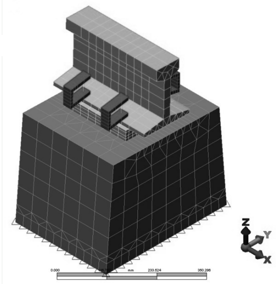

Fig. 5. Numerical model of fastening system ICOSTRUN 03

Subgrade (under the asphalt layer) was modeled by a spring element. During the computation a very weak subgrade, with C coefficient of 75 MN/m^3 was used. Similarly as in the laboratory, backfill was omitted in the numerical model (Fig. 6).

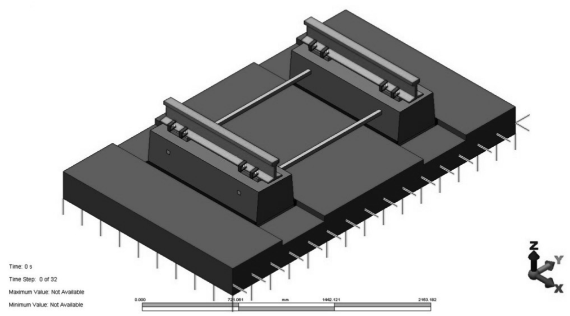

Fig. 6. Numerical model created in Autodesk Simulation Multiphysics

Force was applied at the contact point of the rail wheels, corresponding to the selected node.

For the purpose of model validation, the comparison of laboratory results and the numerical model was made. The obtained results of vertical displacement were similar to those laboratory ones and were equal to 2.5 mm.

In order to verify the influence on the sample of adjacent fastenings a 3D model was extended (Fig. 7). With such a method the behavior of the railway, the repetition of elements, and significant disparity dimensions were achieved, for example the width to the length ratio of the object.

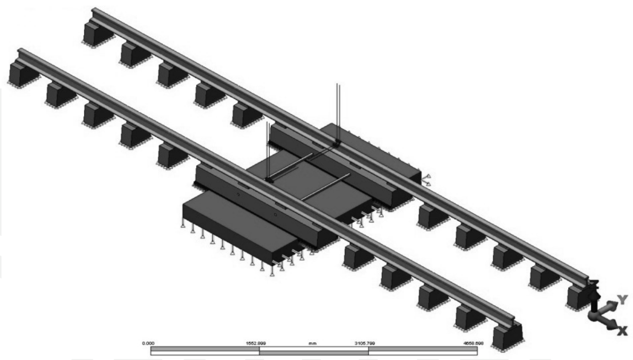

Fig. 7. Extended numerical model created in Autodesk Simulation Multiphysics

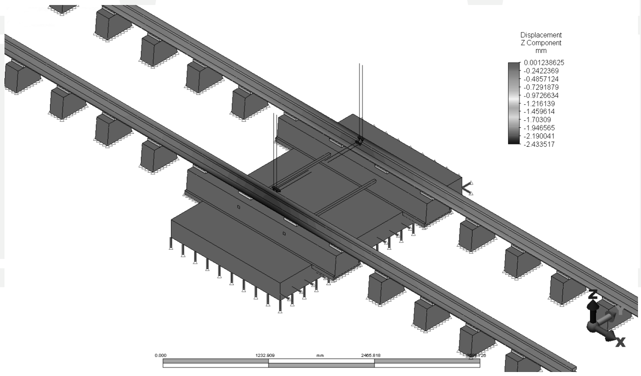

Fig. 8. Vertical displacements of LONGASF railway track

As a result of the extended model simulation, displacement of the rail was computed. The maximum vertical displacement was equal to 2.4 mm (Fig. 8). This result did not differ significantly from laboratory tests.

The simulation showed the maximum horizontal displacements as 2.4 mm (Fig. 9). This result was significantly different from the laboratory tests results, indicating the influence of the adjacent fastening. Maximizing dimensional model, its extension affects the results and illustrates the work of analyzed railway track.

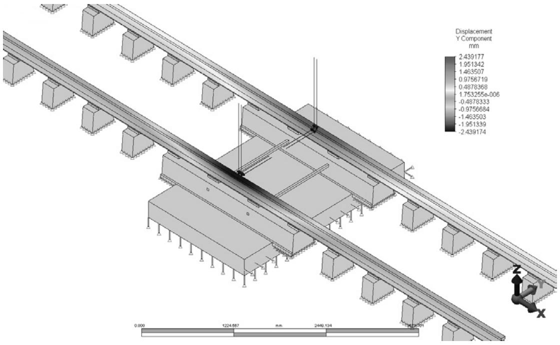

Fig. 9. Horizontal displacements of LONGASF railway track

4. Conclusions

This paper presents the comparison between micro and macro scale of the rail displacement in the LONGASF type of railway track. The displacement results were simulated in Autodesk Simulation Multiphysics and have shown that the vertical and horizontal displacement of the analyzed type of track didn't exceed the value of 2.5 mm. The results of the computer simulation were consistent with the results obtained from laboratory model. Accuracy of the results indicated that the appropriate parameters were chosen for numerical modeling of the sample. Therefore, such 3D modeling should be used to design such structures like railway tracks. The objective of these experiments was to propose a method of numerical modeling which allows the designer to obtain a variability of the mechanical and geometrical prosperities of a railway track. The recommendations are to adopt the presented methodology in order to decrease long computations.

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