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A STUDY OF THE DEFLECTIONS OF METAL ROAD GUARDRAIL ELEMENTS

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Abstract. Statistical data on traffic accidents in 2008 in Lithuania is presented. Referring to statistical data, 'grounding on an obstacle' makes one-tenth of all registered traffic accidents – 9.4% (an obstacle may be a road guardrail, a lamp post, a tree, a bar, a gate, etc.). Road guardrails of various types are installed on the shoulders and dividing strips of urban and suburban roads. They are as follows: reinforced concrete guardrails, cable guardrails and metal guardrails. Metal guardrails, consisting of Σ-shape metal posts and a protective W-shape horizontal beam, are most popular. The authors of the present paper examine the deformation processes of the elements of the above mentioned guardrail. A mathematical model of metal road guardrail was developed. Metal road guardrail was modelled using one-dimensional first-order finite elements, taking into account only elastic deformations, as well as the effect of soil on the buried post section of the guardrail. Based on the developed mathematical model of metal road guardrail, the deflections of its elements caused by the impact of a vehicle moving at varying speed were determined. The obtained values of deflections of guardrail elements (a protective W-shape horizontal beam and a Σ-shape post) presented in paper do not exceed the admissible values (of beam deflections).

Keywords: guardrail, beam, post, traffic safety, traffic accident, vehicle, simulation, finite element, deformation, deflections.

1. Introduction

The development of automobile transport is a positive factor for social and economic development of a country. Motorization is growing continually and, according to forecasts in the press, will be still growing in the future. In spite of the positive role of motorization, it also produces some negative effects on humans and the environment. The most negative factors are associated with traffic accidents and lowering traffic safety standards in some countries (Skrodenis *et al.* 2008; Šliupas 2009; Lama *et al.* 2007; Faure and DeNeuville 1992; Elvik *et al.* 1997). According to the statistical data provided by Prentkovskis and Bogdevičius (2005), Prentkovskis *et al.* (2008), about 700 thous. people are annually killed and about 20 million people are injured in traffic accidents in the world.

Traffic safety largely depends on vehicles, traffic participants and road infrastructure (Lundkvist and Isacsson 2008; Antov *et al.* 2009; Dragčević *et al.* 2008; Kapski *et al.* 2008; Vorobjovas and Žilionienė 2008; Nagurnas *et al.* 2007 and 2008; Sokolovskij 2007a and 2007b; Sokolovskij *et al.* 2007; Sivilevičius and Šukevičius 2007; Kinderytė-Poškienė and Sokolovskij 2008).

For many years, Highway Patrol Police of Lithuania has been registering 5–6 thous. traffic accidents per year (Accident Rate Information 2009). The dynamics of the registered traffic accidents in 2000–2008 is shown in Fig. 1. In 2008, there were fixed 4 897 traffic accidents. Their per cent distribution is presented in Fig. 2. In Fig. 3 per cent distribution of perpetrators of traffic accidents registered in 2008 is given.

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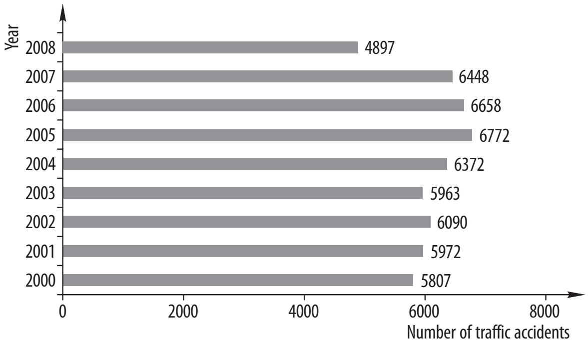

Fig. 1. The dynamics of traffic accidents registered by Highway Patrol Police of Lithuania in 2000–2008

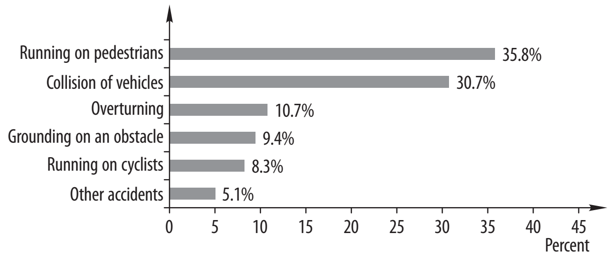

Fig. 2. Per cent distribution of traffic accidents registered in 2008 in Lithuania

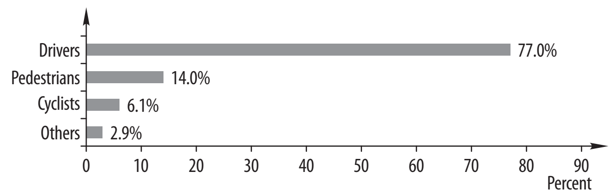

Fig. 3. Per cent distribution of traffic accident perpetrators in 2008 in Lithuania

As shown in graphical relationships presented in Figs 1–3:

- in recent years, traffic accident rate has been reducing;
- *running on pedestrians* makes the largest part of all traffic accidents – 35.8%;
- *grounding on an obstacle* makes one-tenth of all traffic accidents – 9.4% (an obstacle may be a highway safety guardrail, a lamp post, a tree, a bar, a gate, etc.);
- *drivers* are usually the main traffic accident perpetrators – 77.0%.

It is well known that the most serious traffic accidents are associated with crossing the driving strips and running on the roadside obstacles at roads' intersections or on bridges crossing a highway. These traffic accidents often occur, when the speed of a vehicle is high and can lead to its collision with dangerous obstacles (e.g. bridge or viaduct structures, objects at the entry to a tunnel, etc.). In these cases, the death-rate and traumatism are very high.

Installing of roadside safety guardrails may reduce traumatism and losses caused by traffic accidents. It is supposed that various types of safety guardrails should be installed only on road sections where run-off-road accidents may occur, or where they protect a vehicle from grounding on the obstacles which may lead to more grave consequences than a collision with safety guardrails. Dividing guardrails between the lanes with traffic in opposite directions on multilane roads are intended for preventing traffic accidents, usually occurring when a vehicle is crossing the driving strips. Safety guardrails helping to avoid human injuries are energy absorbing structures installed in front of stationary objects making a part of road structure, e.g. at the entry to a tunnel. They also include the parts of an over-bridge at the crossing at different levels or bridge pier. There are guardrails of various types, e.g. in the form of rolls partly filled with sand or guardrail like 'a skirt', presenting not fixedly attached elements of guardrail, which are folded when a vehicle hits them.

In an ideal case, guardrails should 'catch' a vehicle and guide it till the controlled stop. It is vitally important that a vehicle grounding on such an obstacle should not be thrown back to a traffic lane at the same speed. Besides, the guardrails of this type should be arranged so that they would not restrict a visual range and mislead the driver about the alignment of the road at the sections of poor visibility.

Various types of safety guardrails are intended for reducing the damage caused by traffic accidents rather than avoiding accidents. It may be also supposed that guardrails reduce not only destructive effects, but their rate as well. Usually, a guardrail is a stationary structure, a collision with which a driver is trying to avoid. The efforts of the driver to avoid collision with a guardrail help to reduce the traffic accident rate. On the other hand, we may suppose that guardrails make the driver be less careful, particularly, on the dangerous roads. The driver, running on the road sections having only a few guardrails, tries to avoid running off the road. Guardrails located on the driving strip of a multilane road may reduce the manoeuvrability of a vehicle, thereby causing traffic accidents. Grounding of a vehicle on a guardrail located on a driving strip (when there are no other vehicles close to it) can hardly lead to great damages, throwing it merely back to the traffic lane and allowing it to continue the trip. These cases are even not registered as traffic accidents. Sometimes, only the material losses may be done.

Installing safety guardrails on a driving strip of a multilane road allows us to reduce casualty rate due to traffic accidents by about 20%. The rate of human injuries caused by traffic accidents is reduced by 5% and material losses caused by traffic accidents are increased by 25%. The most resilient guardrails (e.g. cable guardrails) are most effective in reducing traffic accidents causing injuries of the humans. However, they increase the rate of traffic accidents causing material losses. Their effect on the death-rate in traffic accidents has not been statistically described in research (Elvik *et al.* 1997).

A possible explanation of the above trend may be provided by supposing that a guardrail on the dividing strip of a multilane road may reduce maneuverability of a vehicle, particularly, when it runs on the dividing strip without any grave consequences, which, in the absence of a guardrail, would not be registered as a traffic accident.

Roadside safety guardrails largely reduce the number of traffic accidents (runoffs) causing fatalities and human injuries. It may be also stated that they reduce the total traffic accident rate on the road. Replacing stiff guardrails (e.g. reinforced concrete guardrails) with the resilient ones (e.g. cable guardrails, easily deformed metal guardrails, etc.) also helps to reduce the rate of traffic accidents.

Damping guardrails are energy absorbing structures usually installed near the entry to a tunnel, at the intersections of different levels and near the piers of bridges and viaducts.

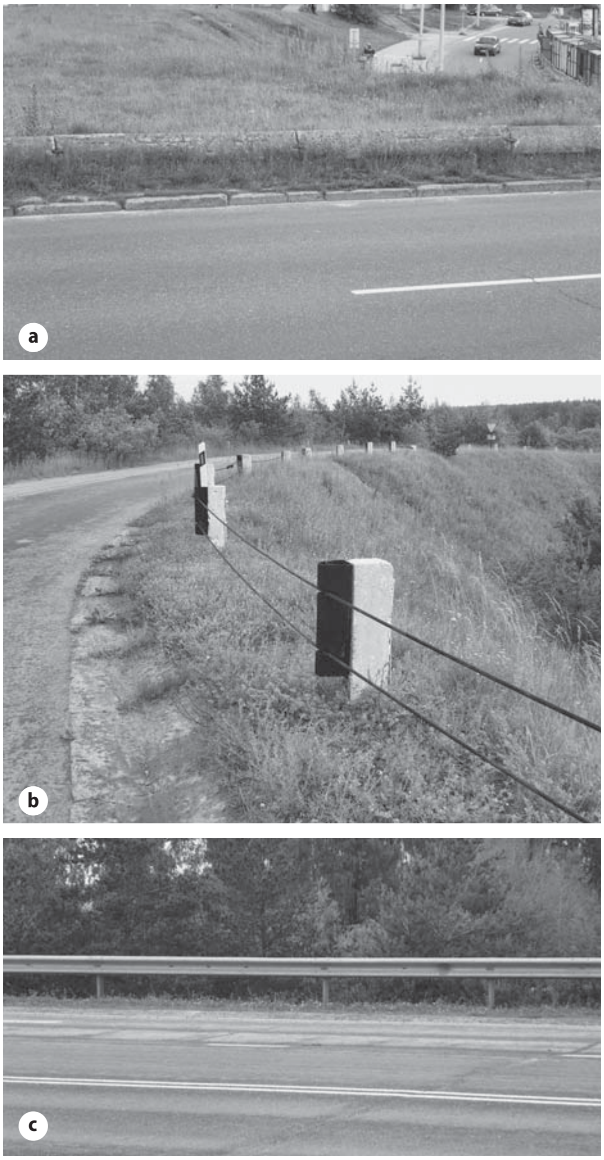

Fig. 4. Guardrails installed on highways: a – reinforced concrete guardrail; b – cable guardrail; c – metal guardrail

Safety guardrails of various types are installed on the shoulders and dividing strips of urban and suburban roads of Lithuania, Ukraine, Russia and other countries. They are as follows (Fig. 4):

- reinforced concrete guardrails (with reinforced concrete or metal posts);
- cable guardrails (with reinforced concrete posts);
- metal guardrails.

Metal guardrails, consisting of Σ-shape metal posts and a protective W-shape horizontal beam (see Fig. 5), are most popular. The authors of the present paper examine the deformation processes of the elements of the above-mentioned type of guardrail.

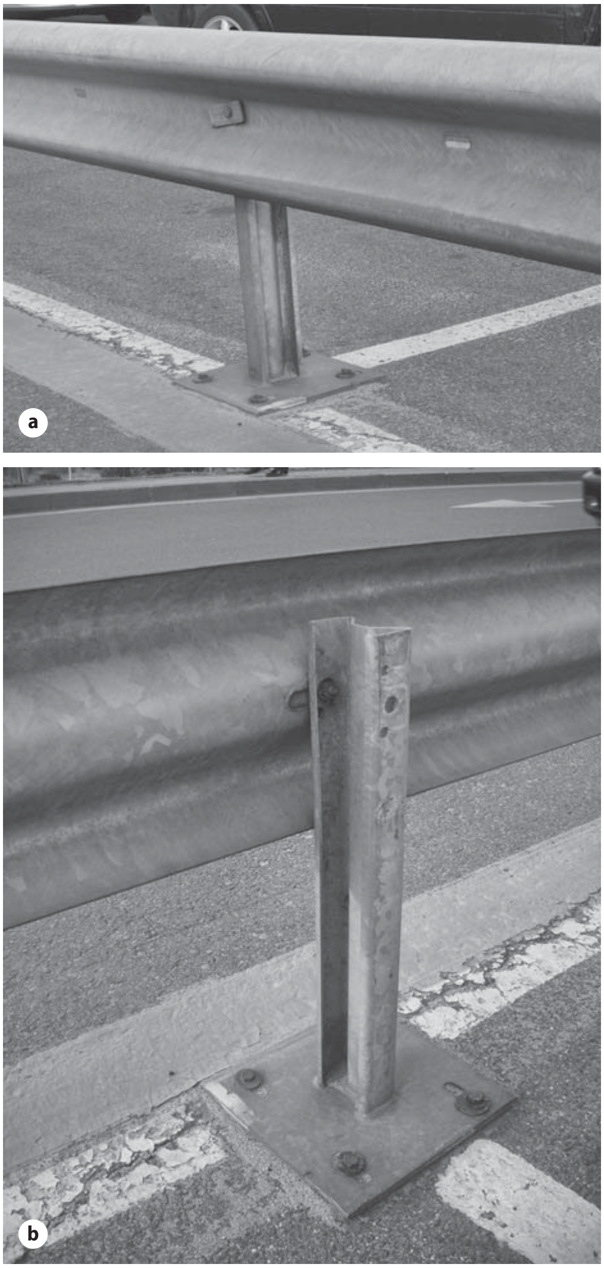

Fig. 5. The elements of metal guardrail: a – protective W-shape horizontal beam (in the foreground); b – Σ-shape post (in the foreground)

2. A Survey of the Papers on the Considered Problem

The elements of a metal road guardrail may be described as a beam system and analysed with the use of finite elements and various software packages. The deformation processes of such a system may be approached as a separate object (Prentkovskis *et al*. 2007 and 2008; Prentkovskis and Bogdevičius 2005; Bogdevičius and Prentkovskis 2001), or analysed by integrating it into transport infrastructure, whose constituent parts are described in the papers of Lundkvist and Isacsson (2008), Antov *et al*. (2009), Dragčević *et al*. (2008), Kapski *et al*. (2008), Vorobjovas and Žilionienė (2008), Nagurnas *et al*. (2007 and 2008), Sokolovskij (2007a and 2007b), Sokolovskij *et al*. (2007), Kinderytė-Poškienė and Sokolovskij (2008), Viba *et al.* (2009), Prentkovskis and Sokolovskij (2008), Vansauskas and Bogdevičius (2009), Tautkus and Bazaras (2007), Pelenytė-Vyšniauskienė and Jurkauskas (2007).

A brief survey of the papers investigating highway guardrails and their elements is presented below.

A mathematical model of a deforming road guardrail is presented in the research made by Prentkovskis and Bogdevičius (2005). Beam metal guardrail is simulated by first-order one-dimensional finite elements. Studying the deformation process of the guardrail posts, the impact of soil is taken into consideration. Referring to the mathematical model of a guardrail it is possible to investigate beam metal guardrails mostly used on the automobile roads of Lithuania, to design new guardrails of this type, and also to investigate different traffic situations (e.g. the interaction between a motor vehicle and a road guardrail). Based on the model of the guardrail, the bending deflections of deforming elements (metal beam, metal posts) of guardrail are investigated.

Prentkovskis *et al.* (2007) presented the investigation of potential deformations developed in the elements of transport and pedestrian traffic restricting gates during motor vehicle-gate interaction. The mathematical model of transport and pedestrian traffic restricting gate was designed. One section of the gate restricted the traffic of motor vehicles, while the other limited the traffic of pedestrians. The gate was modelled based on the first-order one-dimensional finite elements, taking into account only the resilience of the gate elements and the impact of soil on the ground-embedded parts of the gate support and auxiliary posts. The potential deformations of gate elements were determined based on the mathematical model designed. The specific traffic accident was investigated using the mathematical model of the gate designed, when four situations of motor vehicle-gate interaction were simulated and investigated.

A procedure for reconstructing run-off-road accidents, involving longitudinal W-beam guardrail systems was developed by estimating energy dissipation during an impact. Correlations were developed between the vehicle's departure angle, velocity, type of vehicle, and the energy dissipated. Energy losses are caused by guardrail-vehicle friction, post/soil deformations, guardrail beam defo-ground friction, with vehicle damage predominating). Guardrail-vehicle friction losses were found to range from about 5 to 36%, depending upon speed and impact angle. The energy to cause permanent deflection of the guardrail posts in a system was found to be roughly equivalent to the amount of energy dissipated by the rail deformation of that system. Comparisons with full-scale crash test results showed that the developed iterative reconstruction procedure accurately estimated impact velocities within 3% (see research by Coon and Reid 2005).

For longitudinal guardrails, it is common practice to use a standard W-beam guardrail along the required highway segments and a stiffened Thrie-beam guardrail in a transition region near the end of a bridge. As a result of the differences in rail geometries, a W-beam to Thrie-beam transition element is typically used to connect and provide continuity between the two rail sections. However, the W-beam to Thrie-beam transition element has not been evaluated according to the current impact safety standards. Therefore, the approach to guardrail transition system, including a W-beam to Thrie-beam transition element, was constructed and crash tested. The transition system was attached to Missouri's Thriebeam and channel-bridge railing system (Polivka *et al*. 2007).

The research by Kokkula *et al*. (2006) presents the results of numerical simulations of bumper beam systems, the important structures of an automobile that provide passenger protection from front and rear collisions. This investigation explores bumper beam – longitudinal systems that are subjected to 40% offset impact loading. The numerical simulations use the nonlinear finite element code LS-DYNA to observe system behaviour. In addition, a comparative study of an industrial-like modelling procedure is performed that includes user-defined material such as state-of-the-art anisotropic plasticity, an isotropic strain, a strain rate hardening rule, and ductile fracture criteria. Numerical crash results agree with the experiments, regarding overall deformation mode and energy dissipation. The simulations give relatively accurate predictions of the collapse mode found in the experimental tests. An exception occurs with one bumper beam – longitudinal system that has AA7003-TI longitudinals. The research also includes sensitivity studies that consider both physical (e.g., strain-rate effects, heat-affected zone) and numerical (e.g., adaptive meshing) parameters.

Wu and Thomson (2007) presented a study of the interaction between a guardrail post and soil during quasi-static and dynamic loading. A roadside guardrail system is anchored in gravel beside a roadway to eliminate the risk of fatal accidents during off-road crashes and collisions with hazardous roadside objects. The desired safety behaviour is ensured not only by the guardrail structure itself, but also by the interaction between the gravel and the guardrail post. The interaction of gravel with a Sigma-post of a standard Swedish guardrail was studied in experiments and numerical analysis. The aim was to measure the strength of the single post embedded in gravel and use the data to validate a computer model for the investigation of the soil-post interaction. A quasi-static and dynamic test series were designed and carried out. Two corridors were formed by the test data for the quasi-static and dynamic loading conditions, respectively. A parametric study was subsequently conducted to investigate the influence of gravel stiffness on the soil-post interaction through computer simulations using LS-DYNA. The numerical results showed that the LS-DYNA soil and concrete model and the Cowper-Symonds steel model effectively captured the soil-post interaction since the calculated strength of the post agreed with the corridors of the test data. The input parameters for the soil and concrete material model were recommended for roadside gravel in crash analyses.

Crash test simulation of a modified thrie-beam high containment level guardrail under NCHRP Report 350 TL 4-12 conditions was presented by Cansiz and Atahan (2006). This research describes the details of a computer simulation study performed on a modified thrie-beam high containment level guardrail designated as SGR09b. Because the SGR09b guardrail system is the only high containment guardrail system passing the NCHRP Report 350 TL4 requirements in its class, developing an accurate finite element model for this guardrail is deemed to be a significant contribution towards enhancement of computer-simulated virtual roadside safety research. For this reason, a detailed finite element model of the SGR09b guardrail system has been developed and subjected to 8000 kg single unit truck impact under NCHRP Report TL4 conditions. The fidelity of the simulation study was evaluated using the full-scale crash test results. As in the full-scale crash test, in the finite element simulation study, the guardrail system successfully contained and redirected the 8000 kg single unit truck. Based on the crash test results, it was determined that the finite element models for both the SGR09b guardrail system and the 8000 kg single unit truck are fairly accurate and can be used with confidence in further computer-simulated virtual roadside safety research.

Simulation of motorcyclist's kinematics during impact with W-Beam guardrail was presented by Ibitoye *et al.* (2006). W-Beam guardrail system has been in use as a standard for roadside safety guardrail since 1950s. Recently, its safety performance standard has been upgraded to absorb impact from large vehicles. This performance standard requires guardrail system to be capable of capturing and redirecting a large range of vehicle types and sizes but its effects on safety of motorcyclists are not yet understood. The research describes a three-dimensional computer simulation of the kinematics impact of motorcycle and dummy rider with W-Beam guardrail inclined at angles 45 and 90 degrees to the initial direction of travel. The simulation is based on the test procedure recommended by ISO 13232 on the configurations for motorcycle-car impact. The focus of this study is not on the motorcycle change in velocity, but on the rider's kinematics and acceleration vs. time history. Multibody model of motorcycle and finite element model of guardrail were developed in commercially available software. The simulation results are presented in this paper in the form of kinematics and acceleration vs. time history.

Mohan *et al.* (2005) presented the research of finite element modeling and validation of a 3-strand cable guardrail system. The primary purpose of longitudinal safety guardrails, such as cable guardrails, is to contain and/or redirect errant vehicles that depart the roadway, hence keeping them from entering opposing travel lanes or encountering terrain features and roadside objects that may cause severe impacts. In this study, a detailed finite element model of a three-strand cable guardrail was developed and validated against a previously conducted full-scale crash test. The full-scale crash test and simulation were setup for an impact of the cable guardrail with a 2000 kg pickup truck at an angle of 25 deg and the initial velocity of 100 km/hr This setup is in accordance with the National Cooperative Highway Research Program (NCHRP) Report 350 guidelines for Test Level 3 safety performance. This paper provides guidelines for simulating cable guardrail systems. Detailed methods for system simulation involving dynamic interactions of soil/post, post/hook bolts, cable/hook bolts and cable/truck were discussed. The results of the simulation and comparisons with the full-scale crash test were presented.

3. A Mathematical Model of Metal Road Guardrail

To study the potential deformations of the elements of metal road guardrail a mathematical model was developed (Bogdevičius and Prentkovskis 2001; Prentkovskis and Bogdevičius 2005; Prentkovskis *et al.* 2007 and 2008).

The metal road guardrail (Fig. 4c and Fig. 5) was modelled by using one-dimensional first-order finite elements (Fig. 6). In the interaction between a vehicle

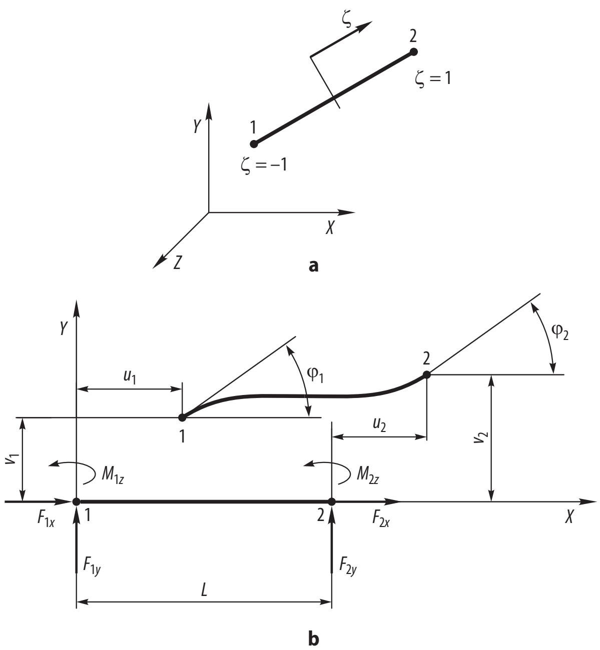

Fig. 6. One-dimensional first-order finite element:
a – scheme in the system of the coordinates $X - Y - Z$;
b – deformations in the plane $X - Y$

and a guardrail, the nodes of the finite elements change their position in the system of coordinates used (the elements are deformed). In simulation, only elastic deformations and the effect of the soil on the buried post section of the guardrail are taken into account.

A guardrail presents a mechanical system. To obtain the equation of the finite element movement, second-degree Lagrange equation is used (Bogdevičius and Prentkovskis 2001; Prentkovskis *et al.* 2007).

Then, the expressions for kinetic and potential energy, the dissipative function of the finite element as well as vector of the external forces acting on the finite element are written, taking into account that finite element displacements were approximated:

$$\left\{u^{(e)}\right\}=\left[N\right]\left\{q^{(e)}\right\}, \tag{1}$$

where: $\left\{u^{(e)}\right\}$ is finite element displacement; $\left[N\right]$ is the function of finite element shapes; $\left\{q^{(e)}\right\}$ is the vector of generalized finite element displacements.

By substituting the expressions of the kinetic and potential energy, the dissipative finite element function and the vector of the external forces acting on the finite element into second-degree Lagrange equation, a system of the equations for the movement of the finite element is obtained in the form of a matrix:

$$\left[M^{(e)}\right]\left\{\ddot{q}^{(e)}\right\}+\left[C^{(e)}\right]\left\{\dot{q}^{(e)}\right\}+\left[K^{(e)}\right]\left\{q^{(e)}\right\}=\left\{F^{(e)}\right\}, \tag{2}$$

where: $\left[M^{(e)}\right]$, $\left[C^{(e)}\right]$, $\left[K^{(e)}\right]$ are the matrices of masses, damping of mechanical energy and stiffness of the finite element; $\left\{\ddot{q}^{(e)}\right\}$, $\left\{\dot{q}^{(e)}\right\}$, $\left\{q^{(e)}\right\}$ are vectors of generalized accelerations, speeds and displacements of the finite element; $\left\{F^{(e)}\right\}$ is the vector of generalized forces acting on the finite element.

By integrating the equations of movement of all finite elements into a unified system, a system of road guardrail movement is obtained:

$$\left[M_{g.r.}\right]\left\{\ddot{q}_{g.r.}\right\}+\left[C_{g.r.}\right]\left\{\dot{q}_{g.r.}\right\}+\left[K_{g.r.}\right]\left\{q_{g.r.}\right\}=\left\{F_{g.r.}\right\}, \tag{3}$$

where: $\left[M_{g.r.}\right]$, $\left[C_{g.r.}\right]$, $\left[K_{g.r.}\right]$ are the matrices of masses, damping of mechanical energy and stiffness of guardrail; $\left\{\ddot{q}_{g.r.}\right\}$, $\left\{\dot{q}_{g.r.}\right\}$, $\left\{q_{g.r.}\right\}$ are vectors of generalized accelerations, speeds and displacements of all nodes of guardrail; $\left\{F_{g.r.}\right\}$ is the vector of generalized forces acting on the road guardrail:

$$\left[M_{g.r.}\right]=\sum_{e=1}^{NE}\left[M^{(e)}\right];$$

$$\left[C_{g.r.}\right]=\sum_{e=1}^{NE}\left[C^{(e)}\right];$$

$$\left[K_{g.r.}\right]=\sum_{e=1}^{NE}\left[K^{(e)}\right];$$

$$\left\{F_{g.r.}\right\}=\sum_{e=1}^{NE}\left\{F^{(e)}\right\};$$

$$\left\{\ddot{q}_{g.r.}\right\}=\sum_{e=1}^{NE}\left\{\ddot{q}^{(e)}\right\};$$

$$\left\{\dot{q}_{g.r.}\right\}=\sum_{e=1}^{NE}\left\{\dot{q}^{(e)}\right\};$$

$$\left\{q_{g.r.}\right\}=\sum_{e=1}^{NE}\left\{q^{(e)}\right\}, \tag{4}$$

where: NE is the number of finite elements.

To obtain the matrices of masses, damping of mechanical energy and stiffness of the finite element, the finite element deformation in the planes X – Y (see Fig. 6) and X – Z (Bogdevičius and Prentkovskis 2001; Prentkovskis *et al.* 2007) is studied.

The matrix of masses $\left[M_{g.r.}\right]$, the matrix of damping of mechanical energy $\left[C_{g.r.}\right]$ and the matrix of stiffness $\left[K_{g.r.}\right]$ of the finite element, as well as the vector of generalized accelerations $\left\{\ddot{q}_{g.r.}\right\}$, vector of generalized speeds $\left\{\dot{q}_{g.r.}\right\}$, vector of generalized displacements $\left\{q_{g.r.}\right\}$ of the finite element and the vector of generalized forces $\left\{F_{g.r.}\right\}$ are expressed in the local system of the coordinates. Then, matrices and vectors are transformed into a global system of the coordinates.

4. The Results Obtained in Computer-Aided Simulation

Computer-aided simulation was performed using a personal computer and software packages *Compaq Visual Fortran* (Chivers and Sleightholme 2008) and *Maple* (Aladjev *et al.* 2002; Meade *et al.* 2009). The software package *Maple* was used to obtain the matrices of masses, damping of mechanical energy and stiffness of the finite element, while *Compaq Visual Fortran* was used for solving a mathematical model of road guardrail.

The deformation processes of metal road guardrail elements caused by the impact of a vehicle (motor car) moving at varying speed (Fig. 7) were examined.

According to specifications and recommendations presented in ГОСТ Р 52607–2006 *Технические средства организации дорожного движения. Ограждения дорожные удерживающие боковые для автомобилей. Общие технические требования*' [GOST R 52607–2006 *Traffic Control Devices. Roadside Barriers. General Technical Requirements*], the following guardrail parameters and the conditions of vehicle interaction with a guardrail were chosen (see the Table).

The obtained values of deflections of guardrail elements (a protective W-shape horizontal beam and a Σ-shape post) presented in Fig. 7 do not exceed the admissible values (of protective W-shape horizontal beam deflections), presented in the Table. The results of computer-aided simulation show that the higher the speed of a moving vehicle at the moment of its collision with a guardrail, the heavier the deflections of the guardrail elements.

Table. Guardrail parameters and the conditions of vehicle interaction with a guardrail

Recommended parameter	Admissible values of the recommended parameter	The parameter value chosen
Guardrail length, m	12, 15, 18, 25	12
Distance between posts, m	1, 2, 3, 4	2
Height of the guardrail (post) above the road surface, m	0.60, 0.75, 0.90, 1.10, 1.30, 1.50	0.75
Height of the buried guardrail section (post), m	–	1.25
Type of vehicle	motor car, truck, articulated truck, bus	motor car
Mass of the chosen vehicle (a motor car), kg	1000, 1200, 1500	1500
Speed of the chosen vehicle, km/h	80, 90, 100	80, 90, 100
Angle of interaction between a vehicle and a guardrail, degrees	20°	20°
Admissible guardrail beam deflection, m	0.75, 1.00, 1.25, 1.50	the values is not chosen, but calculated and compared with the admissible values (see the results of computer-aided simulation given in Fig. 7)

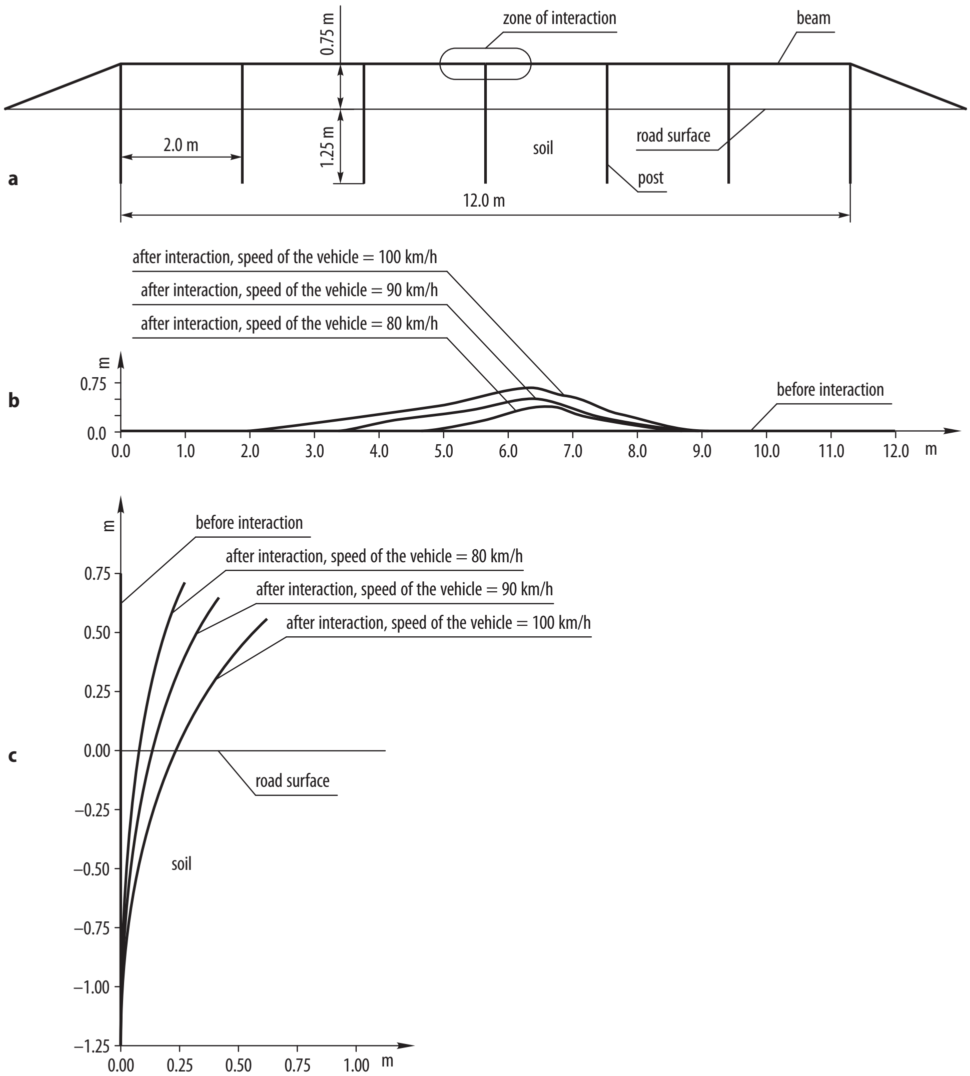

Fig. 7. The deflections of metal road guardrail elements caused by the impact of a vehicle moving at varying speed (angle of interaction between a vehicle and a guardrail – 20°): a – scheme of the metal guardrail; b – deflections of protective W-shape horizontal beam; c – deflections of Σ-shape post

5. Conclusions

1. A mathematical model of metal road guardrail was developed.
2. Metal road guardrail was modelled using one-dimensional first-order finite elements, taking into account only elastic deformations, as well as the effect of soil on the buried post section of the guardrail.
3. Based on the developed mathematical model of metal road guardrail, the deflections of its elements caused by the impact of a vehicle moving at varying speed were determined. The results of computer-aided simulation show that the higher the speed of a moving vehicle at the moment of its collision with a guardrail, the heavier the deflections of the guardrail elements. The obtained values of deflections of guardrail elements (a protective W-shape horizontal beam and a Σ-shape post) presented in paper do not exceed the admissible values (of beam deflections).
4. To perform the computer-aided experiment (mathematical model solution) with road guardrail, some application programs based on using software packages *Compaq Visual Fortran* and *Maple* were developed.
5. The mathematical model of road guardrail presented in the paper may be used by researchers, practical workers and experts for modelling and studying various traffic situations (e.g. the interaction between a vehicle and a guardrail).
6. The model developed may be modified to use it for the analysis of deformation processes of beam system's structures in transport infrastructure (e.g. light posts, traffic-lights and road signs).

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