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# Experimental verification of stiffness characteristics of railway freight wagon buffers

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## 1. Introduction

Increasing length, weight and speed of freight trains lead to higher requirements on the running safety. The problem is related specially to braking of trains and their running through small-radius curves (including diverging parts of switches) where undesirable longitudinal dynamic effects can occur within the trainsets. From the point of view of the longitudinal train dynamics, a knowledge of stiffness characteristics of draw- and buffing gear of individual vehicles seems to be very important. Nowadays, the older types of friction-type suspension elements used in these components (conical belt springs, ring springs) are often replaced by various rubber-steel- or elastomer components with significantly different characteristics. Therefore, this paper deals especially with requirements on the stiffness characteristics of railway freight wagon buffers as well as their experimental verification in the context of application of these characteristics into the multi-body simulations.

## 2. Stiffness characteristics of railway buffers – requirements and measurements

The basic requirements on railway buffers are defined in the European standard EN 15551 [2]. According to this standard, the buffers can be classified into categories with respect to their maximum stroke (105 up to 150 mm) and dynamic energy capacity. The buffers for freight wagons, which are not intended for the transport of dangerous goods (RID), usually use the maximum stroke of 105 mm and belong to the category A (i.e. a requirement on the minimum dynamic energy capacity of 30 kJ). From the point of view of stiffness characteristics, EN 15551 defines only basic requirements on (quasi-)static force–displacement curves, particularly a force range at defined values of the buffer stroke, the minimum stored energy at the maximum stroke as well as the minimum absorbed energy (i.e. the damping ratio). However, the dynamic behaviour of railway buffers is not considered as stiffness characteristics under the conditions of dynamic loading (which are important, e.g., for simulations of longitudinal train dynamics effects), but in a different way – with respect to the buffer properties during impact of wagons to protect load as well as the wagon structure (e.g. during shunting).

To obtain dynamic stiffness characteristics of real components of draw- and buffing gear, two different types of side buffers and two different types of suspension of drawbar hook were tested in the dynamic test lab of the Educational and Research Centre in Transport (ERCT) at the Faculty of Transport Engineering of the University of Pardubice in framework of solving the diploma thesis [3] in 2020. For determination of the dynamic stiffness characteristics of the investigated components, an extensive test program – including scenarios with various values of prestress, amplitude and frequency of harmonic loading – was defined. The parameters of the performed dynamic tests (see Fig. 1) were limited by properties of the used test equipment

(INOVA dynamic test stand), i.e. the maximum force value of approximately 600 kN and the maximum loading frequency up to ca. 2.5 Hz.

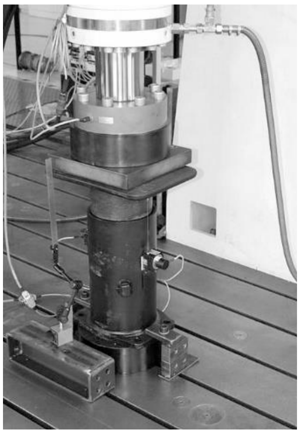

Fig. 1. Railway buffer during measurements in the ERCT dynamic test lab

In Fig. 2, there is presented an example of measurement results for the buffer equipped with elastomer suspension element. The dotted line represents the (quasi-)static force–displacement curve, determined by means of a simple compression and unloading of the buffer at a constant velocity of 5 mm/s. Selected dynamic characteristics are presented by the set of solid lines. In the graph, the results for three different values of required prestress (20, 50 and 80 mm) are shown. All these results represent the harmonic loading cycles with the maximum velocity of loading of approximately 80 mm/s; the individual loading cycles differ in the amplitudes (and therefore in the frequency of loading, as well).

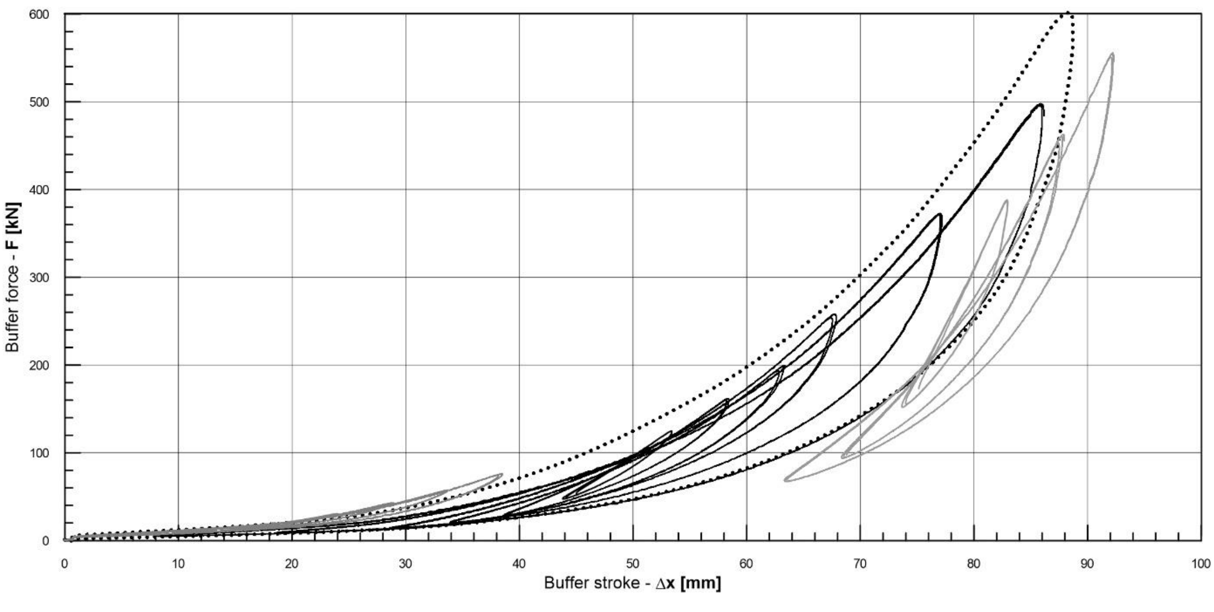


Fig. 2. Measured (quasi-)static and dynamic characteristics of a buffer equipped with elastomer spring

These results show that the dynamic characteristics of the buffer equipped with elastomer suspension element can in some cases fall more or less outside the area defined by the loading and unloading curves of the (reference) quasi-static stiffness characteristic. On the other hand, the dynamic characteristics does not even touch these curves in some cases. The explanation of the observed effects can be based on the following two phenomena:

- the influence of dynamics, i.e. the frequency of loading – increasing loading frequency leads to a higher dynamic stiffness of the spring;

- the influence of temperature of the spring material – because of energy dissipation in the spring material during the loading cycles, the spring is warming up which leads to changes of the (quasi-)static stiffness characteristic of the buffer (i.e. a decrease in the stiffness). Measurement results show that the temperature-caused decrease in the force at a given stroke value can reach up to 50 % if the temperature increases by 50 °C.

## 3. Conclusions and outlook

Knowledge of the dynamic properties of longitudinal suspension for railway vehicles (i.e. the dynamic stiffness characteristics of side buffers and suspension elements of drawbar hooks or central couplers) is essential for the simulation and assessment of longitudinal train dynamics effects (see, e.g., [1, 4, 5]). However, these characteristics are generally not known because the relevant European standard [2] requires only the basic parameters of their (quasi-)static force–displacement curve. Therefore, experimental investigation of the dynamic characteristics of two samples of railway buffers was realized. The results show that the shape of these characteristics is strongly influenced by loading frequency as well as temperature of the suspension elements (see the examples above). The observed effects are distinctive for the new spring types used in the buffers (i.e. the rubber-steel- and elastomer springs) and can also have some consequences in the field of operation (and maintenance) of railway vehicles.

In the next stage of this research, these experimental results will be used to create a general model of railway freight wagon buffer which can reliably describe its dynamic behaviour for purposes of application in multi-body simulations of longitudinal train dynamics. It should be also possible to perform a model validation on basis of the measured data.

## Acknowledgements

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