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ESTIMATION OF DYNAMIC QUALITIES OF FREIGHT WAGONS ON BOGIES OF A PERSPECTIVE MODEL

Summary. The work provides an analysis of the impact of bogies of different construction on the main dynamic indicators of movement safety of freight wagons, in the present case, of gondola wagons: coefficient of vertical dynamics of a body frame (K_d), coefficient of vertical dynamics of the unsprung bogie frame (K_{du}), relation of the frame force to the static axial load (N_f/P_a), coefficient of the stability reserve against derailment (K_s) [5, 8-11, 15, 17].

Scientific novelty includes the experimentally obtained dependences of the main dynamic indicators of motion of gondola wagons with the use of Model 18-9771 bogies, having different variants of bearers, this giving an opportunity for choice of bearer parameters for receiving the highest effect as regards the reduction of dynamic loading both of the wagon and the track.

Of practical value are technical decisions concerning fastening of the bearers to the bolster beam, which are under protection of the patent for invention [18, 20], and stiffness parameters of bogie bearers.

ОЦЕНКА ДИНАМИЧЕСКИХ КАЧЕСТВ ГРУЗОВЫХ ВАГОНОВ НА ТЕЛЕЖКАХ ПЕРСПЕКТИВНОЙ МОДЕЛИ

Аннотация. В данной работе выполнен анализ влияния различных конструкций тележек на основные динамические показатели безопасности движения грузовых вагонов, в данном случае полувагонов: коэффициент вертикальной динамики рамы кузова (K_d), коэффициент вертикальной динамики необрессоренной рамы тележки (K_{du}), отношение рамной силы к статической осевой нагрузке (N_f/P_a), коэффициент запаса устойчивости от схода колеса с рельса (K_s) [5, 8-11, 15, 17].

К научной новизне следует отнести полученные экспериментально зависимости основных динамических показателей движения полувагонов с использованием тележек модели 18-9771, имеющей разные варианты скользунов, что дает возможность выбора параметров скользунов для получения наибольшего эффекта по снижению динамической нагруженности как вагона, так и пути.

Практическую ценность имеют технические решения по креплению скользунов к надрессорной балке, которые защищены патентом на изобретение [16, 18], и жесткостные параметры скользунов тележек.

1. INTRODUCTION

In the recent years, elastic bearers of permanent contact have been widely used in railways with a track gauge of 1520 mm. Herewith, it is necessary to note that both metal springs and elastic elements with the use of polymeric materials have been used in their construction. Since the moment of development of elastic bearers, quite a large number of theoretical and experimental investigations, pertaining to the selection of bearer parameters and exploration of the impact of bearer type on dynamic qualities of wagons, have been conducted [1–2, 7, 14, 21, 22]. The constructive peculiarities of freight wagons by different manufacturers, however, presuppose accordingly the use of different variants in the manufacture of bogie bearers for gaining the maximum effect in terms of improving the dynamic characteristics of a wagon in general.

2. METHODS AND RESULTS

For conducting experimental research, primarily, the constructive peculiarities of Model 18-9771 bogie have been examined, and further the results of trials were analyzed according to the main dynamic indicators of gondola wagons with the use of those bogies in the different constructive performance in empty and loaded modes on straight and curved sections of the track within the entire range of operating speeds.

For a more complete evaluation of the dynamic qualities of freight wagons with the use of different constructions of the running gear, the dynamic running trials of a gondola wagon, put into production by Promtraktor-Vagon ZAO (Kanash, Chuvash Republic, Russian Federation), were conducted. As the running gear, a bogie of Model 18-9771 (Fig. 1), one of the new developments of the plant [1–4, 6, 13, 16, 18–20, 23], having the increased run between repairs of 500 000 km (Table 1), was used. Bogie construction makes it possible to diminish the dynamic impact of a wagon on the track due to the application of the spring set with its static deflection increased up to 68 mm, to increase the stability of the rolling stock, to decrease expenditure for the operation and repair of the running gear due to the use of removable wear-resistant elements in the friction units.

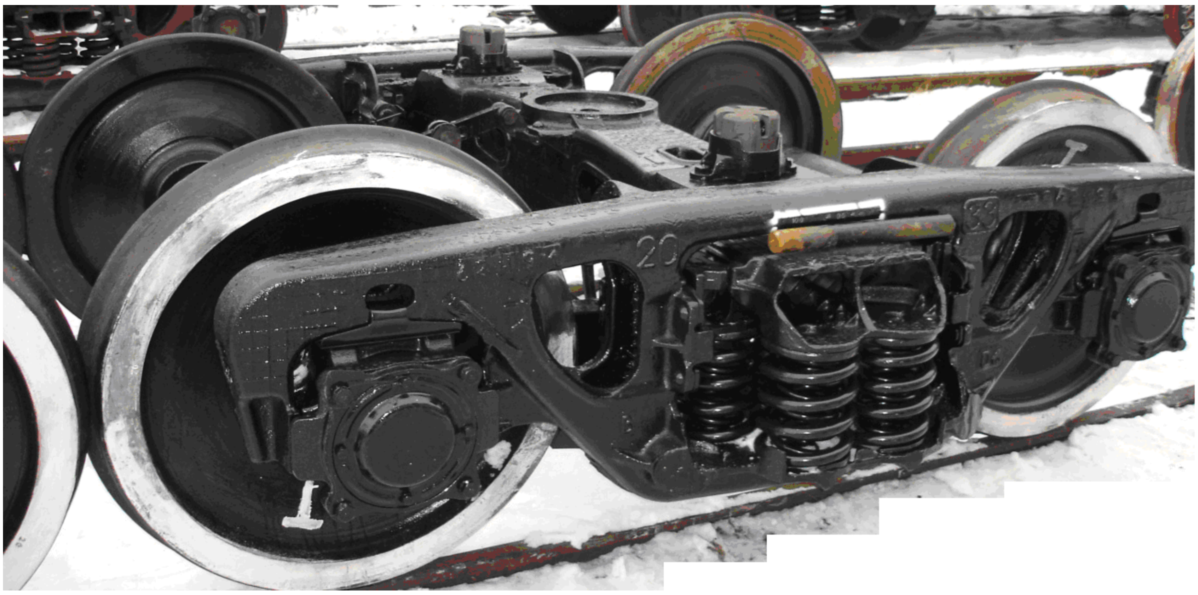

Fig. 1. Model 18-9771 bogie
Рис. 1. Тележка модели 18-9771

Technical specifications of bogie 18-9771 are presented in Table 1.

The developed construction of a biaxial bogie for freight wagons has a number of differences [6, 16, 18–20] as compared to the developments of other railway engineering producers which are as follows:

- the side frames and bolster beams in the form of steel castings are produced according to vacuum-film technology;
- side frames are of reinforced construction;
- central spring suspension with the increased static deflection;
- bearers of permanent contact;
- removable wear plates are used in friction units.

Tab. 1

Technical specifications of bogie 18-9771

Main parameters and dimensions	Value
1. Maximum estimated static load from the wheelset on rails, kN(tf)	230.5 (23.5)
2. Constructive speed, km/hr	120
3. Bogie base, mm	1850
4. Weight of a bogie in assembly, not more, kg	4900
5. Distance from the level of rail heads to the level of supporting surface of the thrust bearing place in a free state, mm	811
6. Distance between lngitudinal axes of side bearers, mm	1524
7. Distance between longitudinal axes of spring sets, mm	2036
8. Static deflection of spring suspension under maximally permissible gross load, mm, not more than	68
9. Static deflection of spring suspension under container, mm, not less (at the load from wheelset on rails 60 kN)	12
10. Coefficient of relative friction of friction damper oscillations in spring suspension: - under maximum gross load - under container	 0.08-0.12 0.10-0.16
11. Diameter of thrust bearing location, not more, mm	304
12. Depth of thrust bearing location, not more, mm	30
13. Overall dimension according to GOST ГОСТ 9238	02-ВМ
* Permissible deviations of parameters and dimensions are referred to in the design documentation	

Bogie of Model 18-9771 has a three-element non-rigid frame. Taking into account the insufficient data on rational parameters of rigid bearers, as well as the necessity of selection of bearers by different types of wagon bodies, universal fastening was worked out for designing of bolster beam. It allows different bearers by the leading world producers to be mounted.

For installation of bearers of different types on the bolster beam above the zone of installation of spring sets from the opposite sides two platforms with dimensions of 17x340 mm are foreseen. Two openings 25 mm in diameter are made on the platform. Interaxial distance between the openings is 216±1 mm. Thickness of the horizontal shelf of the bolster beam beneath the platform is not less than 15 mm. These platforms are performed in one plane with the plane of the thrust bearing of bogie [6, 16, 18–20].

The presence of the indicated surfaces on the bolster beams makes it possible to apply the different types of bearers of permanent contact as well as ordinary thrust bearer. Fastening of each bearer to the beam is carried out with the help of two bolts M 24x75 according to GOST 7798-70 and nuts M24 according to GOST P 50273-92. Due to the indicated construction of a bolster beam on Model 18-9771 bogie, gapless bearers of the Mainer company, A-STAKI and other manufacturers, possessing the mounting height of 128.6±1.6 mm, may be used. Adjustment of the mounting size is carried out by the adjustment plates, fixed on the lower leaf of the wagon body bolster beam and fastened with bolts M1 6x60. Thus, Model 18-9771 bogie construction foresees the option for installation of elastic (Fig. 2) and elastic-roller bearers of the firm Vagonmash OOO, Uralvagonmash FGUP PO, as well as of other developers and manufacturers, e.g., a bearer of Model Dnipro, elaborated at the Chair of Wagons and Wagon Facilities of the Dnipropetrovsk National University of Railway Transport named after Academician V. Lazaryan.

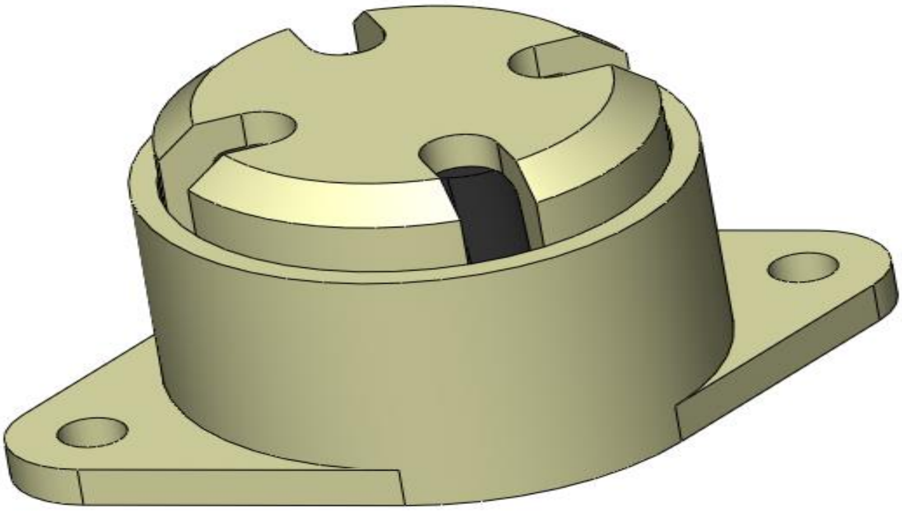

Fig. 2. Elastic bearer
Рис. 2. Упругий скользун

Namely, Model 18-9771 bogie has 4 performance variants. A variant with bearers by Vagonmash OOO was taken as the basis (bogie performance 00, 01).

Reciprocal parts, mounted on the wagon body for the rigid and elastic bearers, are of different construction. However, in practice a necessity may arise for rolling up of bogies 18-9771 under the wagon body, designed for operation on the bogie 18-100. For that reason, construction of the bolster beam foresees the opportunity for installation of the rigid bearer (Fig. 3), fully reiterating the bearer of Model 18-100 bogie.

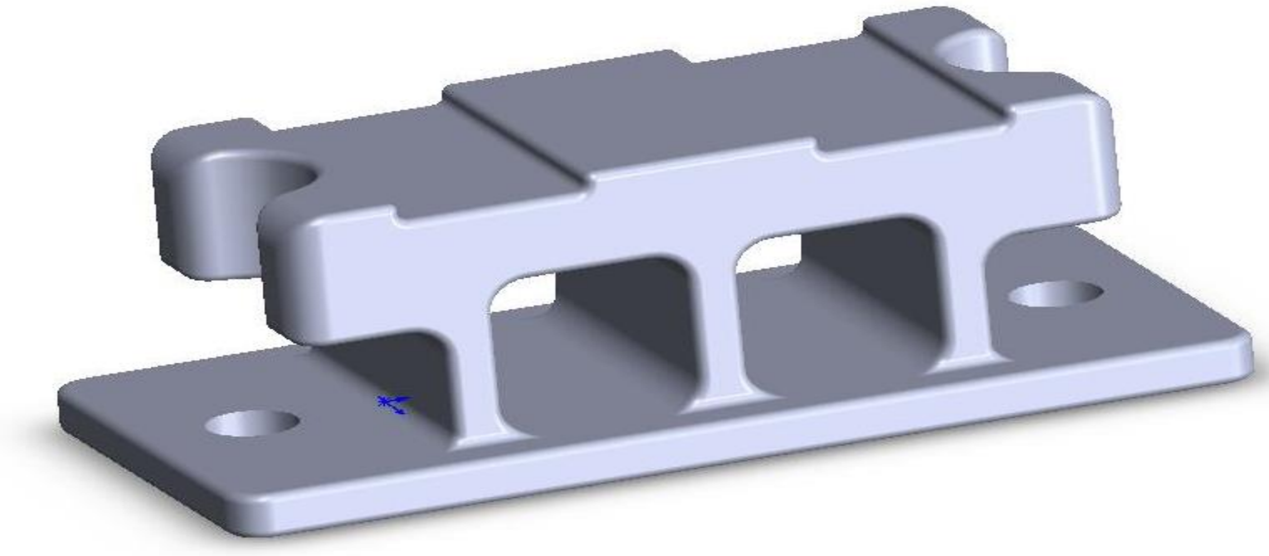

Fig. 3. Rigid bearer
Рис. 3. Жесткий скользун

Model 18-9771 bogies underwent the operational trials on the high-speed polygon of the Railway Research Institute “ВНИИЖТ” ОАО (station Belorechenskaya of the North Caucasian Railways) in the composition of gondola wagons of Model 12-1302 12-1302 (Fig. 4, a) and Model 12-1303 (Fig. 4, b), manufactured by Promtraktor-Vagon ЗАО [6, 16, 18–20] in empty and loaded modes.

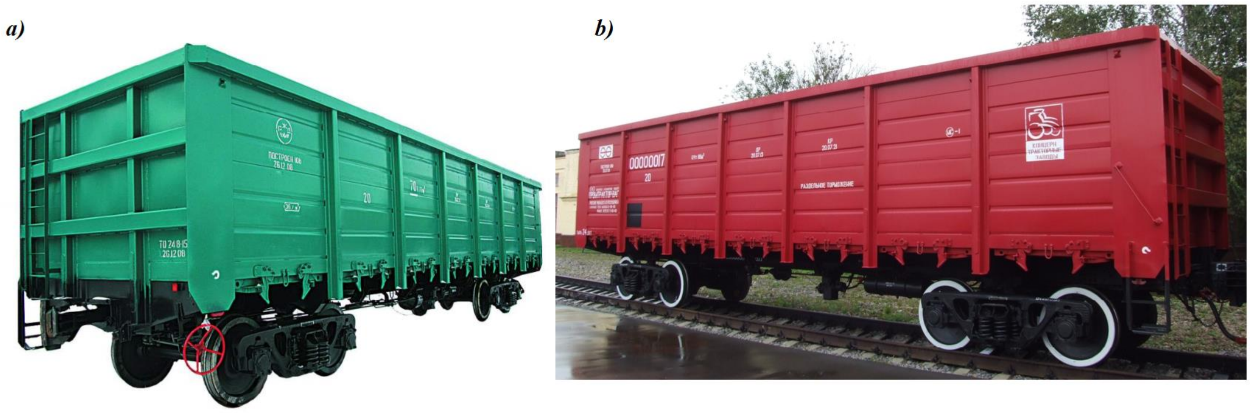

Fig. 4. General view: a) model 12-1302 gondola wagon; b) model 12-1303 gondola wagon
Рис. 4. Общий вид: а) полувагона модели 12-1302; б) полувагона модели 12-1303

For experimental research four options of performance of bogie 18-9771 have been formed. Their completion and bearer parameters, obtained according to the results of static and dynamic bench trials, are provided in Table 2.

Tab. 2

Bearer parameters, obtained according to the results of static and dynamic bench trials of Model 18-9771 bogies

Bearer	Performance	Vertical stiffness of the bearer, kN/mm	Working stroke, mm
BM 003.000 “Vagonmash”	00,01	0.91	15
ISB-12 “A.Stacki”	02,03	2.12	8
CCB 6000 XT “A.Stacki”	04,05	1.01	15
Rigid bearer	06,07	–	–

At conducting trials, indicators were measured, according to which coefficients characterizing the quality of wagon motion were determined. Dynamic indicators were specified in accordance with RD 24.050.37.95 for bogies 18-9771 with variants of performance 00(01) and 06(07).

The below-given diagrams provide the results of investigation of dynamic characteristics of wagons:

– coefficient of vertical dynamics of the unsprung bogie frame (K_{du}) and relation of the frame force to static axial load (N_f/P_a) on the straight track sections (Fig. 5, a–b) and the relation of the frame force to the static axial load (N_f/P_a) in the curve at a radius of 500 m (Fig. 5, c) in empty mode;

– coefficient of vertical dynamics of the body frame (K_d), coefficient of vertical dynamics of the unsprung bogie frame (K_{du}), the relation of the frame force to the static axial load (N_f/P_a) on the straight (Fig. 6, a–c) and curved track sections at a radius of 500 м (Fig. 7, a–c) in loaded mode.

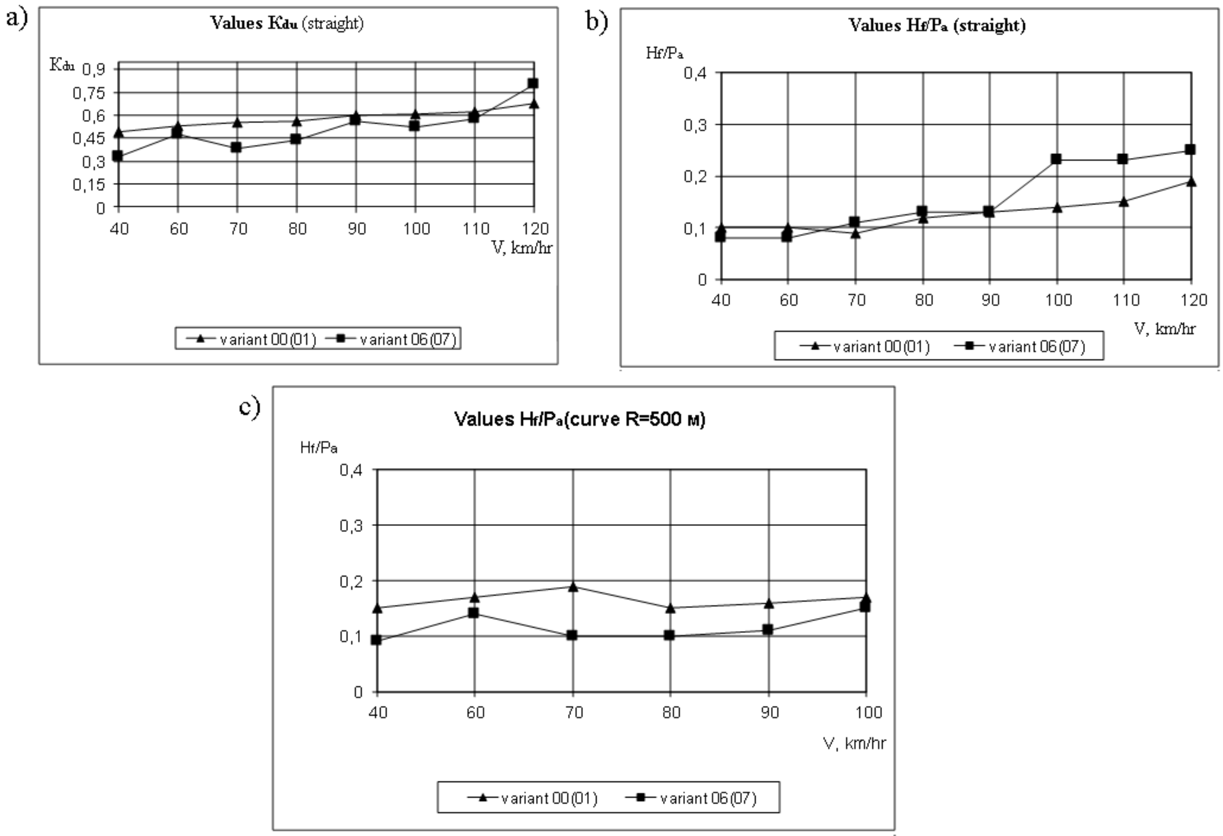

Fig. 5. Diagrams of dependence of dynamic indicators on the motion speed in empty mode: a) coefficient of vertical dynamics of the unsprung bogie frame K_{du} (straight); b) relation of the frame force to the static axial load H_f/P_a (straight); c) relation of the frame force to the static axial load H_f/P_a (curve R = 500 m)

Рис. 5. Графики зависимости динамических показателей от скорости движения в порожнем режиме: a) коэффициента вертикальной динамики необрессоренной рамы тележки K_{du} (прямая); b) отношение рамной силы к статической осевой нагрузке H_f/P_a (прямая); c) отношение рамной силы к статической осевой нагрузке H_f/P_a (кривая R = 500 м)

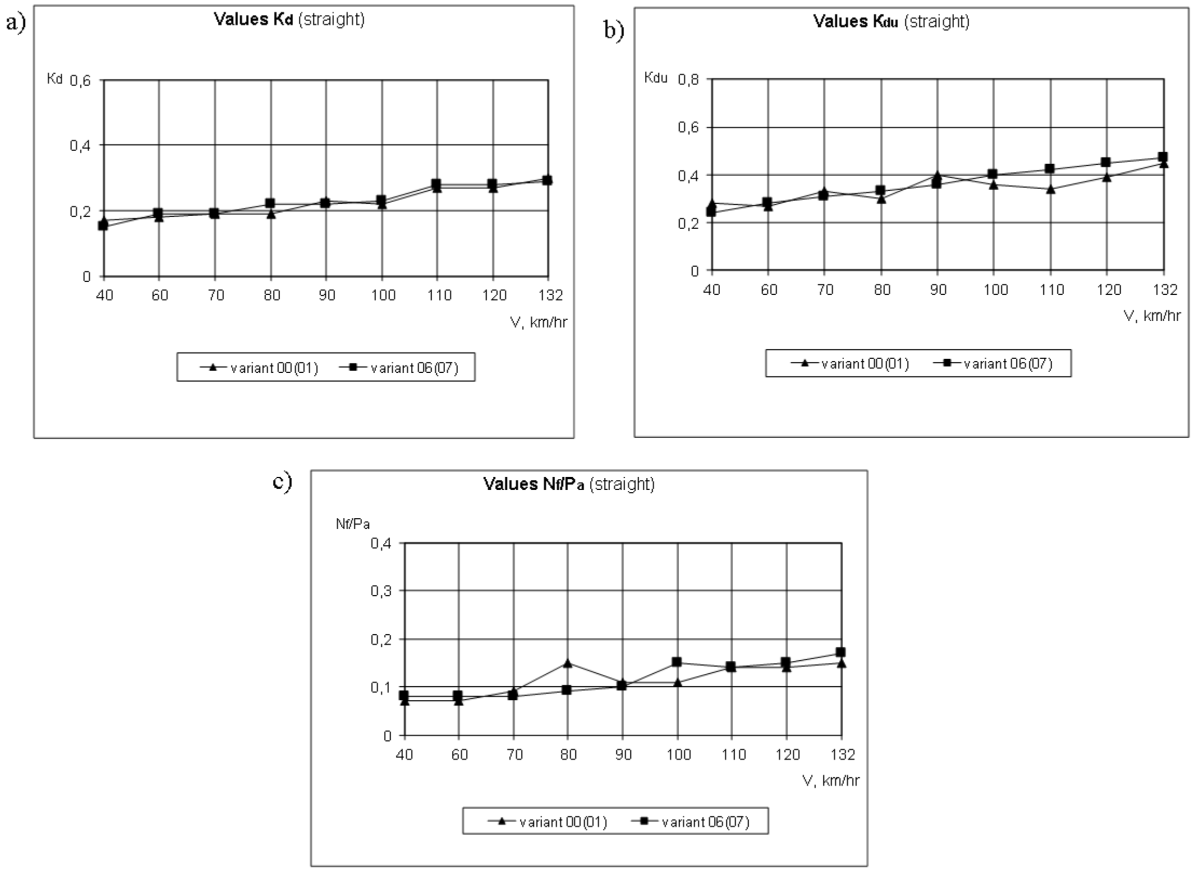

Fig. 6. Diagrams of dependence of dynamic indicators on motion speed in loaded mode on the straight track sections:a) coefficient of vertical dynamics of the body frame (K_d); b) coefficient of vertical dynamics of the unsprung bogie frame (K_{du});c) relation of the frame force to the static axial load (N_f/P_a)

Рис. 6. Графики зависимости динамических показателей от скорости движения в груженом режиме на прямых участках пути: a) коэффициент вертикальной динамики рамы кузова (K_d); b) коэффициент вертикальной динамики необрессоренной рамы тележки (K_{du}); c) отношение рамной силы к статической осевой нагрузке (N_f/P_a)

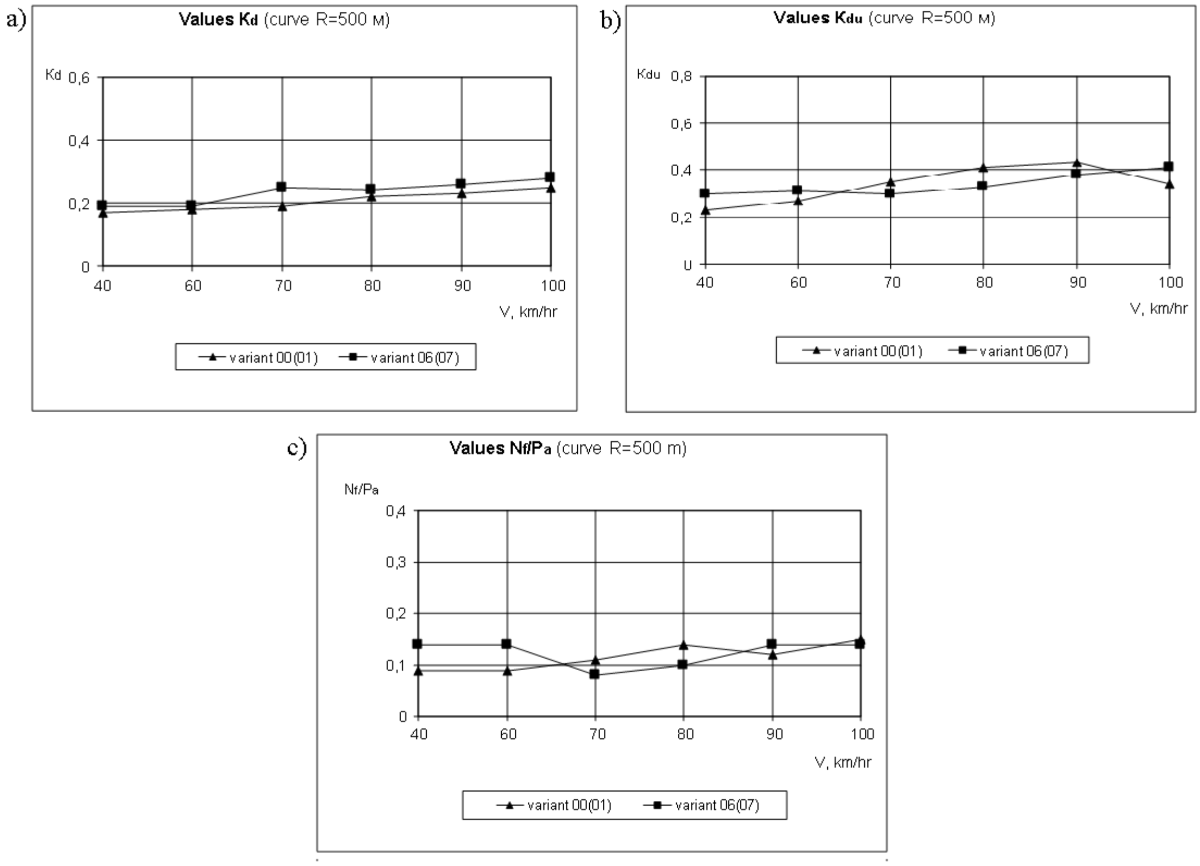

Fig. 7. Diagrams of dependence of dynamic indicators on motion speed in loaded mode on the curved track sections (R = 500 m): a) coefficient of vertical dynamics of the body frame (K_d); b) coefficient of vertical dynamics of the unsprung bogie frame (K_{du}); c) relation of the frame force to the static axial load (N_f/P_a)
Рис. 7. Графики зависимости динамических показателей от скорости движения в груженом режиме в кривых участках пути (R = 500 м): a) коэффициента вертикальной динамики рамы кузова (K_d);b) коэффициента вертикальной динамики необрессорной рамы тележки (K_{du}); c) отношение рамной силы к статической осевой нагрузке (N_f/P_a)

Some data of trials for visualization are given in Tables 3, 4 below.

Tab. 3

Values of coefficient of transverse stability reserve (Kr) in the curves (in loaded mode)

Dynamic indicators of motion safety	Bogie model 18-9771	
	performance 00(01)	performance 06(07)
V = 100 km/hr R = 500 m	2.79	> 3
V = 10 km/hr R = 350 m	> 3	> 3

Tab. 4

Trial results, obtained at switching (in loaded mode)

Indicator	Bogie model	Permissible value	Motion speed, km/hr	
			25	40
Coefficient of vertical dynamics of the sprung sections of the wagon (K_d)	00(01)	0.6	0.17	0.19
	06(07)		0.18	0.18
Coefficient of vertical dynamics of the unsprung wagon sections (K_{du})	00(01)	0.8	0.3	0.32
	06(07)		0.3	0.32
Frame force in P_a N_f/P_a portions from the wheelset on the bogie frame	00(01)	0.38	0.14	0.14
	06(07)		0.11	0.17

Thus, correctness of the selected technical parameters of bearers was confirmed experimentally for several variants of bogie performance.

3. CONCLUSIONS

Comparison of the results of the research conducted allows one to make a conclusion that for all variants of 18-9771 bogie performances the values of dynamic indicators of wagon motion safety do not exceed the permissible values.

However, the dynamic indicators of wagons for bogies of 00(01) performance are somewhat better that for bogies of 06(07) performance, this witnessing the correctness of the selected technical solutions.

Analysis of the values of coefficients of vertical and horizontal dynamic and stability coefficients confirm that bearers of permanent contact improve the motion qualities of freight wagons by reducing the loads, transmitted from the rolling stock to the railway groundwork.

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