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RESISTING MOMENTUM IN THE ABUTMENT TO ROTATING OF FREIGHT CAR BOGIE

Summary. On the Latvian railway, derailments of freight cars take place in the course of shunting work on marshalling yards. A number of factors during shunting work on marshalling yards may contribute to the derailments of rolling stock: longitudinal dynamics during braking of cars with the turned off brakes by locomotive, hauling down cars from a marshalling hill with braking position controlled by an operator, dry internal rails in curves, absence of greasing in the pivot unit of freight bogies. At present, measures allowing elimination of the car derailments during shunting work are developed.

During the period between repairs, the abutment unit of freight car often works in conditions of dry friction. Our observations suggest that at the time of taking a car into repair, there is often an absence of greasing between trail bearing and center plate of the abutment, and a presence of sandy dust. It increases a friction and, together with high contact pressures and dynamic influence, hinders the turn of bogie at motion of car.

In this paper, the results of studying the resisting moment in the abutment to turning of bogie is reported. The study was conducted on the basis of freight bogie of type 18-100; the body was leant on the center plate unit of the abutment, on the center plate unit, and on the sliders. Experiments were conducted, with the use of greasing and at the dry friction of center plate unit.

МОМЕНТ СОПРОТИВЛЕНИЯ ВРАЩЕНИЮ ТЕЛЕЖКИ ГРУЗОВОГО ВАГОНА В ПОДПЯТНИКОВОМ УЗЛЕ

Резюме. На Латвийской железной дороге имеют место сходы грузовых вагонов при выполнении маневровой работы на сортировочных станциях. Существует ряд факторов при производстве маневровой работы на сортировочных станциях, приводящих к сходам подвижного состава: продольная динамика при торможении локомотивом состава с выключенными тормозами, роспуск вагонов с горки при управлении оператором позицией торможения, сухие внутренние рельсы в кривых, отсутствие смазки в шкворневом узле грузовых тележек. В настоящее время разрабатываются мероприятия, позволяющие ликвидировать сходы вагонов при производстве маневровой работы.

В межремонтный период подпятниковый узел грузового вагона часто работает в условиях сухого трения. По нашим наблюдениям, при поступлении вагона в ремонт постоянно наблюдается отсутствие смазки между пятником и подпятником, наличие песочной пыли. Это увеличивает

трение при наличии высоких контактных давлений и динамичного воздействия, что препятствует повороту тележки при движении вагона.

На базе грузовой тележки типа 18-100 проведены исследования по определению момента сопротивления повороту тележки в подпятниковом узле – при опирании кузова только на подпятники, так и на подпятники и скользуны. Эксперименты проводились, с применением смазки, так и при отсутствии смазки в подпятниковом узле.

The number of derailment of freight carriages on the Latvian railway has increased over the last 10 years. Research results indicate that the greatest number of derailments of carriages took place in 1997 (21 cases), in 2003 (20 cases), 2005 (27 cases), while in other years the number of carriage derailments did not exceed 17 cases per year (fig. 1).

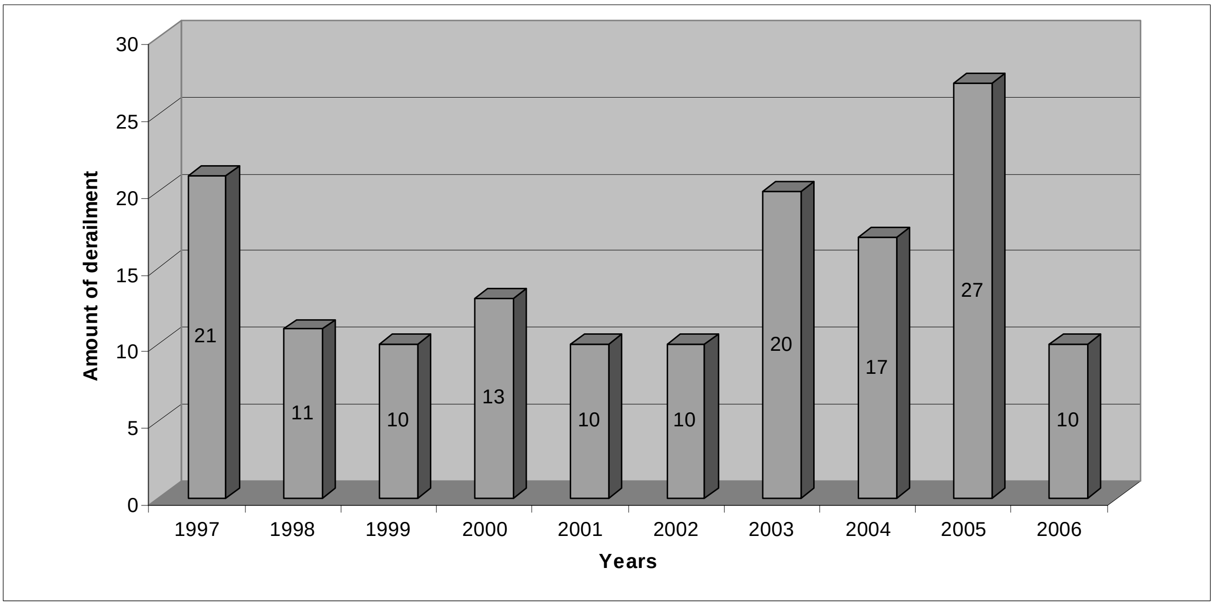

Fig. 1. Distribution of derailment of freight carriages on years in a period from 1997 to 2006
Рис. 1. Распределение сходов грузовых вагонов по годам в период с 1997 по 2006 годы

During shunting works on the stations, 66% of derailments were registered; 24% of derailment happened in the process of descent of carriages from hills, 6% took place at repairs of the railway, and 4% of incident occurred on sprains between stations. Statistics shows that on the Latvian railway the derailment of freight carriages most often happened at the time of carrying out shunting work on marshalling yards [1]. Some of the reasons, resulting to the derailment of train carriages on spands between stations [2], in the process of carrying out shunting work on marshalling yards by the locomotive with the turned off brakes, and as a result of releasing unhooked carriages from a hill with manual braking position managed by an operator [3] are studied in the Institute of railway transport of the Riga technical university.

As a carriage passes the crooked areas of the railway, the light cart turns and accordingly so does also the center plate in relation to trail bearing. The vertical loading on trail bearing amounts 15 to 40 тс. A dry friction between the trail bearing and the center plate creates considerable friction momentum, which impedes the turn of the light cart. While overcoming the resistance of the friction forces at a turn, the light cart of carriage due to structural gaps changes a form. Thus, forces of resistance in the plate center hinder its return to the optimum working position. Warping of light cart leads to the large angles of wheelpairs' running-on on rails, which result in the origin of the large transversal loadings contributing to the lateral wear of railhead and the incision of light cart's wheel edges, and which on occasion may lead to the derailment.

In this work, the resistance to the rotation created by friction forces in center plate at the light cart of freight carriage were determined. The bogie model 18-100 of freight carriage was used in the experiments; the results of the experiments are presented in this paper.

According to our observations, 80 – 90% of freight carriages arriving at a depot or a capital repair in the Daugavpils depot completely lack of greasing in the supporting place of basket on a light cart between the ground surfaces of the trail bearing and the center plate. The horizontal and vertical working surfaces of trail bearing and center plate are worn unevenly; there are fins, wherein sandy dust can sometimes be found (see fig. 2).

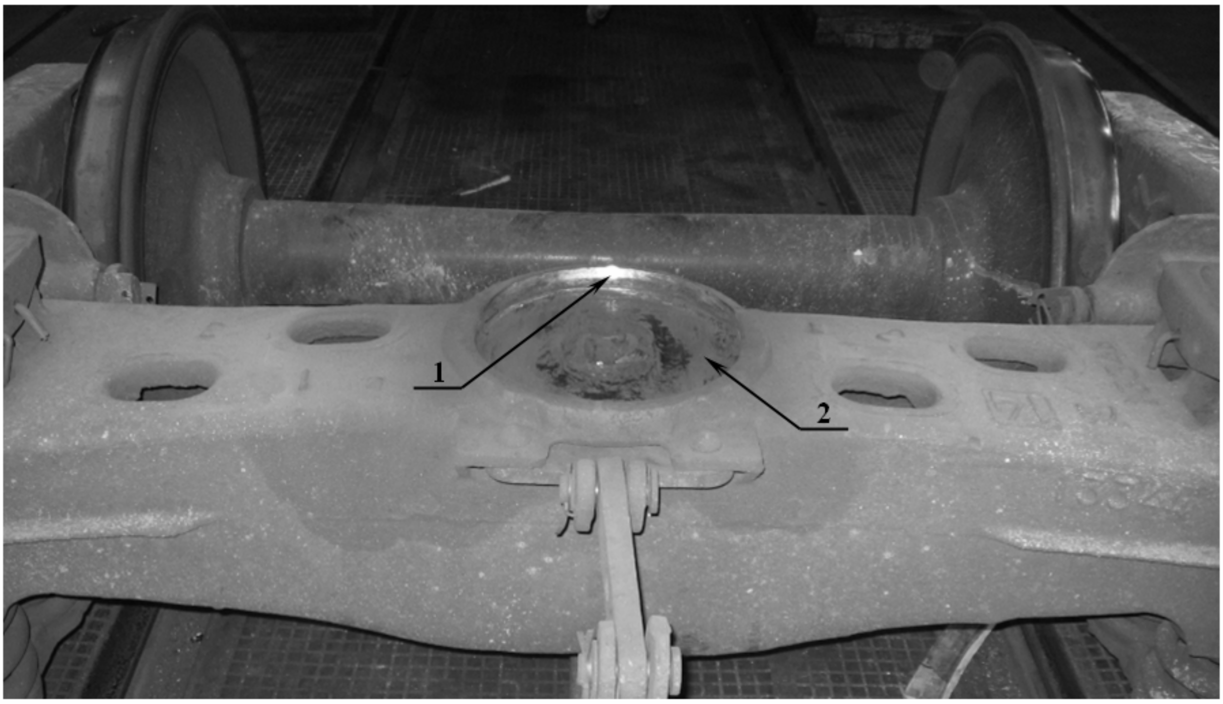

Fig. 2. Worn element of light model cart 18-100: 1 is a pad of the center plate, 2 is underlayment of the center plate
Рис. 2. Изношенный элемент тележки модели 18-100: 1 – буртик подпятнника, 2 – опорная поверхность подпятника

To determine the friction resistance in the support of resistance momentum friction in the supporting place, a set of tests were conducted on the light cart of freight carriage model 18-100 with threadbare center plate. Loading on the center plate was transferred by the trail bearing fastened on a frame. The weight with mass m was placed on the frame; as a loading weight, the wheelpair was used with box, whose mass is m_1 = 1400 kg, and a model of carriage frame with mass m_2 = 200 kg (fig. 3). Thus, the total mass m of the loading weight imposed on the center plate is $m = m_1 + m_2$, i.e. 1600 kg. The momentum of the resistance to rotation caused by a friction in the supporting place is determined by force *P*, which is applied to the loaded frame at the distance of $d = 1$m in order to move it out of a quiescent state by rotating round the center of the supporting place. The force *P* was created by a jack, and it was measured with a dynamometer. The test-bed system used for experimental measuring is presented on fig. 3.

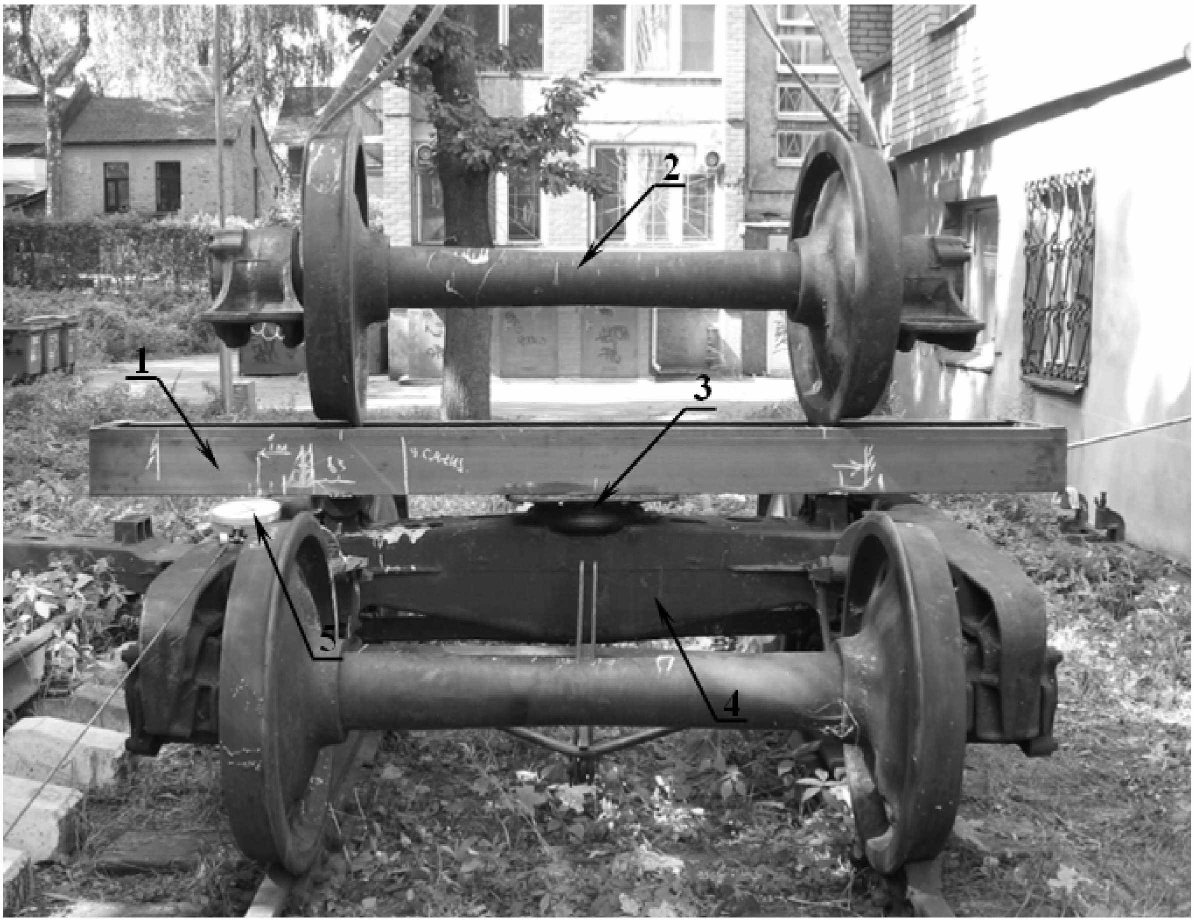

Fig. 3. Experimental system to determine the friction resistance momentum in a supporting place from forces of resistance to the rotating of the light cart. Component elements of the system: 1 is a frame, 2 is a weight, 3 is a supporting knot, 4 is a light model cart 18-100, 5 is a dynamometer and rope, related to the jack

Рис. 3. Экспериментальная система для определения момента от сил сопротивления вращению тележки в опорном узле. Составные элементы системы: 1 – рама, 2 – груз, 3 – опорный узел, 4 – тележка модели 18-100, 5 – динамометр и трос, связанный с домкратом

It is assumed in this work that the momentum of resistance to the rotation of light cart in a supporting knot is proportional to the loading on the supporting knot of light cart *N*:

$$M_{fr.r.} = f_{fr.r.} \cdot N, \quad N = m \cdot g \tag{1}$$

Here $f_{fr.r.}$ is a proportionality coefficient between the momentum of rotation friction and the loading on the supporting place of light cart; it has a dimension of length. Experimental determination of this coefficient is one of aims of this work. For this purpose, the loading on the supporting knot is created by the weight of load, that $N = m \cdot g$.

$M_{fr.r.}$ was first determined experimentally in the laboratory setting. The force *P* necessary for overcoming the forces of resistance to the rotation in a supporting place was measured by a dynamometer, and the momentum of forces of resistance to the rotation $M_{fr.r.}$ was calculated as follows:

$$M_{fr.r.} = P \cdot d \tag{2}$$

With respect to the coefficient $f_{fr.r.}$, equations (1) and (2) give:

$$f_{fr.r.} = M_{fr.r.} / N = P \cdot d / m \cdot g \tag{3}$$

where g in (3) represents the standard gravity.

The process of determining $f_{fr.r.}$ consisted of tests carried out at presence of greasing in a supporting place and on slide-block, and at its absence in these elements. Experiments were also conducted in the case of setting skating rinks on slide-block.

The weight was positioned on the frame symmetrically to the center of its turn and with a shift of 0,57m in relation to the center. When the load was positioned on the frame symmetrically to the center of its turn, the loading was transferred onto the center plate. It is known that, while a carriage is moving in a curve with the rise of external rail, its frame leans against a supporting place and slide-block. Therefore, in the experiments, the position of the frame of carriage was modeled by changing the load on the frame in relation to the center of its turn.

Measuring of the force P at every position of load on a frame were repeated three times. The values of $f_{fr.r.}$ were calculated according to (3) and using mean values of $M_{fr.r.}$. The values of proportionality coefficient $f_{fr.r.}$ corresponding to different experimental settings are presented on the diagram in fig. 4.

On the second stage, using the values of $f_{fr.r.}$ presented in fig. 4, the momentum of resistance to the rotation of light cart were calculated in a supporting place: 1) for the frame leaning against a supporting place, 2) for the frame leaning against the supporting place and slide-block, and 3) similarly, for the carriage frame leaning against a supporting place and slide-block with the skating rinks set on him. In these cases, the expression for $M_{fr.r.}$ becomes:

$$M_{fr.r.} = f_{fr.r.} \cdot (m_3 + m_4) \cdot g / 2 \tag{4}$$

here m_3 - mass of basket of freight carriage (13000 kg), m_4 - mass of load (60000 kg).

The results of calculating $M_{fr.r.}$ based on (4) are shown a fig. 5.

The results of our research indicates that the absence of greasing in the supporting place of the light cart of the freight carriage causes a considerable momentum influence, which impedes its rotation in relation to trail bearing. Especially this phenomenon manifests itself when the basket of carriage leans against the supporting place of the light cart and the slide-block.

It was experimentally found that the negative (for the train) influence of resistance to the rotation of the light cart in relation to trail bearing can be reduced by the presence of greasing in the supporting place. Moreover, a yet greater decline of such resistance can be achieved by applying a skating support on the slide-block.

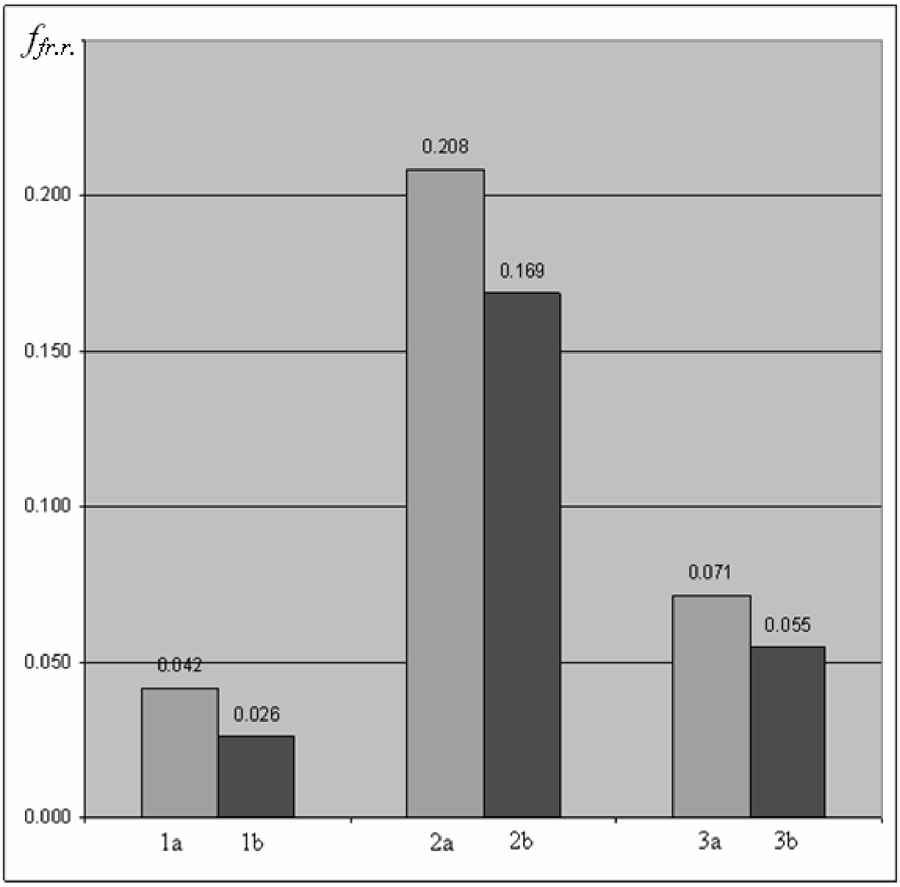

Fig. 4. Value of proportionality coefficient $f_{fr.r.}$ calculated according to (3) for three positions of the load; a) in the case of absence of greasing; b) at presence of greasing: 1 is the frame with the load leaning only against the center plate of the train beam, 2 is the frame with the load leaning against the center plate and one of the slide-block; 3 is the frame with the load leaning against the center plate and the skating rinks, set on the slide-block

Рис. 4. Вычисленные по (3) для трех положений груза значения коэффициента пропорциональности $f_{fr.r.}$ в случае отсутствия смазки (диаграммы a) и при наличии смазки (диаграммы b): 1 – рама с грузом опирается только на подпятник надрессорной балки, 2 – рама с грузом опирается на подпятник и один из скользунов; 3 – рама с грузом опирается на подпятник и катки, установленные на скользуне

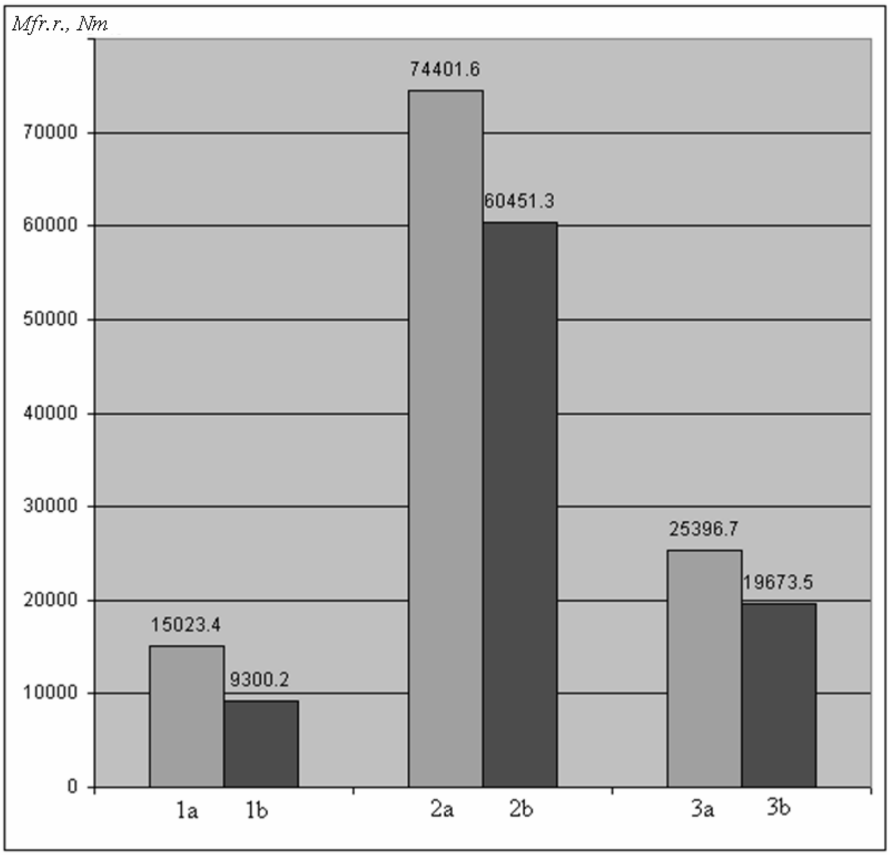

Fig. 5. Values of $M_{fr.r.}$ calculated according to (4) for three states of leaning of basket of freight carriage: a) in the case of absence of greasing and b) at presence of greasing: 1 is the frame with the load leaning only against the center plate of the train beam, 2 is the frame with the load leaning against the center plate and one of the slide-block; 3 is the frame with the load leaning against the center plate and the skating rinks, set on the slide-block

Рис. 5. Вычисленный по (4) для трех состояний опирания кузова грузового вагона $M_{fr.r.}$ в случае отсутствия смазки (диаграммы a) и при наличии смазки (диаграммы b): 1 – рама с грузом опирается только на подпятник надрессорной балки, 2 – рама с грузом опирается на подпятник и один из скользунов; 3 – рама с грузом опирается на подпятник и катки, установленные на скользуне

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