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Analytical Investigation of Cargo Motion Lengthwise the Wagon under the Action of Plane Force System

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Received: 11 December 2012 Accepted: 2 January 2013 Published: 15 January 2013

Abstract

For the first time in the theory of solid cargo fastening there has been investigated a case when the cargo is in motion in relation to the wagon floor with acceleration r a , its speed being at this moment equal to r v . There have been set out the results of analytical investigation of cargo shift in dynamics and accordingly elongation and tension in flexible fastening elements under the action of plane force system. It has been established that the longitudinal force perceived by the flexible fastening elements in value is smaller than the force obtained when inertia in relative motion (at rest) is not taken into account. Hence, the cargo shift lengthwise the wagon in this case will be smaller. This, in its turn, will affect the decrease of elongation value and consequently the decrease of the effort of every flexible element, thus increasing their load-carrying capacity.

Index terms— cargo, thrust bars, flexible fastening elements, cargo shift in dynamics, efforts in flexible fastening elements.

Summary-For the first time in the theory of solid cargo fastening there has been investigated a case when the cargo is in motion in relation to the wagon floor with acceleration r a , its speed being at this moment equal to r v . There have been set out the results of analytical investigation of cargo shift in dynamics and accordingly elongation and tension in flexible fastening elements under the action of plane force system. It has been established that the longitudinal force perceived by the flexible fastening elements in value is smaller than the force obtained when inertia in relative motion (at rest) is not taken into account. Hence, the cargo shift lengthwise the wagon in this case will be smaller. This, in its turn, will affect the decrease of elongation value and consequently the decrease of the effort of every flexible element, thus increasing their load-carrying capacity.

Keywords: cargo, thrust bars, flexible fastening elements, cargo shift in dynamics, efforts in flexible fastening elements.

1 I.

Formulation of a Problem ormulas derived for determining efforts in flexible fastening elements of the cargo under the action of longitudinal and vertical forces presented in Appendix 8-Technical conditions [1,2], (as has been pointed out in **??**3 -22]) have been the result of incompletely solved problems when the longitudinal force value perceived by fastening means according to the gravity power of cargo G is understated (i. e. is always within the limits (0,97 ÷ 1,2)G) while during shunting collisions in a hump-yard or emergency braking this force may vary within -(1,2 ÷ 2)G . Moreover, they don't take into account the efforts of preliminary twisting of every fastening wire R0, without which the cargo is not liable to dispatching. Just because due to effort R0 the cargo is pressed against the wagon floor, friction force is increased. In [1,2] there is no mention of the notion «shift of the cargo lengthwise the wagon" and hence, no mention of "elongation of each fastening element" to the value of which the efforts in each fastening elements are according to Hooke's law directly proportional. As a result, the efforts of each fastening element have one and the same value, which disagrees with reality. It should be noted that in **??**3 -22] a technical problem of cargo fastening under the action of space force system and, as a special case, under the action of plane force system, is solved within the fundamental law of dynamics during relative motion at rest. Unfortunately, there has not been yet considered the case when the cargo is moving lengthwise the wagon floor with acceleration r a its speed at the moment being equal to r v [23,24].

On this basis it can be noted that determining of cargo shift lengthwise the wagon floor and correspondingly elongation and efforts in each fastening element during cargo motion with acceleration lengthwise the wagon floor at a given relative speed is an urgent technical problem for transport research.

2 a) Problem Formulation In Dynamics (It is for the first time that the problem is set)

To derive an analytical formula of cargo shift lengthwise the wagon, elongation and efforts in flexible fastening elements in case of the cargo moving in relation to the wagon floor with acceleration r a at speed r v , as in case of motion of deformable thread on an imperfect curved surface [25].

3 b) Problem Specification

As in [7], let us consider the case, when cargo with gravity force G , located on the wagon on down grade at angle 0 ? (rad. 0.006 ÷ 0.021 or 0.344 ÷ 1.2 degrees which agrees with grade within 6 ÷ 21°/ °°) in the mode of both brake release and service braking is kept from lengthwise shifting by flexible fastening elements. The contours of the cargo when it is placed on the wagon the effective area makes it possible to use thrust and/or spacer wooden bars (Fig. 1a, b). b -aerodynamic resistance force [24].

4 c) Man-Made Assumption

In working out a computable model as in [17] we assume wagon frame to be the major constrain for the cargo (object) and flexible elastic fastening elements and thrust bar to be additional constraints [10,18,23,24].

We assume that effective longitudinal and vertical forces are perceived by flexible elastic fastening

5 F F x <

).

As it is known [7,10,18], external constraint reaction (non-ideal) R is resolved into normal and tangent ? F component, i.e. ? + = F N R . Coordinates

6 d) Formation of Dynamic Model

We apply theoretically to the mass center of material system (cargo) C just as in Fig. 1a II.

7 Methods OF Solution

The formation of dynamic and constructing a mathematical model of cargo movement on a wagon is based on classical concepts and provisions of theoretical mechanics (for example, Constraint and their reactions, the Principle of ties release of the fundamental law of dynamics of the relative motions of records) [23,24]).

8 a) Problem Analytical Solution

Unlike in [7,10,18], for deriving an engineering formula we will use the fundamental law of relative transferring cargo motion during rolling stock movement along tangent described by the equation in vector form? e r I I R F a M + + + = , (**1**)

where r a is cargo relative acceleration (or acceleration of cargo relative to the wagon floor).

As applied to the problem in question Let us assume that as in [25], cargo is in motion lengthwise the wagon floor with acceleration r a and let its speed be r v at the moment. Then equation (1) in projections upon coordinate axes Ox and Oz is presented in the form ( )G F = is active force, ? + = F N R is reactive force,rx x x x ? r x ex Ma R F F F G I = ? ? ? ? + . bar b. ? ;(**2**)

( )rz z r z ez z Ma N F F I G = + ? ? ? ? b. ,(**3**)

9 Global Journal of Researches in Engineering

Volume XIII Issue X Version I) (i

F means that the force is dependent on the number of fastening elements but it doesn't mean that it is to be summed according to i.

10 Elastic force

) (i

F has only one value.

11 III.

12 Results o f Solution a) Mathematical Solution of The Problem

In compliance with this and applied to (2) and (3) the following can be derived) ? sin(0 G G x = ; ? ? = = + = ? ? 1 1 ; 0 n i ix n i ix x R R F) ? cos(0 b b. r x r F F = ; (**2?**)) ? cos(0 G G z = ; ? ? = = + = ? ? 1 1 ; 0 n i iz n i iz z R R F) ? sin(0 b b. r x r F F = ; (3?)

According to the Coulomb law we'll write downfN F ? ? , (**4**)

where f is sliding friction coefficient f = 0,7f coh with allowance made for f coh being the coefficient of cohesion friction between contact surfaces of cargo and wagon floor which are accepted according to reference data) [7,10,17,18]. Substituting (4 ? ? ? ? ? ? + + + ? = ? ? = = ? ? 1 0 b 1 0) ? sin(0)) ? cos((n i r iz n i iz ez F R R I G f F ? (5)

Just as in [10,17,18] let us present expression (5) in the form e F F F ? ? ? + = . elast ,**(6) where**.) ? cos( ) ? sin(0)) ? cos((0) ? sin(bar. 0 b 1 0 b 0 1 1 1 0 ? ? ? ? rx x r n i r iz ez n i iz n i ix n i ix ex Ma R F F R I G f R f R R G I = ? ? ? ? ? ? ? ? ? + + ? ? ? ? ? ? ? + ? ? ? ? = = = = (7) ( ) ( ) ( ) .) ? sin( ) ? cos(0 0) ? cos( ) ? sin(bar. 0 0 b 1 0 0 1 1 ? ? ? rx x r n i iz ix ez ex n i iz n i ix Ma R f F fR R fI f G I R f R ? ? + ? + ? ? + ? + = + ? ? ? = = =

We rewrite the derived expression in the form ( ) ( ) ( ) .) ? sin( ) ? cos(0 0) ? cos( ) ? sin(bar. 0 0 b 1 0 0 ? rx x r n i iz ix ez ex x Ma R f F fR R fI f G I F ? ? ? + ? + ? ? + ? + = ? ? =

Here we are to take into account the fact that x R bar. is a design value of fastening thrust elements reactions (thrust bars) calculated either according to arbitrarily chosen or just as in [22] in accordance with scientifically grounded number of fastening elements (nail) in agreement with clearance outline. For example, After elementary manipulations with the above expression we determine projections of elastic forces (effort or tension) of i-flexible fastening elements onto axis Ox it is in this way that reactions of thrust bars are determined **??**12 [21]):

13 Global Journal of Researches in Engineering

[R nail] = 1, 08 is an assumed value of force per one fastening item (nail), (Table **??**2 Appendix 14 to International Rail Freight Transportation Agreement); n bar.? is accepted number of thrust bars according to cargo location and fastening scheme, item (Fig. **??**); k 1 is a strength coefficient of fastening thrust bars, taking into account the state of wagon floor, items (usually accepted to be 0,5 ÷ 0,6); n nail.? is accepted value of needed number of nails per each thrust bar, item;R bar.? = k 1 ?n nail.? ?n bar.? ?[R nail]

is allowable load per one fastening item (nail) (46 Appendix 14 to). For example, for a nail with ?4and length 100 ÷ 120 mm By introducing notions of "shearing" and "retentive" forces [7,10,11,18] we rewrite the above expression. ret . shear F F F x ? = ? ,**(9)**

where) ? sin(0 . shear G I F ex + = ( ) ( ) ( ) .) ? sin( ) ? cos(0 0) ? cos(bar. 0 0 b 1 0 . reet ? rx x r n i iz ix ez Ma R f F fR R I G f F + + + + + + + ? = ? =**(11)**

From now on, for simplicity of problem solving we'll study a case when cargo is retained lengthwise the wagon by i-flexible fastening elements (? n i , 1 =

) and thrust bar (Fig. **??**). Then according to the method of determining deformations at minor displacement we project a new point position first onto "original" or "old" direction of thrust element **??**17, 18 -21]. As a thrust element is arbitrarily located in space for calculating the projection it is necessary to make use of the method of double projection the way it is done in theoretical mechanics for arbitrarily located force [10,15,18]. Based on this we'll derive a formula for finding elongation of fastening flexible elements depending on cargo shift along wagon It is obvious that elongation in the flexible elastic fastening element will occur only when there is cargo shift lengthwise the wagon at value x ? .

According to **??**7, 10, and 15] the movement of cargo lengthwise the wagon as one-mass oscillatory system can be presented in the following way (Fig. 3). R] = 0,047 ??, for a nail of ?6 and length 150 ÷ 200 mm = ?N. According to the standards of European countries for a fastening item of ?5mm and length 100 ÷ 150 [= 1, 25 ?N, and for an item of ?6mm and length 150 ÷ 200mm [= 1,5 ?N [26].

[ ]]

1,08

nail.

[R] nail. R R (10a) nail. nail.

Designations in Fig. 3 and 4 are the same as in In expressions (**??**) and (11) projections of elastic forces (effort and tension) of i-flexible elastic fastening elements onto longitudinal and vertical axes Ox and Oz are determined according to the formulas? ? = = ? ? = ? ? 1 1 n i i i i i n i xi l l a c R ; ? ? = = = ? ? 1 1 0 0 n i i i i n i xi l a R R ;**(13)**

;? ? 1 1 ? ? = = ? ? = n i i i i i n i zi l l h c R , 0 0 ? ? 1 1 ? ? = = = n i i i i n i zi l h R R (14)

or taking into account (12), In formulas (13) and (**??**4) rigidity of i-flexible fastening element (kN/m) with a number of threads n i (item), diameter d i (mm) and l i of length (m) of fastening wire: Putting the first expressions (13a) and (14a) in (8) we obtain , ? ? 1 1i i n i i i i n i xi l a x l a c R ? ? ? = ? ? = = ? ? 1 1 ; ? ? = = = ? ? 1 1 0 0 n i i i i n i xi l a R R ; (**13?**) ; ? ? 1 1 ? ? = = ? ? ? = n i i i i i i n i zi l h x l a c R , 0 0 ?

? 1 1 ? ? = = = n i i i i n i zi l h R R (14?)x n i i i i i i i i n i i i i F l h x l a c f l a x l a c ? = ? ? ? + ? ? ? ? ? = = or . ? 1 x i i n i i i i i i F l a x l a l h f c ? = ? ? ? ? ? ? ? ? ? ? ? ? + ? =

The above expression with consideration for (15) has the form n . 854 , 7? 1 2 x i i i i i i i i i i F l a x l a l h f l n d ? = ? ? ? ? ? ? ? ? ? ? ? ? + ? =

Hence we can find cargo shift lengthwise the wagon , 854 , 7? 1 2 i i n i i i i i i i i x l a l a l h f l n d F x ? = ? ? ? ? ? ? ? ? ? ? + ? = ? (16)

where . longF F x ? = ?

? is longitudinal force, determined by formula (9), (10) and (11) with consideration for second expressions (13), (**??**4):) ? sin(0 . shear G I F ex + = ; (**10**) ( ) ( ) .) ? sin( ) ? cos(0) ? cos(bar. 0 0 b 1 0 . ret ? rx x r n i i i i i i ez Ma R f F l a l h f R I G f F + + + + + ? ? ? ? ? ? ? ? ? + + ? = ? = (11?)

Here, if aerodynamic resistance force b r F acts from the cargo rear back, this force should be put in the formula with a negative sign with consideration for coordinates of its application. Just as in [7,10,15) cargo shift lengthwise the wagon x ? is the distance from the cargo butt surface that is able to provide joint performance of flexible and thrust fastening means if a thrust bar is nailed to the wagon floor from the cargo butt at a distance less than x ? .

It can be observed from (**??**6) that first, cargo shift lengthwise the wagon will occur only when schedule from (10) and 11a) there will be excluded descend angle ? (i. e. 0 0 = ?). In these cases (10) and (11a) will be That is why (11b) will have a simple form of: (11?)rx x n i r i i i i i ez Ma R F l a l h f R I G f F + + + + ? ? ? ? ? ? ? ? + + ? = ? =(

While solving practical problems by using formula (9) or (**??**6) just as in [10,15,17,18] Using the derived value of cargo shift lengthwise the wagon x ? , just as in [10,18] in compliance with Hooke's law (as the product of (15) multiplied by (**??**2)) we determine effort (tension) i R in i- (17) or with consideration for (12) [ ], case will also be smaller. This, in its turn, will affect the decrease of elongation value and hence the decrease of the effort of each fastening element meanwhile increasing their loading capacity. The results obtained in analytical investigation are an important contribution to the theory of cargo fastening.

14 Global

a

Figure 1: Figure1 a :

[1] [2]

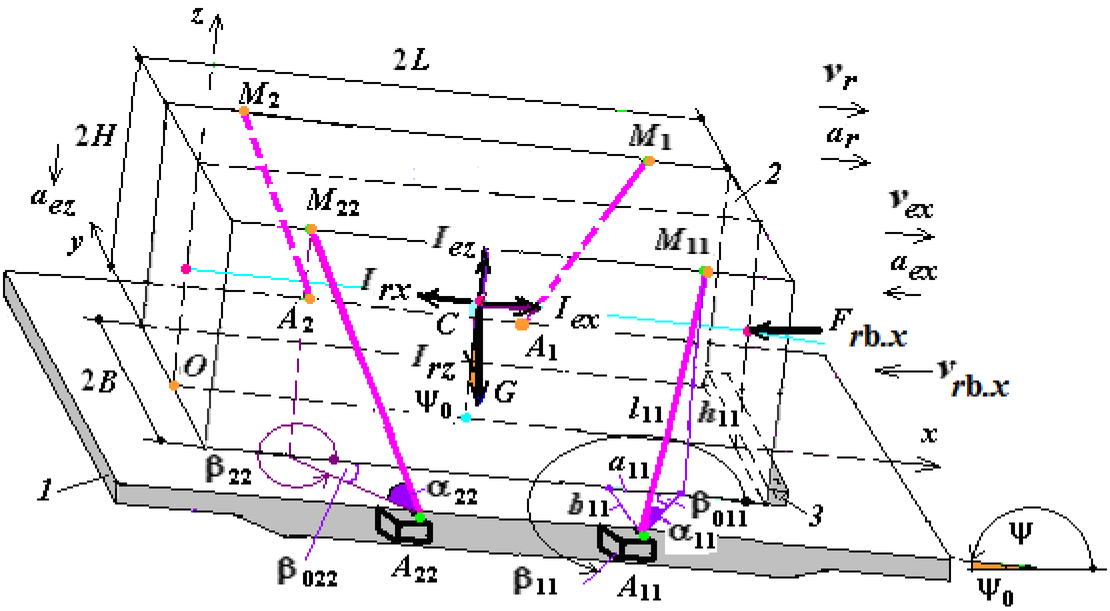

Figure 2:

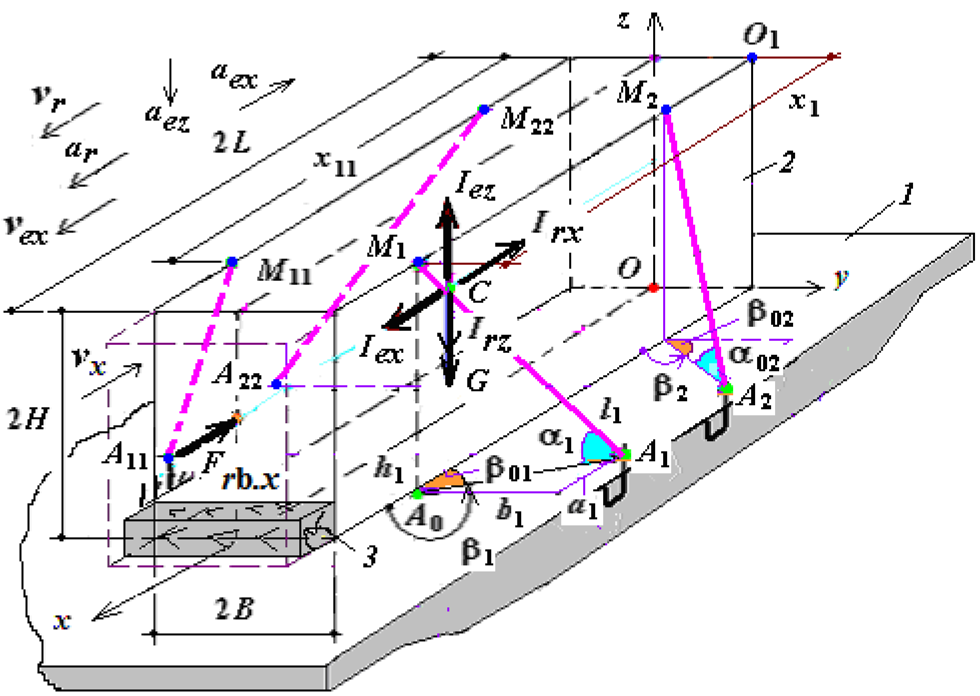

Figure 3:

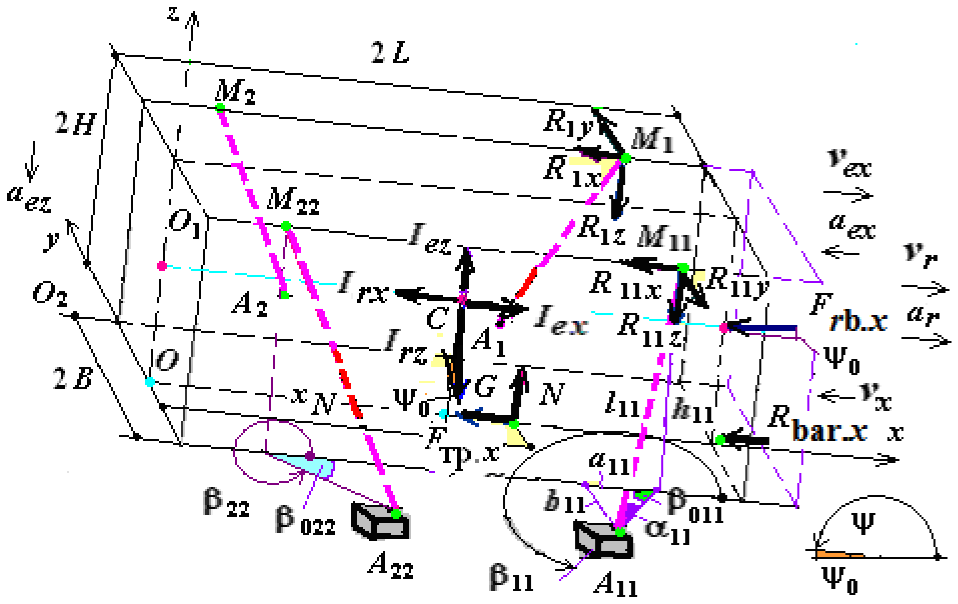

Figure 4:

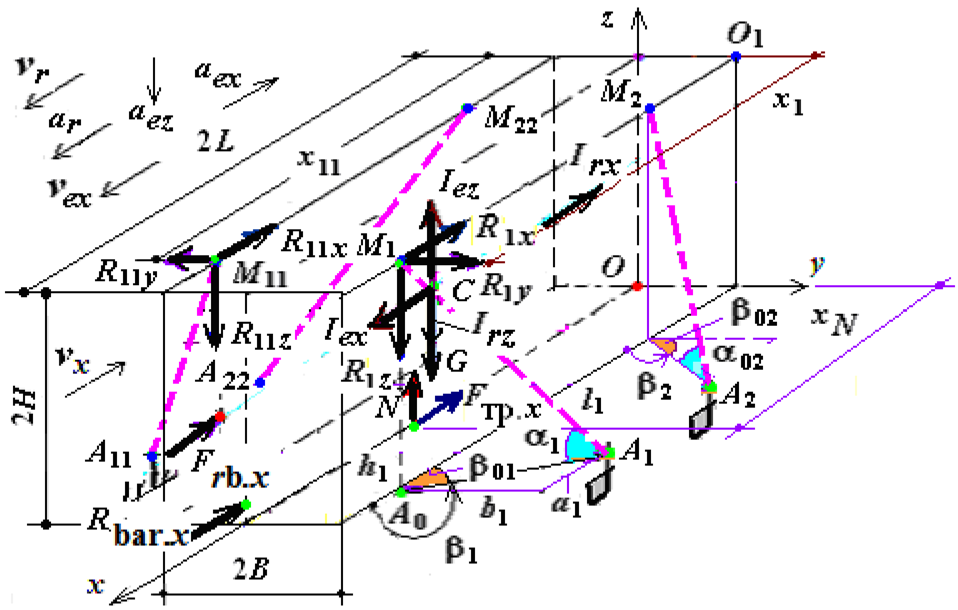

Figure 5: F

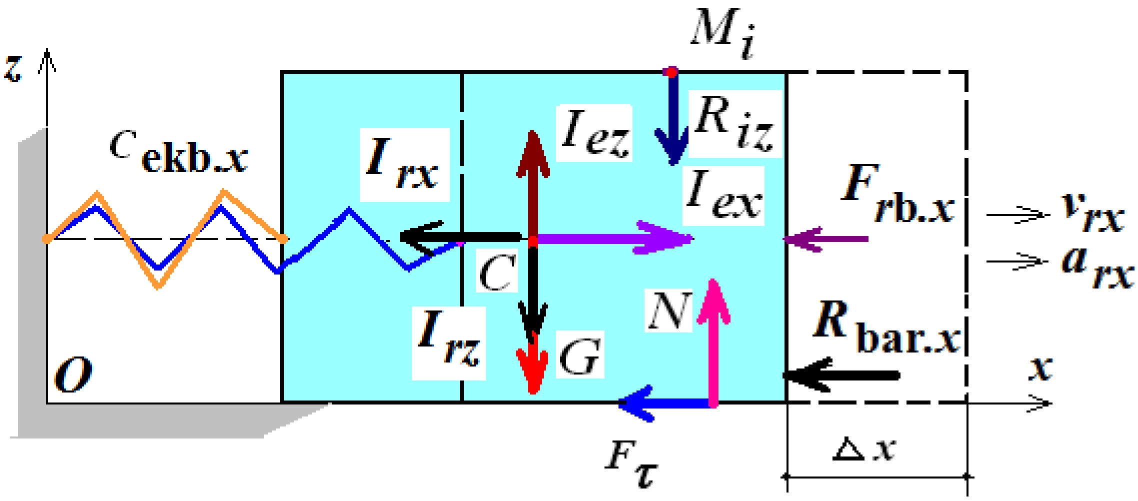

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Figure 6: Figure 2 a:

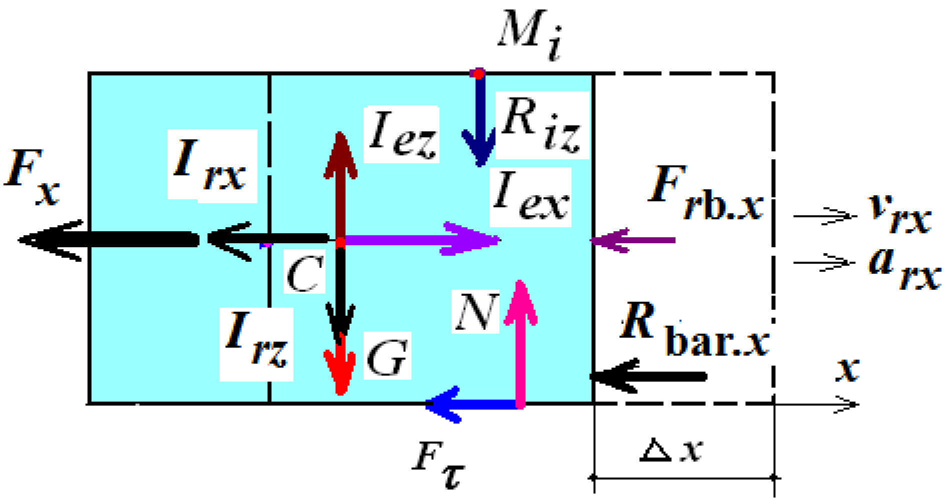

Figure 7:

[Turanov Kh ()] *An example of calculation of elastic elements of cargo fixation on a wagon against longitudinal shift / Kh.T. Turanov // Transport: science, engineering and operation*, . T Turanov Kh . 2013. p. .

[Turanov ()] *Analytical basis of technology asymmetrical allocation of cargo masses common centre in wagons / Kh. Turanov // Transport Problems*, Kh Turanov . 2009. p. .

[Turanov ()] *Analytical modeling cargoes displacement in wagon and tension in fastening / Kh. Turanov, E. Timukhina // Transport Problems*, Kh Turanov . 2008. p. .

[Appendix 14 to International Rail Freight Transportation Agreement "Cargo allocation and fastening regulations in wagons and ‘Appendix 14 to International Rail Freight Transportation Agreement "Cargo allocation and fastening regulations in wagons and containers’. *Planeta (Planet)*, 2008. 191 p. pp.

[Turanov Kh (ed.) ()] *Calculation of cargo fastening in wagon collisions*, . T Turanov Kh . Kh.T. Turanov, E.D. Pserovskaya, D.Yu. Korolyova // Railway transport (ed.) 2002. p. .

[Turanov Kh (ed.)] *Calculation of longitudinal shift of cylindrically shaped cargo and efforts in fastening elements by varying the number of fastening elements*, . T Turanov Kh . / Kh.T. Turanov, E.D. Pserovskaya // Urals Transport (ed.) p. .

[Kh Turanov Timukhina Volkov Transport (ed.)] *Conclusion © 2013 Global Journals Inc. (US) center displacement lengthwise the wagon*, . T Kh, E N Turanov, D V Timukhina, // Urals Volkov, Transport (ed.) p. .

[Anderson et al.] *Equipment for Rational Securing of Cargo on railway Wagons / VINNOVA*, Nils Anderson , Peter Anderson , Robert Bylander , Sven Sokjer , Bob Petersen , Zether . VR 2004:05 //. (Report/Rapport)

[Turanov Kh ()] *Generalized mathematical model of cargo fixation with pads jointly with flexible and thrust elements under the action spatial force system*, . T Turanov Kh . 2012. p. . Rostov State Railway University

[Turanovkh ()] *Interaction of open rolling stock and solid-state cargo:teaching aid for railway universities / Kh.T. Turanov. -M: Federal State Educational Institution "Railway methodical training center*, Turanovkh . 2011. (374 p)

[Turanov Kh ()] *Loading capacities of flexible elastic fastening elements in cargo location with mass ?3 ?3 Saarbrücken*, . T Turanov Kh . 2012. Germany: LAP LAMBERT Palmarium Academic Publishing. (423 p)

[Turanov Kh ()] ‘Mathematical modeling of cargo shift lengthwise the wagon under the action of longitudinal and vertical forces’. . T Turanov Kh . *Khadzhimukhametova // Transport: science, engineering and operation*, 2008. p. .

[Turanov Kh ()] *Mathematical modeling of joint fixation of flexible and elastic cargo fastening elements under the action of spatial force system*, . T Turanov Kh . 2011. p. . Rostov State Railway University

[Turanov Kh (ed.) ()] *Mathematical modeling of stress loading of cargo fastening flexible elements with a pad under the action of spatial force system*, . T Turanov Kh . Kh.T. Turanov, E.N. Timukhina. // Urals Transport (ed.) 2011. p. .

[Turanov Kh et al. ()] *Method of cargo fastening calculation / Kh*, . T Turanov Kh , E D Turanov , G A Pserovskaya . 2001. p. . (Turanova // Railway transport)

[Turanov Kh] ‘Modeling of technology of cargo fastening under the action of spatial force system’. . T Turanov Kh . *Olentsevich // Urals Transport. -2010*, p. .

[Turanov Kh et al.] *Modeling of tensions in flexible fastening elements / Kh*, . T Turanov Kh , S A Turanov , A L Sitnikov . p. . (Rykov// Transport science and technology)

[Kh ()] *New methods of calculation of elastic elements of cargo fixation on a wagon against longitudinal shift / Kh.T. Turanov // Transport: science, engineering and operation*, Turanov Kh . 2013. p. .

[Kh ()] *New methods of determining longitudinal shift in the simultaneous presence of elastic and thrust cargo fastening elements in the wagon / Kh.T. Turanov // Transport: science, engineering and operation*, Turanov Kh . 2013. p. .

[Urazbaev and Tashkent ()] *Publishing house of Academy of Sciences of Uz SSR*, M T Urazbaev , Tashkent . 1951. (91 p)

[Khabibulla] *Special problems on cargo handling operations: teaching aid for students of railway universities / Khabibulla Turanov*, Turanov Khabibulla .

[Technical requirements for cargo location and fastening in wagons and containers. ?M.: Urtrans ()] *Technical requirements for cargo location and fastening in wagons and containers. ?M.: Urtrans*, 2003. 544 p. pp.

[Loitsyansky ()] ‘The course of theoretical mechanics’. L G Loitsyansky . *Nauka (Science)*, 1983. p. 347.

[Urazbaev] *The fundamentals of mechanics of weighty deformable flexible thread: monograph*, M T Urazbaev .

[Khabibulla ()] *The theory of fastening solidstate cargo on open rolling stock: monograph / Khabibulla Turanov*, Turanov Khabibulla . 2012. Saarbrücken, Germany: LAP LAMBERT Palmarium Academic Publishing. p. 259.

[Turanov Kh ()] *Theoretical mechanics in cargo handling problems: monograph / Kh.T. Turanov. -Novosibirsk: Science*, . T Turanov Kh . 2009. (376 p)

[Turanov Kh ()] 'Theoretical mechanics in special problems of freight traffic: teaching aid for students of railway universities'. . T Turanov Kh . *Kh.T. Turanov. -Novosibirsk: Nauka (Science)* 2012. (447 p)

[Turanov ()] *Working out of generalized dynamic model of cargo fixation with cargo pads jointly with flexible and thrust elements under the action spatial force system / Khabibulla Turanov*, Khabibulla Turanov . 2011. Elena Timukhina // Transport Problems. 6 p. .