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The journal is published 4 times a year and contains publications in the following main areas:

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CONTEXT / MUNDARIJA

Mathematical model of fastening conditions in piggyback transport, taking into account different conditions

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Abstract: The main goal of the work is to determine the forces affecting the vehicle loaded on the railway platform and to systematize them. In this article, analyzes of security requirements are carried out on the basis of cargo transportation. In the study, the options for choosing the type of fastening means were considered based on the analysis of the forces acting on the mass of the transported load. Transportation of semi-trailers was chosen as a study of the types of transport, based on the stability conditions of the forces acting on the transportation of semi-trailers in rail transport, truck transport, trailer transport, road transport and semi-trailer transport. It is possible to determine the number and requirements of fastening means by determining the results of the influencing forces.

Keywords: safe transportation, fastening elements, road train, wagon, type of transport, type of transport, loading and unloading, traffic movement, acting forces

Turli sharoitlarni inobatga olib kontreyler tashishlarda mahkamlash shartlarining matematik modeli

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Annotatsiya: Ishdan asosiy maqsad temir yo‘l platformasiga ortilgan avtotransport vositasiga ta’sir ko‘rsatuvchi kuchlarni aniqlash va ularni tizimlashtirishdan iborat. Ushbu maqolada yuklarni kontreyler tashishlar asosida xavfsizlik talablarini ta’minlash tahlillari olib borilgan. Tadqiqotda tashilayotgan yukning massasiga bog‘liq holda ta’sir qiluvchi kuchlarning tahlili hisobiga mahkamlash vositalari turini tanlash imkoniyatlari ko‘rib chiqilgan. Tashish turlarini tadqiq qilish sifatida avtopoyezd tashish, tirkama tashish, avtomobil transportida tashish va temir yo‘l transportidagi yarim tirkamalarni tashishda ta’sir qiluvchi kuchlarning turg‘unlikni ta’minlash shartlarini asoslashda yarim tirkamlarni yetkazib berish tanlangan. Ta’sir qiluvchi kuchlarning natijalovchilarini aniqlash yordamida mahkamlash vositalari sonini va talablarini belgilash imkoniyati yaratilgan.

Kalit so‘zlar: xavfsiz tashish, mahkamlash elementlari, avtopoyezd, vagon, transport turi, tashish turi, yuklash va tushirish, transport harakati, ta’sir qiluvchi kuchlar

1. Kirish

Hozirgi kunda xalqaro tajriba shuni ko‘rsatmoqdaki temir yo‘l transportida kontreyler tashishlarda yuklarni yetkazib berish samarali hisoblanadi. Shu nuqtai nazardan “O‘TY” AJ sharoitida yuklarni kontreyler tashishlarda yetkazib berish bir muncha afzalliklarga ega, bundan kelib chiqilsa aynan Respublikamiz temir yo‘llarida kontreyler tashishlar yangi yo‘nalish sanaladi. Qolaversa, bu sohada o‘z yechimini kutayotgan muammolar talaygina ya’ni harakat xavfsizligini ta’minlash uchun albatta bu tashishlarning texnik shartlarini, mahkamlash qoidalarini mahalliy standartlarga moslashtirgan holatda ishlab chiqish lozimdir [1-4, 7, 10].

Yuklarni tashishga qo‘yilgan asosiy talablar ya’ni yuklarning o‘z manziliga xavfsiz holda yetib borishida turg‘unlik mezonlarini tekshirishdan iborat. Yuk jo‘natuvchi yuklarni o‘z manziliga yetkazishda keltirilgan ta’sir etuvchi omillarning barchasini inobatga olgan holda samarali mahkamlashlash usulini tanlash va tashishni amalga oshirish kerak bo‘ladi. Tadqiqotda Dalamber tamoyili, Nyuton qonunlari, matematik modellashtirish va tizimli yondashuvlar usulidan foydalanilgan [1-4].

Temir yo‘l transportida kontreyler tashishni tashkil etishda avtopoyezd, yuk avtomobili, tirkama, shatakchi va yarim tirkama kabi tashish birliklarini belgilangan talablarga rioya qilgan holda temir yo‘lning 13-9961, 13-4095, 139004M modellaridagi platformalaridan yuklashda foydalanish mumkin. Ushbu platforma modellarida tushirilgan yuk maydoni bo‘lib, tashish birliklarini mahkamlash uchun g‘ildirak juftliklarini o‘rnatishda qo‘llaniladi. Bundan tashqari, bu platformalar yordamida konteynerlar va yechiluvchi avtomobil kuzovlarini tashishni inobatga olgan holda o‘rnatish joylari mavjud [1].

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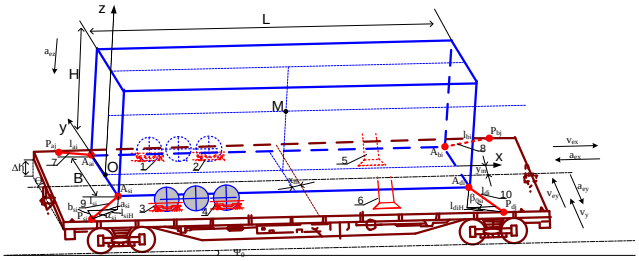
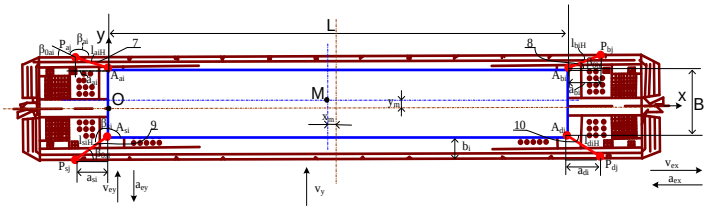
Kontreyler tashishlarda yuk sifatida tashiladigan yukli avtotransport vositalarining o‘lchamlari oddiy yuklardan kattaroq bo‘lishi mumkinligini inobatga olib, me’yoriy hujjatlarda belgilangan temir yo‘l transporti platformalaridan foydalaniladi. Tashish birliklari temir yo‘l platformasi bo‘ylama simmetriya tekisligiga simmetrik joylashtiriladi. Ularning ko‘ndalang yo‘nalishlarda siljishi 100 mm dan hamda platforma ramasidan tashqariga chiqish 400 mm dan oshmasligi kerak. Platformaga bir nechta tashish birliklarini ortishda yuklarni joylashtirish va mahkamlash bo‘yicha texnik shartlarda keltirilgan ko‘rsatmalarga to‘liq rioya qilinadi [5-6, 8-9].

2. Adabiyotlar tahlili va metodologiyasi

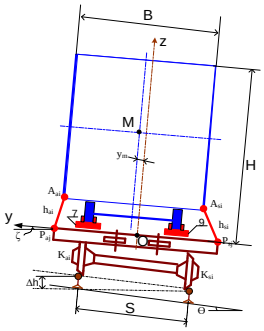
Avtopoezdlarni maxkamlash va joylashtirish chizmalarini uning ko‘ndalang bo‘ylama yo‘nalishlardagi ko‘chishini aniqlashda vagon-mahkamlash-yuk tizimidan foydalaniladi va kuchlarni XYZ o‘lchamli fazoda joylashishi e’tiborga olinishi lozim [11-12]. Avtotransport vositalarini ochiq harakat tarkiblariga joylashtirish va mahkamlash chizmalari ularning siljishi tebranishi natijasida mahkamlash elementlariga tushadigan zo‘riqishlarni aniqlash yuzasidan shuningdek, harakat tarkiblarini temir yo‘l egriligida harakatlanishi va tashqi shamol ta’siridagi siljishini aniqlash yuzasidan takliflar [2]-ilmiy izlanishda batafsil yoritib o‘tilgan. Biroq ochiq harakat tarkibida tashilayotgan avtopoyezdlarni mahkamlash tartibi haqida qisman to‘xtalib o‘tilgan, nimagaki avtopoezdlar tuzilishiga ko‘ra [2]-ilmiy izlanishda ko‘rilgan avtotexnika chizmasidan tubdan farq qiladi shu maqsadda avtopoezdlarni “O‘TY” AJ sharoitlariga moslashtirgan holda mahkamlash shartlarini ishlab chiqish dolzarb ahamiyat kasb etadi. Universal to‘rt o‘qli platformaga (model 13-9961) yarim tirkama joylashtirilgan va mahkamlash ishlari bajarilgan holatda harakat davomidagi ta’sir qiluvchi kuchlarni asoslash muhim ahamiyat kasb etadi (1-rasm).



a) yon tomondan ko‘rinishi



b) yuqoridan ko‘rinishi



v) orqa tomondan ko‘rinishi

1-rasm. Universal to‘rt o‘qli platformaga (model 13-9961) yarim tirkamani joylashtirish va mahkamlash sxemasi

Tahlil natijalari (1-rasm)ga ko‘ra, harakat tarkibiga doimiy ta’sir qiluvchi kuchlardan tashqari, harakat davomida qiyalik va egriliklarda hosil bo‘luvchi boshqa kuchlar ham ta’sir qiladi.

1-rasmda $\overline{Q}_{yuk}$-avtopoyezd, yarim tirkamaning yuklangan yoki bo‘sh holatdagi og‘irligi, N;

n_i-mahkamlash vositalari (tortqich) ning soni;

H,L,B -mos ravishda, yarim tirkamaning balandligi, uzunligi va eni, m;

$l_{ai}, l_{bi}, l_{si}, l_{di}$-mahkamlash vositasi (tortqich) ning uzunligi, m;

$h_{ai}, h_{bi}, h_{si}, h_{di}$-mahkamlash vositasi (tortqich) ning ko‘ndalang o‘qdagi proyeksiyasi balandligi, m;

$a_{ai}, a_{bi}, a_{si}, a_{di}$- mahkamlash vositasi (tortqich) ning bo‘ylama o‘qdagi proyeksiyasi uzunligi, m;

$b_{ai}, b_{bi}, b_{si}, b_{di}$- mahkamlash vositasi (tortqich) ning ko‘ndalang o‘qdagi proyeksiyasi uzunligi, m;

α_{ai},α_{bi},α_{si},α_{di}- mahkamlash vositasi (tortqich) va platforma tekisligi orasidagi burchak, º;

β_{ai},β_{bi},β_{si},β_{di}- mahkamlash vositasi (tortqich) ning proyeksiyasi va platformaning x o‘qidagi tekisligi orasidagi burchak, º;

Δh -tashqi va ichki rels balandliklari farqi, $\Delta h = \frac{S \cdot v^2}{g \cdot R}$, m;

S -rels o‘qlari orasidagi masofa, m;

θ - tashqi relsning ichki relsga nisbatan balandligini tavsiflovchi burchak, $\theta = arctg(\frac{\Delta h}{S})$, º;

ξ -platformaning bo‘ylama x o‘qda siljiganida yuklangan vagon ramasi egilishi hisobga olinadigan burchak, º;

ζ - platformaning ko‘ndalang y o‘qda siljiganida yuklangan vagon ramasi egilishi hisobga olinadigan burchak, º;

ψ_0-tarkibning qiyalikda harakatlanish burchagi, $\psi = arctg(\frac{\Delta H}{l_y})$, °.

3. Natija va muhokama

Temir yo‘l uchastka va yo‘nalishlari bo‘yicha yuklari harakat tezliklari ifodalarini [14, 15] tahlil qilish natijasida yuklari harakat tezliklariga ta’sir ko‘rsatuvchi omillar darajalar kesimida tizimlashtirildi. Tizimlashtirish temir yo‘l transporti PHGning asosiy ko‘rsatkichlaridan biri bo‘lgan uchastka va marshrut tezliklari misolida amalga oshirildi. Uchastka tezligini aniqlash ifodasiga [14, 15] birinchi darajali ($O_{uch.1}$) ikki xil omil bilan tavsiflanadi, ya’ni texnik (temir yo‘l uchastkalarining uzunligi (L_{uch})) va texnologik (temir yo‘l uchastkalarida poyezdlarning yurish (t_{yur})), oraliq stansiyalarda poyezdlarning umumiy o‘rtacha turib qolish ($\sum t_{or.st}$) va tezlashish va sekinlashish harakatlari uchun sarflagan ($\sum t_{t/s}$) vaqtlari.

Platformaga ortilgan avtotransport vositasiga uning massasi (Q_y)dan tashqari harakat vaqtida tezlanish va sekinlanish jarayonida hamda manyovr va saralash vaqtida ta’sir qiladigan bo‘ylama inersiya kuchlari (F_b); harakati vaqtida va yo‘lning egri burilish joylarida ta’sir qiladigan ko‘ndalang inersiya kuchlari (F_k); harakat vaqtida platforma tebranishlari keltirib chiqargan vertikal inersiya kuchlari (F_v); shamol yuklamasi (W_{sh}) hamda bo‘ylama ($F_{(ish.b)}$) va ko‘ndalang ($F_{(ish.k)}$) yo‘nalishdagi ishqalanish kuchlari ta’sir qiladi [3]. Ta’sir qiluvchi kuchlarning kattaliklarini aniqlashda hamda sxema ko‘rinishida ifodalashda kuch yo‘nalishlari gorizontal va vertikal o‘qlar kesishgan nuqtada ko‘rsatiladi. Kuch yo‘nalishlari ta’sir qilayotgan tekisligiga perpendikulyar qabul qilinadi.

Fizikaning dinamika qonuni:

$$\sum_{i=1}^{n} \overline{F_i} = \overline{F_1} + \overline{F_2} + \ldots + \overline{F_n} = m\overline{a} \quad (1)$$

bu yerda, M - yukning og‘irlik markazi nuqtasi;

$\overline{F}$- faol kuchlar ($\overline{Q_{yuk}}$, $\overline{F^I}$, $\overline{F^A}$), N;

$\overline{Q}^x_{yuk}$, $\overline{Q}^y_{yuk}$, $\overline{Q}^z_{yuk}$- koordinata o‘qlarida yukning og‘irlik kuchi proyeksiyasi, N;

$$\overline{Q_{yuk}} = m\overline{g} \quad (2)$$

$\overline{F^R}$- qo‘shimcha mahkamlash vositasi (tortqich) ning bog‘lanish reaktivlik (elastiklik) kuchi, N;

$$\overline{F^R} = \overline{N_{kx}} \cdot \bar{i} + \overline{N_{ky}} \cdot \bar{j} + \overline{N} \cdot \bar{k} \quad (3)$$

$\overline{F^K}$- Koriolis inersiya kuchi, N;

$$\overline{F^K} = \overline{F}^K_x \cdot \bar{i} + \overline{F}^K_y \cdot \bar{j} + \overline{F}^K_z \cdot \bar{k} = m \cdot \overline{a_k} \quad (4)$$

$$\overline{a_k} = 2 \cdot \overline{\omega_e} \cdot \overline{v_n} \quad (5)$$

$$\overline{F^K} = 2m\overline{v_r} \times \overline{\omega_e} = 2 \cdot m \cdot \omega_e \cdot v \cdot sin(\overrightarrow{\omega_e}, \vec{v}) \quad (6)$$

Koriolis kuchini hisobga olganda natijaviy tezlanish quyidagi ko‘rinishda bo‘ladi:

$$a = \sqrt{(\frac{dv}{dt})^2 + \frac{v^2}{R} + 4 \cdot (\omega_e \cdot v \cdot sin(\overrightarrow{\omega_e}, \vec{v}))^2} \quad (7)$$

$\overline{v_\tau}$-tangensial yoki nisbiy tezlik, m/s;

$\overline{\omega_e}$- nisbiy burchak tezlik, m/s;

$\overline{F}^K_x$,$\overline{F}^K_y$- Koriolis inersiya kuchi proyeksiyalari, N;

$\overline{F}^I_n$- normal inersiya kuchi, N;

Normal inersiya kuchi va uning tashkil etuvchilarini quyidagicha yozib olish mumkin:

$$F^I_n = \frac{m \cdot v^2}{R} \quad (8)$$

$$F^I_{ny} = F^I_n \cdot cos(\theta + \xi) \quad (9)$$

$$F^I_{nz} = F^I_n \cdot sin(\theta + \xi) \quad (10)$$

$\overline{F^I}$- o‘tkaziladigan inersiya kuchlari;

$$\overline{F^I} = \overline{F}^I_{kix} \cdot \bar{i} + \overline{F}^I_{kiy} \cdot \bar{j} + \overline{F}^I_{kiz} \cdot \bar{k} \quad (11)$$

$\overline{F}^I_x$,$\overline{F}^I_y$,$\overline{F}^I_z$- x,y,z o‘qlarida yukga ta’sir qiluvchi inersiya kuchlari, N;

$\overline{F^A}$- aerodinamik qarshilik kuchi, N;

$\overline{F^A_x}$,$\overline{F^A_y}$,$\overline{F^A_z}$- koordinata o‘qlaridagi aerodinamik qarshilik kuchining proyeksiyalari, N;

$$\overline{F^A} = \overline{F}^A_x \cdot \bar{i} + \overline{F}^A_y \cdot \bar{j} + \overline{F}^A_z \cdot \bar{k} \quad (12)$$

$$W_{shi} = k_i \cdot S_i \quad (13)$$

$$F^{AW}_i = s_1 \cdot \rho_h \cdot \frac{v^2_h}{2} \cdot w_{shi} \quad (14)$$

bu yerda,

k_i- yukning shamol yuzasining uzluksizligini hisobga oluvchi koeffitsient, N;

S_i - shamol ta’sir qiluvchi yuza, m^2;

ρ_h- havoning zichligi ($\rho_h = 1{,}29 kg/m^3$);

v_h- havoning tezligi, m/s;

s_1 -yukning shamol yuzasi shaklini hisobga olgan holda koeffitsient;

X_{F_A}, Y_{F_A}, Z_{F_A}- aerodinamik qarshilik kuchi ta’sir nuqtalari;

$\overline{F^R_{ni}}$- g‘ildirakni mahkamlash vositasi komplektidagi reaktivlik kuchlari, N;

$$\overline{F^R_{ni}} = \sum_{k=1}^{n} \overline{N_k} \quad (15)$$

n - yarim tirkamaning umumiy g‘ildiraklari soni;

k - yarim tirkama g‘ildiraklari raqami;

$\overline{F^R_{nix}}$,$\overline{F^R_{niy}}$- mahkamlash vositasi (tirak to‘sin)ning gorizontal va ko‘ndalang reaksiyasi, N;

Δs - yukning siljishi, m;

$\overline{F_{sh}}$- yarim tirkama shinasining platforma ustida harakatlanishiga to‘sqinlik qiladigan ko‘ndalang kuch, N;

$$F^x_{sh.b} = \mu_{sh} \cdot Q^{yuk}_z \quad (16)$$

$$F^x_{sh} = \mu_\alpha \cdot Q^{yuk}_z \quad (17)$$

$$F^y_{sh.b} = \mu_{sh} \cdot Q_{yuk} \cdot (cos(\theta) \cdot cos(\psi + \upsilon_0) - \frac{a_z}{g}) \quad (18)$$

$$F^y_{sh} = \mu_\alpha \cdot Q_{yuk} \cdot (cos(\theta) \cdot cos(\psi + \upsilon_0) - \frac{a_z}{g}) \quad (19)$$

μ_α- shinalarning yon tomonga sirpanish koeffitsiyenti;

a_z- vertikal nisbiy tezlanish, m/s^2;

$\overline{N_f}$- shina tebranishiga qarshilik kuchi, N;

$$\overline{N_f} = \mu_t \cdot \overline{F_z} \quad (20)$$

μ_t- tebranishga qarshilik koeffitsiyenti ($\mu_t = 0{,}007 \div 0{,}3$);

$\overline{F_{Px}}$- platforma poliga bo‘ylama reaksiya kuchi, N;

$$\overline{F_{Px}} = \overline{N_f} + \overline{F_{ishx}} \quad (21)$$

$\overline{F_{ishx}}$- bo‘ylama yo‘nalishda ishqalanish kuchi, N;

$\overline{F_{Py}}$- platforma poliga ko‘ndalang reaksiya kuchi, N;

$$\overline{F_{Px}} = \overline{F_{sh}} + \overline{F_{ishy}} \quad (22)$$

$\overline{F_{ishy}}$- ko‘ndalang yo‘nalishda sirpanish ishqalanish kuchi, N;

Kuch vektorlarining koordinata o‘qlaridagi proyeksiyalari:

X: $F_x^I - F_x^K - (Q_{yuk}^x + F_x^A) - F_{ix} - N_x - F_{nix}{}^R = ma_{rx} - F_{mqx}$ (23)

Y: $F_y^I + F_y^K + \left(F_{mqy} + F_y^A\right) - Q_{yuk}^y - F_{iy} - N_y - F_{sh} - F_{niy}{}^R = ma_{ry}$ (24)

Z: $-(Q_{yuk}^z - F_z^I) + N - F_{iz} - (F_z^A + F_{mqz}) = ma_{rz}$ (25)

bu yerda,

$F_{mqy} = -m\frac{v_{ry}^2}{R}$ va $F_{mqx} = -m\frac{dv_{\tau x}}{dt}$ dan hamda $\overline{v_\tau} = \overline{v_r}$dan

X: $F_x^I - F_x^K - (Q_{yuk}^x G_x + F_x^A) - F_{ix} - N_x - F_{nix}{}^R = m \cdot (a_{rx} + \frac{dv_{rx}}{dt})$ (26)

Y: $F_y^I + F_y^K - (Q_{yuk}^y - F_y^A) - F_{iy} - N_y - F_{sh} - F_{niy}{}^R = m \cdot (a_{ry} + \frac{v_{ry}^2}{R})$ (27)

Z: $-(Q_{yuk}^z - F_z^I) + N - F_{iz} - (F_z^A + F_{mqz}) = ma_{rz}$ (28)

$\overline{v_r} = const$ dan

X: $F_x^I - F_x^K - (Q_{yuk}^x + F_x^A) - F_{ix} - N_x - F_{nix}{}^R = ma_{rx}$ (29)

Y: $F_y^I + F_y^K - (Q_{yuk}^y - F_y^A) - F_{iy} - N_y - F_{sh} - F_{niy}{}^R = m \cdot (a_{ry} + \frac{v_{ry}^2}{R})$ (30)

Z: $-(Q_{yuk}^z - F_z^I) + N - F_{iz} - (F_z^A + F_{mqz}) = ma_{rz}$ (31)

bunda, ma_{rx}, ma_{ry}, ma_{rz} - koordinata o‘qlaridagi nisbiy inersiya kuchi proyeksiyalari, N;

$\overline{Q}_{yuk} \in (\overline{Q}_{yuk}^x, \overline{Q}_{yuk}^y, \overline{Q}_{yuk}^z)$ - koordinata o‘qlarida yukning og‘irlik kuchi proyeksiyalari, N;

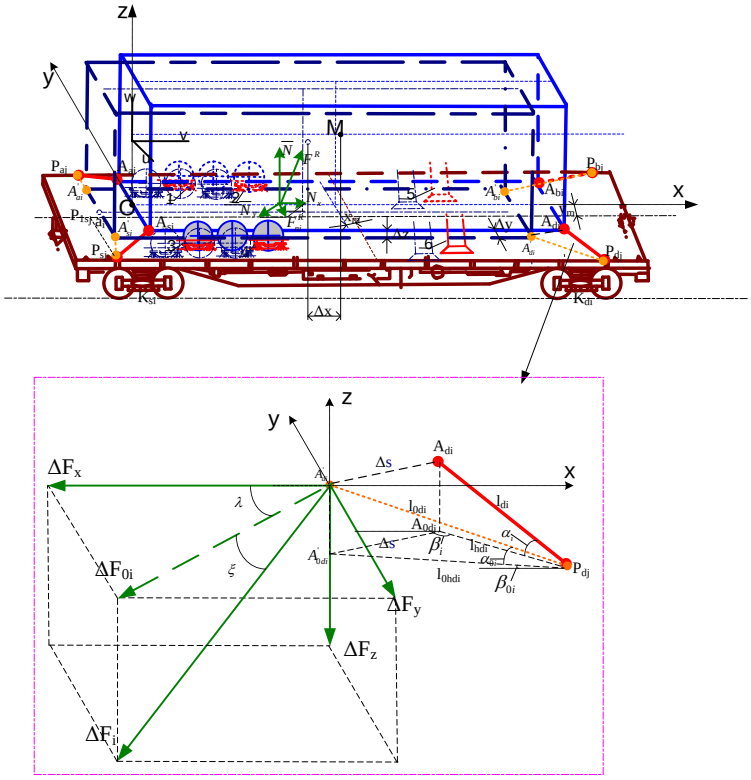
$\overline{F^K} \in (\overline{F}_x^K, \overline{F}_y^K)$ - Koriolis inersiya kuchining o‘qlardagi proyeksiyasi, N;

$\overline{F^I} \in (\overline{F}_x^I, \overline{F}_y^I, \overline{F}_z^I), \overline{F}_n^I$, $\overline{F^A} \in (\overline{F_x^A}, \overline{F_y^A}, \overline{F_z^A})$ - faol kuchlar va ularning o‘qlardagi proyeksiyalari, N;

$\overline{F^{(i)}}, \overline{F}_{sh}, \overline{F^R} \in (\overline{N}, \overline{N}_x, \overline{N}_y), \overline{F_{ni}^R} \in (\overline{F_{nix}^R}, \overline{F_{niy}^R})$ - reaktiv kuchlar va ularning o‘qlardagi proyeksiyalari, N;

Kontreyler tashishlarda avtotransport vositalarini temir yo‘l platformasiga mahkamlashning matematik modelini ishlab chiqish uchun yukning qiyin sharoitlarda harakatlanganida Δs siljish holatini ko‘rib chiqish lozim.

Harakat davomida yo‘lning murakkab sharoitlarida yukning siljish holatlari sodir bo‘ladi (2-rasm).



2-rasm. Yuk siljishining mahkamlash vositasiga ta’siri

Temir yo‘l uchastkalarida yuk poyezdlari uchastka tezliklariga birinchi darajali ($O_{uch.1}$) texnik va texnologik ta’sir ko‘rsatuvchi omillarning qiymatlari PHG bilan muvofiqligi va rejalashtirilganligi sababli shartli ravishda doimiy deb tasniflanadi. Shartli ravishda doimiy ta’sir ko‘rsatuvchi texnik va texnologik omillar uchastka tezliklarining o‘rnatilgan texnik me’yorlari qiymatlarini o‘rnatishda noaniqlik keltirmaydi, biroq ikkinchi darajali ($O_{uch.2}$) ta’sir ko‘rsatuvchi omillar uchastka tezliklarini bajarilish darajasiga ta’sir ko‘rsatadi (2-rasm).

Yuklarga ta’sir qiluvchi kuchlarning yo‘nalishlari va qiymatlari turlicha bo‘lganligi uchun ularning natijaviy ko‘rsatkichlarini aniqlash lozim. Bunda har bir o‘q bo‘yicha ta’sir qiluvchi kuchlar alohida hisoblanadi. Ta’sir qilayotgan nuqtaga perpendikulyar yo‘nalmagan kuchlarni hisoblashda ularni mos o‘qga proyeksiyalash usuli qo‘llaniladi. Bunda ta’sir qiluvchi kuchning o‘qga nisbatan burchagi va yo‘nalishi inobatga olinadi. Turli mahkamlash elementlari va vositalarining turi hamda sonini tanlash uchun ularga tushuvchi siljitish kuchlarini aniqlash kerak.

Mahkamlash elementining tashqi kuch ta’sirida uzayishi:

$\Delta l_i = \Delta s \cdot (\cos\alpha_i \cdot \cos\beta_{oi} \cdot \cos\lambda^{(i)} + \cos\alpha_i \cdot \sin\beta_{oi} \cdot \sin\lambda^{(i)} + \sin\alpha_i) \cdot \cos\varepsilon^{(i)}$ (32)

bunda,

$\cos(\overline{\Delta F^{oi}}, \overline{\Delta F^{i}}) = \frac{\Delta F^{oi}}{\Delta F^{i}}$ yoki $\cos\varepsilon = \frac{\Delta F^{oi}}{\Delta F^{i}}$ (33)

Mahkamlash elementining proyeksiyasidan:

$\Delta l_i = \Delta s \cdot (\frac{a_i}{l_i} \cdot \cos\lambda^{(i)} + \frac{b_i}{l_i} \cdot \sin\lambda^{(i)} + \frac{h_i}{l_i}) \cdot \cos\varepsilon^{(i)}$(34)

bunda,

a_i, b_i, h_i- tortqichning bo‘ylama, ko‘ndalang va vertikal koordinata o‘qlaridagi uzunliklari, m;

$\lambda^{(i)}$, $\varepsilon^{(i)}$- kuchlar fazoviy tizimlarining yo‘nalishlarini tavsiflovchi burchaklar, °;

Guk qonuniga asosan mahkamlash vositasining zo‘riqish kuchi:

$F_i^R = k \cdot \Delta l_i$ (35)

$k = \frac{E \cdot S}{l_0}$ (36)

$S = \pi \cdot R^2 = \pi \cdot \frac{d^2}{4}$ (37)

(37) dan (36) ning ko‘rinishi quyidagicha bo‘ladi:

$k = \frac{\pi}{4} \cdot \frac{E}{l_0} \cdot d^2$ ekanligidan po‘lat sim uchun

$F_i^R = \frac{\pi}{4} \cdot E \cdot d_i^2 \cdot \frac{n_i}{l_i} \cdot \Delta l_i$ (38)

bu yerda, k - tortqichning deformatsiyasini xarakterlovchi bikrlik, N/m;

π - 3,14

E - Yung moduli (po‘lat uchun 190-210 Gpa);

F_i^R- zo‘riqish kuchi (kN);

n_i va d_i- tortqichdagi simlarning soni va mahkamlash simining diametri, m;

$l_i = l_0$- moslashuvchan mahkamlash vositasi (tortqich) ning boshlang‘ich uzunligi, m;

(34), (38) dan Δs siljishdagi zo‘riqish kuchi:

$F_i^R = \Delta s \cdot \frac{\pi}{4} \cdot E \cdot d_i^2 \cdot \sum_{i=1}^{n_p} \frac{n_i}{l_i} \cdot (\frac{a_i}{l_i} \cdot \cos\lambda^{(i)} + \frac{b_i}{l_i} \cdot \sin\lambda^{(i)} + \frac{h_i}{l_i}) \cdot \cos\varepsilon^{(i)}$ (39)

(39) ga qo‘llash orqali:

$$\Delta s \cdot \frac{\pi}{4} \cdot E \cdot d_i^2 \cdot \sum_{i=1}^{n_p} \frac{n_i}{l_i} \cdot (\frac{a_i}{l_i} \cdot \cos\lambda^{(i)} + \frac{b_i}{l_i} \cdot \sin\lambda^{(i)} + \frac{h_i}{l_i}) \cdot \cos\varepsilon^{(i)} \times \times \sqrt{(\frac{a_i}{l_i} + \mu_{sh} \cdot \frac{h_i}{l_i} \cdot \cos\lambda)^2 + (\frac{b_i}{l_i} + \mu_{sh} \cdot \frac{h_i}{l_i} \cdot \sin\lambda)^2 + \frac{h_i}{l_i}^2} = \Delta F_i$$ (40)

Ta’sir kuchi yo‘nalishida yukning siljishi:

$\Delta s = \frac{\Delta F_i}{c_{ekv}^F}$ (41)

c_{ekv}^F- ta’sir kuchi yo‘nalishi bo‘yicha yarim tirkamaning egiluvchan simli nahkamlagichlari va elastik vositalarning ekvivalent qattiqligi;

(41) ifoda orqali mahkamlash vositasining ekvivalent qattiqligini quyidagicha ifodalash mumkin:

$$c_{ekv}^F = \frac{\pi}{4} \cdot E \cdot d_i^2 \cdot \sum_{i=1}^{n_p} \frac{n_i}{l_i} \cdot (\frac{a_i}{l_i} \cdot \cos\lambda^{(i)} + \frac{b_i}{l_i} \cdot \sin\lambda^{(i)} + \frac{h_i}{l_i}) \cdot \cos\varepsilon^{(i)} \times \times \sqrt{(\frac{a_i}{l_i} + \mu_{sh} \cdot \frac{h_i}{l_i} \cdot \cos\lambda)^2 + (\frac{b_i}{l_i} + \mu_{sh} \cdot \frac{h_i}{l_i} \cdot \sin\lambda)^2 + \frac{h_i}{l_i}^2}$$ (42)

Yarim tirkamani mahkamlash mustahkamligi uchun:

$F_i^{Rel} = \Delta s \cdot \frac{\pi}{4} \cdot E \cdot d_i^2 \cdot \sum_{i=1}^{n_p} \frac{n_i}{l_i} \cdot (\frac{a_i}{l_i} \cdot \cos\lambda^{(i)} + \frac{b_i}{l_i} \cdot \sin\lambda^{(i)} + \frac{h_i}{l_i}) \cdot \cos\varepsilon^{(i)} \le [F_i^R]$ (43)

bu yerda,

$[F_i^R]$ - mahkamlashda ruhsat etilgan zo‘riqish qiymati, N;

$\Delta s_x = \frac{\Delta F_{ix}}{c_{ekvx}^F}$ (44)

$\Delta s_y = \frac{\Delta F_{iy}}{c_{ekvy}^F}$ (45)

$\Delta s_z = \frac{\Delta F_{iz}}{c_{ekvz}^F}$ (46)

Siljish qiymati:

$\Delta s = \sqrt{(\Delta s_x)^2 + (\Delta s_y)^2 + (\Delta s_z)^2}$ (47)

bu yerda,

Δs_x, Δs_y, Δs_z- yukning bo‘ylama, ko‘ndalang va vertikal siljishi, m;

Olingan formula kontreyler tashishlarda avtotransport vositasini platformaga mahkamlash texnologiyasining yanada aniqroq, xavfsiz va ishonchli tanlash imkonini beradi.

4. Xulosa

Temir yo‘l platformasiga ortilgan yarim tirkama uchun ishlab chiqilgan matematik model yordamida mahkamlash vositasining mustahkamligi chegarasini inobatga olib, yukning siljish masofasi, mahkamlash vositasi (tortqich) ning umumiy soni, simlari soni, simning diametri va qattiqlik darajasiga asosan materilini tanlash imkoniyati mavjud.

Bunda poyezdning harakat tezligi 5 m/s bo‘lganida tortqichga ta’sir etuvchi kuch 100,1 kN, tezlik 15 m/s bo‘lganida kuch 100,3 kN, 25 m/s bo‘lganida kuch 100,9 kN bo‘lishi yarim tirkama uchun aniqlandi. 2-rasmda esa mahkamlash vositalari ortishi yukning siljish masofasini kamayishiga olib kelishi ko‘rsatilgan. Bunda mahkamlash vositalarining soni 2 ta bo‘lganida siljish masofasi 30 mm, 3 ta bo‘lganida siljish masofasi 20 mm, 4 ta bo‘lganida siljish masofasi 15 mm atrofida bo‘lishi olindi.

Olingan formula va blok-sxema kontreyler tashishlarda avtotransport vositasini platformaga mahkamlash texnologiyasining yanada aniqroq, xavfsiz va ishonchli tanlash imkonini beradi.

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