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Numerična analiza kazalnikov izkoristka nosilnosti cestnih vozil

Numerical Analysis of the Capacity-Exploitation Parameters of Road Vehicles

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Za določanje učinkovitosti transportnega dela cestnih vozil obstajajo številni tehnično-tehnološki in uporabnostni kazalniki, med katerimi imajo poseben pomen kazalniki izkoristka nosilnosti. V prispevku je analiziran način ugotavljanja koeficientov statične in dinamične izkoristka nosilnosti cestnih vozil ter njihove medsebojne primerjave. Numerična analiza je opravljena za primer izkoristka enega vozila v eni vožnji s tovorom, za eno vozilo v določenem časovnem obdobju, za homogeni vozni park ali skupino vozil iste nosilnosti in nehomogeni vozni park ali n skupinami vozil iste koristne nosilnosti.

(Ključne besede: vozila cestna, nosilnost vozil, učinkovitost transporta, modeliranje numerično)

There are numerous technical, technological and exploitation parameters for determining the transportation work efficiency of road vehicles, among the most important are the capacity-exploitation parameters. In this paper, the determination of static and dynamic coefficients of the capacity-exploitation parameters of road vehicles and their mutual comparison is analysed. A numerical analysis is realised for the case of one vehicle in one ride with cargo, for one vehicle in a defined time period, for a homogeneous motor pool or a group of vehicles with same capacity and an inhomogeneous motor pool or n groups of vehicles of the same benefit capacity.

(Keywords: road vehicles, vehicle capacity, transportation effects, numerical modelling)

0 UVOD

Načrtovanje, raziskovanje in ocenjevanje učinkovitosti dela cestnih vozil v potniškem in tovornem prometu niso mogoči brez analize določenih kazalnikov za vrednotenje ustvarjenih rezultatov dela [1].

Obstajajo številni tehnološko-uporabnostni kazalniki dela cestnih vozil, npr. kazalniki časovne bilance dela vozil, kazalniki izkoristka prevožene poti, kazalniki pogojev pri opravljanju transportnega dela, kazalniki izkoristka zmogljivosti cestnih vozil ter prevozne zmožnosti cestnega voznega parka idr.

Med vsemi temi kazalniki, posebej pa v skupini kazalnikov izkoristka zmogljivosti cestnih vozil, so najpomembnejši tisti, ki se nanašajo na nosilnost. Slab izkoristek cestnih vozil zmanjšuje njihov transportni učinek, izražen v tonskih kilometrih (tkm), prostorninskih kilometrih (m^3km) ali potniških kilometrih (pkm), kar je posebej pomembno na večjih razdaljah [3].

0 INTRODUCTION

Planning, researching and grading the work efficiency of road vehicles in public and cargo traffic is not possible without an analysis of the determined parameters for grading the acquired results of work [1].

There are numerous technological and exploitation parameters for road-vehicle work, for example: time parameters of vehicle-work balance, exploitation parameters of the transportation route, condition parameters in realising transportation work, capacity exploitation parameters of road vehicles and the transportation capability of a road motor pool etc.

Among all these parameters, especially in the group of capacity-exploitation parameters of the road vehicle, the most important are the parameters that refer to capacity. Under exploitation of road vehicles decreases their transportation effect in ton kilometres (tkm), volume kilometres (m^3km) or passenger kilometres (pkm), which is especially important over longer distances [3].

Izkoristek nosilnosti cestnih vozil se ugotavlja z numerično analizo modelov statične in dinamične izkoriščenosti koristne nosilnosti in njihovih medsebojnih odnosov.

1 RAČUNSKI MODEL STATIČNEGA IZKORISTKA NOSILNOSTI CESTNIH VOZIL

Model statičnega izkoristka nosilnosti cestnih vozil predstavlja način ugotavljanja koeficienta statičnega izkoristka kot razmerja količine prepeljanega tovora in količine tovora, ki bi lahko bila prepeljana pri popolnoma izkoriščeni nosilnosti.

Koeficient statičnega izkoristka cestnih vozil (γ) dobimo z naslednjimi enačbami.

- Za eno vozilo v eni vožnji s tovorom:

$$\gamma = \frac{q_x}{q} \tag{1},$$

kjer sta:
q - dejanska količina tovora, ki je prepeljana v eni vožnji s tovorom,
q_x - koristna nosilnost vozila.

- Za eno vozilo v določenem časovnem obdobju:

$$\gamma = \frac{Q_1}{qZ_x} = \frac{\sum_{i=1}^{Z_x} q_{xi}}{qZ_x} = \frac{\sum_{i=1}^{Z_x} q_{xi}}{\sum_{i=1}^{Z_x} q} \tag{2},$$

kjer sta:
Q_1 - količina tovora, ki je prepeljana z enim vozilom v določenem časovnem obdobju,
Z_x - število voženj s tovorom v določenem časovnem obdobju.

- Za homogeni vozni park ali skupino vozil iste koristne nosilnosti v določenem časovnem obdobju:

$$\gamma = \frac{Q}{qAZ_x} = \frac{\sum_{i=1}^{AZ_x} q_x}{qAZ_x} = \frac{\sum_{i=1}^{AZ_x} q_{xi}}{\sum_{i=1}^{AZ_x} q} \tag{3},$$

kjer so:
Q - količina dejansko prepeljanega tovora,
q - koristna nosilnost enega vozila,
AZ_x - število voženj voznega parka s tovorom v določenem časovnem obdobju.

- Za nehomogeni vozni park ali več skupinami vozil iste koristne nosilnosti:

$$\gamma' = \frac{\sum_{i=1}^{n} Q_i}{\sum_{i=1}^{n} AZ_{xi} q_i} = \frac{\sum AZ_{xi} q_i \gamma_i}{\sum_{i=1}^{n} AZ_{xi} q_i} = \frac{\sum_{i=1}^{n} AZ_{xi} q_i \gamma_i}{q_Q' \sum_{i=1}^{n} AZ_{xi}} \tag{4},$$

The capacity exploitation of road vehicles is determined with the help of numerical analysis models of static- and dynamic-benefit capacity exploitation and their mutual comparison.

1 NUMERICAL MODEL OF STATIC CAPACITY EXPLOITATION FOR ROAD VEHICLES

The model of static-capacity exploitation for road vehicles represents the way of establishing the coefficient of static exploitation compared to the quantity of transportation goods and the quantity of goods that could be transported by complete capacity exploitation.

The coefficient of static exploitation for road vehicles (γ) is determined with the following equations.

- For one vehicle in one drive with cargo:

$$\gamma = \frac{q_x}{q} \tag{1},$$

where:
q - is the real quantity of cargo that is transported in one drive with cargo,
q_x - is the benefit capacity of road vehicles.

- For one vehicle in a determined time period:

$$\gamma = \frac{Q_1}{qZ_x} = \frac{\sum_{i=1}^{Z_x} q_{xi}}{qZ_x} = \frac{\sum_{i=1}^{Z_x} q_{xi}}{\sum_{i=1}^{Z_x} q} \tag{2},$$

where:
Q_1 - is the cargo quantity that is transported with one vehicle in a determined time period,
Z_x - is the number of drives with cargo in a determined time period.

- For a homogenous motor pool or a group of vehicles with the same benefit capacity in a determined time period:

$$\gamma = \frac{Q}{qAZ_x} = \frac{\sum_{i=1}^{AZ_x} q_x}{qAZ_x} = \frac{\sum_{i=1}^{AZ_x} q_{xi}}{\sum_{i=1}^{AZ_x} q} \tag{3},$$

where:
Q - is the cargo quantity which is actually transported,
q - is the benefit capacity of one vehicle,
AZ_x - is the number of drives in a motor pool with cargo in a determined time period.

- For an inhomogeneous motor pool or more groups of vehicles of the same benefit capacity:

$$\gamma' = \frac{\sum_{i=1}^{n} Q_i}{\sum_{i=1}^{n} AZ_{xi} q_i} = \frac{\sum AZ_{xi} q_i \gamma_i}{\sum_{i=1}^{n} AZ_{xi} q_i} = \frac{\sum_{i=1}^{n} AZ_{xi} q_i \gamma_i}{q_Q' \sum_{i=1}^{n} AZ_{xi}} \tag{4},$$

kjer je:

$$\sum_{i=1}^{n} Q_i = AZ_{x1}q_1\gamma_1 + Z_{x2}q_2\gamma_2 + ... + AZ_{xi}q_i\gamma_i + ... + AZ_{xn}q_n\gamma_n$$

oziroma skupna količina tovora, ki jo prevažajo vse skupine vozil, ter razmerje količin, ki bi se lahko prepeljale, če bi nosilnost vseh vozil v vseh skupinah in pri vsaki vožnji s tovorom bila popolnoma porabljena.

$$\sum_{i\_1}^{n} AZ_{xi}q_i = AZ_{x1}q_1 + AZ_{x2}q_2 + ... + AZ_{xi}q_i + ... + AZ_{xn}q_n$$

q'_Q - povprečna nosilnost heterogenega voznega parka za obseg prevoza.

Iz enačbe za koeficient statičnega izkoristka nosilnosti cestnega vozila izhaja:

$$\sum_{i=1}^{n} Q_i = \gamma' \sum_{i=1}^{n} AZ_{xi}q_i = \gamma' q' \sum_{i=1}^{n} AZ_{xi} \quad (5),$$

Ker so nosilnosti cestnih vozil po posameznih skupinah različne ($q_1 \neq q_2 \neq q_i \neq q_n$), se pojavlja problem določanja povprečne nosilnosti vozil v nehomogenem voznem parku.

V praksi se najpogosteje uporablja razmerje celotne nosilnosti vseh vozil v voznem parku in števila vozil v voznem parku, ki se dobi po enačbi [5]:

$$q'_s = \frac{A_{k1}q_1 + A_{k2}q_2 + ... + A_{kn}q_n}{A_{k1} + A_{k2} + ... + A_{kn}} = \frac{\sum_{i=1}^{n} A_{ki}q_i}{\sum_{i=1}^{n} A_{ki}} \quad (6).$$

Ko v enačbo za obseg prevoza vstavimo povprečno nosilnost vseh vozil (q'_s), dobimo za $\sum_{i=1}^{n} Q_i$:

$$\gamma' \sum_{i=1}^{n} AZ_{xi}q_i = \frac{\gamma' \sum_{i=1}^{n} A_{ki}q_i}{\sum_{i=1}^{n} A_{ki}} = \frac{\sum_{i=1}^{n} AZ_{xi}}{\gamma' \sum_{i=1}^{n} AZ_{xi}}$$

oziroma

$$\frac{\sum_{i=1}^{n} AZ_{xi}q_i}{\sum_{i=1}^{n} AZ_{xi}} = \frac{\sum_{i=1}^{n} A_{ki}q_i}{\sum_{i=1}^{n} A_{ki}} \quad (7).$$

Dinamična povprečna nosilnost cestnih vozil za obseg prevoza heterogenega voznega parka (q'_Q), ki se edina lahko uporablja pri preračunu, je v bistvu povprečna koristna nosilnost vozil pri vsaki vožnji s tovorom celotnega heterogenega voznega parka, izračunamo pa jo z enačbo:

$$\frac{\sum_{i=1}^{n} AZ_{xi}q_i}{\sum_{i=1}^{n} AZ_{xi}} = \frac{AZ_{x1}q_1 + AZ_{x2}q_2 + ... + AZ_{xi}q_i + ... + AZ_{xn}q_n}{AZ_{x1} + AZ_{x2} + ... + AZ_{xi} + ... + AZ_{xn}} = q'_Q$$

in other words, the total cargo quantity which is transported by all groups of vehicles and compared to the quantities that could be transported if the capacity of all vehicles in all groups and in all drives with cargo would be totally exploited.

where:

q'_Q - is the average capacity of a heterogeneous motor pool for transportation volume.

This equation originates from the equation for the coefficient of static-capacity exploitation of road vehicles:

Because the capacities of road vehicles in individual groups are different ($q_1 \neq q_2 \neq q_i \neq q_n$), there is the problem of determining the average capacity of vehicles in an inhomogeneous motor pool.

In practice, the most frequently used relation is the total capacity of all vehicles in the motor pool and the number of vehicles in the motor pool. It is defined by equation [5]:

When we insert the average capacity of all vehicles in the equation for the volume of transportation (q'_s), we obtain $\sum_{i=1}^{n} Q_i$:

or

The dynamic average capacity of road vehicles for the transportation volume of a heterogeneous motor pool (q'_Q), which can only be used for calculating, is really the average benefit capacity of vehicles in every drive with cargo of the total heterogeneous motor pool. This equation defines it as:

$$q'_Q = \frac{\sum_{i=1}^{n} AZ_{xi} q_i}{\sum_{i=1}^{n} AZ_{xi}} \qquad (8).$$

$$q'_Q \neq q'_S$$

V posebnih primerih je povprečna nosilnost za obseg prevoza celotnega heterogenega voznega parka (q'_Q) enaka statični srednji vrednosti (q'_s). To se dogaja, ko sta izpolnjena naslednja dva pogoja [6]:

- da je knjigovodsko število vozil v vseh n skupinah vozil enako,
- da je vsaka skupina vozil heterogenega voznega parka opravila enako število voženj s tovorom.

Ta pogoja lahko prikažemo na naslednji način:

In special cases, the average capacity for the transportation volume of the total heterogeneous motor pool (q'_Q) is identical to the static medium value (q'_s). This happens when these two conditions are realised [6]:

- that the bookkeeping number of all vehicles in all n groups is the same,
- that all groups of vehicles of the heterogeneous motor pool realise the same number of drives with cargo.

These conditions can be shown in this way:

$$A_{k1} = A_{k2} = A_{k3} = ... = A_{kn} = ... = A_{ki}$$

$$AZ_{x1} = AZ_{x2} = AZ_{x3} = ... = AZ_{xn} = ... = AZ_{xi}$$

Če spoštujemo navedene pogoje, dobimo (q'_s) po enačbi:

If we consider the listed conditions, we obtain (q'_s):

$$q'_s = \frac{\sum_{i=1}^{n} A_{ki} q_i}{\sum_{i=1}^{n} A_{ki}} = \frac{A_k q_1 + A_k q_2 + ... + A_k q_n}{nA_k} = \frac{A_k (q_1 + q_2 + ... + q_n)}{nA_k} = \frac{A_k \sum_{i=1}^{n} q_i}{nA_k} = \frac{\sum_{i=1}^{n} q_i}{n} \qquad (9),$$

kjer je:

n - število skupin vozil heterogenega voznega parka

where:

n - is the number of group vehicles in the heterogeneous motor pool

$$q'_Q = \frac{AZ_x q_1 + AZ_x q_2 + ... + AZ_x q_n}{nAZ_n} = \frac{AZ_x (q_1 + q_2 + ... + q_n)}{nAZ_x} = \frac{AZ_x \sum_{i=1}^{n} q_i}{nAZ_x} = \frac{\sum_{i=i}^{n} q_i}{n}$$

Tako je dokazana enakost ($q'_Q = q'_s$) v primeru, ko sta izpolnjena navedena pogoja, kar pa se v praksi zelo redko pojavlja.

The equality is proven in this case ($q'_Q = q'_s$), when the listed conditions are met, however, this is rare in practice.

2 RAČUNSKI MODEL DINAMIČNEGA IZKORISTKA CESTNIH VOZIL

Model dinamičnega izkoristka nosilnosti cestnih vozil oziroma koristne nosilnosti, pomeni način ugotavljanja koeficienta dinamičnega izkoristka kot razmerja med skupno opravljenim transportnim delom in mogočim transportnim delom.

V nasprotju s koeficientom statične izkoriščenosti koristne nosilnosti cestnih vozil, ki upošteva količino dejansko prepeljanega blaga, vključuje koeficient dinamične izkoriščenosti koristne nosilnosti tudi razdalje, na katerih se tovor prevaža [5].

Koeficient dinamičnega izkoristka nosilnosti se določa po naslednjih enačbah.

- Za eno vozilo in eno vožnjo s tovorom:

2 NUMERICAL MODEL OF THE DYNAMIC EXPLOITATION OF ROAD VEHICLES

The model for the dynamic-capacity exploitation of road vehicles, or benefit capacity, presents a way of establishing the coefficient of the dynamic exploitation in relation to the totally realised transportation work and the possible transportation work.

As distinguished from the coefficient of static exploitation of benefit capacity of road vehicles that considers the quantity of actually transported goods, the coefficient of dynamic exploitation of benefit capacity also includes the distance over which the cargo is transported [5].

The coefficient of dynamic capacity exploitation is determined with the following equations:

- For one vehicle and one drive with cargo:

$$\delta = \frac{q_x L_{stx}}{q L_{stx}} = \frac{q_x L_{tx}}{q L_{tx}} = \frac{q_x}{q} \qquad (10),$$

- za eno vozilo v določenem časovnem obdobju:

- for one vehicle in a determined time period:

$$\delta = \frac{S}{S_{\text{maks}}} = \frac{\sum_{i=1}^{Z_x}(q_x L_{tx})_i}{\sum_{i=1}^{Z_x}(qL_{tx})_i} = \frac{\sum_{i=1}^{Z_x}(q_x L_{tx})_i}{q\sum_{i=1}^{Z_x} L_{txi}} \qquad (11).$$

kjer so:
S - opravljene transportne storitve,
S_{maks} - največje število možnih storitev,
n - število voženj s tovorom v določenem časovnem obdobju,
q_x - količina tovora, ki se prepelje v posameznih vožnjah,
L_{tx} - razdalja s tovorom v posameznih vožnjah,
L_{stx} - srednja razdalja ene vožnje s tovorom.

where:
S - are the realised transportation services,
S_{maks} - is the maximum number of possible transportation services,
n - is the number of drives with cargo in a determined time period,
q_x - is the cargo quantity during individual drives,
L_{tx} - is the distance with cargo for individual drives,
L_{stx} - is the medium distance of one drive with cargo.

- Za homogeni vozni park ali skupino cestnih vozil iste nosilnosti:

- For a homogenous motor pool or a group of road vehicles with the same capacity:

$$\delta = \frac{S}{AL_t q} = \frac{\sum_{i=1}^{AZ_x}(q_x L_{tx})_i}{\sum_{i=1}^{AZ_x}(qL_{tx})_i} = \frac{\sum_{i=1}^{AZ_x}(q_x L_{tx})_i}{q\sum_{i=1}^{AZ_x} L_{txi}} = \frac{\sum_{i=1}^{AZ_x}(q_x L_{tx})_i}{qAL_t} \qquad (12),$$

kjer sta:
AZ_x - število voženj s tovorom vsega voznega parka,
AL_t - razdalja s tovorom vsega voznega parka.

where:
AZ_x - is the number of drives with cargo for a motor pool,
AL_t - is the total distance for the whole motor pool with cargo.

- Za heterogeni vozni park:

- For a heterogeneous motor pool:

$$\delta' = \frac{\sum_{i=1}^{n} S_i}{\sum_{i=1}^{n} S_{\max i}} = \frac{\sum_{i=1}^{n} S_i}{\sum_{i=1}^{n} AL_{ti} q_i} = \frac{\sum_{i=1}^{n} AL_{ti} q_i \delta_i}{\sum_{i=1}^{n} AL_{ti} q_i} = \frac{\sum_{i=1}^{n} AL_{ti} q_i \delta_i}{q' \sum_{i=1}^{n} AL_{ti}} \qquad (13),$$

kjer je vsota opravljenega transportnega dela vseh skupin vozil v voznem parku:

where the amount of realised transportation work for all groups of vehicles in the motor pool:

$$\sum_{i=1}^{n} S_i = AL_{t1} q_1 \delta_1 + AL_{t2} q_2 \delta_2 + \ldots + AL_{ti} q_i \delta_i + \ldots + AL_{tn} q_n \delta_n$$

in razmerje možnega transportnega dela vsega heterogenega voznega parka:

and the relation of the possible transportation work heterogeneous motor pool:

$$\sum_{i=1}^{n} AL_{ti} q_i = AL_{t1} q_1 + AL_{t2} q_2 + \ldots + AL_{ti} q_i + \ldots + AL_{tn} q_n$$

3 PRIMERJAVA STATIČNEGA IN DINAMIČNEGA IZKORISTKA CESTNIH VOZIL

Za eno cestno vozilo v nekem časovnem obdobju ali za homogeni vozni park oziroma skupino vozil iste nosilnosti je ugotovljeno, da je koeficient dinamičnega izkoristka nosilnosti večji ali manjši od koeficienta statičnega izkoristka za tolikokrat, kolikokrat je srednja razdalja transporta ene tone tovora večja ali manjša od srednje razdalje vožnje s tovorom, to je:

3 COMPARISON OF STATIC AND DYNAMIC EXPLOITATION OF ROAD VEHICLES

For one road vehicle in a determined time period or for a homogenous motor pool or a group of vehicles of the same capacity it is determined that the coefficient of dynamic-capacity exploitation is bigger or smaller than the coefficient of static exploitation. This coefficient is bigger or smaller by the number of times the medium distance of the transportation of one ton of cargo is bigger or smaller than the medium distance of the drive with cargo:

$$\delta = \frac{S}{AL_t q} \qquad \gamma = \frac{Q}{qAZ_x}$$

$$\frac{\delta}{\gamma} = \frac{\frac{S}{AL_t q}}{\frac{Q}{qAZ_x}} = \frac{S \cdot AZ_x}{Q \cdot AL_t}$$

$$\frac{S}{Q} = L_{st} \quad \text{in/and} \quad \frac{AZ_x}{AL_t} = \frac{1}{L_{stx}}$$

$$\text{ter/then} \quad \frac{\delta}{\gamma} = \frac{L_{st1}}{L_{stx}} \quad \text{ali/or} \quad \delta \cdot L_{stx} = \gamma \cdot L_{st1} \tag{14},$$

kjer je:
L_{st1} - srednja razdalja prevoza ene tone tovora.

where:
L_{st1} - is the medium distance travelled with one ton of cargo.

To razmerje ne velja za ves heterogeni vozni park. Pri koeficientu dinamičnega izkoristka koristne nosilnosti (δ) je težni faktor povprečne nosilnosti število kilometrov s tovorom, pri koeficientu statičnega izkoristka (γ) pa je število voženj s tovorom [3].

This relation does not consider all of the heterogeneous motor pool. The coefficient of dynamic exploitation of benefit capacity (δ) is an estimated factor of the average capacity of the number of kilometres with cargo. The coefficient of static exploitation (γ) is the number of drives with cargo [3].

Ker je:

Since:

$$\delta' = \frac{\sum_{i=1}^{n} AL_{ti} q_i \delta_i}{\sum_{i=1}^{n} AL_{ti} q_i}; \quad \gamma' = \frac{\sum_{i=1}^{n} AZ_{xi} q_i \gamma_i}{\sum_{i=1}^{n} AZ_{xi} q_i}; \quad L'_{stx} = \frac{\sum_{i=1}^{n} AL_{ti}}{\sum_{i=1}^{n} AZ_{xi}}; \quad L'_{st1} = \frac{\sum_{i=1}^{n} AL_{ti} q_i \delta_i}{\sum_{i=1}^{n} AZ_{xi} q_i \gamma_i}$$

$$\text{je/is} \quad \delta' L'_{stx} = \gamma' L'_{st1}$$

$$\frac{\sum_{i=1}^{n} AL_{ti} q_i \delta_i}{\sum_{i=1}^{n} AL_{ti} q_i} \frac{\sum_{i=1}^{n} AL_{ti}}{\sum_{i=1}^{n} AZ_{xi}} = \frac{\sum_{i=1}^{n} AL_{ti} q_i \delta_i}{\sum_{i=1}^{n} AZ_{xi} q_i}$$

$$\sum_{i=1}^{n} AL_{ti} q_i \delta_i \sum_{i=1}^{n} AL_{ti} \sum_{i=1}^{n} AZ_{xi} q_i = \sum_{i=1}^{n} AL_{ti} q_i \delta_i \sum_{i=!}^{n} AL_{ti} q_i \sum_{i=1}^{n} AZ_{xi}$$

$$\frac{\sum_{i=1}^{n} AZ_{xi} q_i}{\sum_{i=1}^{n} AZ_{xi}} = \frac{\sum_{i=1}^{n} AL_{ti} q_i}{\sum_{i=1}^{n} AL_{ti}} \tag{15}.$$

Ta enakost ni točna in tudi razmerje $(\delta \cdot L_{stx} = \gamma \cdot L_{stx})$ ne velja, ker je:

This equality is not correct and the relation $(\delta \cdot L_{stx} = \gamma \cdot L_{stx})$ is not valid, because:

$$\frac{\sum_{i=1}^{n} AZ_{xi} q_i}{\sum_{i=1}^{n} AZ_{xi}} = q'_Q \quad \text{in/and} \quad \frac{\sum_{i=1}^{n} AL_{ti} q_i}{\sum_{i=1}^{n} AL_{ti}} = q'_U \quad \text{ter/and} \quad q'_Q \neq q'_S$$

razen v primeru, ko so izpolnjeni pogoji, velja enakost:

except in the case when the conditions are met:

$$q'_S = q'_U = q'_Q$$

4 SKLEP

Numerična analiza kaže način ugotavljanja statične in dinamične izkoriščenosti nosilnosti cestnih vozil ter njihov vpliv na transportni učinek. Statični in dinamični izkoristek cestnih vozil je pri tem analiziran z vidika števila voženj z cestnimi vozili, časovnega obdobja in sestave voznega parka.

S primerjavo numerične analize statične in dinamične nosilnosti cestnih vozil je ugotovljeno, da je za eno vozilo ali skupino vozil iste nosilnosti za določeno časovno obdobje koeficient dinamičnega izkoristka večji ali manjši od koeficienta statične izkoriščenosti za tolikokrat, kolikokrat je srednja razdalja transporta ene tone ali m^3 tovora večja ali manjša od srednje razdalje transporta s tovorom.

Za heterogeni vozni park to ne velja, temveč je pri koeficientu dinamične izkoriščenosti koristne nosilnosti utežni faktor povprečne nosilnosti število kilometrov s tovorom, pri koeficientu statičnega izkoristka pa je to število voženj s tovorom.

4 CONCLUSION

The numerical modelling shows a way of establishing the static- and dynamic-capacity exploitation of road vehicles as well as their influence on the transportation effect. The said exploitation of road vehicles is analysed with respect to the number of drives by road vehicles, time period and the structure of the motor pool.

By comparing the static and dynamic capacity of road vehicles it has been established that for one vehicle or a group of vehicles of the same capacity for the determined time period the coefficient of dynamic exploitation is bigger or smaller than the coefficient of static exploitation. The difference is found to be proportional to the difference between the medium distance of the transportation of one ton or m^3 of cargo and the medium distance of the transportation with cargo.

For a heterogeneous motor pool this does not work, therefore the coefficient of the dynamic exploitation of benefit capacity has the estimated factor of the average capacity number of kilometres with cargo, whereas the coefficient of static exploitation presents the number of drives with cargo.

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