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AUTOTRANSPORT COSTS OPTIMIZATION ON TRAFFIC WAYS BUILDING

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Abstract. *Original model is used for minimization autotransport system costs on traffic ways building. Autotransport system costs dependency on total number of used machines is emphasized to optimize number of vehicles with minimal costs. Analyses of autotransport system costs and optimal number of machines determination is of great importance because transport distances are mutable, bulk of transported material is huge, and transport costs very often count more than 30% of total traffic way building costs. Costs, as main optimality criteria are directly depending on mutable transport distances, number of machines in composition and agency rate of the prime machine. These factors have been analyzed and their functional dependency is presented as well diagrams and tabular interpretation.*

Keywords: *Building Industry; Traffic Ways; Autotransport System*

1. INTRODUCTION

Autotransport process has significant part in organization and technology of traffic ways building referring to huge amount of transported material and to its own complexity. Special problem in transport planning during traffic ways building are stochastic input data, as well transport distance muting during the whole building period. In spite of that, transport process must be organized effectively and in real time to provide continual, qualitative, reasonable object constructing.

In order to analyze problem of autotransport system optimization on traffic ways building, applicability of some available optimization methods on this problem was studied. As no one of them gave satisfying results, mathematical model TAMS was developed for autotransport system optimization on traffic ways building. This complex model also can give solution for costs minimization on traffic ways building. One short

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example TAMS model application is presented in this paper. Autotransport system costs dependence on total number of engaged machines is emphasized for determination optimal number of machines in system in order to minimize autotransport system costs.

2. COSTS DEPENDENCE ON NUMBER OF ENGAGED MACHINES

There is significant difference of the costs on autotransport system optimization on traffic ways building, depending on number of machines in the system, especially referring on shipping machines, while transport vehicles have some less influence and concomitant machines influence is negligible. Concomitant machines are usually used for material scattering, outspreading, wetting and compacting.

It is very significant to determine optimal number of shipping machines in autotransport system as a condition for opportune object building preparation. Minimal autotransport system costs was adopted as optimal criteria, considering high level of mechanization on traffic way building.

Mathematical model TAMS have been used for analyses of autotransport system costs on traffic way building during earth works depending on the number of used machines (Fig. 1). Optimal number of shipping machines $n = 2$ and transport vehicles $m = 5$ has been determined in existing conditions.

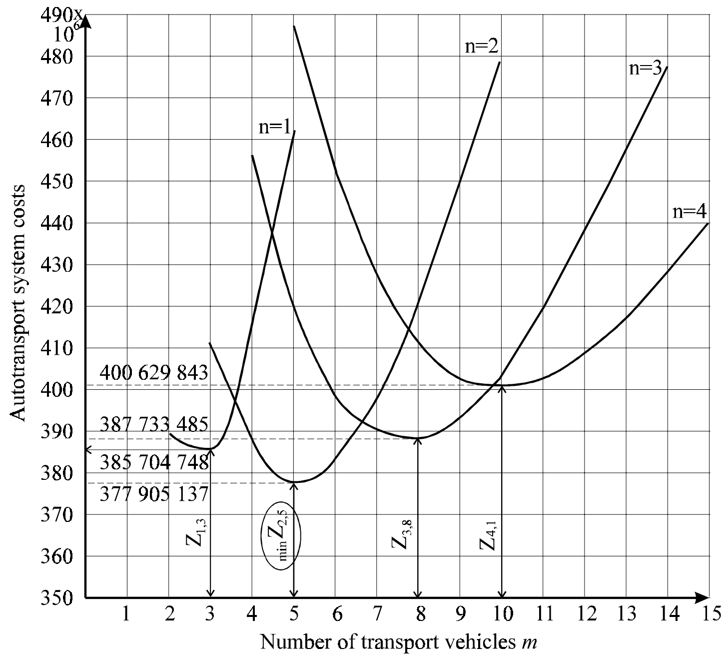

Fig. 1. Costs depending on the number of used machines

If one shipping machine is used for synchronized process, three transport vehicles are necessary but transport system costs are increased for 2.06%. Using bigger or less number of transport vehicles will cause significantly higher costs.

If three shipping machines are used, eight transport vehicles should be engaged for synchronized process, and transport system costs are increased for 2.60%, what represents minimal costs increased with three shipping machines referring to optimal solution.

If four shipping machines are used transport system costs are higher for 2.60%, and for greater number of shipping machines costs are notably higher, so that combinations are not interesting.

Optimal building machines composition application depends principally on traffic way building dynamics, apropos on time period planned for transport realization. If transport time period is not predetermined optimal machine composition will be applied, otherwise needful number of shipping machines and appropriate number of transport machines will be used to execute transport of material in predetermined time period. In that case costs vary from the optimal solution in few percents.

3. Costs depending on execution time period

If optimal number of machines in system respecting costs is not used, it is needful to consider number of necessary working days for transport process execution. The main reason for this is that two different compositions of machines can produce similar costs, but execution time period can be pretty longer for the composition with less number of machines.

This is very important note, because building time period is of great importance as well as building costs, so autotransport execution time period has important role.

Model TAMS have been used in autotransport system costs on traffic ways bed analyses considering execution time period. For predetermined number of shipping machines and appropriate optimal number of transport vehicles amount of working days for autotransport have been determined (Fig. 2).

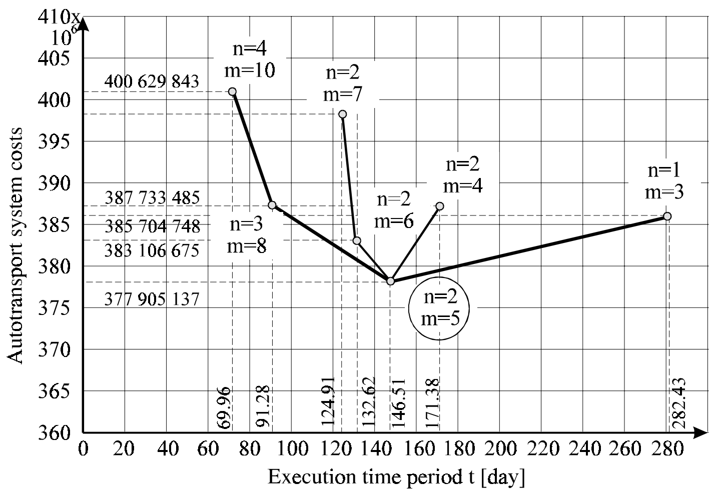

Fig. 2. Costs depending on execution time period.

Minimal costs are realized if system is composed of two shipping machines and five transport vehicles, and transport should take time period of 147 working days.

If amount of working days for transport execution needs to be reduced, working intensity can be increased slightly by engaging additional transport vehicles (from $n = 2$ and $m = 5$ to $n = 2$ and $m = 7$), but costs will be significantly increased. It is more effective to increase number of shipping machines with appropriate number of transport vehicles (from $n = 2$ and $m = 5$ to $n = 3$ and $m = 8$). This would shorten transport period duration ($\Delta t = 60.51\%$) with expected slight autotransport costs raise ($\Delta Z = 2.60\%$), Fig. 2.

In general consideration that increasing amount of working days reduces production process execution costs is not valid, as shown on Figure 2. Composition of one shipping machine and three transport vehicles ($t_{2,5} = 282$ days) produces higher costs than composition of two shipping machines and five transport vehicles ($t_{2,5} = 147$ days).

If the composition of two shipping machines and four transport vehicles is modified to the composition of two shipping machines and eight transport vehicles execution time period $t_{2,4} = 171$ days would be shortened on $t_{3,8} = 91$ days ($\Delta t = 46.78\%$) and transport costs raise would be negligible from $Z_{2,4} = 387\,627\,227$ din to $Z_{3,8} = 387\,733\,485$ din ($\Delta Z = 0.027\%$). Autotransport costs raise depending on the transport duration is influenced by fixed costs of one hour machine working on the unique autotransport system costs.

4. Execution time period depending on the number of machines

In further analyses execution time period is considered depending on the number of autotransport vehicles. Execution time period depends prior on the number of shipping machines, but also on the number autotransport vehicles in composition. It was already discussed that autotransport system costs depend on the number of machines.

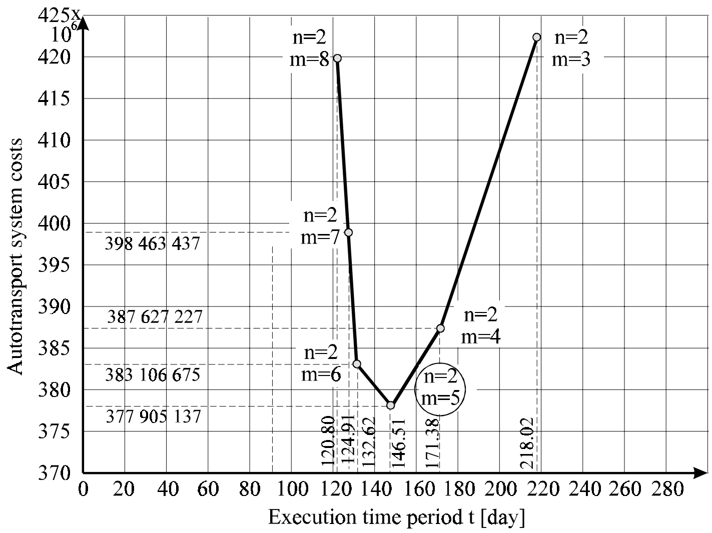

Fig. 3. Execution time period depending on the number of transport vehicles.

If execution time period should be shorten, initial number of shipping machines should be increased and after that appropriate optimal number of transport vehicles determined. Execution time period can be shorten up to some extent by increasing only the number of transport vehicles, but this leads to significant costs increasing. It relates especially on compositions with number of transport vehicles notably different from optimal. Minimal execution time period can be achieved by further increasing number of transport vehicles for established number of shipping machines. Minimal execution time period is limited by maximal shipping machine agency norm, which can not be increased by further increasing number of transport vehicles (Fig. 3.).

5. AUTOTRANSPORT SYSTEM COSTS DEPENDING ON TRANSPORT DISTANCE

Transport distance affects directly on autotransport system costs. For optimal number of machines in composition (n = 2 and m = 5) TAMS method gave minimal unique costs values, as well minimal total costs for predetermined transport distances (Table 1).

As duration of the transport process is prolonged agency norm will be reduced and this will cause higher transport costs for longer transport distances.

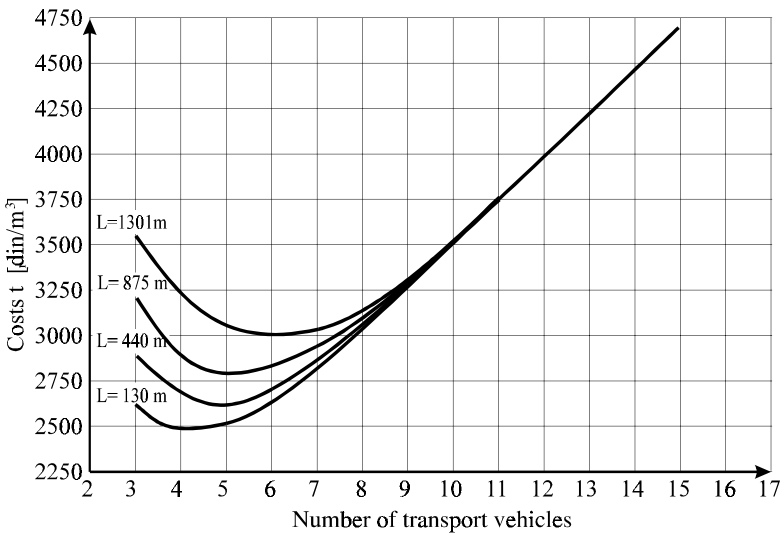

Fig. 4. Costs depending transport distances

Unique transport costs for one autotransport system composed of constant number of shipping machines (n = 2) and mutable number of transport vehicles are shown on Fig. 4 for transport distances L_1 = 130 m, L_2 = 440 m, L_3 = 875 m and L_4 = 1301 m. Difference between unique costs for two different transport distances becomes less with taking greater number of transport vehicles. The reason for that is that shipping machines (n = 2) can not supply all vehicles and some of them have to wait for shipping unwelcome long time period. So, autotransport system agency norm is not higher but autotransport system unique costs are rapidly increased.

Table 1.

Transport distance (m)	Unit costs (din/m^3)
130	2 508.11
161	2 519.66
182	2 527.66
223	2 543.39
300	2 573.94
310	2 577.99
312	2 578.81
322	2 582.88
346	2 592.74
353	2 595.63
411	2 619.95
427	2 626.77
440	2 632.33
450	2 636.64
455	2 638.79
488	2 653.14
501	2 658.83
517	2 665.88
613	2 709.01
700	2 749.24
751	2 773.30
762	2 778.53
861	2 826.29
875	2 833.14
927	2 858.76
960	2 875.18
1098	2 945.02
1301	3 050.91
1467	3 139.91
1585	3 204.32

6. Concluding remarks

This paper presents adequate number of parameters on autotransport system costs to have complex production process general outlook. Big difference in working costs is notable when autotransport system works with different number of machines. It especially relates on shipping machines, although transport costs significantly depend on number of transport vehicles in system.

Model TAMS [6] has been recommended for economizing traffic ways building process, i.e. autotransport system costs minimizing. It is used for determining optimal number of machines in composition giving minimal transport costs.

Transport distance growth raises: probability of shipping machine staying, shipping machine exploitation rate, average number of staying transport vehicles and system agency norm. Agency norm is increased until it achieves shipping agency norm value, which represents maximal agency of transport system.

Exact valuation of autototransport system costs on traffic ways building is very important and essential task for all participants in object building process. Unreliable costs estimate causes investor, designer and constructor wrong decisions. Optimal number of machines in composition determination and optimal material transport schedule enables autotransport system costs minimization. This is very important because of high level of building mechanization application on traffic ways constructing.

Assumed consideration in civil engineering that reducing execution time period will increase production costs can not be adopted as general. Whenever constructing dynamics allows, bicriterial autotransport optimization should be performed: costs optimization and time optimization as well.

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OPTIMIZACIJA TROŠKOVA AUTOTRANSPORTA NA IZGRADNJI SAOBRAĆAJNICA

Milorad Zlatanović, Dima Trajković

Koristeći originalni model za optimizaciju transportnog sistema u radu se ukazuje na troškove autotransportnog sistema na izgradnji saobraćajnica. Posebno se prezentira zavisnost troškova izvršenja autotransporta u funkciji od ukupnog broja upotrebljenih mašina u transpoportnom sistemu sa ciljem da se odredi optimalan broj transportnih vozila u sistemu uz minimizaciju troškova. Rezultati do kojih se došlo odnose se na autotransportne sistema kod izgradnje saobraćajnica, mada su značajni i za druge građevinske objekte, što se posebno odnosi na linijske građevinske objekte. Analiza troškova autotransportnog sistema i određivanje najpovoljnijeg broja mašina u sistemu značajno je kod izgradnje saobraćajnica, tim pre što su kod ovih građevinskih objekata transportne daljine promenljive, obim transportnog materijala veliki, a troškovi transporta često premašuju 30% ukupnih troškova izgradnje saobraćajnica. Rezultati do kojih se došlo, sigurno su od značaja za povećanje stepena organizovanosti autotransportnog sistema pri građenju saobraćajnica, doprinose smanjenju troškova transporta, a samim tim i smanjenju ukupnih troškova građenja saobraćajnica.

Ključne reči: *Građevinska proizvodnja, saobraćajnice, autotransportni sistem*