OPTIMIZATION OF TRANSPORT TRAFFICS IN OPEN-PIT

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ABSTRACTS To increase efficiency of functioning of cargo traffics. It is possible by development and introduction of a number of organisational and technological measures and on the basis of perfection and introduction of new methods of planning, organisation and management of mining [1971, 1986] As the transport flows in essence predetermine of actual productivity of the loading equipment and a large part of all carrying costs receipt on a subsystem "Transport", it is obvious, that the significant reserves of growth of efficiency of mining-transport systems are contained in increase of a level of organisation and planning train and auto traffics.

1 INTRODUCTION

The effective planning of flows of means of transport really is possible only if there is sufficient the information's for this purpose. Besides such known and standard parameters, as distance of transportation, coefficient of irregularity of traffic of mobile means, the transport work, factors of intensive use of mobile means and is etc. necessary to know the qualitative and quantitative characteristics of congestion of sites and power consumption of the transport communications, parameters of flows The reception of this information in real conditions basically, if there is necessary for this purpose means, enabling m sufficient volume to accumulate and to process current data, difficulties does not cause. However the application of the received thus information without an opportunity of the analysis of alternate variants does not give of complete effect. Availability of adequate models, of interaction authentically reproducing all specific character of the of the transport communications and of mobile means on open-pits is for this purpose necessary In the given paper the main aspects of a method of optimisation of transport flows on open-pits with automobile and railway and combined auto-rail are stated.

2 ANALYSIS OF TRANSPORT PLOWS

The analysis of prtiametci:. limn and auto traffics is made after the tommon analysis of work of a mining-transport system, when are already revealed "narrow" links of a technological circuit. The decision of problems of "Narrow" links is connected to detail consideration of work of their elements, with revealing of availability of reserves of increase of their efficiency and manufacture of measures directed on realisation of those.

In common case the parameters train and auto traffics are reflection of conditions of their passage. The qualitative analysis of parameters will allow to evaluate these conditions and will enable of acceptance of the sharp and reasonable decisions on their updating

It is known, that the realisation of transport opportunities of separate blocks-sites of the circuit of railway development are in many respects determined by organisation of mining-transport work, order cif formation of routes on station and tram traffics in quarry For an establishment of such dependence, bat also its quantitative valuation there is necessity n. more detailed parameters, enabling quantitatively ro express influence of the listed factors on transport (pportunities of a site and to establish of a way of thei. effective realisation. For this purpose such indexes, as average busy time of a site at the passing till it one tram on directions, as with the record-keeping, and without the record-keeping of idle times are offered

The average time expended on the passing of one train on a site in empty and cargo directions in view of idle times is considered under the formulas

$$t_{t,p} = \frac{T_{f,z,p}}{N_p} ,$$ (D

$$t_{t,g} = \frac{T_{t,z,g}}{N_g} ,$$ (2)

where T_{fzp} and $T_{r,g}$ - busy time of sites accordingly in empty and cargo directions during shift, minute , N_e and N_p - numbers of trains past on a site accordingly in empty and cargo directions for this period, pieces

Without the record-keeping of idle times, proceeding from the record-keeping only of time of its routing employment the given parameters are considered as follows

$$t'_{t,p} = \frac{T_{m\,z\,p}}{N_p} ,$$ 0)

$$t'_{t,g} = \frac{T_{m\,7\,g}}{N_g} ,$$ (4)

where T_{m7p} and $T_{w,g}$ - time of routing employment of a site accordingly in empty and cargo directions, minute

The indexes considered under the formulas 1-4 permit to make a conclusion about reasonable of accepted variant of organisation of train traffics concerning *a considered* wlc *To an* example smaller shift mean time of routing employment by a train of ,i site on out, ol directions speaks aboui expediency of orientation on the passing ol t rami, preliminary in this dirvuioii However il is possihli thai in view of idle times of tiains on a >ilc IilL ave-raie aclua! time ol us o(tu|Jiiion on lit fivcn Jin (.don will appeal moii il .lli t ad\ spin il ics drseι rpancy of the sinn Una! and ιnganiiatιoιul factors I' Ilial il is possible addιlιonaHy lo be convint d having uιlι ni ιh d (>' t ,ιιr\ιιi' .ap,ιcιl\ ol a stιe t pairs ol Ir.ιifis ιintlei [in iuιιιιιl.ι

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of elements of the circuits of railway development the researches were conducted The research of parameters consisted of fixing, directly during modelling, of time and intervals of arrival trains on all probable ways to a zone of a revealed "narrow" link For this purpose on a beginning of modelling in initial databases fastening of "counters" at sites directly contiguous to researched zone as in empty and in cargo directions is made The information received during modelling then is processed, therefore indexes of non-uniformity of train traffics in empty, cargo directions and as a whole on object (station, post and etc) are established, the diagram of intervals of train traffics, demonstrating character distributions of intervals on directions is under construction, as it is shown on fig I
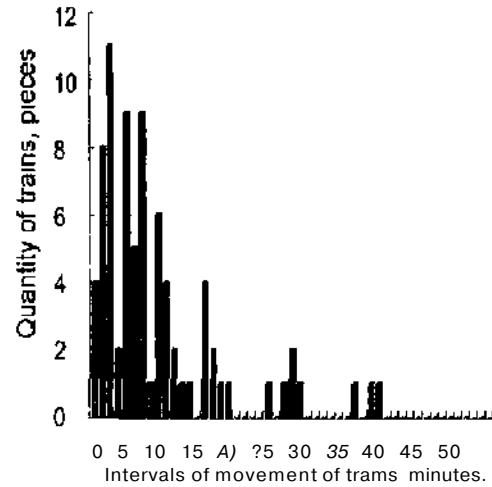

Fig 1 The diagiam of intervals of moveineι t of trains (oirtfo direction)

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possible to achieve at the expense of redistribution of elementary train traffics (if size of intervals of arrival on it is smaller), or at the expense of entering of respective alterations in the circuit of railway development (division of a block-site and etc)

3 ABOUT FACTOR OF NON-UNIFORMITY OF TRAIN TRAFFICS

Factor of non-uniformity tram traffic (Èi 1) is accepted as a numerical parameter, describing fluctuations of size of tram traffic [1990] Shift internal - there is the relation of the heaviest size hour or minute (in our case hour) train traffic to its average size for shift Agree of definition, in process of simulation modelling through each hour the numbers of trains, past on object in empty, cargo directions and as a whole on object, is fixed On the ending of modelling the average quantity of passing trams is calculated under the formulas

$$N_{s,r}^{p} = \frac{n_t^{p}}{T} \qquad (6)$$

$$N_{s,r}^{g} = \frac{n_t^{g}\cdots}{T} \qquad (7)$$

$$N_{s,r} = \frac{(n_t^{p} + n_t^{g})}{T} \qquad (8)$$

where, $N^{\wedge}$, $N^{\wedge}_{r}$, N_{sr} - average quantity of trains past accordingly in empty, cargo directions and as a whole on object, $n^{\wedge}$, nj^{1} - numbers of trains past on object accordingly in empty and cargo directions for t-th hour of simulated working shift, T - duration of working shift, hour

The account of a parameter of non-uniformity is made as follows

$$K_{n,p}^{g} = \frac{n_{max}^{p}}{N_{s,r}} \qquad (9)$$

Table 1 The conditions of dependence of the index of irregularity of tram traffics

Van ant	The coefficient of irregularity, E,,	Average size train traffic, Nfl_E	Di reçu n	Size of tram traffics on hours of shift 1 2 3 4 5 6					
1	1,5	20	1	10	15	20	30	25	20
	1,5	20	2	10	15	20	30	25	20
	1.5	40	3	20	30	40	60	50	40
2	1	20	1	20	20	20	20	20	20
	1	20	2	20	20	20	20	20	20
	1	40	3	40	40	40	40	40	40
3	1,5	20	1	10	15	20	30	25	20
	1,5	20	2	30	25	20	10	15	20
	1	40	3	40	40	40	40	40	40
4	1,5	20	1	10	15	20	30	25	20
	1,5	20	2	20	10	25	10	20	15
	1,125	40	3	30	45	45	40	45	35
5	1,5	20	1	10	15	20	30	25	20
	1,5	20	2	20	25	30	20	15	10
	I 25	40	3	30	40	50	50	40	30
6	1,5	20	1	10	15	20	30	25	20
	1,7	11,6	2	20	15	10	0	15	10
	1	30	3	30	30	30	30	30	30

The note * - I, 2, 3 - accordingly empty, cargo directions and as a whole on object

$$K_{n,p}^{g} = \frac{n_{max}^{g}}{N_{s,r}} \qquad (10)$$

$$K_{n,p} = \frac{n_{max}}{N_{s,r}} \qquad (11)$$

where, $Kj^{\wedge}$, $K^{\wedge}_{p}$, K_{np} - parameters of non-uniformity of train traffics accordingly in empty, cargo directions and as a whole on object, $n^{\wedge}$, n_{max}' $''»x''$ maximum meaning of train traffics accordingly in empty, cargo directions and as a whole on object

Some opportunities of application ol the index of non-uniformity of train traffic are considered on an example of six variants of the passing of trams on station (tab 1) On the first variant it was considered, that each hour of working shift in both directions identical numbers of trains is passed In thesecond variant - as well as m first, but only under condition of uniformity of train traffics ondirections, in third - the uniformity is observed only as a whole on object, in fourth - the order is not observed, but maximum of train traffics do not coincide in time, in fifth - too, as in fourth but with some displacement in the party of increase of general train traffic, m sixth - uniformity of general train traffic is observed, but at the expense of reduction of train traffic m a cargo direction

From the table it is clear, that I) minimum meaning of index it is possible to achieve by three vinants of organisation of the passing of trains on lation at uniformity of train traffics in time on both directions, at uniformity general tram traffic at the expense of reduction of train traffic m one of directions, at uniformity general tram traffic at the expense *of* appropriate adjustment of tram traffics on directions, 2) the maximum meaning of index of non-uniformity it is possible only at concurrence of maximum train traffics in empty and cargo directions 3) in the other cases the meaning of index changes m a range from 1 up to maximum meaning, 4) the meaning of index has not rigid dependence with carrying capacity of object, it grows by increase of a degree of its congestion, 5) at the same realisation of carrying capacity of object the mdex of non-uniformtty of tram traffic can take meanings within the limits of bottom and top borders

Proceeding from the fourth conclusion il is possible to conclude, that the analysis of train traffics with orientation to the index of non-uniformity and in view of a degree of congestion of object permits puiposefully and wcll-foundedly to adjust sizes of tram traffics and to achieve increase of a degree of adildi realisation oj technologically possible cairrying capacity of stations

Thus the conducted researches have allowed to establish, that index of non-uniformity of train traffics does not determines carrying capacity of elements (or links) of circuit oi railway development Its use as correction coefficient to settlement meaning of carrying capacity of a site established proceeding from the least inteival of movement of trains, icsulls in an en or up to SO % and more

4 POWER CONSUMPTION OF THE TRANSPORT COMMUNICATIONS

One of important cntenam indexes of rationality of train and auto traffics is a index of power consumption of sites Concerning the circuit of railways those can be quantity of the electric power or fuel expended by electric locomotive or traction agrégat on a site for shift Concerning a truck this is charge of fuel These indexes are formed during the modelling proceeding of the record-keeping of energy expenses in a cargo and empty direction, at movement of various types of trucks and of railway traction means depending on incline of a line on a site and its extent With reference to a truck here the
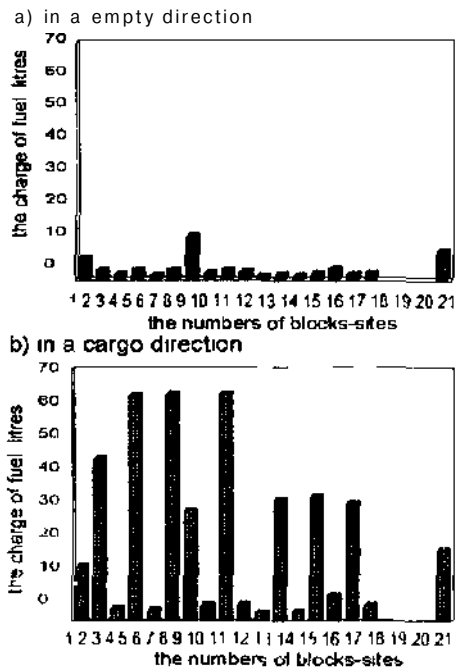

Fig 2 The diagram of the replaceable chaige of fuel on blocks-sites of a (me

essential lolc is played by quality of covet of ways On fig 2 the diagram of the charge of fuel on sues of an automobile line is submitted I iom the drawing it is obvious, that tht most wasteful in this relation are the sites 4 6 and ^{C}J as in whole on a site as in a t argo direction however in an empty direction the most wasteful aie the sitts 1 7 and ^{I}> I he similar didgi am on one of railway stations of Sarbai quarry is sLibmiilul (M li) *

The developed methods of the analysis congestion and power consumption of sites of the transport communications, rationality of formed routes of movement of trains are necessary and important attributes of a complex of measures connected with organisation, managen.°nt and scheduling of open-pit's mining-transport systems, as they give the sharp qualitative and quantitauvt characteristic of use of the transport equipment Their effective application can be found and during researches at stages of designing and reconstruction of open-pits

Fig 3 The diagram of the charge of the
electric power on blocks-sites on
the circuit of railway development

5 TH1 ANALYSIS 01' TRANSPORT C0MMUNICA1 IONS' CONGLSI ION

I he theory of methods of research distinguishes operations of the analysis, synthesis and valuation of objects of consideration To operations of the analysis concern ones connected with dcleimiriairon of [lie [imposes and conditions ol functioning of oh]eit prtp.uaiion ol ii Mial dila and sludy of intermediate results, by an establishment of cntena of valuation and their priorities, by revealing of components of a problem and their interrelations, by establishment of limiting meanings of vanable parameters, by consideration of vanous vanants of the design decisions on object or its part To operations the valuations concern operations on preliminary and final account of technological parameters, determination of qualitative parameters, but also operation of companson and choice of variant of the design decisions The contents of operations of the analysis, synthesis and the valuations are distinguished for vanous types of object, stages and phase of designing [1985] With reference to the open-pit's circuits of railway development the mam purpose of application of the given methods of research is an establishment of character of distribution of loads under the circuit of railways, determination of a degree of congestion of sites, which is a structure of time of occupation and reason, revealing of the most loaded sites in time and on quantity of passing means of transport It will allow to conduct purposively search of available reserves of increase of a degree of realisation of potential carrying and carnaging ability, to choose i'te most effective for the given conditions a structure of the circuit of railway development and appropriate organisation of trams movement and formation train traffics in quarry
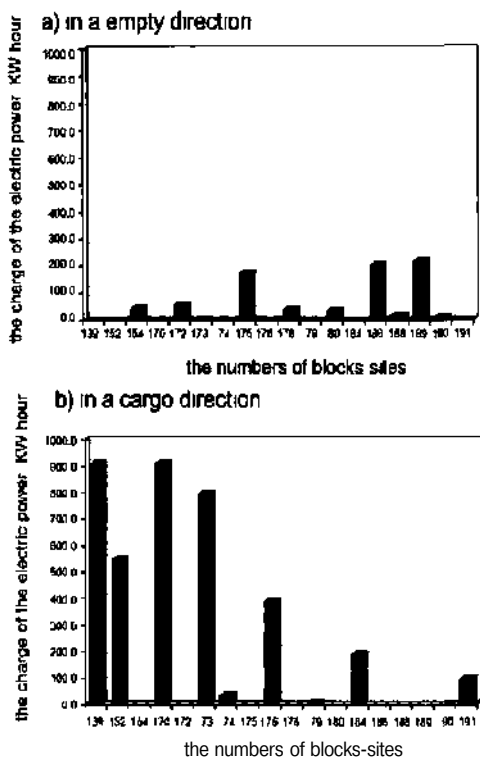
The circuits of railway development on open-pits have very important practical significance H is enough to note, that about 50 % of the direct costs on maintenance of mining-transport systems in working oıder leceıpt on then share The common extent of ways involved in technological process can be achieved about hundreds kılometıes I o an example on the Sarbai quarry it is almost 1 S7 km Besides it, the open-püs structure of the circuits oi railway development is extremely complex and vaned, especially on large and deep open-pits In these conditions, very serious problem is decision tasks valuation congestion elements of circuit railways, that is very important at formation of prospect of its development delermination carrying and carnaging ability, establishment of rational productivity

The main idea of the offered method of valuation and analysis of congestion of the open-pit's circuits of railway development consists thai the index of congestion, as well as indexes of carrying and carnaging ability is result of complex proci ss of interaction of the numerous factors, mi ludiny such,

as technical, technological, economic character, organisational and etc The qualitative its establishment should be based to methods enabling with a high degree of accuracy and reliability to take into account character of interaction of the specified factors, qualitative and quantitative their parameters Besides being, alongside with other parameters, as a result of one process and having with them ngid dependencies, the index of congestion reflects one of the essential its parties and, hence, should be taken into account by choice that or other variant of organisation of mining-transport work on open-pits

Thus, in a context of the decision of problems of formation of effective railway systems of open-pits and valuation of their carrying capacity, it is necessary to be engaged with development of methods of determination of their congestion

The offered method of valuation and analysis of congestion of the open-pit's circuits of railway development is based on results of simulation logic-statistical modelling of minmg-transport complex work [1989]

The reliability of results received by use of the given method is determined by the order and degree of detail of formation of circuits-models of railway development, by adequacy of reproduced principles of organisation of train traffics, therefore during preparation of initial data of modelling to these aspects the special attention should be given

1 he formation of circuits-models of railway development is made in view of the following main itquiremcnts
- m kision o' HI sites of the urcui! of railway (nAtlopment engaged in technological pioccss
- nhscivance of adequacy lo sectioning of the circuit of idilway development on sites in connection with organisai ion of the system of central blocking and communication,
- in one site partitioned sites can be united only if the occupation of it by one tram excludes (on conditions of safety) inclusion one in roules of other trains,
- thi record keeping of technological assignment of sites of railways and their specialisation in directions
The tonnatio» of routes of movement of trains is made by sut h pıincıples as
- initial and concluding transport sites of a route ate sili s with the sanction to them of stops
Ihr ,IlL is excluded from a route and ıs lonsıdercd free only aıleı passing of a turn ou ıl

- the transport site included in one route can not be involved for other route,
- the free site with prohibition of a stop can be included in a route if neither subsequent one with a similar attribute is not included in a route of other train,
- the sanction and prohibition of stops on sites is made so as it takes place in a reality on researched object

Directly modelling of work of a mining-transport complex precede of natural supervision and analysis of the documentation, therefore main principles of organisation of movement of trains on quarry are allocated and acquired, statistical numbers, reflecting work of excavators on loading and unloading and etc are made if it is necessary

On the basis of the received information and available program complex "CEBADAN" the model of work of the mining-transport equipment is created

In process jf simulation modelling on each of sites of the circui of railway development the information on busy time them by trains is fixed And the busy lime is taken into account as actual, ı e the train is directly on a site, and indirect - when the site was included in a route any tram and could not be involved foi the passing on it for other train In turn the time of attua! employment of a site is divided on time of idle times. on a site and time of movement of a train on it

As at modelling the record-keeping ol the information on a site is carried out in caigu rtiid empty directions separately on the ending o' modelling the appropriate indexes on directions are summarised and the icceivcd results, aie <dıu.dy used for the analysis of congestion of the circuit of railway development

In a complex CbBADAN" the analysis of congestion of the circuit of railway development is earned out by two prr ^ram modules The IHM "DIAGRAM[I] is user[I] regarding on time of common conj ^stion of iites and determines a index of congestion of each of them II is executed under the formula

$$K_{r\,\iota} = \frac{t_{\iota} \times 100}{t_m} \qquad (12)$$

where t, common busy lime of a sue fin simulated period, minute, t_m simulated lune minute

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As the generalising index, describing common congestion of the circuit of railway development and enabling to judge about availability of reserves of increase of its efficiency is the index of specific congestion of the circuit, which can be determined under the formula

$$K_u = \frac{(l_i \times t_s) \times 100\%}{L \times t_m} \qquad (13)$$

The similar parameters can be determined on each of station or post of the circuit of railway development The comparison of these indexes with a common specific parameter of congestion enables to judge about uniformity and rationality of loads on it, and also to present character of distribution of reserves of efficiency of the railway circuit The further established degree of congestion of each of sites of the circuit of railway development serves as an attribute of their differentiation The sites with a degree of congestion from 0 up to I will form multiplicity M1, sites with a degree of congestion from 1 up to 5 - multiplicity M5, from 5 up to 10 - M10 and etc up to an establishment of multiplicity of area M100

In accordance with differentiation of sites the indexes of common extent of sites belonging to various received multiplicity's are determined under the formula

$$L_{qp} = \sum_{q \leq K_i > p} l_i \qquad (14)$$

where q - bottom border of area of multiplicity, p - top border of area of one, I, - length of i-th block-site, m
Further under the formula

$$D_{qp} = L_{qp} \times 100\% / L \qquad (15)$$

where L - the common extent* of the circuit of railway development, is determined a share of sites on each of established multiplicity's in a common structure of the circuit of railway development

By results of made accounts on the screen of a display the diagram of congestion of the circuit of railway development with the indication of its common extent is removed, as it is shown on fig 4

The nost loaded sites, as a rule, are "narrow" links in a structure of the circuit of railway development or specify i n those in case of availability of significant idle times on them For the analysis of character of

congestion of these sites the other program module "Max" serves, which chooses the most loaded on time sites and forms whole available information on each of them as a whole, and on directions (empty and cargo), switching on busy time, quantity of trains past on a site, numbers of idle times and their common duration, degree of congestion of a site The received information permits to reveal "narrow" links of the circuit of railway development and of mining-transport system as a whole, but also to analyse their condition and to understand the reasons of a usual situation

The method of valuation and analysis of a degree of congestion of the circuit of railway development on base of simulation modelling of work of mining-transport systems was used at research of transport opportunities of the circuit of railway development of Sarbai quarry of joint stock company "SSGPO" The
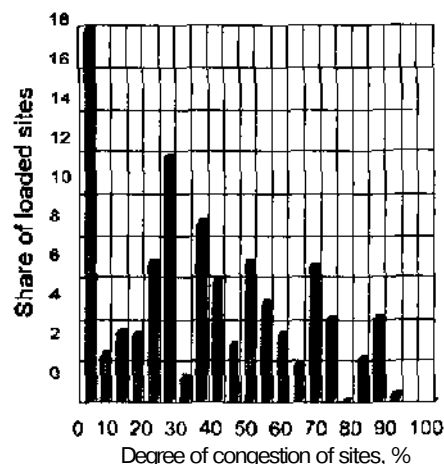

Fig 4 The diagram of congestion of the quarry's circuit of railway development
The note common extent of ways-152 3

results of the given research on one of vananls of organisation of mining-tiansporl work aie indicated on fig 4 and in tab *1* ft is follows from them thdi a mam shaieofways, making *11* "« of uimimm cxicnt of the circuits of rail development is loaded k-*s than 1 %, the significant shares of u.iys (about 21 %) have a degree of loading from i up to Iªi V arid only of 3-4 % of lhem arc io.ulaf on til! % and more The analysis of i ni|ilov>" IM of (hi most loaded sites has shoun, thai ,ilion! (>" " . ul tin' whole time connected with idle lnm'.ul lumı. <\! ol lhıcsu speak about large |itıiurlı.ıl *>|*|*:*i imniii s of »lit; existing circuit of rarlw.iv rit vi lnjum m on t hi quaiiy

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Table 2 The information on the most loaded sites of the Sarbai's circuit of railway development

The block -site	Time of employment of a site, minute			Idle times mines		Quantity of idle times		Quantity of missed struc- tures, pieces		Degree of charging
	I	II	III	II	III	II	III	II	III	
150	0	680	680	639	639	16	16	17	17	0,94
151	0	6S6	656	626	626	15	15	15	15	0,91
317	0	648	648	225	225	21	21	40	40	0,90
156	0	627	627	591	591	15	15	17	17	0,87
84	0	615	615	427	427	29	29	38	38	0,85
148	0	594	594	574	574	16	16	16	16	0,82
274	0	591	591	19	19	3	3	8	8	0,82
62	0	588	588	521	521	30	30	37	37	0,82
174	0	582	582	503	503	13	13	17	17	0,81
299	0	176	576	484	484	31	31	38	38	0,80
318	0	574	574	530	530	33	33	39	39	0,80
[57	0	554	554	532	532	12	12	15	15	0,77
175	0	514	514	447	447	8	8	15	15	0,71
320	0	508	508	456	456	26	26	39	39	0,71
275	0	50)	50]	11	11	3	3	7	7	0,70

The note I, II - accordingly m empty and cargo directions. III- as a whole on a site

CONCLUSION

It should be noted, that the realisation of similar researches in real conditions of functioning of a mining-transport complex is not practically feasible Besides the opportunity gearing of various vanants of organisation of mining-transport work on a model opens large opportunities to establish the most rational of them with a high degree of validity of the accepted technological decisions

Thus, the practice of application of the method of the analysis and valuation of congestion of the open-pits citcuits of railway development on the basis of simulation logic-statistical modelling of work of mining-transport systems with use of the program complex "CEBADAN" shows, that it provides high efficiency at realisation of t. ular researches, permits to have authentic qualitative and Quantitative representation about character of congestion of the railway circuit, but also about reserves in it available *of* increase *of* its efficiency

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