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sandy deserts; railway; drifts; sand fixation; physical and chemical methods; parameters of protection technological gap; waste locally produced solution; resource

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PROSPECTS FIXATION DRIFT SANDS PHYSICOCHEMICAL METHOD

Summary. This article is based on the theoretical foundations of secure mobile sand being considered for reducing the negative impact of one of the manifestations of exogenous plains on such an important natural-technical system as a railroad. It suggests practical measures to build a system of design protection against sand drifts. The article also suggests ways to conserve resources and rational use of machinery and performers as well as the consolidation of mobile sand wet with water soluble waste of local production of waste dextrin. Consolidation is exposed on dry and wet sand.

ПЕРСПЕКТИВЫ ЗАКРЕПЛЕНИЯ ПОДВИЖНЫХ ПЕСКОВ ФИЗИКО-ХИМИЧЕСКИМ МЕТОДОМ

Аннотация. В статье, основываясь на теоретических положениях снижения негативного влияния экзогенных проявлений на железную дорогу, в частности, борьбы с песчаными заносами и исходя из практики закрепления подвижных песков, а также в целях экономии ресурсов и рационального использования машин и исполнителей, делается вывод о преимуществе водорастворимых вяжущих веществ из отходов местной промышленности, например, декстрина и применения его и других рекомендованных вяжущих в песках влажного состояния.

1. INTRODUCTION

An ecological approach to the protection of railways and roads from moving sands is closely linked with the creation of windbreaks, which lead surface moving sands in the stationary state, delaying the sand brought by the wind from the outside. The reason is the increasing roughness and consequent reduction of the wind speed. It is known that wind velocity of less than 4 m/s grains is dormant. To come to the grains must have a movement speed of 5.3 m/s at the height of the wind vane, which corresponds to a rate of 4.1 m/s at the sand surface (threshold speed) [1]. The transfer of sand from one place to another is called deflation; its negative impact on the railways and other natural and technical systems (TCP) is shown in blowing sand subgrade and drifts of the permanent way.

Any measures to reduce the wind speed is below the threshold referred to as fixing shifting sands (FFW), securing sands equivalent to end or prevent deflation as a manifestation of dangerous exogenous processes, thus reducing its negative manifestations. Therefore, strengthening the surface layer of sand vegetation is one of the ways to combat exogenous processes. Moreover, by having an advantage over the other in mind in its environmental cleanliness. Such a consolidation of sand is called the biological method.

The sand drifts fixation in its arsenal has [6, 7] some biological or technical method, consisting of mechanical, physical and chemical techniques. The latter are used in emergency situations when it is necessary to take measures to halt the rapid deflation. Furthermore, these methods are used, primarily, to improve the efficiency of work agroforestry, i.e. sowing and planting. Sharing biological and technical methods forms a combined method [2, 5].

Each of the methods presented technological solutions different from each other. The implementation in practice of these methods results in protection, which should meet a number of requirements. One of the most important requirements—its environmental requirements, i.e. PTSD as a result of protection environment—should not become dirty [4].

It is known that among the most environmentally friendly methods is the biological method. Its use in its pure form is limited to a number of reasons related to the state of the soil and climate (salinity, low precipitation, high evaporation, wind regime and al.), which leads to a low efficiency of the method. So 10% survival rate is considered an excellent result. Engineering approaches are aimed at improving the efficiency of 60-70%. Therefore, to improve the efficiency of the biological method and achieve the short-term effect of deflation, sands termination methods are combined. Engineering methods must meet the following requirements: availability, low cost and the possibility of industrial production technology.

Mechanical barriers consist of two varieties: the traditional and the industrial. Traditional as shields, ordinary, cellular barriers of plant material are performed mainly by hand, so they are time-consuming and expensive. The industrial as a ditch-shaft of various constructive solutions allows comprehensive mechanization as well as industrial, agricultural run serial machines.

The physicochemical method, which consists in applying to the moving surface of the sand binder, has the distinct advantage of a protective layer to create favourable thermo-humidity conditions. However, for the methods of physico-chemical method for the rare exception of the road, it is difficult to prepare a chemical improver. Their use is associated with a number of requirements by the astringent and polymer material derived from them. This article attempts to summarize the available data on the physical and chemical methods (chemical ameliorants). Binder coated on the surface of the sand spraying and soaking the sand forms a crust (a protective layer of sand soaked astringent). The stability of the crust to the effects of wind flow saturated sand tolerated it and protects the underlying loose sand rendering it to anti-deflationary action.

The ability of bind sandy protective cover to fulfil its function depends entirely on the physical and mechanical properties of sand and physicochemical properties of the binder.

1.1. Criteria for physico-chemical method sand fixation

The physicochemical method of applying binder to the moving surface of the sand, which accomplishes reclamation function, with few exceptions, satisfies the requirements mentioned above. Its employment is connected with a number of requirements to the binder and polymer material derived from them [5].

Requirements for knitting: *To be non-toxic and non-herbicidal, accessible, absorbable into the sand and forming, after penetration into the sand, an elastic-viscous-plastic protective layer (crust), technological in mixing and applying.*

Requirements for protective crust: *To be resistant to the natural (wind, sand abrasive action of wind flow) and climatic factors (solar radiation, humidity, temperature) and cost-effective.*

Technological requirements to the methods of FFW: *Accomplishment of the works on the fixation of moveable sand must be industrial and possibly prolonged throughout the year except for the period of freezing temperatures and snow cover.*

From a variety of binders only those that are available on the territory of Uzbekistan are highlighted. These include high molecular with low amounts of fractions oil from the Djarkurgan oil field [5], bitumen from it [8], sulfite yeast mash [10], resin acetone-formaldegydamine chemical wastes [11], emulsion resin gossypol [9]—a byproduct of oil extraction plants [5,12]. Oil is heated to achieve the desired viscosity, bitumen end gossypol emulsion dispersed in the presence of surfactants to produce an emulsion; others are used as binding solution. Common for recommended binders is that studies were carried out on the sand of air-dry state. In this case, there is a contradiction –

the physicochemical method and all related methods involving the use of binders, proposed in order to improve the efficiency of the biological method as the most environmentally friendly solution to the question of fixing shifting sands. At the same time in the sand FFW air-dry condition limits their holding time when the surface layer of the sand is in air-dry condition.

Resource requirements dictate continuously or intermittently with the least mechanized production work, which allows continuous use of available human and material resources. To do this, consolidation of mobile sand must be carried out in the sands of the wet state [4,5].

Cementing should be non-toxic, available and absorbable into the sand and form after penetration into the sand elasto-visco-plastic (th) security (th) layer (crust), technologically advanced in the preparation and application.

Crust must be resistant to natural (wind, sand abrasive action of wind flow) and climatic factors (solar radiation, humidity, temperature) and economical. In this case, its application should be possible for long.

To obtain a stable crust enough to give it the required elastic-visco-plastic properties, estimated aggregate criteria is the thickness of the protective cover ($h \geq 5$ mm) and plastic strength ($P_m \geq 2{,}5x10^3$, Pa).

2. IDENTIFICATION OF THE PROBLEM

Resource requirements during the construction and operation of the railways in general and to protect them from sand drifts, in particular, dictate continuous or with minimal interruptions mechanized production work, which allows continuous use of available human and material resources [12]. For this *fixation*, mobile sand must be carried out also *in the wet sand*.

3. EVALUATION OF THE DATE RECEIVED AS A RESULT OF STUDY

3.1. Method of research

In the process of forming a protective crust on the basis of binding agents, such as emulsions, solutions and the heavy oil and sand conglomerate formed, a protective crust under vigorous warming for 2 hours reduces the evaporation of moisture from beneath it by 3.9 - 5.5 times [5].

At 30% sand moisture and a temperature of 50°C under ambient temperature, it is below a protective crust at 10-120 C to a depth which decreases 90-100 mm.

It is known that the germination of plants needs certain humid-temperature conditions, which will create favourable conditions for seed germination and plant phytomelioration, which improves performance. Therefore, for a protective cover for the impregnation process, it is important to investigate the different states of sand.

Impregnation is studied in two phases: construction and technological parameters of wet sand and proper impregnation.

In the first phase you must first consider:

1. Limit humidity sand moistened sand sprinkling.
2. Change in moisture content over time sand.
3. Spraying binder on the sand at the time of termination and every 30 minutes after sprinkling until a positive result, i.e. impregnation sand binder.
4. Establish critical value humidity below which the sand becomes a permeable binding of different concentrations.
5. Based on the critical moisture content, using a plot of moisture from time to time to determine the start spraying binder.

In the second stage we study in detail the impregnation of binding of various concentrations with an estimate of the protective cover on the two aggregate quality parameters: plastic strength and depth of impregnation.

3.2. Interpretation of the experimental data

Resource saving requirements dictate the conduct of continuous or minimally interrupted mechanized production work, which allows continuous use of available human and material resources. This *fixation* of moveable sand must be carried out also *in wet sand*.

Elastic-viscous-plastic properties of the protective cover are fundamental in ensuring its stability [12]. The two following characteristics are essential and sufficient conditions for the stability of the protective cover: strength plastic P_m and the thickness of the crust h. Values of P_m = (2,5-2,7)x10^3 Pa and h = 5 mm [5] correspond to the optimal structure formation. An increase in the steepness of the slope for the smallest value of a continuous layer of plastic strength is equal to P_m = 5x10^3 Pa.

The study of the ability of binding to penetrate into the wet sand shows that the set limit humidity of sand varies between 32 and 35% when below this level of moisture infiltration becomes possible (table 1).

Table 1

Changes in the standard conditions of moisture

Time, hour	0	1	2	3	4	5	6	7	8
Moisture %	33	30	26	20	17	15	10	7	5

Changing the sand moisture in time with 32,64% to the air-dry state of 14% has lined dependence with R^2 = 0,98 (figure 1).

$$W = 32{,}64 - 3{,}63\,t, \tag{1}$$

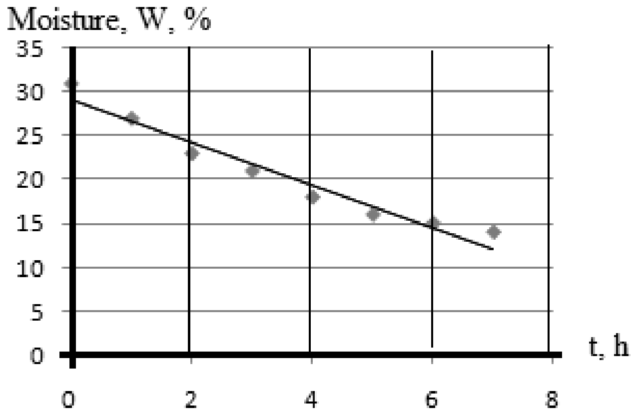


Fig. 1. Reduction of sand moisture in time
Рис. 1. Зависимость влажности песка от времени

Conducted research showed an inverse dependence of the concentration and expenses of binding from the sand moisture. For achieving desired thickness of the protective cover on the wet sand compared with drying, less concentration and less consumption of binder are required. Thus, if 24% sand moisture concentration emulsion resin gossypol is 20-25%, while at a moisture content of 32%, it is sufficient to use only 5-15% of concentration. It is defined as an inverse dependence of the concentration of binder (used in the form of emulsions) from humidity—the higher the humidity, the lower the concentration of the binder.

The concentration of the binder compared with the previously given values of dry sand are lower at 10-15%, on wet sand lower at 30%. In particular, for the emulsified binders at 10-12% concentration of fuel consumption, providing optimal strength plastic, it is 1,0–2,5 $dm^3/m^{2.}$ However, in the wet sand this condition is satisfied at a cost of 1,5-2 times smaller (q=0,5-1,5 dm^3/m^2), possibly due to the changing nature of impregnation and acceleration of the processes of filtration binder in the wet sand. It is apparently due to the plug-impregnation mechanism occurring because of this decay and coalescence of emulsified binder particles in the upper layers of the impregnated sand, which naturally prevents further penetration of the binder in the wet sand.

Binders used in the form of solutions can be impregnated sand, starting from 24% relative humidity. Solutions RRT, SAFA, PFD and multicomponent macromolecular oil filtered (table 2) however the impregnation rate, are reduced in astringent least penetrate into the wet sand (24%).

Table 2

Building the technological parameters of technological solutions

№	Optimal construction and technological parameters		Name of the binder				
			Premium resinous oil (petroleum)	Emulsion of		Solutions	
				bitumen	REG	RRT	RPT
1	Humidity limits of sand to allow impregnation%		17	32	32	24	24
2	Concentration, %	air-dry sand	100	10-15	10-15	10-12	9-11
		the wet sand	100			10	7
3	Consumption, dm^3/m^2	air-dry sand	1,5-1,7	2,7	1,5-1,8	2,5-3,5	3-4
		the wet sand	0,7-1,2	1-1,5	0,5-1,1	2-3	2,5-3,5

Solutions RRT, SAFA, PFD and multicomponent macromolecular oil filtered more intensively against a decrease in the rate of infiltration; therefore, binding to a lesser extent penetrates into the wet sand [12]. Perhaps with the increase of water adsorbed colloid layers on the surface of the sand particles pore space is reduced. The size of the channels through which penetrates the binder in the sand is reduced to less than 2.10 mm in size, resulting in a change in the character of the gravitational advantageously capillary impregnation. Evidence of this is the sharp decline in the rate of impregnation (figure 2).

It should be remembered that the prior humidification leads to an increase in the colloid layers of water adsorbed on the surface of sand particles and reduce the pore space. The size of the channels through which the binder penetrates into the sand is reduced to less than 10^{-2} MM, resulting in a change in the character of the gravitational advantageously capillary impregnation. Evidence of this is the sharp decline in the rate of infiltration.

Because of the hydrophobicity of certain binders, such as petroleum resins, they are concentrated in the upper crust. This leads to an uneven distribution of binder in thickness and reduced peel strength of the protective cover in the lower layers.

Table 3

Distribution of the binder impregnation depth

Methods for impregnating	The mass of the crust, g	The depth of the layer from the surface crust, mm	The weight loss of sand by washing,%
On air-dry sand (5%)	224,1	0-3	1,35
		3-6	1,2
		6-9	1,1
On wet sand (24%)	224,9	0-3	2,3
		3-6	1,2
		6-9	1,2

Thus, an emulsion should be impregnated well in both dry and wet sand. However, the preparation of emulsions due to some difficulties in obtaining homogeneous emulsion resins requires intensive mixing with water with the addition of a surfactant and heated up to 70°C [8,9]. Solutions, unlike emulsions and binder premium resins are more involved with sand during impregnation, easily mixed with water compositions, easy to manufacture, and energy efficient [12].

However, previously studied water soluble substances are relatively expensive or their production as waste industry in Uzbekistan is absent.

It follows that, in spite of proof of the possibility of expanding the scope of the previously recommended methods and achieving real savings when working on wet sand, there is a need to find a more affordable and cost-effective materials for the preparation of solutions. One of those is dextrin.

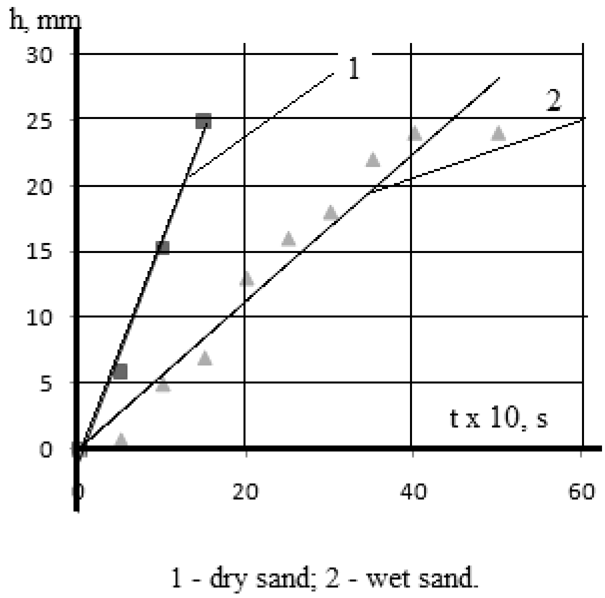


Fig. 2. A plot of the depth of impregnation of gossypol resin emulsion
Рис. 2. Скорость пропитки песка эмульсией из госсиполовой смолы

- dry sand $h = 1{,}69\,t - 1{,}07$ (2)
- wet sand $h = 0{,}56\,t - 0{,}01$ (3)

4. NEW BINDER FOR PHYSICOCHEMICAL METHOD OF FIXING SHIFTING SANDS

4.1. Characteristics of dextrin

Dextrin is local binding from the waste of processed grain (starch polysaccharide used in the manufacture of glue and adhesives), an intermediate product of starch hydrolysis.

The ability to form a knitting mass is no herbicide, non-toxicity, availability and relatively low purchase price caused the research capabilities of its application to create a protective cover binding sand.

Dextrin has a low viscosity: 50%. Dextrin solution viscosity corresponds to 5% solution of the starch glue. To increase the elasticity necessary additives, the hydrolysis of starch was prepared in three versions, soluble in cold water: the white dextrin 75%, 85% yellow and fawn 95%. When heated in a water bath all dextrins turned completely into solution, but after a few days of white and yellow the dextrin part of the liquid turned into a jelly-like mass.

Increased solubility dextrin in cold water and high stability of an aqueous solution allows its use as a binder in the preparation of binding sand protective cover.

Moisture of the dried product less than 5%, mass fraction of ash, based on dry matter does not exceed 0.22%, acidity: 100 grams of dry dextrin of not more than 50 cubic centimetres of sodium hydroxide concentration of 0,1 to neutralize the acids and acid salts. Acidity ranges 6-8 pH. Number of specks of 1 square decimetre level surface dextrin to the naked eye no more than 300 pieces.

The product is environmentally friendly; it is supplied in dry form and is ready for use after dilution with water, the ductility of the finished binder is dependent on the amount of water. Shelf life of dry dextrin is 1 year from the date of manufacture.

Binding properties, high stability of an aqueous solution, environmental safety and increased solubility dextrin in cold water were the main parameters for its use as a binder to consolidate the shifting sands.

The result is a need to find a more economical structure forming a water-soluble. As such, the dextrin is used.

Dextrin-Intermediate hydrolysis of starch. Has a low viscosity of 50% solution; viscosity of dextrin corresponds to 5% solution of the starch glue. Properties are somewhat reminiscent of acacia but more fragile. To increase the elasticity necessary to add glycerin or honey (30%), the hydrolysis of starch was prepared in three versions, soluble in cold water: the white dextrin 75%, 85% yellow and fawn 95%. When heated in a water bath all dextrin turned completely into solution, but after a few days of white and yellow dextrin part of the liquid turn into jelly. The cost is 3.5 UZS (Uzbek so'm) per 1 kg in prices in 2014 to create a protective coating for 1 year. It is used in diluted form as a solution.

Time to get started on the wet sand 3 hours after rain. A dextrin solution is applied to air-dry and wet sand gasoline sprayer Champion PS257, sprayers series “OVX” and “OVT” (table 4).

Table 4

Specific consumption of dextrin solution to obtain a protective cover that meets the requirements of sustainability

Composition,%	Consumption, l/m^2	
	wet sand 24%	air-dry sand
Dextrin - 2,2; NaOH - 0.7; GE - 0.7; Water - 96.4	≥ 2,0	≥ 3,0

The solution of the dextrin, gossypol plasticized resin, not inferior to its construction and technological characteristics of the previously recommended astringent and after research on the influence of climatic factors can be recommended to secure the shifting sands.

4.2. Methodology research of new ways to secure the shifting sands using dextrin

Experiments were carried out on the sands of the air dry and wet conditions. Humidity corresponds to a value of impregnation of sand and formation of a protective cover.

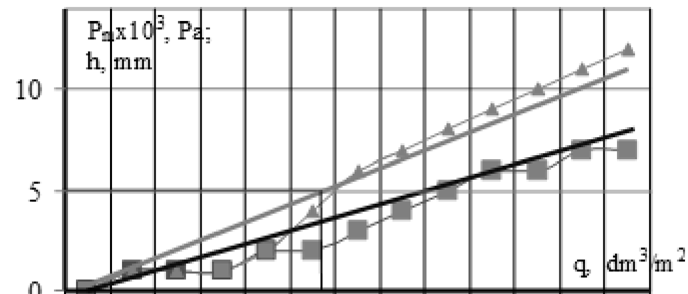
Samples of the protective cover and resulting impregnation were tested for compliance with criteria aggregate resistance to wind-sand flow.

With solution flow rate equal to the specific thickness of the crust on wet sand 1.5-2 times the thickness of the crust, resulting in the dry sand, the thickness of the cover in both cases exceeds the desired value (≥ 5 mm) on the aggregate stability requirement (table 2).

However, the protective crust of the solution of this composition has insufficient ductility although it is fragile and brittle. Therefore, under the second condition $P_m > 3x10^3$ Pa·s relative solution flow can be reduced. For this purpose, a modification is effected with the addition of gossypol resin (HS). Composition in % is dextrin - 2, NaOH - 1, HS - 2, and Water - 95.0 which corresponds to the second requirement of stability—strength plastic.

For experimental verification of the hypothesis of a deeper adsorption binder in wet sand at lower speeds impregnation, a gravimetrically determined amount of binder is in the depth of the protective layer. For this, after the dry impregnation of wet sand and binder, there is equal flow cut layers of equal thickness weighed on an analytical balance for reference weighed samples of sand saturated with clean water.

Graphical interpretation of the experimental results is obtained in the medium Excel depending on the plastic strength and thickness of the protective cover from the specific consumption of the solution (fig. 3, 4) with a sufficiently high level of confidence ($R^2 \cong (0,96 - 0,97)$, table 5).



	1	2	3	4	5	6	7	8	9	10	11	12	13
$P_m x10^3$, Pa	0	1	1	1	2	2	3	4	5	6	6	7	7
h, mm	0	1	1	1	2	4	6	7	8	9	10	11	12

Fig. 3. Graphs of the plastic strength and depth of impregnation P_m h of dry sand on the flow rate of the working consistence 2% solution of dextrin

Рис. 3. Графики зависимости пластической прочности P_m и глубины пропитки h сухого песка от расхода рабочего состава 2 % раствора декстрина

- dry sand $h = 0,63 q - 0,96$ (4)
- wet sand $h = 3,35 q - 1,97$ (5)

The required strength of the plastic on the stability achieved by the specific consumption of the solution in the range of 2.5 - 3.5 l/m2 on dry sand in the range 2 - 2.5 dm^3/m^2 - wet sand.

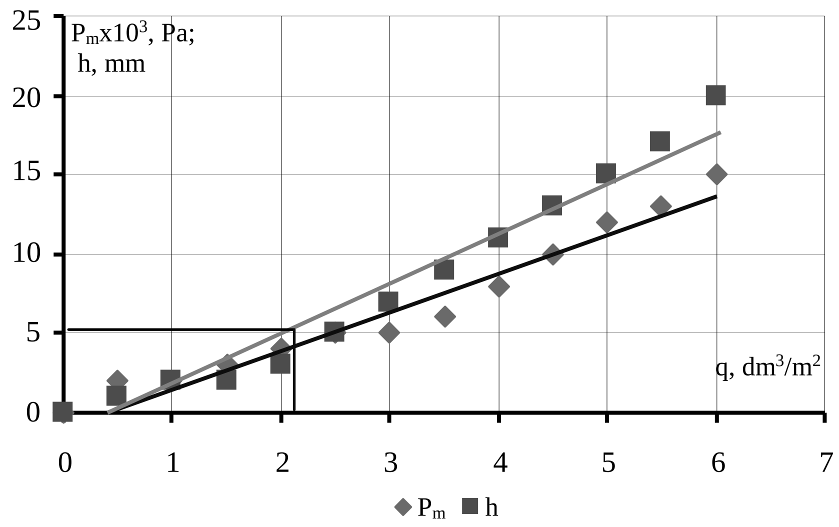


Fig. 4. Graphs of the plastic strength and depth of impregnation P_m h of wet sand on the flow rate of the working consistence 2% solution of dextrin

Рис. 4. Графики зависимости пластической прочности P_m и глубины пропитки h влажного песка от расхода рабочего состава 2 % раствора декстрина

- dry sand $P_m = 1,08\ q - 2,04$ (6)
- wet sand $P_m = 2,36\ q - 0,55$ (7)

The impregnation rate in moist sand is less than that in dry sand. The depth of impregnation wet sand at a flow rate is equal to 1,5 binder - 2 times. Checking the samples showed that the crust on the wet sand with construction and technological characteristics of the respective values of the required stability criteria is obtained by using less binder.

5. CONCLUSION

As a result, the authors proposed the use of a rapid method for assessing the quality of the protective coating (a layer of sand, soaked in astringent) against deflation sands. This reached a typing method for studying the possibility of using the binders. This is achieved by the effect of resource:

- Limits the number of prametrov which is determined in experiments. Necessary protective coating quality criteria are satisfied for the concentration, and rate of the binder is 20-30% less than for the conventional method;
- Reducing the concentration and cost compared to previously recommended binding by 10-20%;
- Modification of the physico-chemical method for fixing shifting sands. The modification consists in treating certain humidity sand, 2-3 hours after irrigation or rain, when the sand has a moisture content referred humidity threshold, i.e. when wet sand becomes permeable to the working structure of the binder.

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