HYDROEFFECT

NEW TECHNOLOGIES in HIGHWAY ENGINEERING AS a GUARANTEE of STRENGTH and DURABILITY of ROAD CONSTRUCTIONS

In recent years a number of waterproofing agents of different purposes of "HYDROEEFECT" trade mark have been developed that change the nature of the interaction between the components of the compounds, give it solidity, hydrophobicity and water-resistant properties.

These characteristics are extremely important in the construction and repair of roads of all categories for different purposes, quarries, road slopes, slopes of channels, airfield pavement, underground storage facilities, and dams (barriers).

Modern roads are complex engineering complex made of building materials – a kind of macroscale composite personifying a single monolith.

Road construction turns out to be one of the most material-intensive and labor-intensive industries.

The main costs of material, labor and financial resources in road construction are associated with the construction of the road structure – road bed and road pavement (dressing) [9-16].

One of the main ways to improve the economic efficiency of road construction is the use of new and local materials and by-products of the industry. New brand waterproofing agents of "HYDROEEFECT" mark are directed to the development of road designs that reduce the consumption of materials and labor road construction on a large scale.

According to the German experts' construction of one kilometer six-lane high road costs 21 million Euro. Therefore, the implementation of new technologies and materials that reduce the cost of roads and increase their quality is one of the most urgent challenges of our time.

The main climatic factors influencing the strength of a road construction are humidity and temperature [17-23].

Humidity affects the deformation and strength of soil-subgrade roads strongly. By increasing the humidity increases their deformation and decreases their resistance. Since the roadbed is the foundation of the road pavement (dressing), it causes the change of the entire road construction strength.

Moisturizing of the road structure is possible due to the two other sources - film and moisture vapor. Film moisture covers the surface of mineral particles, and under the influence of the temperature gradient (differential temperature) - may be moved from warmer to colder locations. This source of moisture operates continuously and can cause the movement of subgrade. The vapor moisture in the form of steam under the influence of temperature gradients moves to the top of the subgrade to steamtight pavement layers and causes intense moisturizing of road dressing foundation soil. Temperature is one of the main factors determining the migration processes of moisture in the subgrade, specific periods of hydrothermal regime of the road structure and its physical-mechanical properties. While designing road constructions our attention should be paid to one of the major aspects – the proper assignment of structural-mechanical characteristics of soils: the relative

humidity, the elastic modulus of the road construction, the internal friction angle amount, specific cohesion. This task is complex and challenging, as you need to predict the value of these characteristics for years to come, as expected lifetime is expensive – about 10-20 years, depending on the zoning and on the whole complex of the factors listed above being taken into account. Subgrade moisture is altered under geocomplexes operation not only by the season of the year, but in a longer term, and it depends on a complex combination of many random factors. When designing road coatings, the specific conditions of humidity, which can vary greatly by individual sites along the road, are to be taken into consideration. In addition, while designing the efficient road designs both the vehicles impact on them, and climatic factors should be taken into account.

Their complex report has allowed us to consider a comprehensive account of the introduction of "Hydroeffect' trade mark water-repellent into the road construction of economical road structures. More economical new road constructions should be developed on this basis.

The main way to improve the strength and durability of the road structure is to increase strength and stabilization properties of subgrade as the weakest part of the structure [10,15,24]. The simplest method is increasing of the mechanical strength of the foundation soil without substantially changing the water-heat mode by soil reinforcement with the layer of reinforcing polymeric material: polypropylene, polyethylene, polyvinyl chloride, etc.

Another more rational way is to regulate the properties of the entire road construction. Control of the heat mode designs varies mainly in regions with severe climatic conditions and is aimed at changing the subgrade freezing depth.

In the USA and the northwest European countries the thickness of road dressing is considered to be close to the depth of soil freezing. The use of heat insulating layers allows us to save the depth of freezing and to reduce the thickness of coating. This is achieved by the means of the use of various insulating layers at the bottom of road coating. There is more rational use of expanded plastic. Such layers have good thermal-insulating properties used in the construction of auto roads in Alaska, Sweden, Russia (Moscow, Moscow region, Kalinin region, Yaroslavl region). The disadvantage of expanded plastics is a low mechanical strength and deformation that threatens the destruction of the underlying layers of dressing. Polysterene concrete obtained by adding to the concrete polystyrene beads is used for rigid insulating layers. Thermal properties of such layers are worse than thermal properties of expanded plastic, but their strength is much better.

The way of controlling thermal water mode of a construction is a more perfect and universal one. Such control is possible by using vapor seal layers. The choice of vapor seal or water insulation barriers depends on the specific conditions and is made with the help of insulation film of a nonwoven polymeric material in a layer of subgrade soil.

Complete isolation of soil requires a large amount of material and intensive labor, but it does not solve the problem entirely.

Thus, the standard (fiducial) road constructions widely used in constructions cannot provide increased strength values of natural ground even under favorable climatic conditions of the roads typical for Ukraine and the southern regions of

Russia. Subgrade soil is a heavy silty clay loam containing 30% of sand, 18% of dust and 52% of clay. The steppe zone of Ukraine is characterized by these soils.

All problematic situations mentioned above of the road constructions formation can be overcome through the use of "HYDROEFFECT" water repellent brand, creating vapor barrier, waterproofing or vapor insulation layers, for example, the creation of a layer of protective action of vapor water insulation by the means of soil treatment to a depth from 1 to 1.5 m by special technology using the appropriate hydrophobisator.

The moisture content of the foundation soil depends on the depth of the groundwater and the relative humidity of the environment and on the time of the year. Processing soil with the hydrophobisator of an appropriate composition is based on the chemical interaction of soil moisture with water repellent ingredients resulting in particles hydrophobisation and the soil pores with manifestation of colmatage. It results in formation of hydrophobic water-blocking that protects the subgrade soil from the base of the influx of moisture, a possible dilution or freezing, i.e. subgrade soil gets heat-shielding properties and protects the road coating from destroying. It is a kind of isolated soil with the soil physical-mechanical and physic-chemical characteristics that distinguish it from the surrounding soils:

- A layer of soil isolated is protected from any kinds of moisture;
  Perhaps partly remained moisture after hydrophobization can be distributed inside a layer within a year. Since isolated soil contains traces of moisture, it is due to less deformability, has high strength and toughness during a whole year.
- Due to the low humidity there is no freezing and decompression, there is too little moisture to increase in volume while freezing and to spread soil particles.
- Insulated hydrophobized soil distributes a load evenly; this soil is of increased strength and of less deformation.
- Layers of isolated hydrophobic soil have a positive impact on water and thermal regime of the entire road construction.

In this case highway subgrade top is protected by vapor and water barrier layer of isolated soil. This layer is a heat insulator and limits the possibility of moisture migration into the roadbed. Insulated layer of hydrophobic soil due to the reduced humidity and high consistence is stiffer than the ordinary soil. So it distributes and reduces the load imparted to the roadbed.

Thus, the road dressing below this layer is protected from all types of moisture. On its top it is protected by a waterproof coating, which can be enhanced by treating the surface with hydrophobisator of "HYDROEFFECT" trade mark. Dressing is located on a rugged hard ground. Local materials can be widely used in a road structure. In the lower layers the usage of gravel layers, ash-and-slad reinforced with organic binder (bituminous binders, mastic gum) is appropriate.

Asphalt as the primary material for road coating is another important issue affecting the strength and durability of road structures. In 2006 in Ukraine domestic and foreign experience of designing, preparation of stone-mastic asphalt being taken into account resulted into the development of national standard DSTU BV 2.7-127:

2006 "Bitumen-Concrete Mix and Stone Mastic Asphalt. Technical Specifications." It has been put into operation since 01.01.2007.

The developed standard regulates the scope of stone mastic asphalt mixes – building of the upper layers of road pavements coating. The new standard allows using stone-mastic asphalt mixes with a maximum grain size of 5 mm (SMA-5). According to this standard the density control coating of SMA is recommended to be carried out only by the magnitude of in place air voids or water content of the selected coating cores, as indicators of in place air voids and water content of asphalt samples are highly correlated. Therefore HYDROEFFECT water repellents can greatly improve the strength characteristics of the stone-mastic asphalt due to hydrophobic in place air voids and water content diminution.

Asphalt road mixtures, airfield and asphalt GOST 9128-97 were developed by the "Transstroy" Corporation, by State Road Research and Design Institute "SoyuzdorNII" of the Russian Federation, and was adopted by the Interstate scientific and technical committee for standardization, technical regulation and certification in construction (MNTKS) 10.12 .1997, and was confirmed by GOST 9128 - 2009.

Asphalt is known to be a common building material for the installation of auto-road and airfield pavement, flat roofs, industrial buildings floors, hydraulic engineering. Asphalt concrete mixture consists of optimally chosen composition:

• Mineral materials – crushed stone or gravel, sand, finely divided mineral filler or without it.

• Organic binder – bitumen.

In accordance with GOST 9128-2009 asphalt and asphalt mixture by type of mineral component (stone material) are divided into:

• Crushed stone (gravel, sand, mineral filler);

• Gravel (sand, gravel or sand-and-gravel material, mineral filler and bitumen).

• Sand (sand, mineral filler, bitumen)

with a strict regulation of the size of the mineral fillers, the percentage of voids content, temperature of hot and cold placing.

Despite the diversity of the methods of selection of the compound the principles of the mix design providing the main requirements for the quality of asphalt. They are the best performance of road structure layer and its high lifetime [9-12,14]. Two design approaches of road concrete mix formulation are known to experts:

- The selection of the mixture with continuous granulometry of the rock material [13].
- The selection on the basis of a mixture of no-voids concrete allows using rock materials with a rounded shape of grains and gapped grading granulometry.

Correct dosage of bitumen used and good adhesion with the surface of the mineral fillers is an important aspect of these two methods. The selection starts with mixture properties components determining and check of their compliance with the standards established by the technical documents. Then there is the optimum ratio between the components guaranteeing a production of a mixture with specific properties. Thus an artificial asphalt or road concrete mix – building material in the form of a compacted mixture of: gravel, sand, mineral filler and bitumen – is

obtained. It's a kind of macroscale composite; the durability of a product depends on its strength. Moisture, water, temperature drop, annual cycles of freeze-thaw eventually destroy it.

With the development of an automotive industry the requirements for quality of roads have undergone significant changes. Creating monolithic coating from organic-mineral and concrete mixes for road dressing are now a priority.

Bitumen and cement are very expensive ingredients of asphalt-concrete. To reduce the required amount of binder and improve the strength and quality of organo-mineral and cement mixes a series of surfactants and a catalytic agent, a kind of admixes, was used. As a result, the amount of necessary adhesives without quality degradation of produced materials reduced, provided that costs of the active adhesives for making asphalt-and cement-concrete mixtures were minimal with maintaining the quality and strength. On this basis manufacturers of admixes activating structure making process called them stabilizers of mineral fillers and soils [21-24]. Some of them are shown in Table 1: Roadbond

Table 1

Stabilizer name	**General characteristics**
1. EH-1 Roadbond (USA)	Multicomponent liquid comprising essential oils pickled in sulfuric acid.
2. Roadbond clay and clay soils, RRP-235 Spesial (Germany and Canada)	multicomponent liquid comprising a ПАВ (surfactant) canned in sulfuric acid
3. Roadbond SPP (South Africa and Russia)	Multicomponent liquid polarizing clay particles actively influences the film and capillary water.
4. Stabilizator SG (Ukraine)	Sulfuric acid, calcium carbonate pasta (45-55%), oil and kerosene-gas fraction.
5. Stabilizator Solitac (Soliworks Company)	polymer-based emulsion
6. The stabilizer Renolit (Alma-2 Company, Australia)	polymeric additive to cement (admixture)
7. Stabilizator soil Perma-ZyneIIX (USA)	enzyme agent

The soil stabilizers given are described as multi-component systems with predominantly acidic environment owning the properties of SAS (superficially active substances); they contain superplasticizers, water repellents, complex organic compounds that include ester groups and ionic complexes.

If asphalt concrete is being considered as (1-18%) open-textured macroscale composite consisting of hydrophilic inorganic fillers and hydrophobic binding bitumen, its working life will be determined by the liquid-water content and temperature of the environment. Destruction will be determined by percolation phenomenon of hydrophilic inorganic fillers and the penetration of moisture and water into the asphalt-concrete (asphalt-grouted macadam). Practitioners' relying on the use of imported stabilizers (Table 1) with the aim of obtaining high-quality

moisture-proof and waterproof asphalt-concrete was not justified. Testing of above mentioned stabilizers taken place in Ukraine was insufficient for producing anticipated results due to their chemical composition and properties. They contribute to soil strength enhancement and the strength itself in non-water-saturated soil condition, but for the majority of soils they do not provide high water resistance, which is required by special events conducting, eliminating the sources of active humidification of subgrade or by adding cement into the soil.

Hydrophobisators of "HYDROEFFECT" trade mark can solve the above mentioned problems easily. Unlike stabilizations which are physically adsorbed on the surface of water-retentive extender pigment of road concrete mix and soil particles, water repellents of "HYDROEFFECT" trade mark – as a result of chemical interaction – create a strong hydrophobic film on the inorganic fillers and on the interstices of the soil. Hydrophobic bitumen makes the asphalt-concrete become moisture and water-resistant. For the same reason soils treated with hydrophobizator of "HYDROEFFECT" trade mark caused by water-repellency treatment of particles and by mud injection of interstices of the soil, form hydro parting layer. The usage of “HYDROEFFECT" hydrophobizator for improving the quality of soils makes road building climatic zones much wider.

By using “HYDROEFFECT" water-repellents we can observe the process of reducing the number of necessary binding materials without reducing the quality of the materials. The costs of active binding materials for the production of asphalt-and cement-concrete mixtures are reduced to a minimum meanwhile maintaining optimal quality and strength of materials.

Due to the possibility of achieving the optimum minimum cost of both bitumen and cement while producing asphalt and cement-concrete mixtures by unequivocal use of "HYDROEFFECT" trade mark water-repellents of different chemical nature and process flow optimization they act as self-sufficient components – in terms of improving the strength and resistance of road-building materials and soils.

"HYDROEFFECT" trade mark hydrophobisators are a broad class of different chemically materials which have a positive effect with low dose on the formation of the road-building constituent properties by virtue of the activation of physico-chemical processes and process flow optimization. These repellents can be used at all technological stages of highway engineering starting with the roadbed constructions and finishing with hard surface constructions, starting with artificial engineering structures and finishing with road furniture. "HYDROEFFECT" trade mark water-proofing agents increase the strength, resistance to water attack, and frost resistance.

The Usage of "HYDROEFFECT" Trade Mark Repellents as the Way of Reduction in Consumption of Road Construction Materials

Reduction in consumption of materials is one of the main objectives of the XXI road builders. Particularly important is the reduction in consumption of scarce and expensive binding materials, and imported materials as well.

The main ways of reducing the consumption of materials that can be implemented by using advanced components with regulated thermal behavior based on the production are:

• Reduction in consumption of binding materials;

• Common usage of local materials, by-products of industry, etc.

• Decrease in the thickness of road surfacing.

While selecting work materials for production of damp-proof layers and vapor proof barriers we took into account a number of specific requirements. The main requirements:

• Materials should provide a vapor proof barrier and water isolation of soil and of highway engineering design as a whole.

• They should ensure top performance of the structural design.

• They must be sufficiently long-lasting, offer stable resistance properties.

• It is important that these materials offer adequate strength and can be a distribute element in highway engineering design.

• These materials should be easily available and in low supply.

• Materials should provide a minimum complexity of road construction.

Numerous works of domestic and foreign scientists are aimed at reducing the use of scarce materials. The bonding material is the most expensive material among road-building materials. Specific proposals to reduce the consumption of bonding materials should be based on the theory of structure formation. The peculiarity of cross-linking in particulate matter reinforced by binder materials may conveniently be discussed under analyzing the change of the two main indicators – bending tension strength and modulus of volume elasticity.

The first one describes the mechanical strength characteristic of the material, and the second one describes the deformation properties. Binding materials rationing must be done taking into account both the strength and deformation parameters.

The application of "HYDROEFFECT" trade mark repellents can significantly change the force deformation relationship between the modulus of elasticity and the content of the binding materials in asphalt-concrete in a positive way.

Carried out investigations of asphalt concrete properties with low content of bonding material though satisfy the relevant state requirements, but they have a lower water resistance compared to conventional mixtures. Therefore, being applied in the upper layers of coatings the surface treatment should be provided, which can be easily offset by the application of "HYDROEFFECT" trade mark water repellent.

One of the main reserves of reduction in consumption of material road construction is the application of asphalt-concretes with a low binding content and the usage of near-by astringents that has caused the application of concrete based on polymeric compound in recent years. For example, the introduction of scalpings of polyvinyl chloride resin into bituminous-concrete compo is known.

Considerable attention was paid to the choice of material for the film insulation. Basically it is a film made of polyethylene, polyvinyl chloride, and less of isobutylene.

It was believed that they were the most chemically resistant hydrophobic materials. In fact, the polymer films temporarily protect road dressing: temperature fluctuations and actual operating conditions eventually lead to their destruction and loss of their protective properties [25]. In addition, the cost of polymers excludes their widespread use in road construction. With decreasing spraying rate of bitumen from 6 - 7% to 3% of the modulus of elasticity and temporary bending tension strength in asphalt-concrete vary slightly, however, a further fall in size standard of bonding materials results in a significant strength weakening.

Reduction of the amount of organic binder can be achieved by its being activated by the substances with active functional groups resulting in active interaction with the mineral fillers.

The big reserve of reducing the need for expensive imported stone materials is the usage of land waste - weathered rocks; land waste reserves in Russia and Ukraine are enormous. Their meet out modification and the application of "HYDROEFFECT" trade mark repellents will provide a sufficiently sound material. The usage of available stone materials treated with repellents is particularly effective in the designs with adjustable water-temperature mode (WTM) as a roadbed of such structures has increased stiffness causing less tensile stresses in road surfacing layers as a result.

Thus, the usage of new technology in the development of rational road constructions with the application of products – **"HYDROEFFECT"** trade mark water-repellents – will significantly increase the following indicators:

- longtime performance of the driveway;
- bearing capacity of the roadbed;
- strength of the roadbed;
- consistency of the soil.

Meanwhile the following indicators reduce significantly:
- soil moisture content;
- soil plasticity number;
- soil shrinkage;
- presence of the dust
- soil expansion;
- working expenditures.

The application of "**HYDROEFFECT**" trade mark repellents is:
- cost saving for construction;
- operating cost saving for the entire working life;
- significant impact reduction of road construction on the environmental ecology.

References

1. V. Kuzmina. Growth Limiter of the Economics. Automobile transport. - 2011, №7, p.2 - 5.
2. V. Kuzmina Highways of northern regions of Russia. Automobile transport. - 2011, №8, p.48 - 51.
3. E. Krinitskyi. Bring together East and West roads. Automobile transport. - 2009, №3, p.22 - 25.
4. E. Krinitsky Roads – Accelerator out of the Crisis. Automobile transport. 2009, №5, p.18 - 22.
5. V. Datsenko The Problems and the Prospects of Normalization of Asphalt-Concrete Properties. Guidebook of Ukraine. - 2011, №2, p.46 - 48.
6. V. Datsenko Studying the Quality of Stone-Mastic Asphalt Concrete Road Coating. Guidebook of Ukraine. - 2011, №3, p.40 - 43.

7. E. Krinitskyi Highways can lead the country out of crisis. Automobile transport. - 2009, №2, p.41 - 46.
8. E. Krinitskyi Highways and Transport Services for the Population are – headaches of local authorities. Automobile transport. - 2008, №3, p.12 - 14.
9. V. Datsenko Update Requirements to "Gusasfalt" Pumpable Asphalt-Concrete Mixtures and Pumpable Asphalt-Concrete. Guide of Ukraine. - 2011, №4, p.33 - 36.
10. Alexander Litvinenko About the Necessary and Sufficient Consistency of Dry Soil, Binding Soils While Constructing Highway Roadbed. Guide of Ukraine. – 2011, №4, p.21 - 27.

11. V. Mozhovyi, A. Onischenko and etc. Experimental Evaluation of Asphalt Concrete Stiffness by the Means of Laboratory Devices. Guide of Ukraine. Special Issue. - 2010, №13, p.93 - 101.

12. M.K. Pozdnyakov, N.V. Bystrov Development of Methods for Evaluating Resistance of Asphalt Concrete to the Wheel Pressure. Annual articles and reports. Sessions Studies of Asphalt Concrete Association. M .: - 2010, p.7 - 17.
13. V.K. Zhdanyuk, V.Datsenko Asphalt-Concrete Stiffness of Different Granulometry Types to Plastic Deformations Pile-Up in the Image of Track Gauge. Guide of Ukraine. - 2009, №1, p.31 - 34.
14. V.K. Zhdanyuk, V. N. Datsenko, S.A. Chuguenko, O.O. Volovik The Issue of Evaluation Method and Indexes of Asphalt-Concrete Stiffness to Yield. Guide of Ukraine. - 2008, №3, p.28 - 30.
15. V.O. Zolotarev Problems of Asphalt-Concrete Stiffness to Yield Require Detailed Consolidate Researches. Guide of Ukraine. - 2008, №5, p.26 - 28.

16. V.A. Verenko. Deformation and Fracture of Road Coating, Causes and Ways of Elimination. Minsk. - 2008. 304 p.

17. STO – GK "Transstroy" 007-2007. Asphalt-Concrete. Method of Evaluating of Resistance to Rutting Ductility. M.: 2007.

18. G.N. Kiryuhin Yield Stiffness Stone-Mastic Asphalt-Concrete. Highways. - 2007, №7, p.13 - 17.
19. A.N. Oev, B.B. Korimov, Crushed Stone-Mastic Asphalt-Concrete for Thin-Film Coatings. Science and Technology in Road Branch. 2006, №2, p.26-25.
20. JTG Richardson. Stone mastic asphalt in UK.// Symposium on stone VMastic Asphalt and Thin Surfacings. London. 19 June 1997.
21. Roadbond Prospects for Use in Russia. Highways. - 1997, №9.
22. Technology of Production of the Product with «Roadbond» stabilizer in Road Construction. Design technology Company. – M. 1996.
23. V.G. Yumashev, S.G. Fursov, V.S. Isiev Adaptabilities of Application of Stabilizers offered by Foreign Companies. Highways. - 1994, №3 - 4.

24. V.V. Enishkin Application of soil stabilizers. Highways. - 1995, №7 - 8.
25. S.A. Reitlinger Transmissibility of Polymeric Materials. Micro Chemistry. 1974. p.270.