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Stone Mastic Asphalt and Stabilizing Additives for its Production

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Abstract: The study provides detailed information on the existing features of stabilizing additives for the production of stone mastic asphalt mixes, the introduction of which prevents runoff and immixing binder during transport and installation. The mechanism of the influence of traditional stabilizing additives on the stability of the mixtures and the possibility of replacing them with structuring additives from local raw materials that will reduce the cost of SMA and increase their life.

Key words: Granulation, cellulose fiber, stone mastic asphalt, stabilizing additive, raw material

INTRODUCTION

Macadam-Mastic Asphalt (MMA, Fig. 1) a material that is designed specifically for the device upper coating layers on roads with high traffic volume. Stone mastic asphalt mixture appeared as a consequence of fighting traffic services in Germany with intense destruction and pavement rutting due to the growth of heavy traffic and heavy vehicles as well as mass use by motorists tires with metal studs in the winter operation of vehicles.

In recent years, the proportion of applications stone mastic asphalt mixes for the device of the upper layers of road surfaces with a rough surface has been steadily increasing. Currently, MMA is used as topcoat on the roads, airports, bridges and river ports in countries such as the USA, South Africa, China, Finland, Norway, Sweden, France, Germany, Russia and others (Stebakov *et al*., 2002; Ulmgren and Dimov, 2003; Arutyunov *et al*., 2002). Roads Russian stone mastic asphalt mixture began to use in 2000 (Arutyunov *et al*., 2002).

Operating experience and studies show that the main operational and functional advantages of coatings stone mastic asphalt compared with coatings of conventional asphalt are:

- High resistance to rutting
- Reduce the risk of hydroplaning and splashing
- Durability of the pavement
- Skid resistance and noise reduction
- Rough surface and good adhesion to the wheel of a car
- Sdvigoustoychivost at high summer temperatures of operation

Fig. 1: Photo coverage of the mastic asphalt macadam

- High wear resistance including the effect of studded tires
- Waterproof
- Fracture at strains of the coating and mechanical effect vehicles

Stone mastic asphalt concrete coatings are characterized comfortable and safe driving qualities and their texture is different roughness and the ability to absorb noise when driving. Rigid skeletal structure of rubble causes excellent resistance layer plastic shear deformations and the presence of large amounts of bitumen makes MMA more durable material.

STABILIZING ADDITIVES

Specificity of the composition and structure stone mastic asphalt provides for mandatory presence as the main structural components of durable rubble with cuboid shape of grains, “volume” of bitumen and a small amount of stabilizing (usually fiber) supplements to disperse reinforcing binder. Under the “volume” bitumen is commonly understood that part of the binder in the mixture which is not subject to the influence of long-range surface structuring forces acting on the interface.

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In accordance with the concept of MMA, the contact between individual particles of rock material must meet specific requirements, namely to achieve a stable structure must necessarily apply crushed gravel, it is desirable to form the cuboid. Furthermore, the desired surface roughness of the coating can be achieved by varying the size of the stone material. Lack of natural sand grains leads to the fact that under the influence of external loads mineral grains do not move, filling the pore space as is the layer of asphalt type A broken (Stebakov *et al*., 2002).

For a better seal and reduce the probability of failure on each grain gravel mineral grains need to create a thick film based bitumen. This in turn necessitates the use of large amounts of binder mixture (6.5-7.5%). To keep such a number of hot bitumen on the surface of crushed stone, you need the mandatory presence of a mixture of special stabilizing additives such as fibers (Fig. 2) (Stebakov *et al*., 2002; Ulmgren and Dimov, 2003).

Unlike traditional asphalt with a dense multi-level structure, stone mastic asphalt has a frame-slot structure, through which has a range of high performance coatings.

Preparation of MMA possible on standard equipment for the production of hot-mix asphalt but the production and asphalting have some specific features. First of all, in the preparation of MMA is very important to maintain its grain structure. An increase in the average particle size leads to what is created closed skeletal structure. On the other hand, reducing the amount of lead to the appearance of unfilled voids in the mixture. It should be noted that the MMA is very sensitive to a glut of mastic which may cause rutting (Efa *et al*., 2003).

Differences in grain composition of the mineral material, the amount of binder and indicators of physical and mechanical properties governed by the requirements of different countries, due to different climatic conditions, differences in maximum permissible load on the axle vehicles and viscosity of the binder used. Normalize

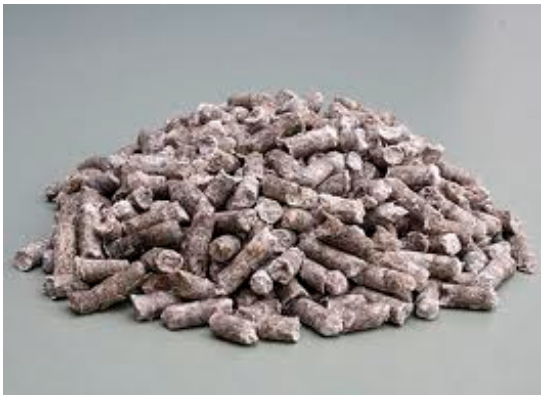

Fig. 2: Photo stabilizing additive

performance properties MMA important as there are cases rise defects on motorways with stone mastic asphalt coverings that have been associated with irregularities in mix design and production techniques of Moscow. Accordingly, this again points to the relevance of proper design and further study of asphalt mixtures by type MMA.

Most coating durability of MMA and less susceptibility to various destruction compared with alternative coatings leads to a reduction of investments even more original cost. Assuming the direct cost of materials, the production of MMA tons of production per ton more expensive conventional asphalt at 30-35%. This is due to the fact that MMA is used for the manufacture of more bitumen, stone material of better quality as well as a stabilizer. However, if we consider not only the production process but also laying and durability stacked layer in general it turns out that the use of MMA is economically justified on the following factors (Stebakov *et al*., 2002; Smirnov, 2005):

- MMA typically contains a thinner layer than conventional asphalt concrete. Where required laying asphalt concrete layer thickness of 35-50 mm, MMA can be placed 25-35 mm thickness which reduces the amount of material per 1 m^2 to 40%. Thus, the cost of 1 m^2 laid asphalt concrete layer type A becomes equal to the value of stacked layers of MMA
- Durability of MMA pavement superior life of the coating of asphalt at 2-3
- Cost of the top layer of pavement made of MMA, 2 times lower than the cost of the service layer made of asphalt from for greater resistance to rutting, less susceptibility to cracking and greater deformability

The main difference between high-quality pavements based on stone mastic asphalt is the presence of stabilizing additive composition based fibers.

Empirically, it has been found that the best stabilizing effect have specially prepared natural cellulosic fibers. Initially used as a stabilizer in the so-called loose cellulosic fibers cut in a special way and feathered. However, after the transition to mass production of MMA are increasingly began to show certain defects mixture. This segregation of the mixture and the appearance of bitumen spots of various sizes on the newly laid road surface directly into the compaction process. Following further investigations, it was found that despite the excellent stabilizing effect, availability fibers have serious drawbacks:

- More hygroscopic: cellulosic fibers like wool perfectly absorbs moisture from the surrounding area, making it impossible to further use
- Loose fibers hamper distribution in the mixer
- Tendency to clump together which makes dosing and further distribution in the mixer
- High probability of erosion when loose fibers are released to the blender in the superheated mineral material (190-200°C) is primarily burning occurs intermolecular OH-bridges molecule which binds to cellulose molecules and bituminous binder material (Efa *et al*., 2003)

Further, evolutionary development of the family has been the emergence of granular stabilizer additives. Granular stabilizer is convenient for transportation and direct injection into the MMA on the point of use. There are three types of granular additives: granules consisting of pure cellulose, pellets with the addition of wax (wax, stearin) to reduce the hygroscopicity of the granules and in which each fiber is cellulosic bituminous coating. Last eliminates moisture saturation of the cellulose fibers which provides a simple and reliable dosing system, perfect distribution in the mixer without increasing the time of mixing dry and as a result a stable mixture. In addition, the presence of bitumen coating prevents burning fibers when applied to a hot stone material.

Global and domestic market are stabilizing additives of different types and manufacturers. Below are details of the most commonly used additives (Kiryukhin and Smirnov, 2009; Kostin, 2009).

Stabilizing additive TOPCEL a granular material, comprising basically cellulose fibers, 95 and 5% of wax granules wraps. High cellulose content in the granules determines its low content in the composition of MMA only 0.28-0.32%. This is one of the most significant differences of stabilizing additive to many other (Kiryukhin and Smirnov, 2009). Presence of paraffin pellets TOPCEL no cause for concern: in SMA used in bitumen wax content not less but in a mixture of asphalt content of SMA 6-7% and additives on average 0.3%. Thus, the presence of additives in SMA TOPCEL increases paraffin content of the mixture of only 0.01% which cannot have a negative impact on the quality of MMA.

Besides performance cellulose additive TOPCEL characterized by the following indicators:

- Resistance when heated to a temperature of 250°C
- Physiological and toxicological safety applications
- Simple and reliable isolation of cellulose fibers of pellets
- Portability and quality of the product for automatic dosing
- Absence of caking during storage

On the world market in manufacturing practices stone mastic asphalt binder proposed stabilizer called «VIATOP». It is produced mainly in Germany and the pellet is impregnated by bitumen exclusive wood pulp. Application of the bituminous coating cellulosic fibers provides a good disintegrating of the granules excludes them caking during prolonged storage.

Such granular material properties significantly simplify the requirements of the dosing system, improve the uniformity of distribution of the granules in the mixer without increasing the time of dry blending. The presence of bitumen coating prevents burning of cellulose fibers in contact with the hot stone material.

A family of supplements VIATOP includes several kinds of stabilizers differing in the percentage of bitumen/cellulose (bitumen content in the pellets from 34-10%). In addition of "VIATOP superior" granules processed bitumen having in its composition a special modifier. Availability additives with different characteristics provides the user with a choice of the optimal variant used stabilizer depending on experience and manufacturing conditions of MMA mixture and thereby ensure stable production and quality mixture (Kostin, 2009).

Application of granular additives having the greatest amount of bitumen (VIATOP 66) requires the least cost technology in the production of MMA mixture (mainly questions dosing) and recommended for beginners contractors having minimum experience in the production of MMA. Contractors who have enough experience in the production of MMA mixture having in producing reliable dispensing systems and large amounts of work can effectively use pellets VIATOP Premium with a minimum content of bitumen as the most economical option. When preparing the additive amount of MMA in the stabilizer mixture is 66 VIATOP to 0.45% excess of mineral and VIATOP Premium 0.3%. Granules, modified bitumen processed, intended for use in regions with hot climates.

«GENICEL» is a granular supplement manufactured from fibers TECHNOCEL and a new asphalt additive SASOBIT for flexible production of asphalt to be modified directly in the mixing plant. Granulation fiber ensures rapid and homogeneous distribution of the additive in the bituminous mixture. Simultaneously, the fiber phase is stabilized bitumen solution and improves the properties of the asphalt. Storage in large bags or small barrels in dry indoors guarantees the possibility of immediate

application and selection of the desired composition of the mixture. In preparing an additive mixture of GENICEL entered manually or automatically using a dispenser of the granulate immediately following dosing mineral substances in a mixer. The temperature during the mixing depends upon the viscosity MMA bituminous binder and is 130-160°C. This makes it possible to reduce the temperature of stacking the mixture.

MMA modified «GENICEL», characterized by reduced depth and rutting significantly higher resistance in the range of operating temperatures. As the technological advantages of using mixtures of the additives include: extension of the temperature and time regimes placement and compaction of mixtures, the possibility of achieving a higher density layer at the same energy costs, less dependence on the process device layer on the climatic conditions.

An alternative to wood pulp cellulose is made of bast crops in particular flax has high yields and growing ecological potential. Russian scientists have developed a new technology for stabilizing additive based herbal pulp and bitumen road grades 60/90, 90/130, 90/130.

As recommended for stabilizing additives, primarily homogeneous korotkofibernoe cellulosic fiber in which structure at least 50% of the length of fiber of 0.5-1.9 mm. Suitability others not tested fibers (acrylic, mineral, glass, rubber powder, polymers) should be supported by tests.

In Germany for example in the construction of roads in Klyuase instead of cellulose fibers were used more durable synthetic fibers. This had a positive impact on the strength of MMA. Fiber length does not exceed 6 mm.

French firm Vectra developed and implemented technologies fiberglass segments as an additive. Fiber length of about 12-60 mm (Dobrynin and Oparina, 2012).

One of the supplements domestic production is granular stabilizer Hrizotop (Dobrynin and Oparina, 2012). Supplement made from mineral fiber and has a number of significant advantages over similar products:

- High temperature resistance (up to 700°C). Fiber not burns, melts or does not lose its properties under the influence of temperature which enables the use of lower process temperature control during mixing with the heated stone material
- High strength of fibers tear gives increased strength asphalt concrete
- Ability of the fiber to fluffs finer and not deteriorate into dust improves the reinforcing properties of the additive
- Being an inorganic material, fibers are not exposed to moisture, bacteria, fungi and rodents, so no need to build special heated warehouses for storage

In 2008, the laboratory of the Federal state unitary enterprise "Russian road scientific research Institute" comparative study of standard and modified "Unirem" samples of MMA. Universal asphalt modifier "Unirem" (Pozdnyayeva and Shtromberg, 2009) is a granular composite material on the basis of active powder discrete devulcanized rubber, obtained by the method of high-temperature shift grinding of unsorted waste tires of domestic and import manufacture.

The "Unirem" modification is recommended for the production of all types of asphalt "dry method". The use of "Unirem" does not require a readjustment of the equipment and asphalt plants and/or changes of temperature-time modes of preparation of road concrete mix. The modifier "Unirem" does not require preheating and entered into the mixer asphalt mix simultaneously with bitumen or immediately after the introduction of bitumen.

Studies of the samples prepared in the laboratory showed that the introduction of "Unirem" the MMA has had a positive impact on the improvement of the standard indicators of the quality of asphalt such as compression strength at +50°C, long resistance and shear features (Pozdnyayeva and Shtromberg, 2009).

There is an opinion (Iliopolov and Mardirosova, 2005) that the most urgent thing is to use for preparation of MMA is not stabilizing additives and structuring complex additives which on one hand would contain polymer modifier with the other active stabilizing and reinforcing component. Thus, the processes of improvement of quality of bitumen and stabilization mixtures could merge which will significantly simplify the technology and reduce the cost of MMA. As such complex additives designed high-modifier stabilizer RTE (rubber thermoplastic elastomer), including polymer component, tire rubber crumb asphalt binder, surfactants and antioxidants. Designed rubber thermoplastic elastomer is effective structuring complex modifier-stabilizer for MMA, allowing:

- To stabilize the components of the mixture at the stage of preparation
- To improve the structure of bitumen
- To increase the adhesion of bitumen to the stone materials
- To increase the damping capacity of coatings from MMA

Similar is the polymer bitumen additive (Nekhoroshev and Dakhnovskaya, 2011). This

Supplement includes binder (bitumen emulsion), polymer -3-5%; amendment (fibers of cellulose) 50-75%; rubber crumb 15-20% and oil 3-5%. Developed a method of obtaining granulated stabilizing additives of fibrous hydrosilicate magnesium.

Stabilizing additive in the form of granules for macadam-mastic asphalt, presented by Dzhanazyan and Mutafyan (2006) includes organic binder and structure creators. And the organic binder choose from the group of tar, bitumen or bituminous emulsion and as an amendment use down the basement and/or Pooh spray, representing a waste of cotton production.

Russian researchers have developed a way of production of MMA without further introduction, structure-forming additives type of cellulose fibres, fibre or VIATOP (Smirnov, 2004). Tests felling of laid road with this coating has shown that MMA with astringent «BITREK»® has a much longer service life than conventional asphalt.

By Yadykina and Kutsyna (2005) proposed principles of improvement of quality macadam mastic asphalt, consisting in the use of gravel and screening crushing quartz sand and fiber supplements from the waste industry which is an efficient stabilizer of bitumen. It is established that the proposed fiber, containing in its composition amide group is a chemical adsorption of bitumen, leading to the formation of stable relationships and providing the necessary rate of leaking of the bitumen. The effect of the studied stabilizing additives on the physico-mechanical characteristics of SMA which is that if the proposed fibrous material there is a significant decrease of water saturation mix, increasing strength at 200° and 50°C, water, frost and heat resistance of a composite.

It is proposed to use for the manufacture of stabilizing additives for MMA pulp and waste paper (Tobolenko *et al*., 2012). Has developed a method of grinding and cooking technologies stabilizing additives. It is established that the quality macadam-mastic asphalt concrete with presents additives not lower than the quality of asphalt concrete with the additive VIATOP and the savings from using the proposed supplements compared with the most frequently used stabilizing additive VIATOP is achieved due to the lower cost of the developed additives.

Production of the stabilizing additives which prevent the leaking of binder and stratifying mixtures at transportation and installation in many regions are still lacking which increases the cost of macadam mastic asphalt. It is therefore necessary to study the mechanism of the influence of traditional stabilizing additives on the stability of mixtures and the possibility of their replacement structuring additives from local raw materials which will reduce the cost of MMA and increase their service life.

CONCLUSION

Regardless of price indices is evident that the economic efficiency of road coverings of MMA is much higher than conventional asphalt. The service life of coatings of the MMA when properly arranged at least 3 times longer than conventional coatings. The thickness of the MMA must be a multiple of three biggest factions. International experience shows that the thickness of 4-5 cm (100 kg/m^2) is better.

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