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FEATURES OF THE PROCESS OF LOADING AND TRANSPORTATION OF HOT ASPHALT CONCRETE MIXTURE. UKRAINIAN EXPERIENCE

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Depicted in the Article are two stages of technological construction processes for asphalt concrete courses, namely: loading and transportation of asphalt concrete mix. As regards the loading, presented in the Article are two versions of discharging directly into dump body of dump truck or into storage hopper. Mentioned are the advantages of storage hopper usage, as well as the variety of such facilities and the storage time for asphalt concrete mix inside them. Described is the preparation procedure for a dump body of dump truck prior to loading (cleaning, lubrication). Explained are both the proper and improper schemes of loading, as well as the visual signs of asphalt concrete quality after discharging. Described is the right way to protect the asphalt concrete mix against cooling in dump body of dump truck, as well as the proper distance and allowed time-interval for transportation, possible problems occurring during transportation, expediency of using re-loaders for discharging the mix into the receiving hopper of asphalt paver.

Key words: bitumen binder; hot asphalt concrete mix; loading; transportation; segregation; storage hopper.

Introduction

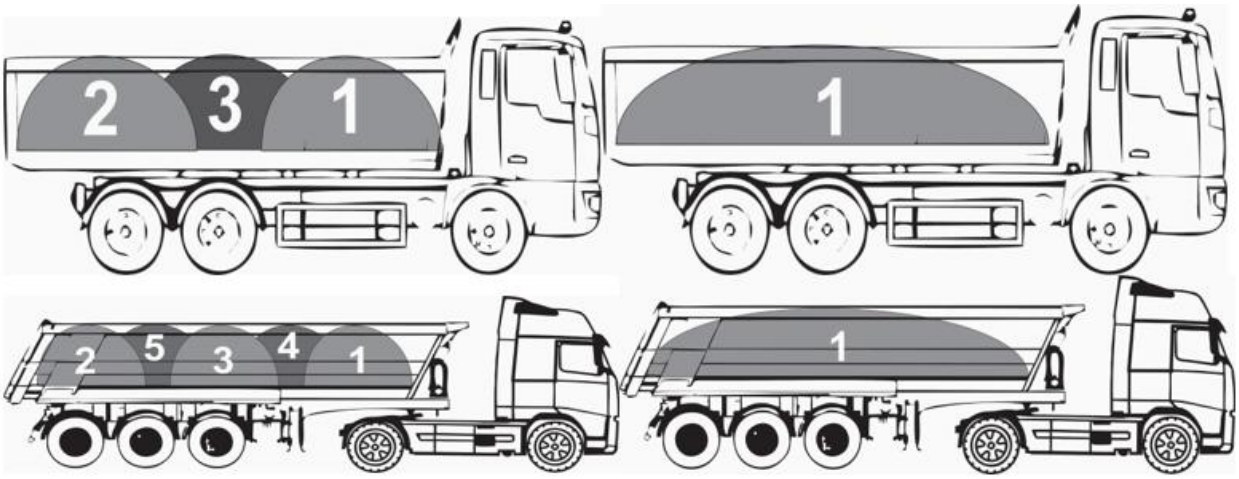
Construction of asphalt concrete courses of road structure comprises stage-wise realization of all the technological processes (both in the asphalt concrete plant and outside it) during the transportation, laying and compaction of the mix. All these stages require much attention with regard to the details and compliance with the established procedures – in order to provide for the end-product (asphalt concrete layer) quality. At present, practical and scientific research in Ukraine (Baran, 2020; Gunka; 2023; Onyshchenko, 2021; Zheltobriukh, 2023; Yunak, 2023) is mainly focused on the stages of asphalt concrete mix design, production and compaction. In turn, less attention is paid to the stages of mix loading and transportation. Still, these stages are important for ensuring the proper laying and compaction of asphalt concrete, as confirmed by foreign experience (Muhammad, 2019; Mahoney, 2000; Kim, 2018; Daniel, 2018; Dessouky, 2011; Bocci, 2020; Yildirim, 2000; Syuhada, 2019)).

Analysis of sources on the research topic

Let us first consider the stage of asphalt concrete mix loading and transportation (or storage), which starts directly after its production in blending hopper of asphalt concrete plant, which very often is named as asphalt mixing plant. After the completion of mixing the ready-for-use asphalt concrete mix is discharged into a dump body of dump truck or otherwise is supplied by means of skip-lifting into a storage hopper (thermostat hopper), while thereafter it is discharged into dump trucks. The storage hopper in asphalt concrete plant is a temporary storage facility allowing increasing the regularity of pace in plant operation, decreasing the loading time and heat losses for asphalt concrete mix in dump truck. The storage hoppers of ready-made asphalt concrete mix may have one or more sections depending upon the

output of asphalt mixing plant. The maximum storage time for asphalt concrete mix in a storage hopper shall not exceed three hours after its production.

Prior to each loading of asphalt concrete mix the surface of dump body of dump truck shall be thoroughly cleaned from any accumulated bituminous and other materials and treated by special lubricant of non-oil origin (water-soap solution, dry soap powder, wax emulsions). If on the bottom of dump body the excess lubricant is formed – it would be necessary to remove it by raising the dump body prior to loading an asphalt concrete mix. Loading of asphalt concrete mix from asphalt mixing plant or storage hopper shall be done by the following scheme: first the asphalt concrete mix is loaded into the front part of dump body, then – into the back one, and only after that – into the middle one. The mix should be loaded into the dump truck by several portions, but not by a single big one. Due to portion-wise loading, the distance, for which the coarse aggregate particles of the mix may roll-down, will be reduced, and thus, the particle-size homogeneity will be preserved. It is not recommended to load the dump truck by mix by a single stage, because it may lead to particles segregation. When being loaded by a single portion, the coarse particles are rolling-down by slopes of conic bulk-fill and take places close to the dump body sides. Both the proper and improper schemes of dump trucks loading are presented on Fig. 1.



a *b*

Fig. 1. Correct (a) and incorrect (b) schemes for loading dump trucks with asphalt concrete mixture (1–5 batches per asphalt plant)

Visual signs of satisfactory quality of hot asphalt concrete mixes: when being discharged from asphalt mixing plant the mix is shining, homogeneous, color is black, there are no dry mineral particles, as well as no obvious signs of separation (bitumen clots, chips clusters); good mobility of the mix (in dump body of dump truck the proper shape cone is formed), mix emits light blue-grey smoke.

Signs of unsatisfactory quality of hot asphalt concrete mix: the mix is dim, sometimes of brown color, non-homogeneous, some mineral particles are uncovered by bitumen, when being discharged from asphalt mixing plant the mix becomes swollen in the dump body, chips segregation is observed, mix emits thick blue-grey smoke or colorless vapor (Solodkyy, 2021).

Upon the completion of the asphalt concrete mix loading stage another stage arrives – of transportation to the laying site. At this stage the important will be the method of asphalt concrete mix transportation to the laying site, as well as the technical parameters of transportation means used for the mix carriage. Transportation of asphalt concrete mixes to the laying site is done by end-dump-body dump trucks with loading capacity of 25–35 Mt and less, equipped by exhaust-gas heating system for dump body. Truck dump bodies shall be clean, with smooth surface and equipped by waterproof tent, capable to cover safely the truck dump body, preventing the asphalt concrete mix cooling. The tent shall be made of waterproof material and tough. It shall be of such size which would provide for the end and side walls of

dump body to be closed for water entering; it shall be fitted closely to the dump body so as not to leave any gaps allowing wind to blow upon, thus weathering the mix. Besides, the tent shall be equipped by sufficient quantity of fixing points with holders – for safe fixing during the truck movement. On the top of tent the water may accumulate. Thus, upon the dump body rising for asphalt concrete mix discharging this water may enter asphalt concrete paver's hopper. Therefore, prior to asphalt concrete mix discharge the protective tent shall be removed or partly opened, thus providing for elimination of the accumulated water. The number of dump trucks or special transportation means, as well as their transportation capacity during the transportation process shall be put into correspondence with the output of both the asphalt concrete plant and the asphalt paver – to provide for the continuous asphalt concrete mix laying process.

The important issue is temperature monitoring for the mix delivered to the work-site in the trucks' dump body. Prior to asphalt concrete mix loading into the asphalt paver hopper the temperature of the mix shall be checked. When checking the asphalt concrete mix temperature the following devices are used: portable thermometers with probes 25–50 cm long for measuring temperature inside the asphalt concrete mix; remote thermometers for measuring temperature on surface. Temperature measurement is done in the spots of upper, medium and lower layers within the so-called core. The spots of the upper layer are located on the surface of asphalt concrete mix in the truck dump body. The medium layer spots are located on the depth of 20 cm from the asphalt concrete mix surface. The lower layer spots are located on the depth of 50 cm (Minakov, 2014; Onyshchenko, 2021). The average temperature of asphalt concrete mix (according to the methods presented in (Minakov, 2014; Onyshchenko, 2021). shall be not less than the temperature of the mix at the initial stage of its compaction, while the value of this parameter depends mainly upon the type of the binder used. For asphalt concrete mix production very often there are used modifying additives based on surfactants and waxes (Zolotaryov, 2002; Kishchynsky, 2017; Tetera, 2023; Pyrig, 2022; Mudrychenko, 2022). These additives are characterized by certain peculiarities of influencing asphalt concrete mixes at all the stages, including the stage of transportation. Asphalt concrete mixes with surfactants and waxes added allow increasing the time interval for transportation, laying and compaction of asphalt concrete mixes. They decrease the production temperature for asphalt concrete mixes by 15 °C and more, while it provides for the decrease of production cost and exhaust gases emissions. Besides, they extend the road season (from early spring till late autumn) and improve the temperature homogeneity of the mix, while it in turn decreases its temperature and particles segregation. According to DBN V.2.3-4:2015 Ukrainian normative document, the maximum distance for asphalt concrete mixes transportation depends upon the following conditions: within the living areas – 75 km; on motor roads with transitive type of road pavement – 110 km; on motor roads with capital-constructed and improved lightened type of road pavement – 150 km. Along with that, the transportation time for asphalt concrete mixes shall not exceed three hours. The final process in the mix transportation is its discharge into the asphalt paver which also may be done by means of re-loader. In particular, when constructing the road pavement from asphalt concrete mixes on international motor roads of the 1st category it is mandatory to use re-loader. The expediency of using re-loader on other types of motor roads is determined by feasibility study. The re-loader shall provide for the absence of mechanical contact between asphalt paver and dump truck, same as for the compulsory blending of the mix prior to supply into an asphalt paver.

When performing the re-loading of the mix, it shall be smoothly discharged into the receiving hopper of re-loader, wherefrom it is supplied by screw-feeder to the conveyor plates. The movement of the loaded mix is supported by vibration-mechanism on the bottom of hopper. The conveyor (due to high output) allows quick emptying of dump truck and feeds the material to an intermediate hopper. The space between the conveyor and hopper is tightly closed by rubber casing – so as to minimize the contact of the mix with atmosphere air. In the hopper it is mixed, as a rule, by screw-feeder with three-step flights, which are narrowed to the hopper walls. The asphalt concrete mix is intensively arriving from sides to the center of a hopper. Thus, its constant movement in whole mass is kept. Simultaneously, the mixing is done, along with homogenization of both the temperature and structure of the mix. Afterwards, the mix is supplied (by intermediate and discharging conveyors) to the asphalt paver hopper. The discharging

conveyor is capable of rotating for more than 50° in both sides, while it allows moving even by a neighboring lane.

Thus, in fact re-loader is a kind of mobile storage hopper, mixing asphalt concrete mix by means of screw-feeder of special construction – before it is supplied directly into the receiving hopper of asphalt paver. When mixing material in hopper, the re-loader homogenizes both the temperature and structure of the mix, thus eliminating the particles and temperature segregation (Illyasch, 2020).

Summarizing the review done, let us bring together (in Table) the main requirements and peculiarities of asphalt concrete mix loading and transportation.

The main requirements and peculiarities of the hot asphalt concrete mix loading and transportation

Stages	Basic requirements	Features
Loading	Dump body of transportation facility	It shall be clean, with smooth surface lubricated by corresponding substance, equipped by waterproof tent and with heating system provided
	Visual inspection of the mix	The mix is shining, homogeneous, color is black, there are no dry mineral particles, as well as no obvious signs of separation (bitumen clots, chips clusters); good mobility of the mix (in dump body of dump truck the proper shape cone is formed), mix emits light blue-grey smoke
	Temperature of the mix	The temperature of the asphalt concrete mix on the outlet from the mixer – depending upon the binder grade – shall be verified experimentally for each version of the mix designed for the specific construction conditions
	Placing the mix	The asphalt concrete mix shall be first loaded into the front part of dump body, after that – into the back part (or vice versa) and only afterwards – into the middle one
	Storage time for asphalt concrete mix in the storage hopper	Shall not exceed three hours after its production
Transportation	Temperature of the mix	After the transportation it shall be not lower than the temperature at the start of asphalt concrete mix compaction, which is determined experimentally depending upon the binder grade for every asphalt concrete mix design version in the specific construction conditions
	Time and distance	Within the living areas – 75 km; on motor roads with transitive type of road pavement – 110 km; on motor roads with capital-constructed and improved lightened type of road pavement – 150 km. The transportation time for the asphalt concrete mixes shall not exceed three hours
	Discharging	When constructing the road pavement from asphalt concrete mixes on international motor roads of the 1st category it is mandatory to use re-loader

Conclusion

Depicted are the main requirements for loading and transportation of the hot asphalt concrete mix – both the unmodified one and modified by surfactants and waxes. Mentioned are the requirements towards dump bodies of transportation means, same as the proper and improper schemes for loading and placing asphalt concrete mix in dump bodies. Reviewed are the issues of temperature parameters, storage time,

time and distance for the mix transportation, necessity of re-loaders usage when discharging the mix into the asphalt paver.

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ОСОБЛИВОСТІ ПРОЦЕСУ ЗАВАНТАЖЕННЯ ТА ТРАНСПОРТУВАННЯ ГАРЯЧОЇ АСФАЛЬТОБЕТОННОЇ СУМІШІ. УКРАЇНСЬКИЙ ДОСВІД

Сьогодні практичні та наукові дослідження в Україні зосереджені переважно на етапах підбору, виготовлення та ущільнення гарячої асфальтобетонної суміші, а етапам завантаження та транспортування суміші приділяють менше уваги. Тому в статті описано два етапи технологічних процесів влаштування асфальтобетонних шарів – завантаження та транспортування асфальтобетонної суміші з погляду набутого вітчизняного досвіду. Щодо завантаження асфальтобетонної суміші наведено два варіанти вивантаження безпосередньо у кузов автомобіля-самоскида або у бункер-накопичувач. Зазначено переваги використання бункера-накопичувача, їх різновиди та час зберігання асфальтобетонної суміші в них. Охарактеризовано процедуру підготовки кузова автомобіля-самоскида до завантаження (очищення, змащення), наведено правильну і неправильну схему завантаження та візуальні ознаки якості асфальтобетонної суміші після вивантаження в автомобіль-самоскид. Розглянуто основні параметри автосамоскидів, використовуваних на етапі транспортування асфальтобетонної суміші. Зазначено, як потрібно захищати асфальтобетонну суміш від остигання в кузові автосамоскида, відстань та дозволений час на транспортування, можливі проблеми, які виникають під час транспортування. Наведено методику контролю середньої температури в кузові автосамоскида асфальтобетонної суміші, доставленої до місця виконання робіт. Розглянуто температурні параметри, час зберігання та час і відстань транспортування суміші, необхідність використання перезавантажувачів під час вивантаження суміші в асфальтоукладач. Здійснено літературний огляд особливостей транспортування асфальтобетонних сумішей, модифікованих поверхнево-активними речовинами та восками. Основні вимоги та особливості завантаження та транспортування гарячої асфальтобетонної суміші зведено для зручності у табличну форму.

Ключові слова: бітумне в’яжуче; гаряча асфальтобетонна суміш; завантаження; транспортування; сегрегація; бункер-накопичувач.