

ASPHALT CONCRETE PRODUCTION MANAGEMENT

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The quality management approach is based on the use of objective data, and provides a rational rather than an emotional basis for decision making. If the right information is not available, the analysis of engineering test results can't take place, errors can't be identified, and so errors can't be corrected. The quality of asphalt concrete pavement depends on the quality of mineral mix materials, uniformity of composition produced asphalt concrete mix at the plant and on the ensuring required density of asphalt concrete pavement after compaction. The available practice revealed that even when modern technologies are used in production of asphalt concrete mixtures and laying the road pavement, the asphalt concrete pavement is of insufficiently high quality because the effective methods of its quality control are not applied. Recommendations as to the application of the principles of quality control of asphalt concrete pavement contained in the present work will contribute to improvement of the quality of asphalt concrete pavement. The aim of the present work is to present the process management principles for ensuring high quality of asphalt concrete pavement.

Key words: quality management, principles of quality control, modern technologies.

Introduction

Over one-half of the Lithuanian state roads are paved with hot-mix with asphalt concrete (58.97 % of the total 21345 km length) [1]. However, there is evidence that their service life is often shorter than it should be. This happens due to the following two causes:

Heavier truck axle weights, increased tire pressures and unplanned intensity of the traffic flow [2–6],

The quality and physical properties of the mineral aggregates and the quality of bitumen is inadequate to the functioning conditions of the pavement [3, 7–18].

The service life of asphalt concrete pavement of Lithuanian roads has shortened in the following way: pavement until the intermediate repair T_v – from 7 years to 5 years and pavement until the major repair T_k – from 13 years to 8 years [3, 4, 19–21]. Thus, it is necessary to eliminate the causes responsible for shortening of service life of the pavement. The elimination of the first cause is very difficult, as it requires new investments into constructing the new roads. Therefore, it is more appropriate to eliminate the second cause, i.e., to determine the optimal composition of asphalt concrete mix under certain exploitation conditions to ensure its longest possible service life. The composition of asphalt concrete mix has to be scientifically well grounded and the production of asphalt concrete mixture must strictly follow the project requirements. The projected composition of asphalt concrete mixture implies its high quality [3, 16]. Asphalt concrete of optimal composition can be produced only based on the knowledge about its functioning under certain exploitation conditions and application of effective control of technological processes. Practical experience revealed [22] that even when modern mixers and paving machines are used the asphalt concrete quality is inadequate (the mixture does not meet the project requirements and the pavement is insufficiently dense and smooth). This happens because the effective field control procedures during mix design, plant operation, laydown and compaction are rarely applied. Investigations revealed [3, 20] that the service life of asphalt concrete pavement (T_v) can be prolonged from 5 years to 8.5 – 11.0 years.

2. Causes influencing short service time of asphalt concrete

The traffic intensity and the proportion of multi-axle vehicles in the traffic flow have been recently rapidly increasing in Lithuania. The load of these vehicles on the road pavement (static and dynamic load) intensifies the deterioration of the pavement reducing its functioning time (the periods between repairs have become shortened). Investigations revealed [23] that the number of ruts on the pavement have considerably increased and continue to increase. The causes of asphalt concrete degradation in the course of time are the following:

effect of heavy multi-axle cargo vehicles is one of the factors leading to increase in premature distress,

climate factors:

a) abrupt weather cooling in winter when the cooling rate of asphalt concrete pavement $v_t^{(a)}$ reaches $v_t^{(a)} = 6 - 10^\circ\text{C/h}$, transverse cracks appear in the pavement [4],

b) frequent air temperature oscillations – fluctuations of the air temperature from positive to negative and vice versa (when the temperature t of pavement frequently passes the limit $t = 0^\circ\text{C}$. Such fluctuations occur in Lithuania 60–80 times [24]) entailing scaling of the pavement followed later by its crumbling; especially when the pavement is insufficiently dense or unresisting to erosion,

- c) solar radiation heating the pavement (on days with clear sky when the air temperature is $t > 30$ °C it heats to 60 – 70 °C) entails the following consequences:
- rapid aging of the cover as a result of intensive evaporation of volatile oil fractions from bitumen. In 3–5 years time cracks appear in the pavement,
 - noticeable reduction of the elasticity modulus of the heated asphalt concrete pavement which softens thus reducing the strength of an entire pavement – the bitumen spots may appear on the surface of the pavement (when the content of bitumen exceeds the optimum) due to greater volume of hot bitumen, which at first fills the cavities (pores) of the pavement and then strains off onto the surface,
 - reduction of resistance to shear stress resulting in appearance of ruts, waves, displacements, and sags. Marked displacement of the upper layer of asphalt concrete pavement with respect to its lower layer (insufficient cohesion) may cause cracking (transverse cracks),
 - insufficient strength of the road pavement results in formation of transverse fissures followed by breaks, what weakens the strength of an entire road construction,
 - rapid degradation of the road pavement (due to its insufficient strength). Its causes are the following:
 - a) disintegrating effect of transport vehicles (especially the heavy ones),
 - b) inadequate drainage due to the negative air temperature (when the pavement has incoherent layers composed of material with low filtration capacity – filtration coefficient is lower than 3 m/day). In such cases the water rises through the capillaries of incoherent layers closer to the surface of pavement. At negative temperatures it may freeze into ice lenses whose volume exceeds the volume of the water (before freezing) in the layers. Due to this the cover may unevenly ruck up – the swells appear followed by cracks,
 - c) shallow groundwater dampens the road-bed reducing the elasticity modulus of the ground (of clay in particular).

3. Main principles of asphalt concrete production management

With the variables of climatic factors, component materials, and traffic loadings found throughout Lithuania, it is not surprising that there are many variations of design and construction requirements. However, there are many things that enterprises can do to improve their current mix design and control procedures [25, 26]. A schematic model of interrelated types of activity on which the quality of the product in different stages depends is presented (Fig. 1). This model presents current state-of-the-art in materials, mix design, plant operation, paving, and other areas relating to quality hot-mix asphalt pavements:

asphalt concrete quality must be controlled in all stages: from the mix design throughout to the formation of its structure when constructing the pavement (Fig. 2),

the system of quality control must be optimal or at least rational – it must ensure that the total expenses and losses (design the optimal project of mix, mix production, paving, maintenance and repairing the pavement) are lowest or at least close to lowest per unit of product (1 m² or 1 km of the pavement);

the following expenses and losses are possible throughout the indicated stages:

expenses on market analysis in order to find out whether the planned product (asphalt concrete) is sufficiently in demand and to plan the necessary output,

expenses for retrieval of raw materials of adequate quality (mineral powder, other mineral aggregates, bitumen and additives), their quality inspection and designing of the optimal composition (expenses of laboratory analysis), as well as expenses on contracts ensuring the realization of high quality product,

expenses on the purchase of raw materials (materials, shipment, storage) and quality control (accordingly to requirements of the normative documentation and contracts),

expenses on the in-house training programs to ensure all personnel possess the required skills to do their jobs (operators, field inspectors, technicians, quality inspection experts, laboratory assistants, etc.),

expenses on plant inspection (monitoring the bitumen metering system, feed belts, moisture, plant temperature, etc.). Nothing goes to the road until mix properties are acceptable and the mix is under control,

expenses on delivery of the mix to the road (object of building the asphalt concrete cover),

expenses on the inspection of road-bed smoothness, compaction level and layer thickness and, if necessary, on the operations designed to achieve the necessary values (quality values must be controlled for each construction layer separately),

expenses on the monitoring of the road operation (laying and compaction) and smoothness, density and thickness inspection. If such properties are a concern, they should be rechecked and improved to achieve the necessary values,

expenses on the reception control of finished asphalt concrete pavement (smoothness, strength of the pavement, density requirements, mix composition and physical properties of asphalt concrete),

expenses on exploitation of transport vehicles (fuel, amortization, etc.). These depend on the level of deterioration of the road pavement and the average speed of traffic,

losses entailed by traffic accidents. These also depend on the state of the road cover,

expenses on maintenance and repair of the pavement. They depend on the evenness of asphalt concrete pavement which must be evaluated, the data obtained must be accumulated and systematized, the causes of insufficient road pavement quality must be determined in order to avoid them in the future (raw materials, design of mix, plant procedures, building of constituent layers).

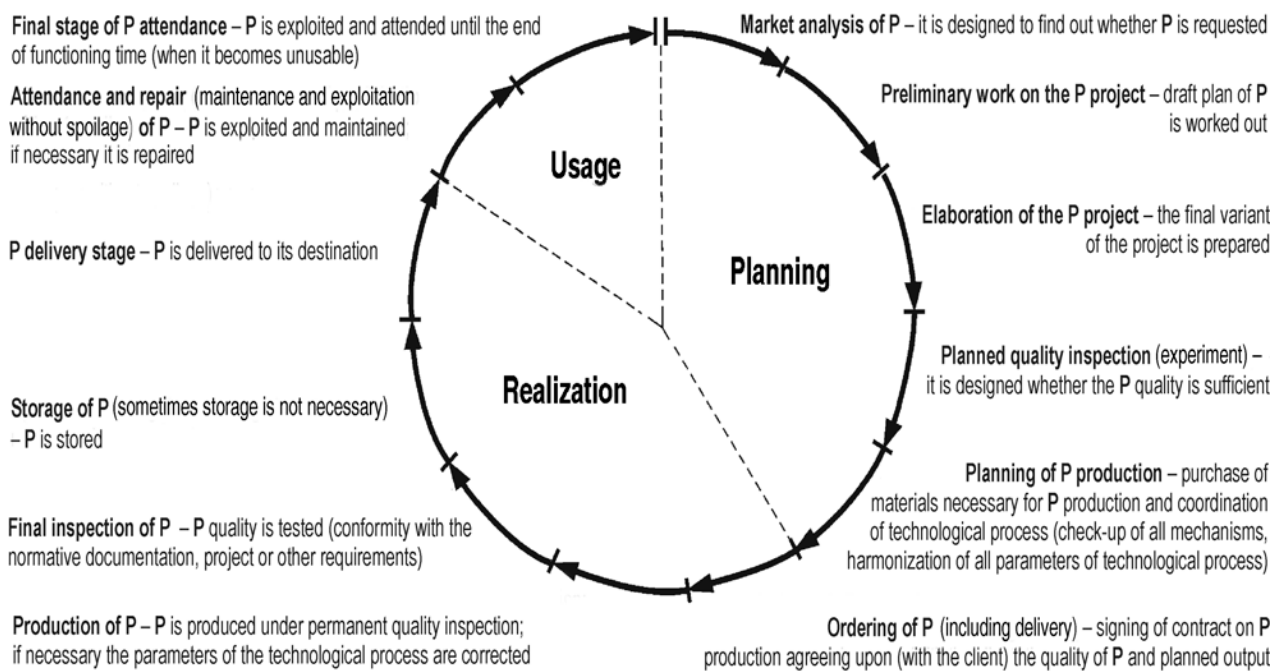


Fig.1. Quality loop (spiral) of production (product) P – schematic model of interrelated types of activity influencing the production quality in all stages from establishment of requirements to their implementation

Fig. 2. Role of asphalt concrete quality control (inspection and regulation) ensuring the proper quality indices of road cover and pavement. Structural schematic model (1 – sequence of project development operations and use of materials; 2 – sequence of operations of asphalt concrete mixture production and control measures of operation parameters; 3 – sequence of building operations of asphalt concrete cover and control measures; 4 – sequence exploitation processes of asphalt concrete cover and pavement and control measures of their status and asphalt concrete quality; 5 – sequence of decision-making on control measures)

Recommended asphalt concrete mix quality assurance system is presented in Fig. 3.

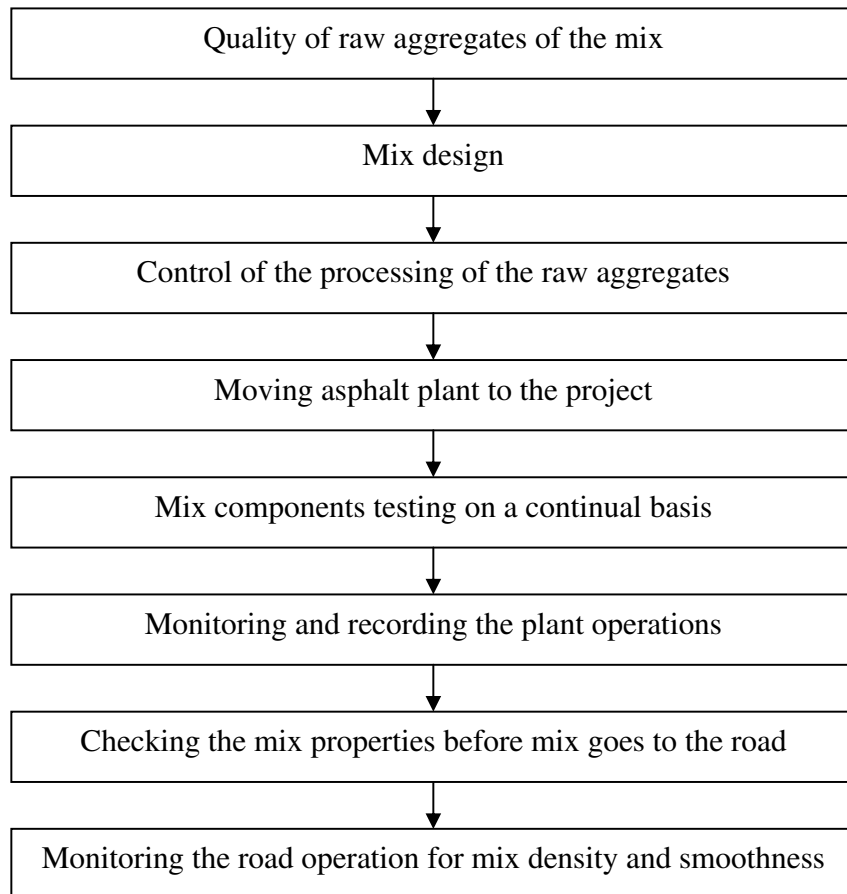


Fig. 3. Asphalt concrete mix quality assurance system

The results of asphalt concrete quality inspection may be used in improving the country standards and normative documentation related to the quality of raw material, current mix design and control procedures, plant inspection, road operation procedures and other pertinent operations.

Quality control of asphalt concrete must be optimal or at least rational. It must ensure that the expenses on mix design and production of asphalt concrete mixtures, construction of pavement, its maintenance and repair are lowest or close to lowest. Procedures to accept out-of-specification material and pavement could be established. These procedures have include definition of lot size/production time, tolerances, and pay factor reductions for raw materials, combined mixture properties, pavement density, pavement smoothness and lift thickness.

Application of the principles of quality control (demonstrated in Figs. 2 and 3) may contribute to prolonging the lifetime of acceptable functioning of asphalt concrete pavement (before the smoothness and the strength of pavement reach the limit values).

Conclusions

1. The service life of asphalt concrete pavement is usually shorter than it should be. The rates of accumulation of defects and service life of the pavement largely depend on the quality of asphalt concrete.

2. In spite of modern mixers used in asphalt concrete plants and modern paving equipment the asphalt concrete pavement is often of inadequate quality because the effective methods of its quality control are used rarely.

3. Quality control of asphalt concrete must be optimal or at least rational. It must ensure that the expenses on design and production of asphalt concrete mixtures, building asphalt concrete pavement, its maintenance and repair are lowest or close to lowest.

4. No one set of specifications can achieve good results because of the variables of environment, component materials, and traffic loadings found throughout the Lithuania. The recommended Quality Control and Quality Assurance system will contribute to improve the current mix design and field control procedures to ensure proper quality of asphalt concrete mix and pavement.

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