ISSN 1822-427X print
ISSN 1822-4288 online

THE BALTIC JOURNAL
OF ROAD AND BRIDGE ENGINEERING

http://www.bjrbe.vgtu.lt

2006, Vol I, No 3, 151–156

ASPHALT CONCRETE QUALITY ASSURANCE DURING PRODUCTION

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Abstract. The quality of asphalt concrete mix depends on the quality of mineral materials, on the quality of bitumen and additives, the uniformity of composition of asphalt concrete mix at the plant. The practice revealed that even when modern technologies are used for producing mixtures, the asphalt concrete mix is of insufficiently high quality because effective methods of its quality control are not applied. Recommendations as to the application of the principles of quality control of asphalt concrete mix during production contained in the present work will contribute to improving the quality of asphalt concrete pavement. The present work purpose was to gather information on asphalt concrete components in order to establish realistic asphalt cocrete mix components tolerances during production for ensuring a high quality product.

Keywords: asphalt concrete mixture, quality assurance, allowable limits, deviations.

1. Introduction

Over one-half of the Lithuanian state roads are paved with hot-mix with of asphalt concrete (60,09 % of the total 21 328 km length) [1]. However, there is some evidence that their serviceability is not so long than it should be. This happens due to the following two groups of causes:

1) heavier truck axle weights, increased tire pressures and unplanned intensity of the traffic flow [2–6];

2) the quality and physical properties of the mineral aggregates and the quality of bitumen is inadequate to the pavement functioning conditions [3, 7–14].

The elimination of the first group of causes is very difficult, as it requires new investments into constructing new roads. Therefore, it is more appropriate to eliminate the second group of causes, ie to determine the optimal composition of asphalt concrete mix under certain service conditions for ensuring its longest possible serviceability. 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, 12]. The asphalt concrete of an optimal composition can be produced only based on the knowledge about its functioning under certain service conditions and application of effective control of technological processes. Practical experience revealed that even when modern mixers are used the asphalt concrete quality is inadequate because the mixture does not meet the project requirements [15]. This happens because the effective field control procedures during mix design and plant operation are rarely applied.

2. Causes influencing the quality of asphalt concrete mix during production

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 cannot be performed, errors cannot be identified and corrected. With the variables of climatic factors, component materials, and traffic loadings found throughout Lithuania, it is not suprising 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 to control procedures [16–20]. For quality assurance to keep progressing, highway building enterprises and contractors might examine several concepts and principles needed to produce and implement sound and effective quality assurance system. A schematic model of interrelated types of activity on which the quality of the product in different stages depends is presented in Fig 1. This model shows a 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

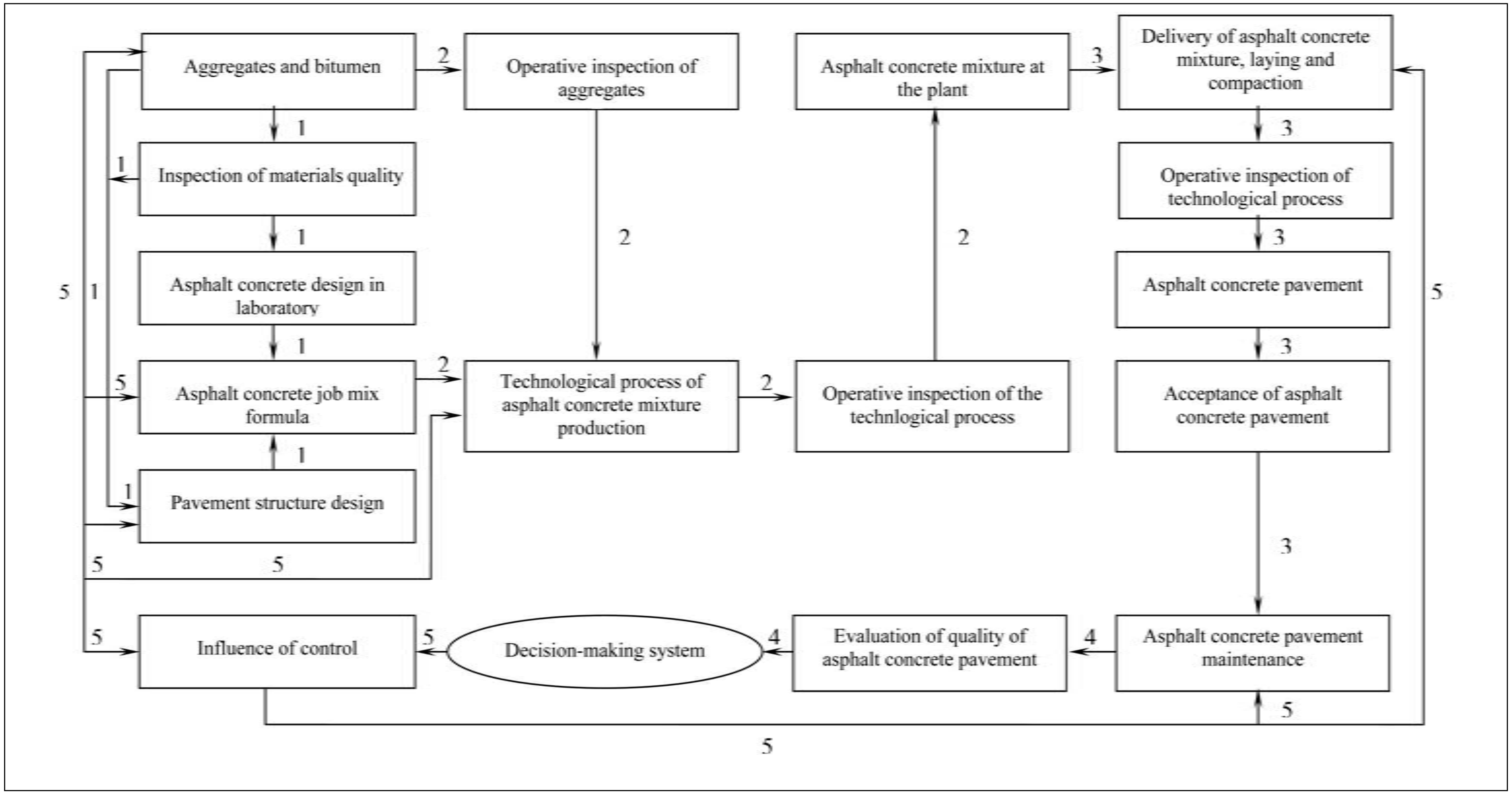

Fig 1. Role of asphalt concrete quality control (inspection and regulation) ensuring the proper quality parameters of road pavement. Structural schematic model (1 – sequence of project development operations and use of materials; 2 – sequence of operations of asphalt concrete mixture production and control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

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

The results of asphalt concrete quality inspection may be used for 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.

Application of the principles of quality control (Figs 1, 2) may contribute to prolonging the serviceability of asphalt concrete pavement.

3. Practical implementation of quality control of asphalt concrete mix during production

The asphalt mix shall be composed of a mixture of uniformly graded aggregate and specified type and grade of bituminous material. The composition table for the type of asphalt concrete mix under contract specifies the limits within which the Job Mix Formula (JMF) will be set by the Laboratory after examination of the materials the Contractor proposes to use. Should the Contractor propose to change the source of the materials, a notice shall be given the Laboratory that samples may be taken and the JMF checked prior to making the change. The Laboratory will establish a JMF, which will produce a satisfactory mix and may make changes as required; no change, however, shall be made unless authorised by the Laboratory. During production, variation from the JMF, as shown by the plant inspector's analysis, of plus or minus 7,5 percent passing the 2 mm sieve, of plus or minus 2 percent passing the 0,09 mm sieve or plus or minus 0,4 percent bitumen shall be investigated and corrected by the Contractor. When requirements for mix acceptance is given to the laboratory to perform the mix quality control, the laboratory where the mix quality control tests are to be performed and the personnel performing the tests shall meet the requirements given in Table 1 [3].

Acceptance for gradation of mineral components of the mix and bitumen content will be based upon the mean of the results of all tests (5–12 tests according to the 85–98 % design reliability) performed by the plant laboratory personnel during a day's production [16]. The production

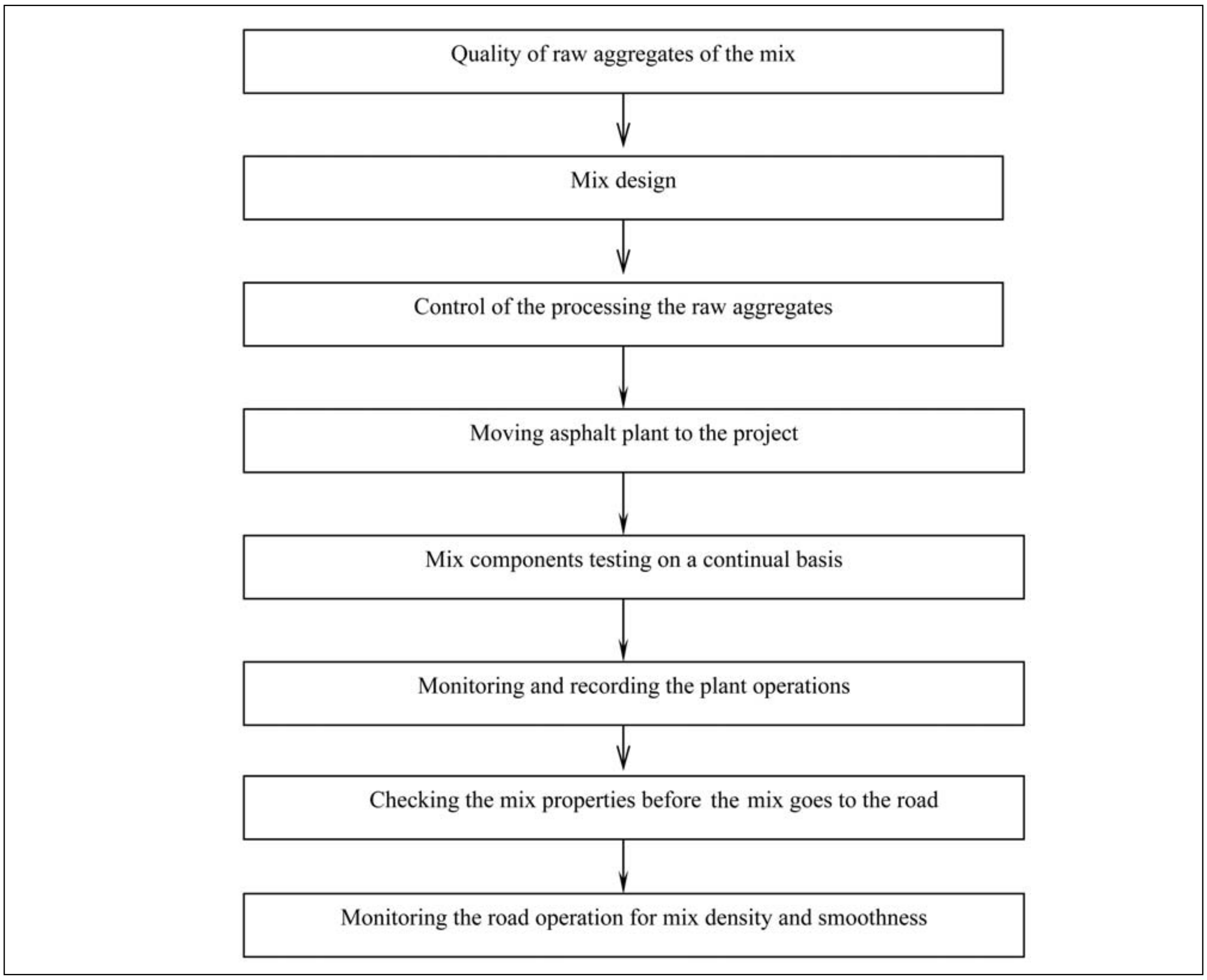

Fig 2. Asphalt concrete mix quality assurance system

Table 1. Recommended allowable limits for asphalt concrete mix composition

Mix components	Component content, % of mass			
	Ratio-nal	Allowable limits		
		Highest T_h	Lowest T_l	Range δ
Crushed stone, > 2 mm	64,0	71,5	56,5	15,0
Sand, 0,09–2 mm	24,5	34,0	15,0	19,0
Mineral filler, < 0,09 mm	11,5	13,5	9,5	4,0
Bitumen content	6,8	7,2	6,4	0,8

will be considered acceptable if the following tolerances are not exceeded and the remaining sieves do not exceed the limits of the applicable specification given in Table 2, where: δ – range of the results of all tests (adequate to interval $6\sigma_{acc}$, Δ_{acc} – allowable deviation from the value established in JMF, σ_{acc} – allowable standard deviation).

Table 2. Acceptable limits for asphalt concrete mix components in wearing course

Statistical parameter	Fractions of aggregate, mm			Bitumen content
	> 2	0,09–2	<0,09	
δ	15,00	19,00	4,00	0,80
Δ_{acc}	1,50	1,9	0,40	0,08
σ_{acc}	2,25	2,85	0,60	0,12

Values of parameters δ, Δ_{acc} and σ_{acc} should be calculated using equations:

$$\delta = T_h - T_l, \quad (1)$$

where T_h and T_l – highest and lowest component content (Table 1).

Tolerance limits around JMF could be calculated using such dependences:

$$\Delta_{acc} = \delta - 6\sigma_{acc}, \quad \sigma_{acc} = \frac{1}{6}(\delta - \Delta_{acc}) \text{ and}$$

$$\Delta_{acc} = Z_p \times \sigma_{acc}, \quad (2)$$

where Z_p is defined from the normal distribution curve tables ($Z_p = 0,674$).

A variation from the JMF exceeding these tolerances shall be a sufficient cause for the laboratory to order production discontinued until the cause of the variation is corrected. If a single asphalt binder content is more than ±0,5 % beyond the JMF, immediately take and test an additional sample. If two consecutive asphalt binder content tests are more than ±0,5 % beyond the JMF, notify the Monitoring Team and cease production until the problem is corrected. If the range difference in any three consecutive asphalt binder content tests is greater than 0,8 % (for wearing course mix) immediately notify the Monitoring Team. If the range difference in any three consecutive gradation tests for the 2 mm sieve is greater than 15,0 %, immediately notify the Monitoring Team. Range is defined as the difference between the largest and the smallest acceptance test result within an acceptance period (production day or lot). For asphalt concrete mix uniformity control it is very convenient to use warning limits, recommended in Table 3.

Table 3. Warning band limits for asphalt concrete mix components in wearing course

Mix component	Specification limits	Warning band limits (2,0 σ_{acc})
Asphalt content	–0,4 % to 0,4 %	–0,24 % to 0,24 %
2 mm sieve	–7,5 % to 7,5 %	–4,5 % to 4,5 %
90 μm sieve	–2,0 % to 2,0 %	–1,2 % to 1,2 %

It is necessary to record consequently all test results. Documentation of all decisions regarding responses to test results referring to the particular test, including reasons why a particular problem may exist, how the problem was evaluated, what action was taken to correct the problem (plant operation or testing), is necessary as well. The previous research performed in Lithuania had indicated that composition of asphalt concrete top course for its functional time T ≥ 11 years, when cyclic load is applied, should be following: crushed stone (> 2 mm) – 64–65 %, mineral filler (< 0,09 mm) – 11,5–12,0 % and bitumen content – 6,7–6,9 % [13]. Investigations performed later showed that the most reliable functional time for asphalt concrete top course should be $T \geq 8,5$ years, and composition of asphalt concrete top course in this situation should be within allowable limits given in Table 1.

Investigations of the most modern plants in Lithuania (type Beninghoven, Amman) have indicated that only about 15 % plants in Lithuania are able to produce a very uniform asphalt concrete mix where statistical parameters Δ and σ are better than in other plants in Lithuania. Such values Δ and σ are shown in Table 4. Results of investigations indicated that quality of asphalt concrete mix could be improved if most up to date batch plants would be used.

Table 4. Statistical parameters for asphalt concrete mix components in wearing course, which are attained in about 15 % highest quality asphalt plants in Lithuania [20]

Statistical parameter	Fractions of aggregate, mm			Bitumen content
	> 2	0,09–2	<0,09	
Δ	1,50	1,50	0,15	0,07
σ	2,00	2,00	0,20	0,10

4. Conclusions

1. The service life of asphalt concrete pavement is ususally 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. Once a rational asphalt concrete mix is selected, there should be as little deviations as possible from this aggregate gradation and asphalt content, to minimise the necessity for making adjustments in the placement operations.

2. No one set of specifications can achieve good results because of the variables of environment, component materials, and traffic loadings found throughout Lithuania. The recommended Quality Control and Quality Assurance system will contribute to improve the current mix design and field control procedures to ensure a proper quality of asphalt concrete mix and pavement. Recommended tolerances would minimise the acceptance of poor material and rejection of good material. It would ensure a practical control procedure for asphalt concrete plant production.

3. The results of investigations show that a sufficient quality of asphalt concrete mix could be attained only in about 15 % of the most modern asphalt plants in Lithuania.

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Submitted 19 June 2006; accepted 12 September 2006