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Quality Control of Hot Mix Asphalt Review

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Abstract

Several roads in world uses asphalt road, Hot mix asphalt technology which is a very conventional method for road construction and has structurally satisfied the performance requirements over many years. Performance wise this has been the most suitable for pavement structures, but their high use have several drawbacks like environmental degradation, high energy consumption, increase in carbon footprint, low output for mix production, low laying work in rains and cold weather, limited construction period in a year, oxidative hardening of binder, health and safety hazard to labour. The present situation with respect to HMA design and quality management has resulted in several instances of poor quality asphalt being placed on the road network. In many cases the poorer qualities have arisen due to variations in the mix which are difficult to rectify without implementing proper quality control and quality assurance systems. The poor quality of the hot mix asphalt leads to the failures of pavement like the rutting, fatigue and stripping of the bituminous layer. In order to reduce these effects by quality control and quality assurance. Also recommendations should be made to implement "Pay Factors" in order to encourage continuous improvements of the quality of HMA.

From the calculations it has shown (i,e Deacon et al 2001) that a "bonus" of up to 20% can easily be justified for good quality asphalt because of its better performance. Quality of the HMA can be maintained by strict supervision in the manufacturing/ batching plant.

Keywords: Hot mix asphalt, Bituminous pavements, Pay Factors, Quality control and Performance testing.

Introduction

The hot mix asphalt mix industries have started to work in managing the quality of the mix to improve its performance against the failures, this process consists of many different activities in construction of high durable performance pavement. Some of the constituents that can be considered in the quality management are as follows:

- Contractor must be responsible for the manufacturing process
- Basic elements like mix design, structural design must ne inextricably linked to ensure the overall process result.
- A strict supervision at the batching plant before and after the construction should be maintained.
- Communication and cooperation between the labours and the supervisor plays a crucial role.

Other than the above mentioned the laboratory performance of the mix can be considered to increase the quality performance, one of the most impactful technique is " Intelligent compaction(IC) " which is offently used in United States in construction of HMA pavement. Intelligent compaction consists of tandem drum rollers that are equipped with technology, software and hardware that works together. This also includes GPS, accelerometer and temperature reading system.

The following flow chart can be followed to maintain the assurance of the HM:

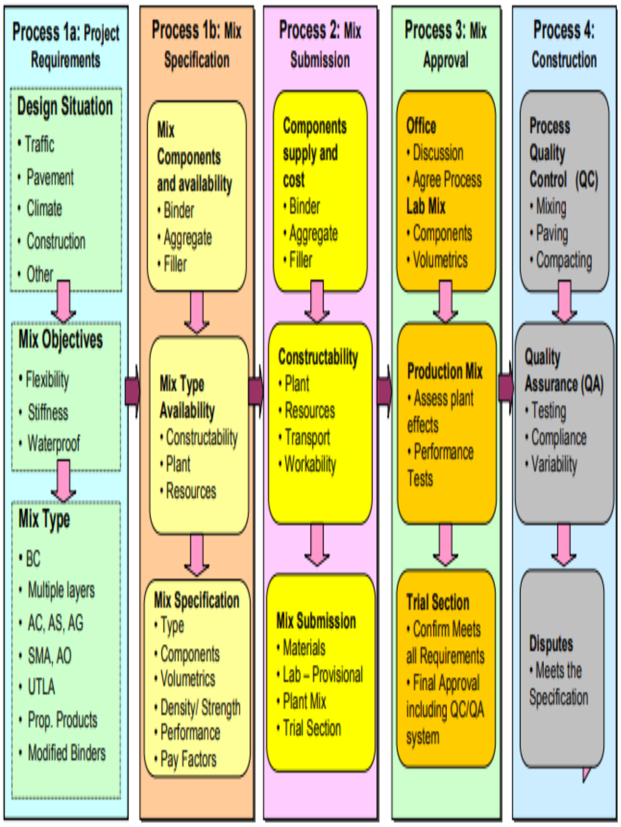


Fig.1: Chart representing the steps of assurance

Objectives

1. To increase the density of the pavement.
2. To improve the durability of the pavement which is subjected to the variation in the temperature
3. To decrease the permeability.
4. To improve the resistance against the failure of pavements by rutting and fatigue.
5. To provide a skid resistance surface.

Literature review

Arthur Taute In his paper *“Hot Mix Asphalt quality control”* says it makes recommendations for increasing the minimum density specification for the various pavement layers to reduce permeability and improve fatigue. The concept of Pay Factors can be implemented with respect to density and binder content within a very short time frame to initiate improvements to HMA quality without making major changes to current specifications.

Improving quality control of hot mix asphalt paving using intelligent compaction technology TRB Paper Number: 12-0916 a paper by Robert D. Horan, P.E and George K. Chang Decrease variability in pavement density by improving the consistency of roller patterns during the HMA compaction operation by training the roller operator to use the on-board color-coded display

“Quality control and quality assurance of Hot mix asphalt construction in Delaware” by Radha Akkinepally and Dr. Nii Attoh-Okine Department of Civil and Environmental Engineering University of Delaware concluded that the density ≥ to 92%, asphalt content = ±0.4 % 100, gradation: Passing the No. 8 = ±7.0%; passing the No. 200 = ±2.0% which were in the recommended limits.

“Quality management of hot mix asphalt” by Dale S. Decker, Editor ASTM Publication Code Number (PCN): 04-012990-08 stated that Thermal conductivity values calculated from the measured thermal diffusivity values and assumed values of density (2000 kg/m^3) and specific heat (900 J/kg K) agree with the measured thermal conductivity values. 4. Thermal diffusivity values determined by the slab cooling method should be suitable for use in the adverse weather paving tool.

Laboratory test

Mix Design Preproduction Parameters and Criteria

The important parameters that are considered in design mix is the Voids in Mineral Aggregate (VMA) and Voids in the Total Mix (VTM). Minnesota's Quality Management Program suggested that VMA through can be controlled by using minimum asphalt content and by gradation controls. Air voids arc maintained by continuous testing through contractor quality control and state quality assurance. Virtually all Quality Management (QM) mix designs are performed by the contractor.

Mix design and preproduction procedures are summarized as follows:

1. Contractor submits aggregate for testing of quality.
2. Marshall mix design includes the following:
   a) Composite gradation based on the above and plotted on FHW A 0.45 power paper
   b) Extracted asphalt content of salvaged asphaltic aggregate and the extracted asphalt content of the total recycle mixture (required for Recycled Asphalt Pavement (RAP) mixtures only)
   c) Percentage of Asphalt Cement (AC) added, based upon the total weight of the mixture
   d) Mix design with a minimum of four points (at least one above and below the optimum asphalt percentage) with the maximum specific gravity at each AC content
   e) Marshall test results for the individual and average bulk specific gravity, density, height, stability and flow of at least three specimens at each AC content percent air voids (VTM) and voids in mineral aggregate (VMA) at each AC content

Production Quality Control (QC) Quality Assurance (OA) and Acceptance

Under QM, asphalt cement and contractor quality control testing are included in the price paid for the asphalt mixture as a whole. In most cases asphalt relative to aggregate has a higher cost, thus contractors will strive to design and control asphalt mixtures at the lowest possible asphalt content allowable by the specifications. This means the contractor typically controls mixture air voids primarily through adjustments of one or more of the individual aggregate components while operating in close proximity to the specified minimum asphalt content. Since adequate VMA is assured through minimum asphalt content the contractor will usually operate in close proximity to the minimum VMA. This condition results in asphalt mixtures being placed at a low cost with specification constraints to assure uniformity.

It also emphasizes the importance of proper contract administration and maintaining good QC and QA which dictate acceptance and ultimately payment for the product supplied. QC is the responsibility of the contractor. This responsibility includes:

1. Making sure his production material has been properly represented in his mix design.
2. Having qualified personnel and sufficient equipment meeting all technical certification requirements to conduct quality control testing. This includes calibration and correlation testing requirements.
3. Performing all tests in conformance with the Schedule of Materials Control for Quality Assurance.
4. Maintaining and providing quality control charts and documentation on an ongoing basis.
5. Taking appropriate action when testing shows material properties are moving toward specification limits. Shutting down when two consecutive moving average points are outside the specifications. QA is the responsibility of the Agency. The purpose of quality assurance is to assure all materials and related activities are in compliance with the specifications. Comparison samples are tested by the Agency in accordance with standard procedures and compared with the contractors' quality control tests. Contractors' tests are used for acceptance and payment only when they are verified by quality assurance comparison tests.

Guidelines for allowable differences between contractor and agency tests are used for verification and validation. Quality assurance activities include:

1. Reviewing the on-site QC records and charts for accuracy and completeness.

2. Overseeing the ongoing QC operations while in progress to minimize variance inherent in split sampling, audit sampling and comparison sample testing.

3. Monitoring contractor QC actions to assure they are in compliance with specifications.

4. Obtaining companion (split) samples, testing and verifying contractors' QC tests. Conducting additional testing when necessary to properly validate contractor QC operations (investigative and audit testing).

Test carried out to determine density

Density test:

Generally, in BRD measurements the bulk volume is determined using water displacement. The most common test method (TMH1, Method B15, 1986) involves representing the sample volume by the volume of the material plus the volume of all water contained within the material in a saturated surface dry (SSD) state. In coarser and more open graded mixes this procedure produces poor results because much of the water that fills the permeable voids during immersion drains out during surface drying resulting in a smaller bulk volume and higher BRD values. Test methods have been developed to solve this problem by wrapping the specimen in plastic wrap or coating it with wax. Recently (Botha and Semmelink 2004) it was proposed that the BRD volume be taken as the volume of aggregate plus the air within the specimen that is not displaced by water when immersed in water for 1½ minutes.

The Corelok vacuum-sealing device indicated that the device can be used to determine the bulk volumes of permeable aggregate and compacted high void HMA samples with good repeatability and reproducibility. Practitioners should recognize this problem and take appropriate actions during construction depending on the water absorption of the aggregate and the porosity of the HMA to determine applicable density values to be used. Practitioners should also recognize that in very thin layers(<25mm) the problem can be aggravated by the unevenness of the specimen surfaces overriding the actual volume measurements being made on the small quantity of material normally obtained from coring.

Fig.2: The Corelok vacuum-sealing device

Binder content:

- Binder content is calculated as the ratio of the difference between the initial mass of the HMA and the mass of the residual aggregate (after ignition) to the initial mass of the sample expressed as a percentage.
- The ignition test provides a clean aggregate sample, which can be used for gradation analysis. Several models of convection asphalt ignition ovens are in use and have given satisfactory results.
- The ignition oven has to be calibrated with laboratory mixed asphalt samples with known grading and binder content as to determine the correction factor that needs to be used when calculating the binder content and grading.
- This is necessary as some aggregate may degrade during the burning process while some modified binders may not burn off completely.

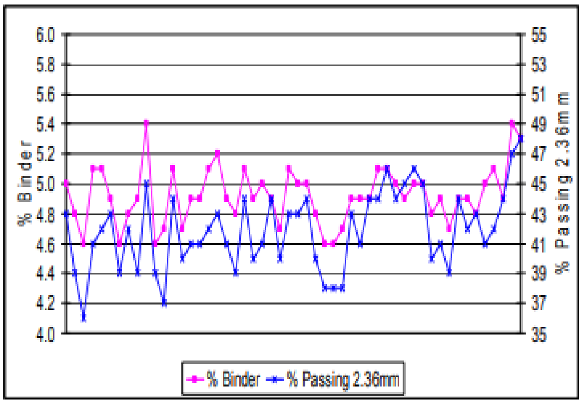


Fig.3 : graph of binder vs passing 2.36mm

Test frequency:

This suggests the process control of binder content, grading and Marshall properties. For QA the test frequency will be dictated by the statistical requirements in the specification as well as the lot size and could be higher than the QC test frequency depending on the degree of control of mix variables at the plant. Internationally the testing frequency is much lower and would be in the range of one sample every 500 ton. This is due to bigger emphasis being placed on recording of all possible process variables during the mixing process and the thicker asphalt layers that are placed. Currently there are not that many plants in the country that are capable of recording all the process variables during the mixing process and it would be sensible to re-assess the required test frequency for such asphalt plants.

Compaction test:

Compaction can be done by using modern technology called as Intelligent Compaction (IC) , it is a maturing technology in the United States that provides beneficial QC tools during construction of Hot Mix Asphalt (HMA) pavements (2). These tools offer unprecedented information and capabilities that could revolutionize the compaction industry. IC is defined as tandem drum rollers that are equipped with technology, hardware and software that work together to provide new and valuable tools to the contractor and owner/agency. The components of IC technology include Global Positioning System (GPS) technology, accelerometer-based measurement systems and temperature readings.

Control of aggregates:

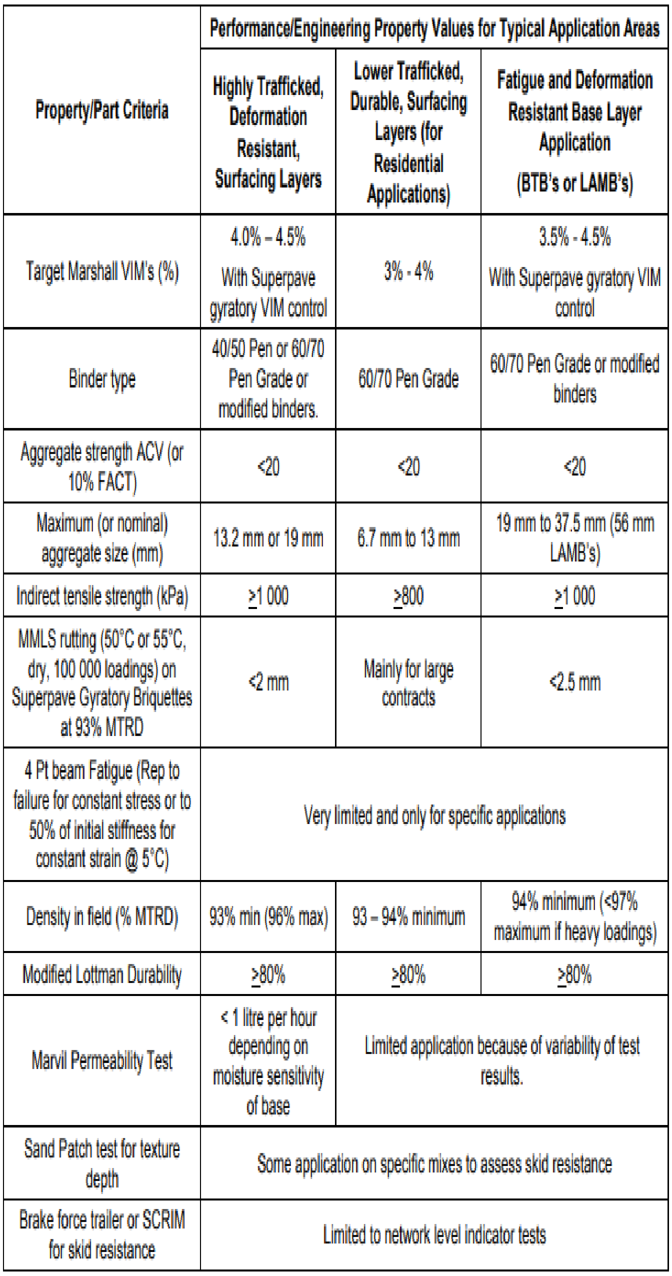
- The results show that the variation in gradation of aggregate sources can vary widely over time with a maximum SD of 9.1% being recorded for the material retained on the 4.75mm sieve within the samples of 9.5mm aggregate.
- It should be noted that the SD of the finer fractions are relatively low due to washing of these crushed dust sands and that much higher values are normally obtained on unwashed materials.
- This is an important issue that needs to be monitored carefully as excessive fines could increase the filler-binder ratio to unacceptably high values that could make the mix difficult to compact.
- The use of this mix should be considered carefully as the SD of the percentage retained on the 4.75 and 2.36 mm sieves already exceeds the allowable variation of aggregates.

Control of binder:

Penetration and R&B Softening Point tests are useful simple tests that can be used to detect contamination during transport and should be carried out on every load of binder received. In addition, these tests should also be carried out after rolling thin film oven ageing for every batch of binder received. It should be noted here that the present test for thin film rolling oven ageing is only supposed to simulate the ageing that takes place in the plant and not once the mix has been laid on the road. QA tests may also be carried out on binder at the plant if the QC testing is limited. In all cases, samples of each load of binder should be taken and stored for a minimum period of three years in order to be able to assess its properties in detail should any asphalt quality problems subsequently arise. This needs to be carefully managed to arrange the required space and control culling of older samples.

Pay factor:
This is also as "bonus-penalty" schemes sometimes this is been criticized based upon the notion that the contractor should produce work that meets the specification in any event and hence should only be penalized if this is not met and that no "bonus" should be paid for exceeding the specification.
Calculations have shown (Deacon et al 2001) that a "bonus" of up to 20% can easily be justified for good quality asphalt because of its better performance. Pay Factors have two major goals:

• To achieve more consistently better quality products that have better performance than currently being achieved.
• To encourage better construction practice and to pay compensation for investments in resources that are used to achieve this in a procurement environment that awards projects to low priced bidders.
Criteria:



Property/Part Criteria	Performance/Engineering Property Values for Typical Application Areas		
	Highly Trafficked, Deformation Resistant, Surfacing Layers	Lower Trafficked, Durable, Surfacing Layers (for Residential Applications)	Fatigue and Deformation Resistant Base Layer Application (BTB's or LAMB's)
Target Marshall VIM's (%)	4.0% – 4.5% With Superpave gyratory VIM control	3% - 4%	3.5% - 4.5% With Superpave gyratory VIM control
Binder type	40/50 Pen or 60/70 Pen Grade or modified binders.	60/70 Pen Grade	60/70 Pen Grade or modified binders
Aggregate strength ACV (or 10% FACT)	<20	<20	<20
Maximum (or nominal) aggregate size (mm)	13.2 mm or 19 mm	6.7 mm to 13 mm	19 mm to 37.5 mm (56 mm LAMB's)
Indirect tensile strength (kPa)	≥1 000	≥800	≥1 000
MMLS rutting (50°C or 55°C, dry, 100 000 loadings) on Superpave Gyratory Briquettes at 93% MTRD	<2 mm	Mainly for large contracts	<2.5 mm
4 Pt beam Fatigue (Rep to failure for constant stress or to 50% of initial stiffness for constant strain @ 5°C)	Very limited and only for specific applications		
Density in field (% MTRD)	93% min (96% max)	93 – 94% minimum	94% minimum (<97% maximum if heavy loadings)
Modified Lottman Durability	≥80%	≥80%	≥80%
Marvil Permeability Test	< 1 litre per hour depending on moisture sensitivity of base	Limited application because of variability of test results.	
Sand Patch test for texture depth	Some application on specific mixes to assess skid resistance		
Brake force trailer or SCRIM for skid resistance	Limited to network level indicator tests		

Fig3: criteria table for the calculation

Conclusion

It is suggested that consideration should be given of adjusting acceptance testing frequencies depending on the quality control plan, and the consistency of tests arising from the plan. It also discusses the concept of Pay Factors and shows that these are not very different to current systems of partial acceptance. However, in contrast to partial acceptance schemes, they provide incentives to reduce variability and improve quality. The paper proposes that these systems can be implemented with respect to density and binder content within a very short time frame to initiate improvements to HMA quality without making major changes to current specifications. The paper discusses density testing and makes recommendations for increasing the minimum density specification for the various pavement layers to reduce permeability and improve fatigue. Various test methods for performance testing are summarized and some limited recommendations for the use of these methods in quality management are made. Finally, recommendations for practical layer thicknesses are put forward to reduce the problems associated with trying to place too thin layers with too large aggregates.

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