ONTARIO ASPHALT PAVEMENT COUNCIL

CHOOSING THE RIGHT PERFORMANCE GRADED ASPHALT CEMENT IN ONTARIO

Performance Graded Asphalt Cements (PGAC or simply PG) were introduced in Ontario in 1997 as part of the Superpave implementation. After almost 20 years, it's time to look back and see what we have learned, and what has changed. The purpose of performance grading is to select an asphalt binder that performs in the local environment for the intended use. The grade of the asphalt binder contributes to the resistance to rutting (or permanent deformation) of a pavement at high temperature, the thermal cracking characteristics at low temperature, and fatigue resistance at intermediate temperatures.

Specifying the right asphalt binder is essential to achieving good pavement performance. The guiding force for the implementation of PGACs in Ontario was the Ontario Superpave Implementation Committee (OSIC), a group of Ontario agencies (municipal and provincial) and industry/user stakeholders who interpreted the Superpave binder selection criteria for use in Ontario and rationalized the criteria at the time.

BACKGROUND INFORMATION REGARDING PGACS

The PGAC system involves choosing a high temperature and a low temperature grade, which is appropriate for the local climate, and increasing (or "bumping") the high temperature properties to suit traffic conditions. In addition, changes may be necessary depending on the quantity of recycled materials used in the mix. These are performance based criteria designed to decrease rutting and reduce thermal cracking and thus improve pavement durability. Both high and low temperatures are chosen in 6-degree grade intervals where the high temperature grades start at 42°C and increase to 82°C, and low temperature grades start at -10°C and decrease to -46°C.

The high and low temperature grades are selected through the use of a software called LTPPBind. Version 3.1 of this software includes approximately 9,000 weather stations across the US and Canada. Algorithms are used to convert these air temperatures to pavement temperatures. The algorithms were developed and later refined during the Strategic Highway Research Program (SHRP) in the US and the Canadian Strategic Highway Research Program (C-SHRP), and were incorporate into the LTPPBind program. This software is meant to help highway agencies select the most suitable grade for a particular site. The program uses a 20-year average of the air temperatures at a weather station, as a basis for the statistics used to suggest the appropriate PGAC.

The high temperature is selected based on the accumulated degree days above 10°C at a site. Formerly the average 7 day high temperatures recorded at a site was used, but this was changed in 2005 to accommodate the southern US where temperatures would remain high for extended periods.

The low temperature grade is selected based on a 20-year average of the lowest air temperature recorded at a weather station as a basis for the statistics used to suggest an appropriate grade.

RELIABILITY

Selection of the appropriate performance grade (PG) depends on the environmental conditions at the site, which is determined by weather station data. LTPPBind v3.1 allows the user to choose a level of reliability in determining the PG based on the tolerance of risk on the part of the agency. For instance, selecting 50% reliability means there is a 50-50 chance in any year that the high and/or low pavement temperature will exceed those used to determine the selected grade. It is also important to note that even choosing 98% reliability does not guarantee that the pavement temperature will not fall below the low temperature selected or above the high temperature selected. Statistically, it will do so about 2% of the time, based on the weather data up to 1996 (the last database date from the weather stations).

This concept is important when considering the simplification of dividing Ontario into PGAC zones. There were and are many locations in any of the zones where the reliability will be less than 98% and may be as low as 60%, and that was recognized 20 years ago. Thus, an agency specifying the grade of asphalt binder based on the specified zone for Ontario may be adopting a higher degree of risk than anticipated.

Go to the OAPC website for maps showing the low temperature grade at 98% reliability for southern and northern Ontario.

ALLOWING FOR TRAFFIC

Grade bumping was introduced to account for high pavement temperature and heavy traffic, whereby the high temperature grade is increased by 6°C or 12°C to improve the rutting resistance. OPSS.MUNI 1101 (Nov 2016) Appendix A gives the appropriate recommendations for bumping the high temperature grade. The table also gives recommendations for additional grade bumping based on AASHTO M 320 grading requirements if issues with rutting are still apparent. An alternate specification based on the Multiple Stress – Creep Recovery procedure (AASHTO M 332) was introduced in the US in 2016 to improve the grade bumping procedure and is being adopted in the US. This procedure is implemented in OPSS.MUNI 1101 (Nov 2016) in Appendix B.

ALLOWING FOR RECYCLED ASPHALT PAVEMENT

Ontario's leadership with using recycled materials in pavements should continue with improved PGAC specifications and recycling should be encouraged. It would appear that current specifications may be limiting the use of RAP.

The grade of virgin PGAC is determined by the recycled asphalt pavement (RAP) quality and content of the mix and the design temperature required for the recycled mix. In the past, grade changes have not been required when up to a maximum of 20% RAP is used in the mix according to OPSS.MUNI 1150.

Through the experience gained in recycling, innovations have been made in the processing of RAP. RAP can be screened into various sizes (fractionation), providing producers more flexibility in meeting mix design requirements. However, based on the surface area of the RAP particles, the fine fraction of the RAP contains more asphalt cement than the coarse fraction. This fact is important when we consider the way RAP limits are specified, and when dealing with changing the grade of the virgin PGAC in the recycled mix. To ensure that the desired resultant grade for the mix is achieved, the binder replacement of the RAP must be considered.

The National Asphalt Pavement Association (NAPA) published a "Best Practices for RAP and RAS Management" in 2015 where it is recommended to specify RAP limitations based on the percentage of RAP binder in the total binder content (or binder replacement).

The permissible level of binder replacement before a change in grade and the maximum level of binder replacement are still under active discussion at the FHWA Expert Task Group on Binders (Binder ETG) and AASHTO Subcommittee on Materials (SoM). In Ontario, we have traditionally used 20% as the level of RAP where a grade change is required. However, given the concerns with using RAP, industry agrees that the level of RAP where the grade needs to be changed should be re-evaluated. Further, industry recommends that percent binder replacement methodology be implemented.

$$\text{\% BINDER REPLACEMENT} = \frac{\text{\% BINDER CONTENT OF RAP x RAP IN MIX}}{\text{\% TOTAL BINDER CONTENT OF MIX}} \text{ x 100\%}$$

TESTING PGAC

The recommendations given in the above discussion are based on testing the purchased asphalt binder according to test methods outlined in AASHTO Standard Specification M 320-10, *Performance Graded Asphalt Binder.*

ASTM International recently published ASTM D7906-14, *Standard Practice for Recovery of Asphalt from Solution Using Toluene and the Rotary Evaporator* which outlines the procedures to be used. However, the specification also warns the properties of the recovered asphalt cement may still differ from that purchased for the project due to aging, contamination, and molecular changes caused by exposure to heat and solvents. Users of ASTMD7906 are cautioned that the recovered binder properties from an asphalt mixture sample may not exactly represent the properties of the original asphalt binder due to factors outside of laboratory control and as such, recovered asphalt binder properties should not be used as a basis for acceptance.

AASHTO M 320 TESTING

AASTHO M 320 is the testing protocol developed by the SHRP and C-SHRP in the late '80s and early '90s. The method is under continuous improvement by the FHWA Expert Task Group (ETG) and AASHTO Subcommittee on Materials (SoM). The protocol involves the use of several devices to test the asphalt and two devices to thermal condition the samples to represent the aging of the binder as it goes from the storage tank at the asphalt mix plant to in service conditions in the pavement.

In Ontario additional testing is cited such as Double Edged Notch Tension Test (DENT), the Extended Bending Beam Rheometer Test (ExBBR), and % Recovery using the Multiple Stress – Creep Recovery (MSCR) test procedure.

Of these additional tests, the MSCR test procedure is considered to be the most significant evolution of the PG specification – it more accurately measures the rutting resistance of asphalt binder and uses a different system for grade bumping.

AASHTO M332 TESTING USING THE MULTIPLE STRESS – CREEP RECOVERY PROCEDURE

This testing procedure alters the test method for determining the high temperature grade as a replacement for the grade bumping convention used with M320 grading. Unlike conventional grade bumping where a higher test temperature is used to specify a material that will be stiffer at the environmental temperature, the MSCR is conducted at the environmental high temperature grade specific to the project location and requires a stiffer asphalt cement where additional rut resistance is required by traffic conditions.

Since the testing is all carried out at the environmental high temperature, it is a more accurate way of determining the rutting performance, particularly for polymer modified binders. One rationale for performing the testing at environmental temperature instead of the artificially elevated temperature required by conventional grade bumping is that polymers may be destroyed at higher temperatures and the testing does not reflect the properties of the materials in place on the road.

The Percent Recovery portion of the specification gives a reliable method of evaluating the effectiveness of the elastomers that may have been used in the modification of the asphalt cement. The benefits of elastomers in terms of pavement durability are shown in Asphalt Institute's document ER-215 *Quantification of the Effects of Polymer-Modified Asphalt for Reducing Pavement Distress*.

SAMPLING PGAC

Sampling PGAC can be difficult and may be hazardous, but it is a very important step in ensuring accurate results from testing. Only appropriately trained individuals complying with the Health and Safety protocols in place in the workplace should sample the hot asphalt binder. In addition, it is important to carry out the sampling in an approved manner. AASHTO T 40-02 (2012) and ASTM D 140M-16 both give details for sampling asphalt binder from tanks or in-line.

One critical aspect to ensure a representative sample is to ensure that sufficient material has been discharged from the sample port prior to taking the sample. Both specifications call for discharging at least 4 litres of product and discarding this before taking the sample. Sample containers should be clean, unused metal containers with triple-seal friction top.

The product will be hot and may cause burns if handled improperly. Sampling should be carried out by trained and qualified individuals equipped with the appropriate personal protection equipment.

CONCLUSIONS

Choosing the appropriate asphalt binder grade for a project is critical for pavement performance. The system of zones used in Ontario for the last 20 years will be applicable to most sites, however owner agencies are encouraged to review the appropriate grade for their location by reviewing updated weather information, and the level of reliability.

FHWA is working on a new web-based version of LTPPBind that uses MERRA data (Modern-Era Retrospective Analysis for Research and Applications) from US National Aeronautics and Space Administration (NASA). The available data will be no more than one month out of date, and will be available on a 10 km by 10 km grid for anywhere in the world.

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A Council of the Ontario Road Builders' Association