PG grade selection – Adjusting $T_{(high)}$ for traffic

AASHTO MP-1 specifies LTPPBIND software (version 2.1) for grade selection:
The most recent revision of the PG binder specification (AASHTO MP-1) references LTPPBIND software for selection of PG grades based upon climate and traffic. This software has undergone revision to reflect new air-to-pavement temperature algorithms, and to modify the traffic guidelines where adjustments to the high-temperature PG grade should be made. The binder ETG now recommends that minimum 98% reliability limits be used for all grade selections when pavement 20-year design life exceeds 300,000 ESALS. For low volume roads and temporary pavements (e.g. crossovers), the high temperature reliability can be relaxed somewhat if binder economics so dictate. The most recent version of LTPPBIND software can be downloaded from the FHWA Turner-Fairbanks website:
http://www.tfhrc.gov/pavement/ltpp/ltppbind.htm
This website also includes system details and features (**LTPPBind Product Brief**) and a PowerPoint presentation describing its use.

LTPP algorithms adjust upper PG grade for traffic ESALs and speed:
Stiffer binders can significantly reduce pavement rutting and moisture damage, particularly as traffic ESALs increase or as traffic speed decreases. Increasing one PG grade approximately doubles the binder modulus. Recent research conclusions from NCHRP 9-10 report that the mixture modulus increases by 35-50% when the binder modulus doubles. Current LTPPBIND algorithms recommend an increase in the high temperature PG grade (commonly referred to as a grade bump) when traffic severity exceeds the minimum criteria used to set PG specification limits. Specified ESALs represent an expected 20-year design life.
Bumping for ESALs: The official LTPPBIND/SHRP algorithm bumps one PG grade at 3 million ESALs, and bumps a second PG grade at 30 million ESALs.
Bumping for Traffic Speed: Slow traffic results in longer loading times and increased rutting risk. LTPPBIND/SHRP recommends bumping one PG grade for slow traffic, and bumping two grades for standing traffic.

Changes to traffic grade-selection algorithms in LTPPBIND software:
Earlier versions of LTPPBIND software (SHRPBIND) offered three alternative algorithms for traffic-defined grade adjustments. The original SHRP method bumped one PG grade at 10 MM or 30 MM ESALs, and allowed for a second grade adjustment (total of 2) only for standing traffic with 10+ MM ESALs. The LTPP method used the algorithm as mentioned in the previous paragraph. As a third alternative, the KMC method used an incremental scale which effectively added 4°C to the exact climate grade (ex. 56.6 °C + 4°C) for each decade (10 times) increase in ESALs (beginning at 100,000 ESALs), plus another 4°C for slow traffic or 9°C for standing traffic. The LTPP and KMC methods bump considerably more aggressively than the original SHRP recommendations, but should not differ from each other by more than one grade.

The current revision of LTPPBIND has eliminated the original SHRP algorithm, and now employs the former LTPP algorithm when the user selects the SHRP method. The KMC method continues to be made available as a reference. Since the newly defined SHRP method makes separate full-grade adjustments for selected climate temperature, ESALs, and traffic speed, it is possible to have three separate incremental decisions that could have a net 3-grade impact on PG selection. The KMC method adjusts ESALs to climate incrementally, and might help resolve borderline decisions.

How have these "grade bumping" algorithms been validated?

FHWA's ALF rutting study accentuates the need to adopt LTPPBIND traffic algorithms. Rut predictions from the French (PRT) rut tester, the SST Repeated-Shear Constant-Height test, and the ALF (Accelerated Loading Facility) all support the conclusion that additional binder stiffness can significantly reduce rutting under heavy, slow traffic. In fact, all three rut prediction tools suggest that the high-temperature PG should increase more than one grade (7-10°C) for each ten-fold increase in traffic ESALs (see appendix – data from FHWA-RD-99-204).

An ETG survey found that most AASHTO agencies now bump two performance grades for heavy-duty surface mixes, particularly when placed on Interstate pavements. Hence, the recommended LTPPBIND/SHRP algorithm does seem to reflect current practice. For high volume intersections, this algorithm can require a bump of three (rarely even four) PG grades. *Caution: the user agency should consult with local suppliers and contractors to confirm availability and constructability when requesting grades of PG 82 or higher. Although PG 82 is available and effective, local constraints can limit the use of such binders. As one example, air quality permits in non-attainment areas may not allow hot-mix plant temperatures to exceed 325°C, leaving little margin for effective compaction of very stiff binders.*

Can I use the new AASHTO Superpave Software to select PG binder grades?

Changes adopted in LTPPBIND software for traffic-defined grade adjustments have not yet been added to recently issued AASHTO Superpave software. AASHTO recognizes MP-1 and LTPPBIND as the official standards for PG binder implementation. The AASHTO Superpave software and AASHTO MP-2 specifications for HMAC will be modified in the future to reestablish uniform recommendations for PG grade selection.

How can I be sure I'm selecting the right binder grade?

Don't underestimate the value of previous experience, because variables other than binder stiffness, climate, and traffic also impact rutting performance in asphalt pavements. Aggregate quality matters too. Furthermore, for deeper pavement layers, structural considerations may play a more important role in binder grade selection than rutting criteria. Wherever possible, binder grade selections should be confirmed with mixture performance/proof tests that have been adapted to best predict local conditions.

On-going research!

In order to make PG specifications more relevent for modified asphalt binders, NCHRP sponsored a five-year research study. The recently published final report of Project 9-10 recommends that binders should be ranked for rutting by measuring accumulated strain in a DSR repeated shear test rather than DSR modulus (G*/sin delta). The binder ETG is reviewing these recommendations, and may propose revisions to current PG binder specifications once these new concepts have been validated. Efforts are also underway to determine whether binder performance can be more accurately tied to traffic speed and load when using these new theories.

Appendix

Table 1. French PRT - ALF Rutting Study

	AC-5 PG 58-34	AC-10 PG-58-28	AC-20 PG 64-22	Novophalt PG 76-22	Styrelf PG 82-22
G*/sin delta (kPa) RTFO; 60°C & 10 rad/s	2.096	4.202	7.897	16.58	28.504
PG Grade (°C)	59.3	65.0	70.2	79.3	88.0
Cycles to 8 mm rut	4890	5500	101,000	96,300,000	3,890,000

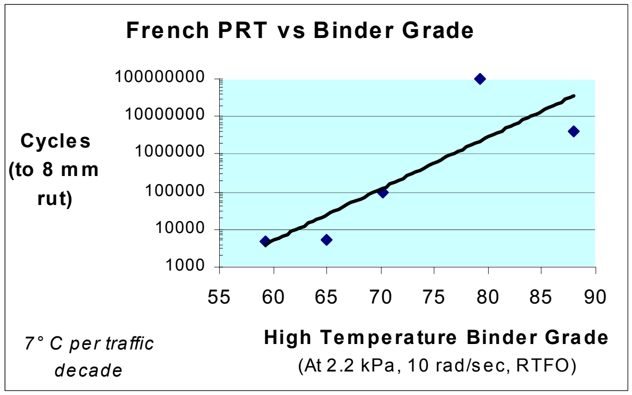

Table 2. SST RSCH – ALF Rutting Study

	AC-5	AC-10	AC-20	Novaphalt	Styrelf
	PG 58-34	PG-58-28	PG 64-22	PG 76-22	PG 82-22
PG Grade (°C)	59.3	65.0	70.2	79.3	88.0
RSCH ESALs to 12.5mm Rut @58C	2.48E+06		4.22E+06	6.53E+07	2.25E+09

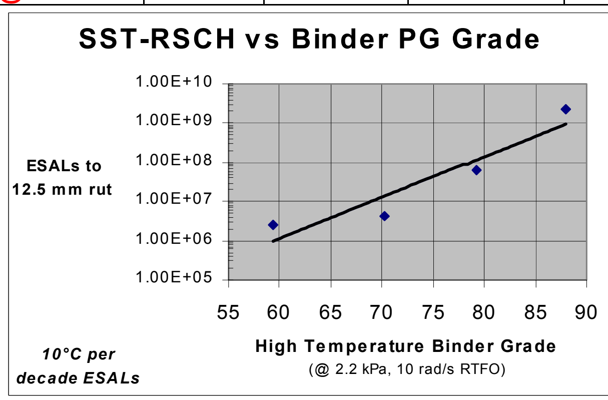

Table 3. ALF Rutting Study – ALF results

	AC-5 PG 58-34	**AC-10 PG-58-28**	**AC-20 PG 64-22**	**Novophalt PG 76-22**	**Styrelf PG 82-22**
G*/sin delta (kPa) – RTFO; 60°C & 10 rad/s	2.096	4.202	7.897	16.58	28.504
PG Grade (°C) - Corrected for actual pavement temperature	59.3	63.0	70.2	82.3	87.0
Cycles to 8 mm rut depth AC layer only	670	1900	2730	6,000,000	220,000
Cycles to 8 mm rut depth Total rut depth	480	1160	1790	39,600	23,200