Roads with flexible pavement

Construction of roads is quite a vast subject. Here, some salient areas or aspects of construction of roads with flexible pavement has been discussed briefly. Purpose is to enable one to quickly have an overall grasp on practical road construction based primarily on British and American specifications.

Unlike a rigid pavement where the load bearing layer is made up of concrete, a flexible pavement has load bearing layer made up of compacted aggregates only. Since, there are no binding materials like cement or bitumen in these layers these are sometimes termed as unbound layers as well.

A typical road formation consists of a lane or several lanes plus two shoulders on both sides plus two verges or slopes on either sides that eventually meet the ground level. While the shoulders too are sometimes sealed with bitumen, quite often they are left unsealed. They are slightly sloped outwards as per requirements.

When a section is considered through this formation we get a road section that is made up of a sub-grade plus the overlying layers. The sub-grade is earthen which is formed by either cutting existing natural ground to required levels or by filling selected earth-fill in compacted layers to the required levels.

All the overlying layers as a whole is called the pavement of a road in technical parlance. In common parlance however, a path with a hard surface, meant for the pedestrians, at the side of a road is widely called as a pavement. The discussion here is about the former one.

A common pavement usually consists of the following: a) A granular sub-base b) Aggregate base course c) Bituminous seal. The bituminous seal consists of a) Tack coat & Prime coat on top of aggregate base course b) Bituminous base course c) Bituminous wearing course.

To put it in a nutshell,
Cross-section of a flexible pavement road = sub-grade plus the overlying layers (i.e., the pavement)

Pavement = granular sub-base plus aggregate base course plus bituminous seal.

Bituminous seal = tack and prime coats plus bituminous base course plus bituminous wearing course.

The usual construction practice is to complete the road section upto the bituminous base course during construction phase. This is mainly to protect the underlying unbound layers as well as to minimise dust generation. The wearing course, if laid during the construction phase, is most likely to be damaged due to movement of heavy machinery and

hence, is laid at the end of the construction phase. Bituminous seal often conforms to local specifications as well in order to suit local environmental conditions.

The pavement structure may vary to some extent, in terms of layer thickness or number of layers etc., from place to place or project to project but the basic concept remains almost the same as discussed above.

the basic structures of flexible road pavement, road formation etc. have been discussed. In this post some more important and practically relevant matters on flexible road pavement are discussed. Construction of these pavement involve the following important aspects:

* Preparation of sub-grade level as per drawings, specifications etc.

* Material testing and delivery to the construction point.

* Blending, screening of pavement materials to meet the prescribed quality requirements as and when necessary.

* Compaction method and procedure.

* Spreading and compacting of layers.

* Tolerances for various layers such as base and sub-base courses.

* Designing of bituminous mix for bituminous seal.

* Construction of bituminous seal as per requirements.

* Preparing a trial pavement section in order to be assured that the entire operation involving all the aspects or stages is good enough and the final product is upto the expectations.

Some important quality test requirements mainly as per BS, American standards as well as some specifications in Gulf are mentioned below.

Some important pre-construction tests on materials are: a) Atterberg limits b) California Bearing Ratio or CBR c) Particle size analysis d) Flakiness index e) Abrasion loss f) Sodium sulphate (NaS04) or Magnesium sulphate (MgS04) soundness g) Sand equivalent h) Friable particles etc.

Granular sub-base: These materials consist of well graded natural gravel and sand or crushed rock. These may be naturally available or may be produced by screening and blending. AASHTO grading classifies granular sub-base

materials into 3 groups i.e., class A, class B and class C depending on percentage of sample s passing through AASHTO sieves.

Some other quality requirements for granular sub-base materials are: liquid limit (maximum 25), plasticity index (max. 6), loss by abrasion (max. 50%), CBR (min. 30%), sand equivalent (min. 25). It is also desirable that in grading analysis, the fraction passing through 75 micron sieve should not be more than two third of that passing through 425 micron sieve.

Aggregates base course: Materials for this course are also divided into 3 classes, i.e., class A, class B and class C depending on percentage of sample passing through AASHTO sieves. Some more important quality requirements for base course materials are: liquid limit (maximum 25), plasticity index (max. 6), loss by abrasion (max. 40%), CBR (min. 80%), sand equivalent (min. 30), Na or Mg soundness (max. 12% or 18% respectively), friable particles (max. 25%).

For sub-grade, tests like Modified Proctor Density, Optimum Moisture Content (OMC) etc. are important pre-construction tests. The key quality parameters to be remembered for sub-grade are: CBR value should not be less than 40% at in situ density and moisture content. Minimum in situ dry density not to be less than 95% of Modified Proctor Density at a OMC /- 2%.

When the sub-grade is to be prepared by filling rather than by cutting, selected earth-fill materials are usually used. These fill materials are laid in compacted layer as per specifications. Some of the important tests conducted on selected fill materials are: Sieve analysis, Atterberg limits, CBR, Modified Proctor test, Sulphate and Chloride content, Organic matters etc. The liquid limit and the plasticity index (PI) for selected fill should not exceed 35% and 10 respectively.

For grannular base materials the ratio of material passing through 75 micron sieve to that of 425 micron sieve should not exceed 0.66. Also, material passing 425 micron sieve needs to have minimum liquid limit of 25% and PI needs to be less than 6. Whenever the above conditions are not fulfilled suitable blending becomes necessary.

Screening is necessary to determine whether blended materials fall in the designated gradation. Same is true for aggregates base course as well. A centrally located mixing plant is quite useful for blending purpose.

The conforming materials are spread over sub-grade for compaction only after the sub-grade section is fully ready to receive the same and written approval is obtained for proceding with it. It is to be noted that tack and prime coats, which are usually made up of cut-back bitumen or bituminous emulsion, are applied on top surface of the completed sub-grade before commencing pavement work.

Like cement concrete mixes, the bituminous mixes or the the bituminous concrete used as pavement seal too need to be designed for economy as well as for best quality results. The mix design, which is also called the Job Mix Formula, for the bituminous base course is different from that of the bituminous wearing course even though the design procedure is the same. This is because certain characteristics such as the size of aggregates and some quality requirements for both the courses may be different. Here too trial mixes are conducted to arrive at the final mix proportions. Detailed procedure for asphalt mix design has not been discussed as it is a lengthy one and exact steps are not available in the notes I keep.

The salient quality requirements for coarse aggregates to be used in the bituminous base course are: Fineness Index (maximum 15%), 10% fines value (140 KN min.), Bitumen stripping (minimum 95%), Aggr. impact value (max. 30%), Water absorption (max. 2%), Mg sulphate soundness (max. 12%).

The binder content, i.e. bitumen content, in the bituminous base course is kept between 3 to 5% while designing the mix. Mineral filler, if needed to be mixed with coarse aggrgates of the bituminous base course, is usuall crusher run rock dust of suitable quality. The combined aggregates for bituminous base course including mineral filler when needed needs to fall in either of the two classes, A and B, of AASHTO particle size distribution and also should have a minimum Sand Equivalent of 45.

Bitumen to be used is defined as a petroleum derivative of penetration grade 60 to 70 conforming to AASHTO M20. The Marshall Test Procedure is often used to determine the optimum % of bitumen for the mixture.

Salient physical properties for bituminous base course as per AASHTO-T245 are: Stability (min. 12KN), Flow (2 to 4 mm), Voids in total mix (4 to 6%), Voids filled with binder (55 to 70%), Voids in aggregates (min. 14%), Residual voids in total mix after 500 blows (3%), Index of retained strength as per AASHTO-T165 (75%).

For mixing purpose, bitumen for the bituminous base course is to be heated to a temperature between 135¤C and 170¤C. The aggregates are to be dried in hot bins at a max. temperature of 170C. In case the aggregates have enough moisture in it to cause foam in the mixture, the same are to be taken back to stockpiles.

Batching plant dry mixing time not to exceed 10 seconds and wet mixing time not to exceed 50 seconds. Mixing time to be counted from the moment of introduction of bitumen to pugmill. Temperature of bitumen not to be less than 14¤C below the temp of aggregates at the time of introduction.

The temperature of the mix at the point of delvery is to be maintained between 140 to 165¤C. Degree of compaction and bulk density of base course are to be maintained or achieved as per standards of AASHTO T230 and AASHTO T166 respectively. Density of asphalt to be at least 96% of max. density value in the Job-mix Formula.

Bituminous Wearing Course: Besides being used as the topmost layer in road pavement, this layer may also be applied in bridges. The overall grading of aggregates for this course is classified into 3 classes – A, B and C. Quality of bitumen and the mix design method is same as those of asphalt base course. Asphalt binder content should be between 3.5% to 5.5%.

Physical properties for Bituminous Wearing Course (AASHTO T245): Voids in total mix (3.5% to 5.5%), Voids filled with binder (63% to 75%), Voids in aggregates (min. 15%), Residual voids in total mix after 500 blows (2%), other properties are same as that of base course (refer previous part).

Tolerances for layer-thickness, surface levels, surface irregularities etc. are usually prescribed in project specifications of the particular project.

Some of the relevant codes are:

BS-1377 (1990), Part 1 to 4 and Part 9 — General requirements and sample preparation, classification tests, chemical and electro-chemical tests, compaction related tests, in situ tests respectively)

BS 812 — Flakiness Index, 10% fines value, Aggregates Impact Value, Soundness, Moisture Content etc.)

AASHTO T104 (Na & Mg sulphate soundness), AASHTO T96 (Loss by abrasion), AASHTO T112 (Friable particles), AASHTO T176 (Sand equivalent), AASHTO T193 (CBR), AASHTO T89 & T90 (LL and PI) etc.

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