5.0 BITUMINOUS LAYERS AND MIXES (Specification 3.4 to 3.12)

Key Points

- At least 14 days in advance of a proposed material’s use, samples of the material along with laboratory test results should be submitted to the Engineer. If approved, the contractor should then carry out trial mixes.

- The surface upon which the bitumen or bituminous mixture is to be placed must be thoroughly cleaned immediately before the bitumen or mixture is placed.

- Bituminous materials should be placed only when the surface is dry, when rain does not appear imminent and when the prepared roadbed is in a satisfactory condition.

- The entire surface to be primed must be covered evenly. Prior to any spraying, the nozzles on the spray bar of the distributor should be checked to ensure that they are all working. Where appropriate the distributor should be calibrated to ensure the required rate of spray is achieved. Depending on the nature of the surface to be primed a light application of water just prior to priming may be beneficial to aid penetration of the bituminous material.

- No bituminous mixtures should be placed until the prime coat has dried.

- Tack coat may need to be applied to make the road surface sticky prior to the bituminous carpeting layer being placed.

- For Primer Seals and Bitumen Surface Treatments the aggregate must be spread and rolled into bitumen immediately after spraying, preferably rolling should be by multi-tyre rollers.
• No dense bituminous surfacing can occur until both the job mix formula and the trial sections have been approved.

• Thereafter all asphalt work is required to follow the approved Job Mix formula and the procedures established by the approved trials.

• Each day dense bituminous surfacing is laid, three Marshall specimens should be prepared and tested (STP 10.9.10.10). Samples to be collected from either the plant or the laid mat, as directed by the Engineer. Samples should also be taken each day to determine the mix composition (Extraction of bitumen test and grading, STP 10.4.72).

• All equipment proposed to be used by the Contractor requires to be in good condition and operated by competent and experienced operatives.

• Dense bituminous surfacing must be thoroughly compacted as soon as the material will support the roller without undue displacement or cracking. Excess use of water on the roller drums is to be avoid as this cools the asphalt mat.

• The surface of the mixture after compaction must be close and tight, and free from dragging cracks. Any mixture that is defective should be removed and replaced with fresh hot material, which should be compacted immediately.

• After final rolling, samples should be cut from areas of bituminous surfacing for density and thickness measurement at 50m intervals. Where samples have been taken, fresh material must be placed and thoroughly compacted.

5.1 General

Samples of all materials proposed to be use in the works, along with test results, should be received by the Engineer at least 14 days before the proposed use of materials. If the materials comply with the Specification, agreement should be given for test mixes or trials to be undertaken. Even if the
initial bitumen sample provided complies with the Specification each consignment of bitumen delivered to site must be accompanied by a certificate. This should show the place of manufacture and the results of standard tests carried out on the particular batch of bitumen.

Before any bitumen is sprayed, or bituminous mixtures are placed, the road surface requires to be inspected. Any areas of base course, which appear broken or loose should be removed. Either the full depth of the base course requires to be reworked, or a bituminous rectifying layer should be placed and thoroughly rolled until it conforms to the surrounding surface. The surface must also be cleaned immediately before any material is sprayed or placed. Bituminous materials should generally be placed only when the surface is dry and when rain does not appear imminent.

The bitumen should only be utilised at the temperature range in Table 5.1 below:

**Table 5.1**

<table>
<thead>
<tr>
<th>Spraying Temperatures For Bitumen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Cut-Backs R.C. or M.C.</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Penetration Grade Bitumen</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Emulsion: As necessary for uniform spraying and satisfactory penetration
5.2 Bituminous Prime Coat

A bituminous prime coat is a thin layer of bitumen sprayed on to a prepared road base. Either MC 30 or MC 70 cut back bitumen should be used, which should be sprayed within the temperature range included in Table 5.1. The prime coat will normally be sprayed from a spray bar at the rear of a bitumen distributor, as shown in Photo 2, at the rate given in the Contract Documents. Alternatively the rate can be directed by the Engineer.

It is important that the entire surface is uniformly covered and so prior to starting any spraying the nozzles in the spray bar need to be checked to ensure they are working. Also the spray bar should be at the correct height, h, and be parallel to the road surface see Figure 9 so that each point of the road is sprayed from three separate jets. As an alternative and only generally on small projects the contractor can propose equipment and methods (including labour intensive methods).

No further bituminous layers must be applied until the prime coat has dried, this should occur within 48 hours.

5.3 Bituminous Tack Coat

A tack coat is normally applied to make the road surface sticky prior to dense bituminous surfacing or carpeting being placed. To ensure this occurs the tack coat should therefore only be sprayed immediately before the carpeting is placed.

The tack coat will normally be applied by bitumen distributor unless labour intensive methods are agreed. The tack coat material requires to be uniformly distributed over the surface without streaking.
Figure 9. Spraying a road surface with Prime Coat

NOTE. After first side sprayed (1); second run undertaken (2). The process can be repeated as many times as required to spray the full road width.
The bitumen used should either be cut back bitumen RC 30, RC 70, or rapid setting emulsion and this should be sprayed within the temperature range given in Table 5.1.

5.4 Primer Seal

A primer seal consists of pea gravel material rolled into a cut back bitumen, which has been sprayed on to a prepared surface. The Pea gravel should be graded so that 100% of the material falls within the size range of 2.4 mm to 6.3 mm. The Pea-gravel must be free from any organic matter or clay and should be completely dust free.

The procedure to be followed is:

- Cut back bitumen is sprayed on the prepared surface
- Screened pea gravel aggregate spread to provide a dense uniform cover one stone thick.
- The aggregate to be rolled into the bitumen immediately using a rubber tyred roller for at least 4 passes before the road is opened to traffic.

5.5 Bituminous Surface Treatment

This surfacing consists of nominal single size aggregate rolled into a bitumen layer, which has been sprayed on to a prepared surface. This is often known as a single surface dressing. The procedure can be repeated using a smaller single size stone rolled into the gaps to promote a good interlock between the layers, this is known as a double surface dressing.

The aggregate requires to be hard, crushed stone or crushed gravel of uniform quality. This should be free from any dust and contain no vegetable matter and should not be flaky or
elongated (see Figure 7). The aggregate must not be used until it appears dry as water prevents bitumen adhering effectively to the aggregate.

The rates of bitumen and aggregates may be specified in the contract documents, but these are normally established from site trials. The bitumen layer will generally be sprayed using a bitumen distributor using the same method shown in Figure 9, but for small areas hand spraying equipment is used. The bitumen should generally be either RC 800 or RC 3000 cut back bitumen or rapid setting emulsion at the appropriate temperature given in Table 5.1.

Immediately after the bitumen is sprayed the aggregate should be spread uniformly using a mechanical aggregate spreader, see Photo 3. At this stage the surface requires to be inspected and further aggregate should be placed in any insufficiently covered areas by using the spreader or covering by hand methods.

Immediately after spreading, the aggregate requires to be rolled, preferably with one or more pneumatic tyred rollers. An example of a multi tyred roller is shown in Photo 4. The rolling must be continued, for as long as is necessary to ensure the aggregate is firmly embedded into the bitumen. If tyred rollers are not available steel wheeled rollers may be permitted. However, in this case the finished surface must be checked to ensure that the aggregate is not crushed and is being fully embedded into the bitumen.

5.6 Dense Bituminous Surfacing (Asphalt)

A dense Bituminous Surfacing consists of graded aggregates, including a filler, coated with bitumen. The material is laid hot and is compacted to form a dense impervious layer. The surfacing can either form the road surface or a seal coat can be laid on the asphalt.
On large contracts the bituminous materials are manufactured, transported and placed by plant (Section 5.6.3). On smaller contracts, more labour intensive methods are generally used (Section 5.6.4). In either case due to the high cost of the materials, it is vital that the works are undertaken to the specified quality. Therefore a job mix should be undertaken (Section 5.6.2) and the asphalt should be to the thickness and compaction standards as specified (Section 5.6.5).

5.6.1 Materials

Samples of materials proposed to be used with their test results have to be received by the Engineer at least 14 days before the materials’ proposed use. Full requirements for materials are given within the Specification. If the materials meet the Specification approval should be given (by the Engineer) for the contractor to manufacture job mixes. The following points, which relate to materials, should be noted when considering whether materials are acceptable:

- Crushed stone or crushed gravel should be used for the coarse aggregate, that fraction larger than 5 mm. The aggregate should be free from vegetable matter and the particles should not be soft, flaky or elongated (see Figure 7).

- The fine aggregate, that fraction smaller than 5mm, should consist of natural sand, stone screenings, or a combination of both. The aggregate should consist of clean angular particles, with the material being free from vegetable matter, soft particles and dust.

- In order to achieve the specified grading mineral filler may be required. This should be either a natural rock dust or a fine mineral matter (Portland cement or hydrated lime) and should be dry and free from lumps.
The quality of the materials needs to be regularly checked throughout the duration of the contract works. If there appears to be any deterioration the Contractor and the Engineer should be notified and samples of the materials should be taken and sent for testing.

5.6.2 Formula for Job Mix

After approval of the materials the contractor must design a job mix formula. To ensure the road surfacing performs satisfactorily the mix must be designed to have a low percentage of air voids and good fatigue behaviour. To ensure these characteristics are achieved it is vital that the proportions are established and this occurs with the production of the job mix. The formula must provide details of the mixing proportions of the various constituents, the percentage of aggregate passing each sieve size and the percentage of the bitumen which will be used.

The mix formula should also provide the methods of mixing and heating of the materials (including means of temperature control) and the means of transportation, laying and compaction. A temperature for the emptying of the mixture from the mixer, and a temperature at which the mixture is to be delivered on the road are also required.

All the above information must be provided to the Engineer who, if satisfied, will approve the job mix. After approval the Contractor is required to lay trial sections of surfacing for each formula to demonstrate that the works will be to the specified quality.

Generally no contract surfacing works may be carried out until the mix formula has been approved and the trial sections have been satisfactorily completed. However, the Engineer may allow the manufacture of asphalt to start on small contracts (this must be approved in writing) in which case, the
temperature and grading of the materials requires to be closely monitored. When a mix formula has been approved it is vital that all the asphalt conforms to the formula within the following tolerances:

Passing sieves 10 mm and larger............................± 8%
Passing sieves between 10 mm and 0.075 mm..........± 5%
Passing 0.075 mm sieve ......................................± 1%
Bitumen content (single test result) .......................± 0.50%
Bitumen content (three consecutive test results) .......± 0.40%
Temperature of mixture when emptied from mixer ......± 15°C
Temperature of mixture at delivery on road ..............± 15°C

Each day three samples of the asphalt must be taken and tested (Marshall specimens). Also the temperature when emptied from the mixer and when delivered to the road should be continuously monitored. Samples should also be taken daily and tested in accordance with STP 10.4 (Extraction of bitumen) to determine the composition and the percentage of bitumen included in the mix, as well as, gradation of the mix. When unsatisfactory results are obtained the Contractor must take immediate corrective action, if he does not, the Engineer must be informed.

The Engineer should also be informed if any changes in the materials occur and he may require a new mix formula and further trials to be undertaken.

5.6.3 Asphalt (Plant Method)

Manufacture, Transportation and Placing

The Contractor must supply sufficient qualified personnel to ensure the correct operation of the asphalt plant and the laying of the material. All the equipment proposed to be used by the Contractor requires to be in good condition and to be operated by competent and experienced operatives. The Contractor must maintain records of batch numbers and the
areas that are asphalt paved. This means if results later indicate that the asphalt did not comply with the Specification its location can be identified and if required the material can be removed.

Trucks for hauling the asphalt must have clean and smooth metal beds. The beds should be sprayed with limited amounts of soapy water, thinned fuel oil, paraffin oil, or lime solution to prevent the mixture from sticking to the beds. Each truckload should be covered with canvas, or other suitable covering, to protect the asphalt from the weather.

Self powered pavers, capable of spreading and finishing to the required cross section will normally be used, as shown in Photo 5. Photo 6 shows a truck containing asphalt backing up to the paver to deliver the material. The paver must be able to place the thickness of material required per square metre. Immediately the mixture has been spread and struck off, the surface requires to be checked and any inequalities adjusted. In irregular sections or small areas where it is impractical to use a paver, hand methods can be used, subject to the approval of the Engineer.

**Rolling**

Due to the quantity produced by asphalt plants and the requirement to achieve satisfactory compaction a number of rollers are required. The mixture must be thoroughly compacted as soon as the material will support a roller without undue displacement or cracking. Sufficient rollers should be used so as to ensure that the required degree of compaction of the asphalt mat (refer to Appendix ‘B’) is achieved before the temperature falls below 107°C.

The first rolling including all joints and edges, and the final rolling should be done with a steel wheeled tandem roller, which must be able to operate with and without vibration.
For initial rolling, the drive roll should be nearest the paver and the speed of the roller should not exceed 4 km/hr. This is illustrated by Photo 7, which shows the steel wheeled roller at the rear of the paver, with a multi tyre roller rolling previously placed asphalt. The second or intermediate rolling, should be done with pneumatic tyred rollers (PTR), see Photo 4, in this case the speed should not exceed 6 km/hr.

Rolling should generally start longitudinally at the sides and proceed toward the centre of the pavement. Successive passes of the roller should overlap by at least one half of the width of the roller and alternative passes should not stop at the same point.

The wheels of rollers must be kept properly moistened with sufficient water to prevent adhesion of the mixture to the roller. However, excess use of water is to be avoided as this will cool the asphalt mat. Also, at no time should rollers be allowed to stand on newly laid material, as the surface may deform if this is allowed to occur.

5.6.4 Asphalt (Manual Method)

For manual methods temperature control is particularly important and a thermometer should be located at each mixing unit. The temperature of the bitumen, mineral aggregates and bituminous mixture should comply with the job mix formula (if applicable), or should be within the limits stated below.

**Bitumen**

The 80/100 penetration grade bitumen normally used can be poured (albeit slowly) into a locally produced wood fired boiler. Once the boiler is approximately 30% full the wood in the firebox should be ignited.

Temperature control at the boiler is critical to prevent the bitumen being over heated (cooked). When the thermometer within the mass of bitumen reaches 150°C the firebox should
Photo 5. Asphalt Paver.

Photo 6. Truck Containing Asphalt backing up to Paver.
Photo 7. Asphalt Compacted immediately by Steel Wheeled Roller, with Multi Tyre Roller in distance.

Photo 8. Gauging Box to ensure delivery of correct volume of Aggregate for each batch.
be emptied or the fire extinguished. The residual heat within the tar boiler will continue to heat the bitumen. The temperature should be monitored and once it starts to fall and reaches 155°C the fire box should be re-ignited as the temperature will soon fall below 150°C. The heating operation should be repeated as many times as necessary to maintain the temperature in the appropriate range. With experience an operator can soon judge the amount of firewood required to achieve and maintain the specified temperatures. The temperature of the bitumen must not be allowed to exceed 163°C. Any bitumen heated above this temperature is to be discarded and the tar boiler refilled with new bitumen and the heating process started again. Such ‘cooked’ bitumen may, with the Engineer’s approval, be subsequently used to make prime coat.

Aggregate and Mixing

Gauging (measuring) boxes should be constructed for each type of aggregate. These must be to the required size to deliver for each batch the correct volume of aggregate to comply with the approved job mix. An example of a gauging box is shown in Photo 8.

The gauging boxes should be emptied into rectangular steel pans, which have handles at each corner. These pans should be heated on top of a metal frame under which heating is provided by firewood and sawdust. The aggregates should be continually raked to ensure thorough mixing and even heating. The temperature of the aggregate must reach above 163°C, after which the pan should be transferred to an unheated frame. The raking should then continue until the aggregate temperature has reduced to the maximum mixing temperature permitted (163°C).

At this stage the heated bitumen should be drawn off from the boiler, (into gauge tins) and added to the aggregate in the pan on the unheated frame. As the two ingredients are at approximately the same temperature there is no risk of fire.
The aggregate and bitumen should then be thoroughly mixed within the range of 135°C to 163°C with the temperature for each batch being recorded and later submitted by the Contractor.

**Spreading and Rolling**

When the mixing is satisfactorily completed, the pan should be carried to the adjacent work for placing. The depth of the finished surfacing can be controlled using mild steel angles as side shutters. For example, an angle of 65 × 65 mm with an uncompacted asphalt depth of 65 mm being placed, is required to achieve a compacted 50 mm surfacing depth. The cross-fall or super elevation should be controlled using 65 × 6 mm steel plate at intermediate points between the edge and the crown of the road.

In manual methods as the speed of asphalt placement is likely to be less in many cases only one roller is used. If the Contractor is using a 3.5 ton vibrating roller the initial pass should be with NO vibration. After this initial roll the side and intermediate shutters should then be moved to their next location while the roller, with vibration ON, completes the compaction process.

Trials will be required to assess the number of passes to achieve full compaction for each type of roller. Compaction is generally achieved when all roller marks have been removed. It is vital that the asphalt is rolled immediately after placing when the mat can withstand the rolling and full compaction must be achieved before the temperature drops below 107°C.

**5.6.5 Finishing, Compaction and Tolerances**

If more than one layer of asphalt is laid the longitudinal joints in successive courses should be staggered by a minimum of 250 mm, with the joint in the top course being in the centre of
the road. Transverse joints should be staggered by a minimum of 1m.

Before placing mixtures against them, all contact surfaces of kerbs, gutters, headers, manholes etc. should be given a thin uniform coating of hot bitumen. In locations where the use of rollers adjacent to these fixtures is not possible hot hand or mechanical tampers, which will give an equivalent compaction to rollers, should be used.

After final rolling full depth samples should be cut for each 50m of completed surfacing to check the density and the thickness of the layer by an approved coring machine. Where samples have been taken, fresh material must be placed, and thoroughly compacted. The density shall not be less than 97% of the marshall density and the thickness of any individual core shall not be less than the specified thickness by more than 5 mm. The average thickness of the mat shall not be less than the specified thickness.

After compaction the surface of the road should appear to be impervious and to be free from any dragging cracks or other surface blemishes. The surface should also be checked at intervals not exceeding 10 m by a 3m straight edge and a crown template. The variation between two contacts should not exceed 5 millimetres.

Any asphalt area that is defective, including any areas where petroleum products have been dropped or spilled, must be removed and replaced with fresh hot mixture. This asphalt requires to be compacted immediately and re-tested as appropriate.

Lastly, ideally sections of the newly laid surfacing should be protected from traffic until the mixture has cooled to ambient air temperature (about 6 hours). However, in many cases it will not be possible to allow all this time to elapse.
5.7 Premix Bituminous Seal Coat (Manual Method)

A seal coat consists of generally fine graded aggregates coated with bitumen. This is placed on newly laid bituminous carpeting or an existing bituminous surface, to seal the surface. However, if well graded premixes, which have been properly controlled, have been placed a seal coat may not be required.

The aggregates should consist of 6.3mm down graded clean pea gravel free from any vegetable matter. Where required to achieve the grading the aggregate should be mixed with clean natural sand, which is non-plastic, and also contains no vegetable matter.

A similar procedure to that detailed in Section 5.6 should be followed. The Contractor must initially submit samples and produce a job mix formula. Thereafter the construction should follow the methods detailed in the relevant sections above.

The completed surfacing after compaction should appear to be close and tight.