# Slurry Surfacing

### *Akzo Nobel and Slurry Surfacing*

Few companies can claim a history of involvement with the development of slurry surfacing as wide ranging as Akzo Nobel, which now incorporates the relevant businesses of Armour (Redicote emulsifiers), Thomas Swann (Catimuls emulsifiers) and Young Brothers slurry pavers. Akzo Nobel has also been involved with the development of test methods for slurry seal. Today, Akzo Nobel continues to supply slurry pavers and laboratory test equipment from a production site in Waco, Texas and supplies Redicote emulsifiers from plants in Europe and America as well as having interests in slurry contracting companies in some countries.

### *What is Slurry Surfacing?*

Slurry surfacing is a blend of fine, dense-graded aggregate mixed with asphalt emulsion, water, filler and additives which is applied in thin layers to form the wearing surface of the roadway. It is normally prepared and laid from a specially made self-propelled mix-paver but can be mixed in simple portable mixers and hand-applied.

*Slurry seal* is an asphalt-rich mixture used primarily for preventive maintenance or to correct minor defects on primary and interstate routes, urban and residential streets, airport runways and parking areas, parking lots and sidewalks. It is normally laid no thicker than 1 ½ times the top size of the aggregate, typically 3-14 mm (1/8-9/16" thick). *Microsurfacing* is based on polymer-modified asphalt emulsions, has a lower asphalt content and can be laid in relatively thick or multiple lifts to correct serious deformations such as rutting and small potholes up to 40 mm (1½ "). For that reason the aggregate skeleton must resist compaction.

| ***Slurry Seal*** | ***Microsurfacing*** |
|---|---|
| Weatherproofing (sealing) | Skid resistance on higher volume roads |
| Crack filling | Rut-filling |
| Skid resistance on low volume roads | Correct raveling/small potholes |
| Color or texture delineation | Provide good texture depth/surface drainage |
| Aesthetics - provides uniform black/colored surface | Sealing on higher volume roads |
| Surface for new road markings | Correct flushed surfaces or stripped chipseals |
| Sealing base courses | Sealing base courses |
| Pad coat for chipseal on hard surfaces | Provide wearing surface on stabilized bases |
| Stabilize surfaces showing minor raveling/fretting | |
| Regulating course under microsurfacing | |
| Tack (bond) coat under porous asphalt | |

Slurry seal and microsurfacing can be applied to new or existing blacktop surfaces (asphalt pavement), to concrete, to stabilized bases and over new or worn chipseals (capeseal). Tack coats are not normally required, except on concrete. Compaction is generally not required except for non-trafficked areas such as parking lots and airport runways.

***The Slurry Surfacing Principle***

Emulsion, water, aggregate, filler and additives are mixed in a mobile mixer to a slurry consistency, then spread over the road surface. As soon as the components mix, a process begins which leads to the eventual setting of the emulsion. The rate of this process depends on the chemistry of the aggregate and filler, the formulation of the emulsion, the type and concentration of additives and the temperature. In order to enable the slurry to spread over the road surface a minimum 'mix time' of 30-180 seconds is required, depending on the design of the machine, during which the slurry remains fluid and can be distributed over the road surface. Handwork may require a longer mix time. Once spread on the roadway the slurry gradually sets when the emulsion can no longer be separated and clear water is expelled. The seal turns from brown to black. This 'set time' is also associated with an initial development of cohesion, which can be measured (see below). Eventually the seal builds sufficient cohesion to allow rolling traffic, the so-called 'traffic time'. Most water loss occurs in 24-48 hours, although thick lifts of microsurfacing may take up to 14 days to fully cure and it may take some trafficking to reduce the voids. Because of their higher asphalt content and thinner lifts, slurry seals cure and densify more quickly.

*Slurry seal* may be formulated to be of the slow-set variety with a traffic time of 2-4 hours or quick-set with a traffic time of up to 1 hour. Slow-setting slurries are generally more tolerant of variations in conditions and require simpler equipment to lay. *Microsurfacing* is quick setting and in the best circumstances may be opened to traffic in 30 minutes or less.

***Slurry Components***

***Aggregate*** - The International Slurry Surfacing Association (ISSA) describes three aggregate gradations, Types I, II and III. Coarser gradations with a top size of 11mm have been used successfully for rut-filling and gap-graded aggregates with or without fiber additives are also well established in some countries.

***ISSA Aggregate Gradations***

| ***Type*** | ***I*** | ***II*** | ***III*** |
|---|---|---|---|
| ***Sieve Size*** | ***Percent Passing*** | | |
| *9.5 mm (3/8")* | 100 | 100 | 100 |
| *4.75 mm (No. 4)* | 100 | 90-100 | 70-90 |
| *2.36 mm (No. 8)* | 90-100 | 65-90 | 45-70 |
| *1.18 mm (No. 16)* | 65-90 | 45-70 | 28-50 |
| *600 micron (No. 30)* | 40-65 | 30-50 | 19-34 |
| *300 micron (No. 50)* | 25-42 | 18-30 | 12-25 |
| *150 micron (No. 100)* | 15-30 | 10-21 | 7-18 |
| *75 micron (No. 200)* | 10-20 | 5-15 | 5-15 |
| *Asphalt content slurry sealing %* | 10-16 | 7.5-13.5 | 6.5-12 |
| *Typical application rate kg/m²(lb/yd²)* | 3.6-5.4 (8-12) | 5.4-9.1 (12-20) | 8.2-13.6 (18-30) |
| *Asphalt content microsurfacing %* | -- | 5.5-9.5 | 5.5-9.5 |
| *Typical application rate kg/m²(lb/yd²)* | -- | 5.4-9.1 (12-20) | 8.2-13.6 (18-30) |

Types II and III gradations are used for microsurfacing and the requirements for the aggregates for microsurfacing are more demanding (see below).

| ***Slurry Seal*** | ***Microsurfacing*** |
|---|---|
| Sand equivalence >45<br>Soundness 15% max ($NaSO_4$) or 25% max ($MgSO_4$)<br>Los Angeles Abrasion Loss 35% max | Sand equivalence >65<br>Soundness 15% max ($NaSO_4$) or 25% max ($MgSO_4$)<br>Los Angeles Abrasion Loss 30% max*<br>Methylene blue value** < 10 |

*before crushing **measure of clay content

The aggregate for microsurfacing should be fully crushed material and may need to meet additional polishing values. A lower sand equivalence down to 50 minimum is accepted by some authorities and aggregates which have provided satisfactory field performance need not meet all of the above requirements.

***Mineral Filler*** - Slurries generally contain a filler such as Portland cement or hydrated lime at a level of up to 2%. The filler may modify the setting behavior of the slurry surfacing and must be included in laboratory mix designs. Slurry pavers allow the separate dosing of filler and the addition may be adjusted in the field to provide the right flow and setting characteristics to the slurry. Fibers or pigments may also be incorporated in the slurry, in which case they are generally added on the paver. Certain special binder emulsions may be already pigmented.

***Asphalt Emulsion -*** Asphalt emulsions suitable for slurry sealing are normally of the CSS-1h type but they need to be specifically tested for compatibility and reactivity with the aggregate used (see Slurry Surfacing Test Methods). The emulsions may incorporate polymer. The level of asphalt in the mix design is primarily determined by the wearing and adhesion properties of the seal.

Quicker-setting slurry seals can be formulated using cationic or anionic quickset emulsions (CQS or QS) which although slow-setting generally do not meet the cement mix requirements of the CSS and SS grades.

Asphalt emulsions suitable for *microsurfacing* must be specially formulated on the basis of laboratory evaluations. They are generally quick setting polymer-modified cationic emulsions. Polymers used include natural rubber, SBR, SBS and EVA. There may be a minimum softening point for the residual binder (typically 57°C). The level of binder in microsurfacing ranges from 5.5 to 9.5% for Type II and Type III aggregate gradings. The level of binder is determined by a combination of the wearing properties of the seal and the resistance to permanent deformation and bleeding.

***Water -*** Water is added to provide the right consistency to the slurry, generally about 10% based on the aggregate dry weight.

***Control Additives*** - Temperature and the reactivity of the aggregate influence setting and curing of the slurry surfacing. In order to adjust the setting rate in the field, additives, which chemically resemble the asphalt emulsifiers, can be added on the slurry paver at levels typically up to 0.1% on the mix.

***Slurry Surfacing Test Methods***

The ISSA has published test methods and guidelines for the design of slurry surfacings and some form part of ASTM standards. Apart from the conventional tests for aggregate grading and quality, the specific methods for slurry properties and seal properties have been developed. The main test methods are summarized here:

***Mix Test -*** 100 g or 200 g samples of aggregate are hand-mixed with first filler, then water (optionally containing control additive) then emulsion. After 30 seconds part of the mix is poured out and the remainder is stirred until the emulsion breaks ('mix time'). The poured-out sample is checked for clear water exuding by patting with filter paper. When the water is clear this gives the approximate 'set time'. Mix times in the range of 30-180 seconds may be acceptable depending on the type of slurry paver used. Handwork may require longer mix times.

***Cone Consistency Test–*** 400 g slurry is mixed, poured into a cone then the cone raised. The slurry spreads over the surface and the width of the spread is a measure of consistency. Water and filler content affect the value. The method is not suitable for very quickly setting systems.

***Wet Stripping Test-*** Boiling-stripping test on cured seal.

***Excess Asphalt Content by Loaded Wheel Tester (LWT)*** A strip of slurry surfacing is laid at the required thickness using a special mold and, when fully cured, subjected to a loaded wheel tracking device typically for 1000 cycles. Hot sand is spread over the seal and a further 100 cycles completed. Excess asphalt is shown by the weight of adhering sand.

***Wet Track Abrasion Test (WTAT)*** A circular test specimen of slurry is prepared with a special mold and, when fully cured, is soaked by immersion in water for a specified period, usually 1 hour or 6 days. Then it is subjected to abrasion under water by a weighted rubber hose mounted on a planetary mixer. The weight loss is a measure of the durability of the surface. The standard test involves curing at 60°C *(140°F)* but modified tests involving room temperature curing may be specified by some authorities.

***Set Time and Traffic Time by Cohesiometer -*** The test method is designed to mimic the forces from power steering. Small circular test specimens are prepared and after different times (typically 30 minutes and 1 hour) they are placed under a pneumatically driven rubber foot. The foot is lowered onto the specimen and the torque required to turn the foot is measured. The time to reach a minimum torque of 12 kg-cm is called the set time. The time to reach 20 kg-cm is called the traffic time.

***Compatibility by Schultze-Breuer and Ruck (SBR) Procedure -*** Samples of slurry are prepared (but excluding the largest aggregate fractions), cured and compacted at 60°C into small cylindrical pills each weighing about 40 g. The pills are subjected to a 6-day soak by immersion in water and any water adsorption determined by weighing. Then they are shaken in water for 3 hours in a specially designed machine, and any weight loss determined. Finally the pills are placed in boiling water for 30 minutes and allowed to dry overnight before re-weighing. A scoring system combining the results of the various tests is used to classify the compatibility.

***Resistance to Permanent Deformation by Loaded Wheel Tester (LWT)*** The test is particularly applicable to microsurfacing used in thick layers for e.g. rut filling. A ½ " thick strip of slurry surfacing is prepared using a special mould and fully cured at 60°C for 18-20 hours. The surfacing is placed under the wheel-tracking device and subjected to 1000 cycles. The deformation is measured by re-measuring the width and thickness. The specific gravity after the test gives an indication of compaction under load.

***Mix Design***

The ISSA gives advice on the procedures to be used for mix design based on these test methods and others. A typical procedure would be as follows:

1. An aggregate is selected which meets the grading and other requirements for use in slurry seal or microsurfacing.
2. A starting point for the emulsion content (within the allowed range) is either calculated from the grading, estimated using the kerosene equivalent test, or from experience.
3. An emulsion formulation giving the right mix time and a water content giving the right slurry consistency are determined by hand-mixed specimens. The level of mineral filler may be adjusted if necessary.
4. The setting behavior of the mix is determined by cohesion tests on small specimens. The emulsion formulation, filler content or filler type may be adjusted.
5. The wearing characteristics of the seal are tested by the WTAT. For slurry surfacing the level of asphalt may be increased until the minimum abrasion loss is achieved. In some cases the emulsion formulation or mineral filler content or type may need to be adjusted at this point.
6. The excess asphalt or maximum asphalt content to avoid flushing of the seal is checked by the LWT.
7. For microsurfacing, the resistance to rutting is determined at different asphalt contents and a design, which gives both satisfactory WTAT and LWT results, is chosen.
8. Compatibility of the components can be measured by the SBR procedure.
9. The adhesion of the components can be confirmed by the boiling compatibility (wet stripping) test.

***Typical Requirements for Slurry Seal and Microsurfacing***

| ***Test*** | **Slurry seal** | **Microsurfacing** |
|---|---|---|
| *Mix time* | >180 seconds | >120 seconds |
| *Wet stripping test* | 90% min | 90% min |
| *Excess asphalt by LWT* | Heavy traffic only | 50 g/sq. ft |
| *Cohesion at 30 minutes* | 12 min for quick-set system | 12 min |
| *Cohesion at 60 minutes* | 20 min for quick-traffic systems | 20 min |
| *WTAT abrasion loss, 1-hour soak* | 75 g/square foot max | 50 g/square foot max |
| *WTAT abrasion loss, 6-day soak* | Not required | 75 g/square foot max |
| *Lateral displacement by LWT* | Not required | 5% max |
| *Specific gravity* | Not required | 2.1 max |
| *Classification by SBR* | Not required | 11 points min |

***References***

1. *Design Technical Bulletins*, ISSA.
2. *Recommended Performance Guidelines for Microsurfacing*, ISSA, 1996.
3. *Recommended Performance Guidelines for Emulsified Asphalt Slurry Seal*, ISSA, 1991.