Tech Spec 20

icpi
Interlocking Concrete Pavement Institute

Construction of Bituminous-Sand Set Interlocking Concrete Pavement

Although sand-set applications represent the majority of interlocking concrete pavements with a flexible base, there are times when a project benefits from a bitumen-sand setting bed or a rigid concrete base. Bitumen-sand set applications on a rigid concrete base have a proven track record of superior performance under heavy vehicular traffic, especially in urban settings. Such applications include crosswalks and intersections subject to concentrated truck traffic. This type of rigid pavement construction has replaced mortar or sand-cement bedding materials in many pedestrian applications and in all vehicular ones. Mortar set pavers have not performed well under vehicular traffic and are not recommended. In addition, mortar-set pavers should not be used in pedestrian applications exposed to freeze-thaw and deicing salts. Mortar tends to deteriorate in such environments.

Bitumen-sand set applications emerged some thirty years ago from the defunct Hastings Brick Company in New York. This setting technique was used as a means to differentiate the Hastings clay brick paving system to win project specifications. Over the years, bitumen-sand set paving specifications moved into concrete paver project specifications and have seen many derivations in architectural specifications. This *Tech Spec* provides current and proven installation techniques.

Typical Cross Section—Bitumen-sand set applications for vehicular traffic consist of 3⅛ in. (80 mm) thick pavers set on a nominal ¾ in. (20 mm) thick bitumen-sand setting bed. Neoprene-modified asphalt adhesive is applied to the surface of the thin setting bed and bonds the pavers to it. The setting bed rests on a thin layer of emulsified asphalt spread over a concrete base. The emulsified asphalt provides additional adhesion of the bitumen-sand bedding to the concrete. Figure 1 shows a typical crosswalk section.

The concrete base is designed to support anticipated traffic. Unlike interlocking concrete pavers on a flexible aggregate base, those on concrete bases are typically given little or no credit for their structural contribution to the pavement cross section. The concrete base distributes wheel loads to a subbase and the soil subgrade. For bituminous-sand set applications, concrete bases are recommended in vehicular and pedestrian areas. Asphalt bases should only be used in pedestrian areas.

The tack coat enhances the bond of the setting bed to the underlying base. For residential and pedestrian applications with no vehicular traffic, the tack coat may be omitted. Typical highway tack coat materials can be used, including diluted asphalt emulsions. The type of tack coat will be based upon the environmental conditions and the procedure used by the installer. Emulsified asphalt should comply with ASTM D977 (ASTM 2013), such as Type SS-1 or SS-1h.

In most cases, the tack coat material will be supplied in pails or drums. They should be stored in accordance with the manufacturer's directions and be thoroughly mixed before application.

The bituminous setting bed is a mixture of asphalt cement and coarse sand (or fine aggregate). The mix detailed here may not be available from all hot mix asphalt plants and a suitable alternate will have to be selected. In all cases the maximum particle size should be less than ¼ in. (6 mm).

Hot-mix plants typically use one or two different grades of asphalt cement to suit local highway construction requirements. When available, AC 20 or AR-8000 viscosity graded asphalt cements complying with ASTM

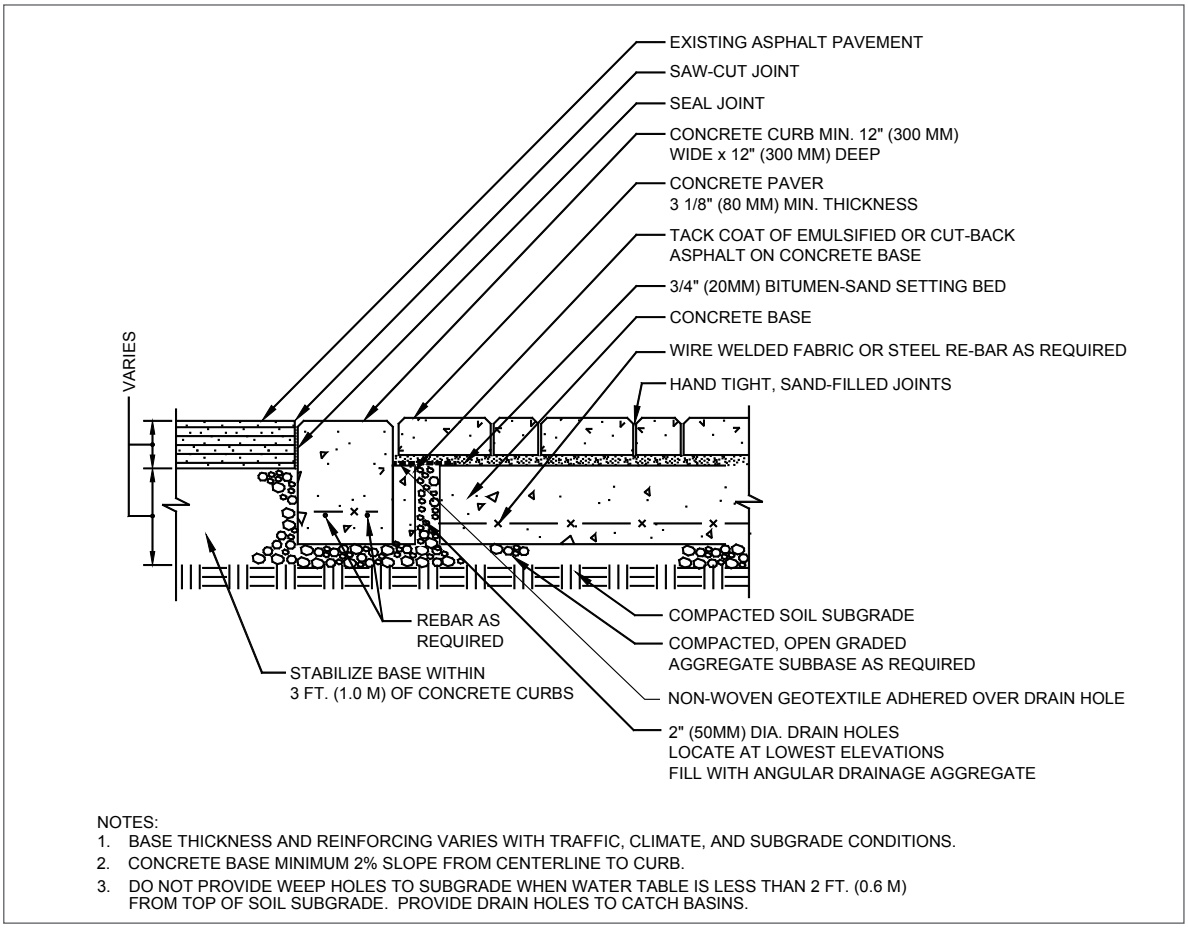

Figure 1. Typical cross section of a bitumen-sand set paver street

D3381 (ASTM 2013) can be used. These materials have a long record of success, but are gradually being replaced with performance grade, PG 58-22, binders complying with ASTM D6373 (ASTM 2013) that provide similar characterisitcs.

Although this grade of asphalt cement is used throughout the United States and Canada, other grades are available to meet local design temperatures and traffic characteristics. Areas with colder climates may use grade PG 58-28 asphalt cement, and those with hotter climates may use grade PG 70-16 asphalt cement.

Fine aggregate materials available at hot mix plants are typically natural or manufactured sands. Fine aggregates should comply with ASTM D1073 (2011). Alternatively, they may comply with local department of transportation requirements that use local aggregates.

The sand should meet the gradation requirements of ASTM C33 (2013) or CSA A23.1-FA1 (2014) and consist of clean, hard, durable particles free from adherent coatings of clay, organic matter and salts. The aggregate should have a verifiable history of being resistant to stripping. Manufactured sands typically have a higher stability than natural sands.

The bituminous setting bed material should be mixed at a hot-mix asphalt plant. The dried aggregates and asphalt cement are heated to the appropriate temperatures and are mixed thoroughly. This will produce a uniform mixture with all of the aggregate particles evenly coated with asphalt cement. The supplier should determine the exact proportions to achieve the best mix to suit the materials, the site and the installation conditions. Typical mix proportions are approximately 6 to 8 percent asphalt cement by weight.

The pavers are bonded to the bituminous setting bed using an neoprene modified asphalt adhesive. Typical proprietary materials contain 75 percent solids in a mineral spirit solvent. The solids consist of 2 percent neoprene, 10 percent asbestos free fibers and 88 percent asphalt. The adhesive is typically supplied in pails or drums. The material should be stored in accordance with the manufacturer's recommendations and be thoroughly mixed before application.

The concrete pavers selected for vehicular applications should comply with the requirements of ASTM C936 (ASTM 2013) or CSA A231.2.

The joint sand should meet the gradation requirement

of ASTM C33 (ASTM 2013) or ASTM C144 (ASTM 2011) or CSA A23.1-FA1 or CSA A179.

Pavers in bitumen-sand set applications will settle only slightly when compacted as the thin bitumen-sand bedding material is already compacted while hot. Pavers are set a few millimeters above the curb edge before compaction so that they sit just above or level with the curb after compaction. Pavers should be set higher if some settlement of the concrete base is expected, relative to the curb, due to traffic, soil settlement or both.

As with all overlays on concrete, attention should be given to draining water from the setting bed through the base. Figure 1 shows a 2 in. (50 mm) diameter drain hole pre-formed in the concrete base with plastic pipe and filled with open-graded, free-draining angular gravel. Holes are typically placed every 10 ft (3 m) along the perimeter and at the lowest elevations. They are covered with a 12 in. by 12 in. (300 mm by 300 mm) patch of non-woven geotextile, adhered to the base, to prevent contamination and ensure long-term drainage. While the amount of water that weeps through the bedding material is minimal, drain holes help assure its removal. If water remains on the bedding layer, the water can freeze and loosen the pavers from expansion. Care should be taken during construction to not clog the drain holes with bitumen-sand setting bed material.

Construction Sequence

Figures 2 through 12 demonstrate the bitumen-sand set interlocking concrete pavement installation sequence for a crosswalk. Once the concrete base is in place and cured for at least 24 hours, a tack coat of emulsified asphalt is applied on the concrete base (Figure 2). For maximum adhesion it is important to create a thin layer of uniform thickness. To achieve this it is best to dilute the asphalt emulsion with water at a ratio of 1:1. Estimated application rates are listed in Table 1.

Table 1. Emulsified asphalt tack coat application rate

	Concrete Base	
	[gal per 100 ft^2]	[liters per 10 m^2]
Undiluted	0.9 to 1.3	3.6 to 5.3
Diluted (1:1)	1.2 to 1.5	4.8 to 6.1
	Asphalt Base	
	[gal per 100 ft^2]	[liters per 10 m^2]
Undiluted	0.6 to 1.0	2.5 to 4.1
Diluted (1:1)	1.0 to 1.3	4.1 to 5.3

Best application results are typically achieved using a synthetic paint roller with a short nap. Once applied the tack coat should not be disturbed and should be allowed to cure before covering with the setting bed material. As the asphalt emulsion cures it should turn from a brown to black color (Figure 3). This may take a few hours depending on weather conditions. When using SS-1 and SS-1h asphalt emulsions the temperature should be between 70 and 160° F (20 to 70° C) to allow for proper curing. Asphalt

Figure 2. Emulsified asphalt tack coat is applied to a concrete base prior to applying the bitumen-sand mix.

Figure 3. Control joints and drain holes are covered with geotextile. Drain holes are provided for any water that manages to enter the pavement surface.

Figure 4. The hot bitumen-sand bedding material is dumped from a truck onto the concrete base.

Figure 5. While the bitumen-sand is still hot, it is screeded to an uncompacted thickness of about 3/4 in. (20 mm).

Figure 6. A hand tamper is used to compact in areas that cannot be reached with the roller compactor.

Figure 7. The compacted bedding elevation at the edge is checked with a paver.

Figure 8. After the bitumen-sand mix cools, a 2% neoprene-asphalt adhesive is applied. The material can be trowel-applied as shown here. Some materials are more viscous and can be spread with a squeegee.

Figure 9. Perpendicular chalk lines are snapped and the pavers placed on the adhesive after the neoprene-asphalt adhesive dries (cloudy black surface).

Figure 10. Cut pavers are added along the edges.

tack coats are recommended for vehicular applications. They are typically not required in pedestrian applications.

The hot bitumen-sand bedding layer is placed, screeded to about 3/4 in. (20 mm) thick and compacted while remaining above 250° F (120° C) (Figures 4 and 5). This layer typically compacts about 1/8 in. (3 mm). The depth of this layer must be consistent. If the area does not have a curb to support a screed, screed bars are placed directly on the concrete base to guide the screed. The bars are removed immediately after screeding and the narrow void spaces left from the removed bars are filled with additional, hot bitumen-sand mix and troweled smooth. The compacted bitumen-sand bedding layer can compensate for only very small surface variations in the concrete base and cannot be used to make up for a rough surface finish on the concrete. The bitumen-sand mix is placed, screeded and compacted in one small area at a time (typically a 100 to 300 sq. ft. or 10 to 30 m^2) in order to screed and compact the mix while hot. Areas that can not be compacted with the roller compactor should be compacted with a hand tamper (Figure 6). Before spreading the asphalt adhesive it is advisable to confirm the bedding elevation using a paver (Figure 7). If it cools prior to compaction, it is impossible to compact and will require reheating prior to compaction.

A thin layer of neoprene-asphalt adhesive is then applied with a squeegee to the top of the bedding layer, and allowed to cure (typically 1 to 2 hours). Some adhesives are a more viscous and are applied with a straight edged towel as shown in Figure 8. The adhesive takes a hazy appearance when ready to mark baselines and place the concrete pavers (Figure 9). Only enough adhesive should be applied that will be covered with pavers in a day's work. Figure 10 shows the paver installation. Once the pavers are placed on the adhesive, they are very difficult to remove. If removed, they can pull up the adhesive and bitumen-sand bedding under the paver. Once all the pavers are in place including cut units, sand is swept into the joints and pavers are compacted until the joints are full (Figures 11 and 12). For more efficient work, sand sweeping and compaction can be simultaneous. Unlike sand-set pavers, there is no need to compact the pavers without sand in the joints first. When completed, the pavement can accept traffic loading immediately (Figure 13).

Figure 11. Sweeping in joint sand

Figure 12. Once the pavers are in place, the joints are filled with dry joint sand and the surface is compacted.

Figure 13. Crosswalk in use under heavy traffic.

Figure 14. A water-filled roller compactor for compacting the bitumen-sand bedding.

Should the surface of the pavers be stained with adhesive during installation, it is very difficult to remove and fresh replacement pavers are required. In-service reinstatement of installed bitumen-sand set pavers is practically impossible because the bitumen-sand material adheres to the bottom of the pavers when removed. It is less expensive to discard the pavers rather than remove the asphalt from the units and attempt to reinstate them.

Specialty Tools—Some specialty tools are required to successfully install bitumen-sand set pavers. For example, Figure 14 shows a roller modified with a long handle welded or bolted to the frame. The drum of the roller should be smooth with no rust, preferably with sharp edges (not rounded). Other specialty tools are shown in Figures 15, 16 and 17.

Cost and Performance—Bitumen-sand set pavers are significantly more expensive (typically 30-50% higher) than sand-set pavers due to additional material and labor costs. However, the additional costs incurred with bitumen-sand set concrete pavers for vehicular traffic are often balanced with the long-term performance characteristics when compared to sand-set installations under the same wheel loads. As noted in *Tech Spec 19* (ICPI 2013), interlocking concrete pavement crosswalks with bituminous-sand setting beds on concrete bases were estimated to have a life span of 7.5 million ESALs.

Pedestrian Areas—Bitumen-sand set applications are sometimes used in public pedestrian areas with concrete paving slabs. Paving slabs used in sidewalks and plazas are often larger than 12 in., typically having one or both dimensions at 16, 18 or 24 in. (400, 450 or 600 mm) and are generally 1.5 to 2 in. (38 to 50 mm) thick. Often the paving units are "gauged" or ground on the top and bottom by the manufacturer to ensure consistent thicknesses among all the units. These types of paving slabs require a very smooth and even concrete base. A tack coat is typically not used prior to placing, screeding and compacting the hot bitumen-sand mix. After placement in the bedding, slabs are compacted with a small plate compactor with rollers attached to help spread the compaction force and prevent cracking of the paving slabs. The joints are typically filled with sand.

Figure 18 illustrates paving slabs placed on the adhesive over the bitumen-sand bedding. This method is superior to using a sand-cement mixture for the bedding over a concrete base as the sand-cement can be subject to deterioration from water, deicing salts and freeze-thaw cycles. Like its counterpart for vehicular applications,

Figure 15. Walking on the hot bitumen-sand bedding with regular construction grade, steel-toed boots is discouraged. For limited walking on this layer, workers should wear boot sole covers shown here that resist damage and better distribute weight to prevent dentations.

Figure 16. Occasionally, uneven bedding surface occurs and it is necessary to re-heat the bitumen-sand bedding with a propane heater tool.

Figure 17. On larger projects, 1/2 in. (13 mm) thick steel screed bars are placed on the concrete base to ensure a uniform bitumen-sand bedding thickness.

Figure 18. Paving slabs adhered to a bitumen-sand bedding in a Washington, DC, sidewalk.

a bitumen-sand bedding under the adhesive is more expensive, but it provides a very low-maintenance solution to rigid segmental concrete pavements, even in severe climates.

Maintenance of Bituminous-set Installations

The neoprene-asphalt adhesive bonds to the concrete pavers and bitumen-sand extremely well. This will make it almost impossible to remove from the concrete paver after it is applied, even if done so accidentally. Once installed and allowed to cure, it will be very unlikely that a paver can be removed without pulling up some of the bitumen-sand bedding material. Repair will typically require the removal and disposal of the pavers and bitumen-sand bedding and replacement with new material. Use of a propane torch as shown in Figure 16 along with a scraper may be required to soften and effectively remove the bitumen-sand from the concrete base. It is unlikely that the bitumen-sand hot mix will be available in a small batch so it may be necessary to use a fine gradation cold-patch material. Follow manufacturer's installation instructions. Allow the cold-patch material to fully cure before applying the neoprene asphalt adhesive.

References

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