INTRODUCTION

Technical Notes 14 Revised and 14A Revised, Parts I and II of this three part series deal with general considerations, classifications, materials selection, design factors, types of installations and suggested paving design assemblies. This issue of Technical Notes will discuss assemblies and installation techniques pertaining to special paving applications.

Brick paving may be adapted to suspended diaphragm bases, reinforced brick structural slabs with conventional mortars and installations using high-bond latex modified mortars. This issue of Technical Notes will discuss these applications and suggest ways of cleaning and maintaining brick floors.

SUSPENDED DIAPHRAGM BASES

To assure long term performance on a roof deck or suspended plaza, certain special design factors must be considered to minimize the risk of deterioration. A roof deck plaza application generally must be structurally sound, esthetically appealing, durable and economical to install. Consequently, there are special moisture, thermal and structural considerations inherent in this type of application.

Moisture. To insure an effective waterproofing system, it becomes necessary to give proper attention to base and counter flashing details of parapet walls as well as to the selection of the proper type of horizontal membrane.

For mortarless paving, adequate drainage is very important to prevent damage to or displacement of pavers due to water and/or frost action. Sloping membranes in conjunction with porous base layers will permit water to percolate or run freely to roof drains. Special all-level roof drains are available which will handle both pavement surface and subsurface water (see Fig. 1).
Consideration should be given to horizontal differential movement between structural concrete slabs and the waterproofing membrane. Built-up bituminous membranes generally have non-elastic properties. Seamless liquid waterproofing and rubber sheet membranes are usually elastic in behavior and are capable of adjusting to horizontal differential movement that may occur in the supporting base.

**Thermal Considerations.** The thermal aspects of roof terraces are similar to those of normal roofs. The position of roof insulation is important with respect to the temperature variation of each element in a paved roof assembly. Under many conditions it is advantageous to place insulation directly over membrane waterproofing when considering thermal and condensation effects.

Generally speaking, roof deck insulation should be of a non-rotting, moisture resistant, closed-cell type of material capable of retaining its thermal resistance in the presence of water. Traffic loadings may be supported on insulation materials in a deck assembly provided the insulation material is structurally adequate.

Brick pavers like all materials change dimensionally with changes in temperature. A slip plane between pavers and a waterproofing membrane is recommended to avoid disruption of the membrane. For example, it may consist of a porous gravel cushion, asphalt impregnated protection board or other materials capable of withstanding both horizontal abrasive movement and vertical traffic loadings.

**Structural Considerations.** The structural design of a suspended base should follow normal accepted design procedures. The dead weight of brick pavers combined with other materials and design conditions, such as live loads, vibration and impact from traffic, should be considered. For structural design purposes, the dead weight of mortared or mortarless brick pavers may be taken at approximately 10 psf per inch of thickness. Since brick pavers are available in various thicknesses, their total weight will vary. The most popular pavers mentioned in Part I are 1 5/8 in. to 2 1/4 in. thick, weighing approximately 16 to 22 psf, respectively.

In residential wood joist design, consideration must be given to the additional weight of brick pavers. It will be necessary to consult a structural design loading table for wood joists and select a suitable grade and joist size. A good reference manual is "Wood Structural Design Data" by the National Forest Products Association (NFPA). The subfloor thickness and grade should also be checked for structural
For mortared paving, diaphragm action becomes important in order to maintain the integrity of mortar joints. Deflection should be limited to \( \ell/600 \) of the span for mortared paving and \( \ell/360 \) for flexible paving.

**REINFORCED CONSTRUCTION**

Reinforced brick paving can be used to span an open space or for use over a fill which may tend toward uneven settlement. Reinforcement of the masonry can eliminate the necessity for a separate reinforced concrete slab or other rigid base.

Reinforced brick masonry slabs are practical, especially over relatively short spans. They are capable of satisfying design loadings for pedestrian and vehicular traffic. Model building codes stipulate live loads ranging from 50 to 250 psf. A 2 1/4-in. thick brick slab may be designed to support a 50 psf live load, spanning almost 6 ft [Fig. 2(a)]. Also, using the same strength brick and mortar, but by simply turning a unit on edge to increase the slab's thickness, the design load capacity can be doubled (100 psf) and the span increased to over 7 ft [Fig. 2(b)].

Reinforced Brick Masonry

**FIG. 2**

The design of reinforced brick masonry slabs, as shown in Table 1, is based on a rational analysis and the Standard, *Building Code Requirements for Engineered Brick Masonry*, BIA(SCPI), August 1969. For additional information on the design of reinforced brick masonry slabs, the 17 Series of BIA *Technical Notes on Brick Construction* contain design examples and calculation procedures.
aNote: Design parameters for the above Table 1 are as follows: The brick compressive strength average is 8000 psi. The mortar is type M (1:1/4:3), portland cement-lime and sand. Reinforcement steel is ASTM A 82-66, fs = 20,000 psi. A simple span loading condition was assumed.

All mortar joints are 1/2 in. thick for the slabs shown, except as noted.

**Brick on Sheet Steel Forms.** A variation of reinforced brick construction utilizes corrugated sheet steel as a base. The steel serves as combined form and reinforcing and can provide an economical solution to the problem of constructing brick floors over open spans. For continuous spans, negative steel is placed in grouted mortar joints. Brick are placed on a bed of mortar and vertical joints are filled with mortar or grout (Fig. 3).

![Corrugated Sheet Steel - Reinforced Brick Masonry Slab Assembly](http://gobrick.com/BIA/technotes/t14b.htm)

**FIG. 3**

A number of years ago, the Research and Development Department, Granco Steel Products Co., tested this method of construction to "determine the feasibility of using 24-gauge Cofar (Cofar is the trade name for combined form and reinforcing corrugated sheet steel produced by the Granite City Steel Corp., Granite City, Illinois) on 14-ft spans, using bricks, mortar and steel acting compositely to give a structurally sound floor slab."

Brick were standard size, dry-press, red brick with an average compressive strength of 7800 psi. The mortar was ASTM C 270, type M, of portland cement and hydrated lime. The steel form was of 24
gauge corrugated sheet steel (4.25-in. pitch, 1.2-in. depth) with positive reinforcement.

The test specimen was approximately 17 in. wide and 5 1/2 in. deep over two continuous 14-ft spans. Test loads consisted of various increments of uniform and concentrated loads on combinations of one and two spans at a time. Repeated concentrated loads were applied and relieved for as many as 500,000 cycles.

Conclusions to the test report emphasized three pertinent points:

1. The brick slab had adequate stiffness and minimal deflections.

2. Fatigue failure did not occur.

3. Failure occurred only when the actual uniform load exceeded 7 times the design load. (Granco engineers designed for 50 psf superimposed loads. When this specimen was tested, allowable design stresses were lower than now permitted. This perhaps explains why such a large factor of safety was exhibited.)

HIGH-BOND MORTARED PAVEMENT

General. Rigid brick paving installed with high-bond mortar may be generally more resistant to water penetration than paving with conventional mortars. This advantage is primarily the result of higher bonding characteristics between the mortar and brick unit.

SUGGESTED BRICK PAVING DESIGN ASSEMBLIES

The following assemblies illustrate how brick paving can be adapted to suspended diaphragm bases of various types. These support bases may consist of reinforced brick masonry slabs, reinforced concrete slabs, steel decking, and wood framing.

Figure 1-Reinforced Structural Concrete Slab. This assembly is suitable for exterior pedestrian traffic. The pea gravel percolation layer will permit rapid drainage to occur, thus preventing possible damage from freeze-thaw cycles of trapped water. The protection board should be at least 1/8 in. in thickness and of asphalt impregnated material.

Figure 2-Reinforced Brick Masonry Slab. The various types of reinforced brick masonry slabs, as illustrated, can support a wide range of live load conditions as shown in Table 1. Reinforced brick masonry slabs eliminate the need for other types of support bases.

Figure 3-Corrugated Sheet Steel-Reinforced Brick Masonry Slab Assembly. This assembly combines both reinforced brick masonry and steel decking, constructed with positive and negative reinforcing steel for continuous span applications.

Figure 4-Reinforced Structural Concrete Slab. This assembly is suitable for exterior pedestrian traffic and utilizes a bituminous leveling bed.

Figure 5-Reinforced Structural Concrete Slab. This assembly, utilizing conventional build-up roofing, can be easily adapted to flexible brick paving suitable for outdoor pedestrian traffic.

Figure 6-Steel Deck Base. This type of construction may be designed as a non-rated or rated fire resistive assembly. Figure 6 illustrates only the general material composition. For specific types of fire resistive assemblies consult Factory Mutual and Underwriters' Laboratories.

Figure 7-Wood Framing Assembly. This assembly is suitable for mortarless paving used in
Figure 8-Wood Framing Assembly. This assembly is suitable for mortared paving used in residential frame construction.

INSTALLATION AND WORKMANSHP

There are certain factors that the designer should be aware of before a final design is selected. These factors will be discussed in relation to Figs. 1 through 8.

Drains and Waterproofing. For suspended decks where control of surface drainage is important, all level drains and waterproofing membranes (Fig. 1) should be installed in strict accordance with the manufacturers' instructions and specifications.

Insulation. In Fig. 4, the insulation is required to support a specific design live load and also must be capable of withstanding the temperatures transferred through the protection board from the application of hot bitumen. Consequently, one installer of this system suggests that the insulation be capable of withstanding a minimum temperature of 300 °F (149 °C).

![Reinforced Structural Concrete Slab](http://gobrick.com/BIA/technotes/t14b.htm)
In Fig. 6, the insulation is usually installed in steep asphalt. If the roofing assembly's wearing surface is temporary in nature, the insulation may be laid loose and removed later for reuse. If a temporary installation is desired, the possibility of uplift due to high winds should be considered.
Mortar. High-bond and latex modified portland cement mortars vary among manufacturers. Therefore, instructions for their installation should be carefully followed. When mortar joints are thumb-print hard, they should be properly tooled. Various types of conventional portland cement-lime mortars are
discussed in Part I.

**Reinforced Brick Masonry Slabs.** Brick masonry slabs spanning open spaces are constructed on forms with brick units spaced accordingly, to allow for proper joint thickness. Mortar is used to seal the bottom of the joint and also to serve as a support for reinforcing steel. After the steel is placed, all the joints are grouted. To insure complete filling of the joints, the grout should be carefully puddled. More detailed suggestions for constructing RBM soffits are given in *Technical Notes* 36, Revised, "Brick Masonry Details, Sills and Soffits".

**CLEANING**

To facilitate cleanup of high-bond mortar or grouted installations, brick pavers may be prewaxed on the exposed face with a good grade of paraffin. The paraffin should have a melting range between 150 °F (66 °C) and 170 °F (77 °C). Experience has shown that paraffins with lower melting points are often affected by hot sunlight, while those with higher melting points are difficult to remove. Prewaxed pavers utilized in conjunction with conventionally grouted joints will also be easier to clean. While waxing the pavers, care must be exerted to prevent the edges or joint surfaces from becoming smeared with paraffin. The edges must remain clean for proper bond.

When cleaning high-bond mortared pavement, it is recommended that cleaning be executed as soon as possible after the mortar joints have been allowed to cure. Due to high bond characteristics of this mortar, the pavement surface should not be left uncleaned for longer than three weeks.

Steam cleaning is effective in melting the paraffin coating and lifting excess mortar. Drains should be protected from clogging by floating wax. A visual inspection after cleaning may reveal problem areas requiring scraping or light brushing with a wire brush.

Generally speaking, if care is exercised during mortar application, cleaning can be avoided or held to a minimum. Mortarless installations should require little or a minimum amount of attention. On conventionally mortared installations, wet sand swept over the surface will often remove mortar droppings. Burlap bags may also be used to remove excess mortar as the mason progresses. If dry cleaning or hosing with water fails to flush the surface clean, use a cleaning solution and the procedures in *Technical Notes* 20, Revised, "Cleaning Brick Masonry". Avoid the use of strong acid solutions where possible. Strong acids can dissolve mortar from the joints and kill grass and shrubbery. They may also cause "acid burn" discolorations on the brick paving. When applied in confined spaces, provide sufficient ventilation to dilute the harmful effects of acid fumes.

**CURING AND PROTECTION OF BRICK MASONRY PAVING**

It is suggested that rigid or mortared paving be allowed to set in an undisturbed condition for a period of at least 3 days. Afterwards, light pedestrian traffic is permissible with protection afforded to the paving as required. Protect from staining and light impact loads through the use of large sheets of plywood or hardboard. Full service of the pavement should be avoided until the masonry has cured a minimum of 28 days.

For guidelines on cold weather protection, refer to the *Technical Notes* 1 Series, "All Weather Construction" and *Technical Notes* 11A Revised, "Guide Specifications for Brick Masonry", Section 1.05.C.

Flexible brick pavement requires no curing time. However, before sweeping sand into the joints, spread damp sand in thin layers and permit it to dry. Sand must be clean and free of clay to avoid surface "scumming" of the finished paving.

**MAINTENANCE**
Brick floors and pavements are usually abrasion resistant and hard wearing. Therefore, they normally do not require coatings to maintain surface appearance. However, coatings and waxes are often desirable on interior brick floors to enhance their appearance and make the surfaces easier to clean. Coatings on exterior brick pavement are not recommended. For interior brick there are a few aspects to be considered before applying any type of coating.

In the past it has been recommended that a sealer be applied before waxing. In many cases this has proven satisfactory. However, sealer and wax compatibility should be checked prior to final application.

Sealers generally have two purposes: (1) to lock loose sand in the cracks, and (2) provide an impervious finish. If a sealer is to be used, it should be tried on a small area and evaluated before full application. A compatible wax should be selected, preferably a water emulsion type recommended for brick floors.

Before a coating is applied, the floor surface should be dry. Each maintenance situation, whether it be with a sealer and wax or a synthetic sealer-finish material (spray-buffing process), must be judged on its own merits to determine the most economical means for maintaining a brick floor.

Snow removal on large or small areas of brick pavement should not present any particular problem. However, there are precautionary measures that can be taken to preserve the character of the brick. Avoid the use of chemicals and "rock" salt to aid in melting ice. Use of these materials will introduce soluble salts to the masonry and may, in turn, be a source of efflorescence. To render icy surfaces passable, use clean sand on the affected area.

For snow plowing efficiency, it is suggested that, where a metal plow blade is used, the edge should be rubber tipped, or mounted on small rollers. The blade edge should be adjusted to a clearance height suitable to the pavement surface. Regardless of the method used, needless chipping of the edges of the brick should be avoided.

**CONCLUSION**

The Brick Institute of America has attempted to discuss the many factors involved in the design and installation of brick paving. The suggestions offered should be utilized under the close direction of a competent professional. Their use does not preclude nor supplant professional judgment, but merely provides general and detailed information on which this judgment can be based. The designer, anticipating the use of suggested paving details shown, should analyze his design conditions in conjunction with the factors discussed in this series of *Technical Notes*.

The Brick Institute of America can *not* assume responsibility for results or designs obtained from suggestions and recommendations discussed. It is beyond the scope of the Institute to anticipate every design situation that may arise, and the designer is urged to consider all of the factors.

**REFERENCES:**


