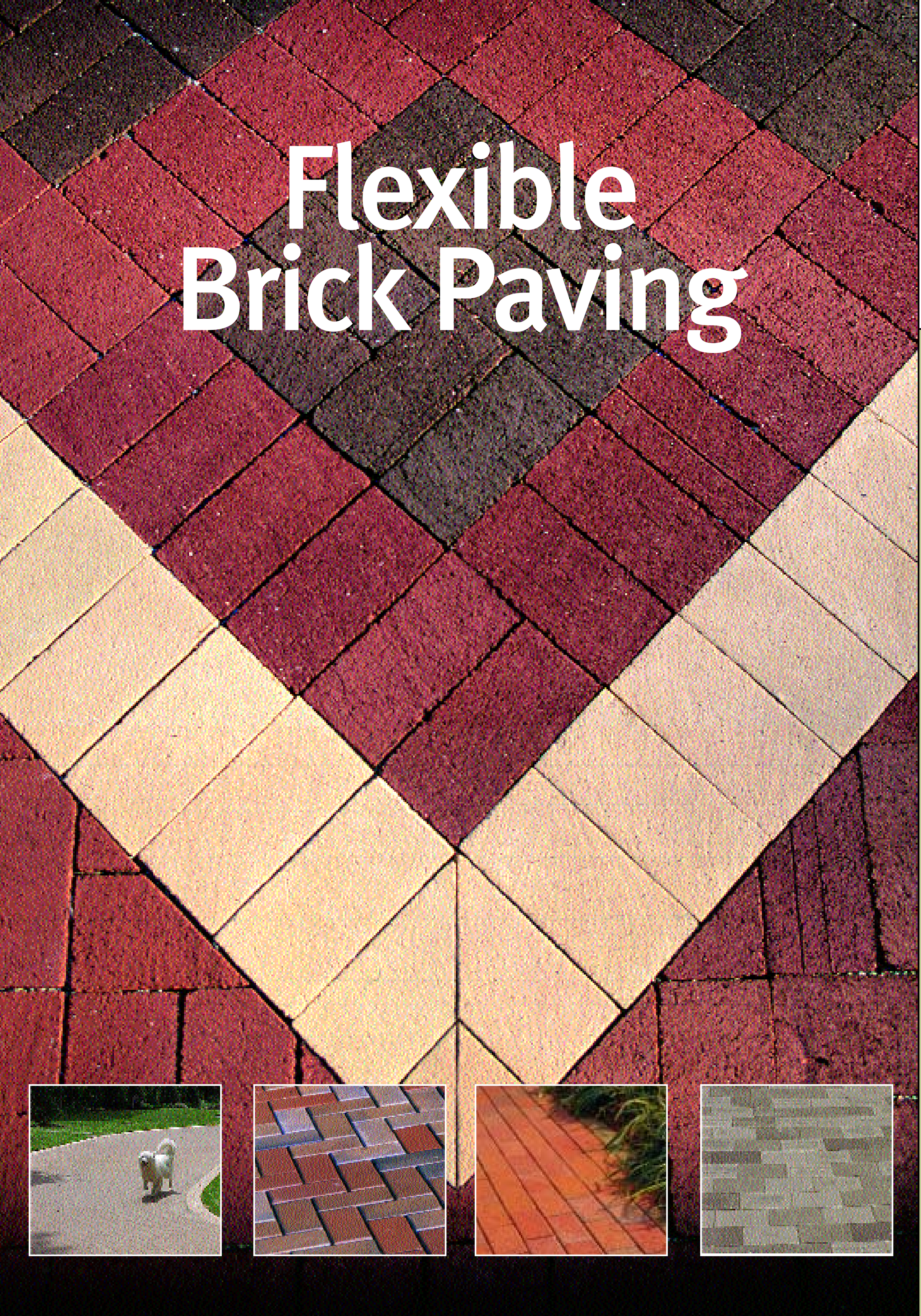
Flexible Brick Paving



Brick Industry Association

Pedestrian and Light Traffic Applications

Introduction

Brick paving has been used for thousands of years. The Romans laid brick in roads crisscrossing their vast empire, some of which still exist. Americans have employed the material since the earliest Colonial days, and brick pathways and sidewalks thread through the landmark sites and historic areas across the country.

Today, as many property owners and architects attest, brick paving is timeless, especially for flexible (or mortarless) paving such as sidewalks, patios, plazas and vehicular traffic. One advantage of flexible brick paving lies in the flexible nature of its foundation and the action of the pavers themselves. In such flexible pavements, the subgrade is compacted and covered with a layer of aggregate which itself is compacted. A layer of bedding sand is added, and brick pavers are arranged upon the bedding sand in the desired pattern. Sand is then spread into the spaces between the pavers as jointing material.

As the whole paving system compacts with time and use, the bricks interact with the jointing sand and base materials to achieve the unique quality of "interlock." Interlock holds the pavers in place and distributes the load through the layers down to the subgrade, enabling the surface to contribute to the strength of the whole system. When properly installed, brick interlocking pavements are highly stable and durable.

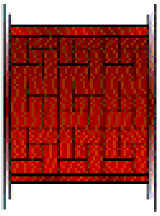
This basic advantage begets others. Because flexible brick paving provides interlock, no rigid concrete base is required. Because no mortar is involved, a flexible brick pavement may be installed with semi-skilled labor, producing cost savings that supplement the savings afforded by the brick itself. In addition, replacement of pavers after repair of utilities beneath a flexible brick pavement is easily achieved.

As an architect's medium, brick is equally flexible. Its basic aesthetic appeal is legendary as a material that exudes warmth and elegance through the permanent color of fired clay or shale. It can be installed in such popular basic patterns as herringbone, running bond, or basketweave, or in creative applications

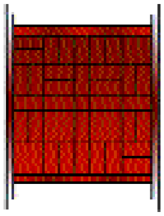
that employ polychromy, ornate patterns, and other paving materials.

Clay pavers in a flexible alignment base system are highly practical as well. They accommodate quick access to underground utilities, permitting simple reconstruction after the work is completed. Without mortar joints there is less maintenance and damaged brick pavers are easily replaced. Flexible paving also allows some water to filter down to the subgrade, thereby reducing puddles, alleviating flooding and runoff, and eventually replenishing the water table. Cleaning usually only requires a simple hose-down. And clay pavers provide a safe, slip-resistant surface in pedestrian areas.

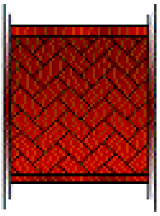
Selection of the most appropriate material for a particular pavement requires consideration of a number of factors that can significantly affect the use, performance and cost of the pavement. Although slightly more to construct initially, the low maintenance aspects of clay pavers in a flexible base system results in life-cycle costs that are more economical than many other pavement types. The use of sustainable materials such as brick makes an important contribution to the built environment. Not only is brick an energy-efficient material to manufacture, its contribution to long-term pavements makes it attractive to owners and municipalities.



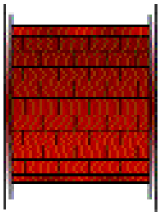
Basket Weave (Variation)



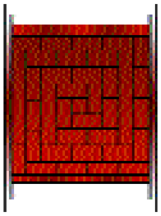
Basket Weave (Variation)



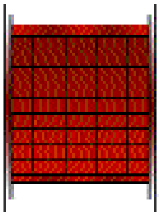
Herringbone



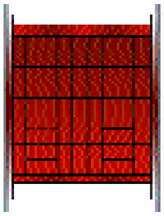
Running Bond



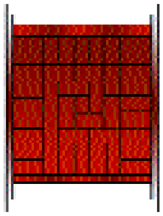
Whirling Bond



Stack Bond



Stack Bond (Variation)



Stack Bond (Variation)

Build a solid fou

Once a flexible brick pavement is completed, the system itself goes to work to achieve the desired threefold state of interlock. Vertical, rotational, and horizontal interlock occurs as the pavers settle and the bedding and jointing materials interact, aided by the rigidity of the edge restraints.

Vertical interlock is present when a single paver doesn't settle under load — the system's compactness and interaction distribute the load beyond the single paver and down through layers to the subgrade. With rotational interlock, the paver won't tilt or rotate on its horizontal axes when force is applied to an edge, but will always remain flat.

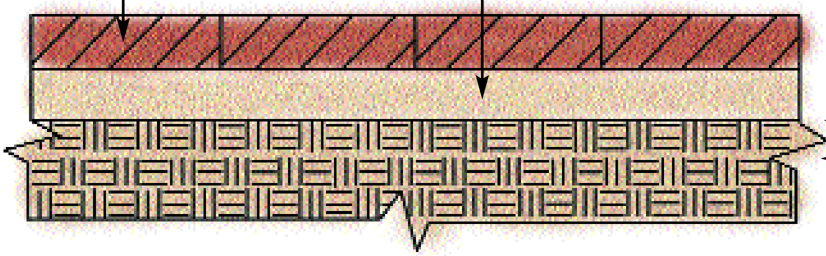
Horizontal interlock is most critical in areas where traffic may force the pavers to shift laterally. Most common in roadways, this condition known as "creep" occurs where horizontal braking and accelerating forces put great stress on individual pavers. Horizontal interlock transfers these forces through the joints and pavers to the rigid edge restraints.

In areas sustaining vehicular loads, pavement pattern is as critical to interlock as the quality of materials and installation. Herringbone is known to distribute "creep" forces more evenly than running bond or basketweave and is recommended for vehicular areas.

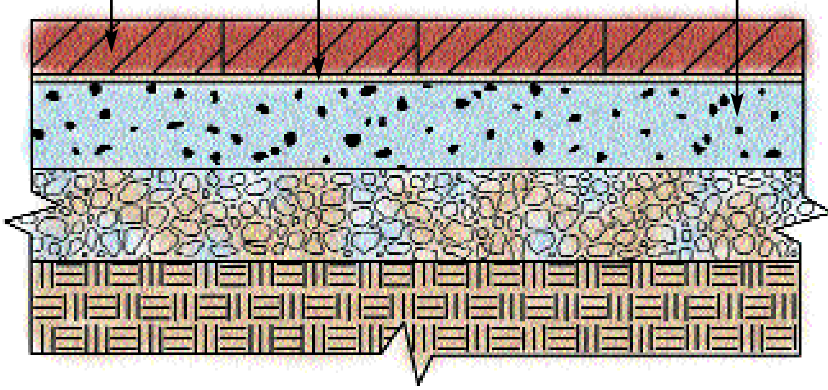
Components of Flexible Brick

ndation

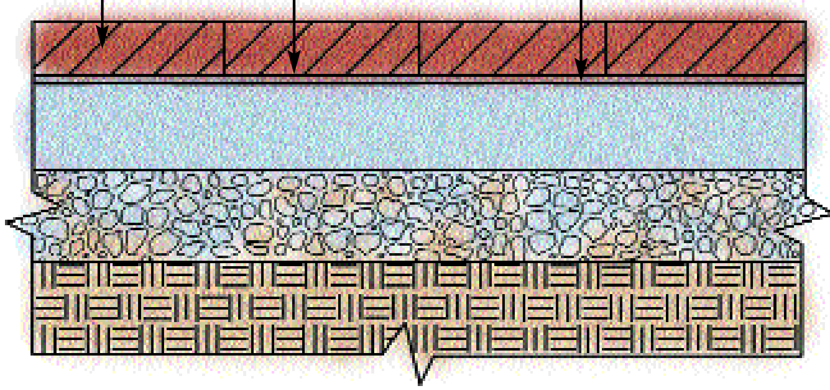
Sand Base



Concrete Base



Asphalt Base



Paving

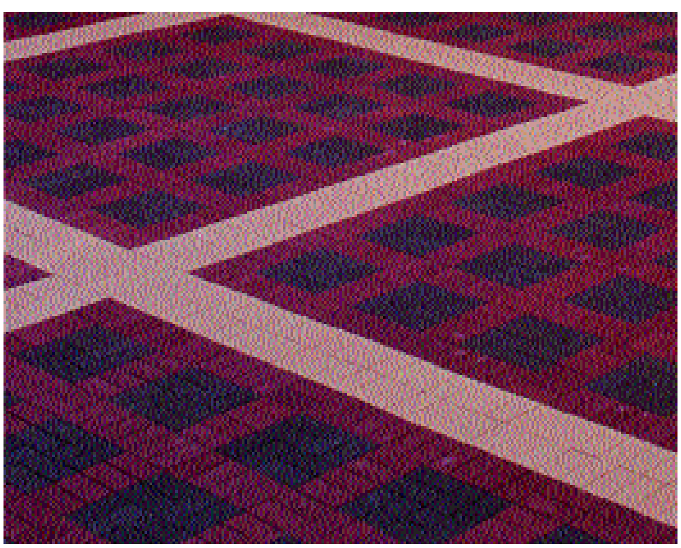
Design Opportun

Designs for flexible brick pavements are as varied as their uses: from basic colors and patterns, to other, newer applications. Whether employed in Colonial or contemporary projects consisting of buildings and pavements, brick has proved itself a medium that's kept pace with the latest design trends.

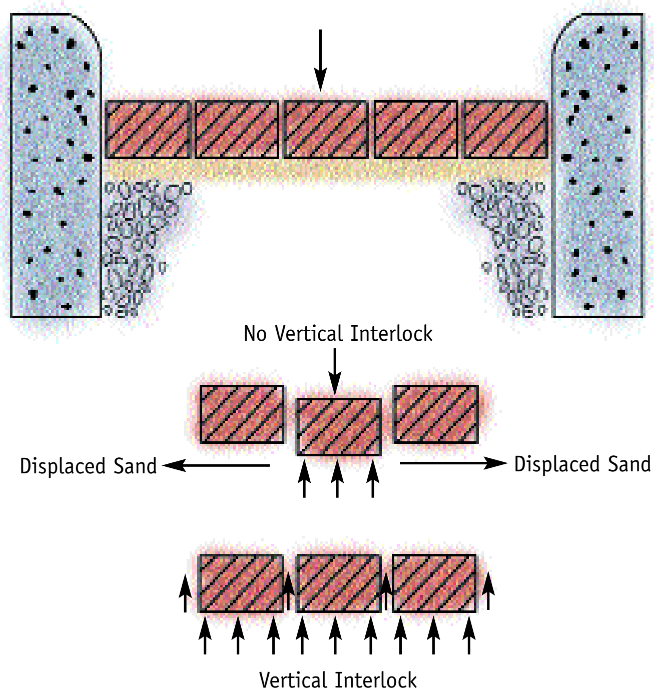
Apart from some specific traffic considerations that will be discussed later, the choice of standard bond patterns generally follows taste. Running bond, basketweave, herringbone, stack bond, and variations on all these patterns exploit brick's modularity and the aura of tradition.

Brick paving sections can alternate patterns or colors, may be used with other paving materials to achieve interesting effects, and to delineate such specific areas as plazas and paths. One popular variation combines running bond with stacked bond placed around planting beds and fountains. Round-edged and chamfered pavers produce bolder lines, enhancing many bond patterns.

Brick paving systems cover the full breadth of pavement uses, from pedestrian applications to heavy vehicular areas. In any application, it is critical that the ground and grade be analyzed carefully, that the foundation be planned properly, that the correct base, materials and pavers be specified, and that the installation be carried out correctly.



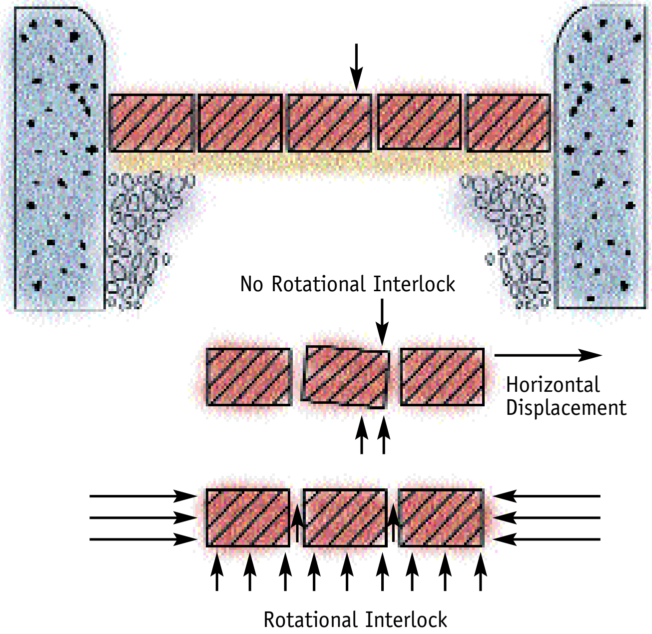
Interlock

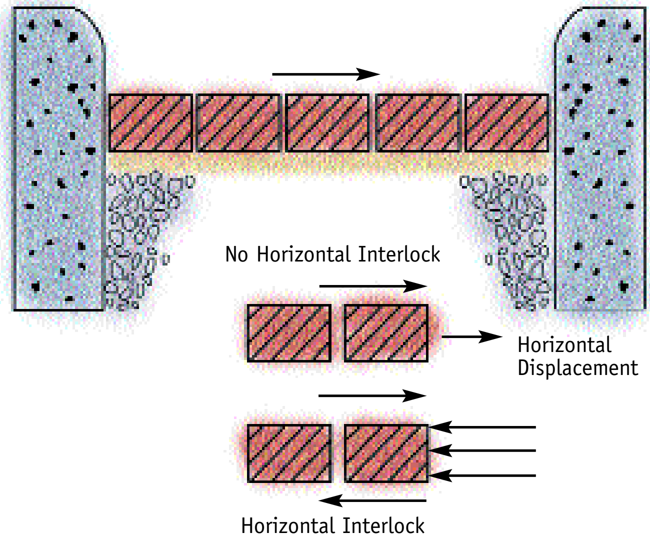


ities

Deciding on the appropriate brick paving system to use is important to ensure proper performance. Since brick can be used in a variety of ways, the following is a guide to help you decide on what works.

Interlock, the key to a stable flexible brick pavement, is formed by the interaction of pavers, base and bedding materials, and jointing sand. As these diagrams illustrate, interlock distributes vertical and rotational loads down to the subgrade and shifts horizontal forces out to rigid edge restraints.





Many of the variables to be considered in the design of a flexible pavement are site dependent. Optimally, the subgrade will be free of tree roots or rocks (they should be removed, and holes filled with appropriate backfill). Proper drainage is essential in all pavements. Adequate slope should be included in the design to avoid standing water (a minimum alignment slope of 1/4 inch per foot is recommended, with a maximum grade of 10 percent). Larger paved areas may require intermediate drains or scuppers. In areas with a high water table or with soils with high moisture retention, sub-surface drainage systems and/or geotextile layers should be planned. Curbs and planting beds are often higher than the paving surface so drainage at these elements must be considered or a "bathtub" effect may occur.

The thickness of the entire paving system should be calculated according to its traffic load. Generally, a minimum base thickness of 4 inches is required for all areas and 6-8 inches for light vehicular areas. Medium and heavy vehicular traffic require design by an engineer. (See *BIA Design Guide for Vehicular Pavements.*) Considerations should also address the potential for frost heave, which can leave permanent changes in the soil and therefore the paving surface. The base, like the subgrade, should achieve a 95% compaction rating.

A rigid edge restraint is required to secure the whole paving system laterally. Since it extends down below the level of the bedding course, the edge also serves to hold that crucial layer in place. Concrete, stone, metal, some types of plastic or a soldier course of brick set in concrete can serve as an edge restraint. The border can be planned to complement the design of the pavement and also to provide a channel for surface runoff. Special shaped bricks can be used to create elegant curbing for your paving project while also acting as an edge restraint.

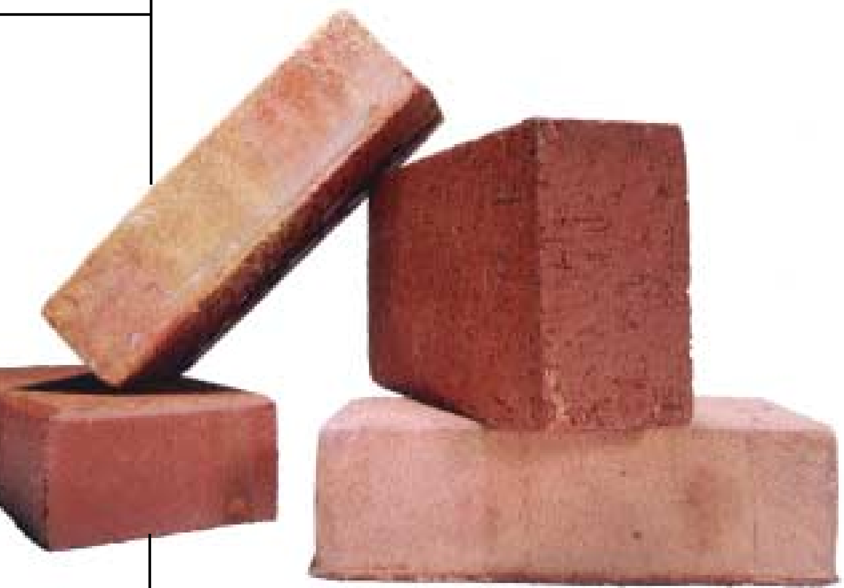
Trees are an important part of any landscape plan. Trees in urban areas are more prone to failure because of soil compaction and lack of water and air.

To avoid this, the use of a structural soil and permeable surface are required. Structural soil usually contains about 80 percent crushed gravel or lightweight aggregates by weight. The nature of flexible brick paving allows water and air to get to the roots. Pavers with slightly wider joints may be used around the tree.

Expansion joints are usually not necessary in flexible brick pavements. The sand joints allow for most expansion to occur without distress. Expansion joints are still a good idea for permanent structures that come from below the base, such as bollards or manholes. Expansion joints are necessary in walls and mortared brick paving since the expansion of the brick can cause cracking.

One item that is often overlooked is a mock-up of the pavement. A mock-up should be built to illustrate just how the paving will look with samples of the actual pavers and bedding materials. This can also serve as a standard for workmanship. All bond patterns should be inspected closely before work begins.

Specifying the P



In addition to correct planning, a successful flexible brick pavement depends on the right materials, both in its wearing surface and in its foundation.

For outdoor brick pavement designed for pedestrian and light traffic, the pavers should be in accordance with ASTM C 902, Class SX. Many brick shapes, colors, and sizes are available with this rating, and the classification signifies the paver's strength and ability to withstand weathering elements. This assures the specifier that it can withstand repeated freeze/thaw cycles and exposure to salt without damage.

A paver conforming to ASTM C 902, Class SX is "intended for use where the brick may be frozen while saturated with water" and may be specified for walkways, patios, pedestrian plazas and driveways subjected to low and medium traffic volumes. Pavers in applications receiving high volumes of heavy vehicles (tractor-trailer trucks) should be specified using ASTM C 1272 and are covered in another publication. *(See BIA Design Guide for Vehicular Pavements.)*

The thickness of the pavers will vary with the application. The suggested minimum thickness for flexible brick paving is: light pedestrian traffic — 1 1/2 inch; for medium and heavy pedestrian or light vehicular traffic — 2 1/4 inch; and heavy vehicular traffic — 2 5/8 inch. Thicker pavers are required in heavy-duty applications to help resist traffic loads as well as develop interlock.

Since safety of a brick pavement is critical, the slip resistance of paving units should be examined. Skid resistance in vehicular areas is also important. Most brick pavers have adequate slip and skid resistance, especially if they have a wirecut texture. Obviously the rougher the paver, the more slip resistant.

Paving bricks, used flat or on edge, should be specified according to the desired pattern. For maximum design flexibility, it is recommended that the brick be twice as long as it is wide. Pavers can be specified with rounded or beveled edges called chamfers. These chamfers emphasize bond patterns, limit the height variation between pavers, and reduce standing water, which in turn assists in drainage and reduces slippery pavements. In areas where snow removal must be considered, the chamfers help prevent chippage due to shoveling.

A flexible brick pavement is only as good as the base beneath it. To ensure a smooth surface over time, a base layer of 3/4-inch or smaller aggregate should be laid over the compacted

roper Materials

earth. A crushed stone, also called crusher run or road base (ASTM D 2940), provides sufficient strength. Heavier loads and more severe frost conditions on the pavement require thicker bases.

For the bedding course, which is laid over the base, washed sand no larger than 3/16 of an inch should be used (ASTM C 33 Concrete Aggregate is acceptable). Caution should be used when accepting stone screenings as a substitute, particularly in vehicular areas. Screenings may not be graded appropriately or may be too soft — compromising interlock. In addition, screenings may contain sodium, lime or calcium that produce efflorescence. The jointing sand, which will be spread over the brick pavers and into the spaces between them, should be smaller than that used in the bedding course. Mason's sand meeting ASTM C 144 is the standard. Bedding sand can be used for jointing sand as a matter of convenience although some larger pieces may remain on the surface after sanding.

In some instances, a membrane such as a geotextile may be used to strengthen the system by keeping the layers separated. A geotextile

can be placed below the base thereby positively separating the layers and reinforcing the base slightly. A geotextile should be used since other plastic membranes do not allow water percolation.

Table 1 Physical Requirements

Designation	Average Compressive Strength, min, (ps)	Average Cold Water Absorption, max, (1%)	Saturation Coefficient, max
Class SX	8,000	8	0.78
Class MX	3,000	14	no limit
Class NX	3,000	no limit	no limit

Physical durability requirements are denoted by "Class" as follows: Class SX is Brick intended for use in freezing conditions; Class MX is brick used where resistance to freezing is not a factor; Class NX is brick used for interior applications

Table 2 Abrasion Requirements

	(1) Abrasion Index, max	(2) Volume Abrasion Loss, max, cm^3/cm^2
Type I	0.11	1.7
Type II	0.25	2.7
Type III	0.50	4.0

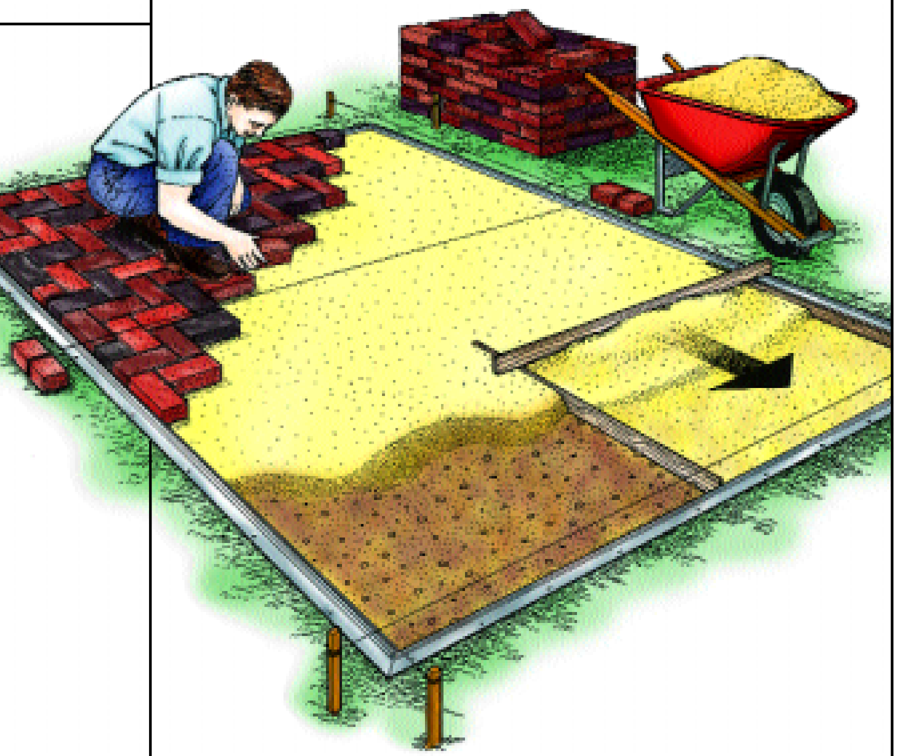
"Type" describes traffic demands. Type I denotes brick exposed to extensive traffic; Type II represents intermediate traffic; Type III signfies low traffic.

Table 3 Tolerances on Dimensions

Dimensions, in.	Maximum Permissible Variation from Specified Dimension, plus or minus, in.		
	Application PS	Application PX	Application PA
3 and under	1/8	1/16	no limit
Over 3 to 4	3/16	3/32	no limit
Over 5 to 8	1/4	1/8	no limit
Over 8	5/16	7/32	no limit

Application: describes use. Application PS represents general use (usually with a mortar joint); Application PX denotes use in a mortarless system or with a special bond pattern; Application PA signifies special architectural effect.

Pavement Instal



Once planning has been completed and the appropriate materials obtained, a flexible brick pavement can be installed relatively quickly. Because there is no mortar involved, brick pavement doesn't require the skilled labor of masons, doesn't need to be completed at one time, and requires no curing.

On site, brick pavers should be stored off the ground. Base and bedding course materials should be stored separately and covered with weighted plastic to maintain dryness and wind protection. Installation during rain or snowfall should be avoided.

The ground must be compacted and stabilized for both strength and drainage. The base should also be well compacted to avoid filtering-down of the bedding sand. Rammers, vibratory plates, or rollers may be used, depending on the compaction needed — 95 percent maximum density is recommended.

Base materials should be laid in consistent, well packed layers (4 inches max) that build up to a surface that will match the intended elevation. Rigid edge restraints are usually installed next, and if they consist of or include concrete, they should be cured before pavers are laid. One or two sides should be left unedged, with a board set as a temporary form. The final edge restraints will be set in place after the brick are installed, so that less brick cutting is required for final adjustments.

Bedding course sand is then spread over the base materials. It is smoothed over with a board known as a "screed board," which runs along pipes placed on the base or the edge restraints. This layer should follow the intended grade of the final wearing surface.

Pavers may now be placed in the desired pattern. A space of $1/16$ of an inch to $1/8$ of an inch should be left between pavers. Care should be taken by the installer to ensure some space is left between the pavers as the tendency is to lay them too tight causing poor interlock or paver chippage. Laying techniques vary with specific patterns. A 45-degree herringbone should start at a corner or the centerline. When using a running bond pattern, the pavers' long edges should be placed perpendicular to the flow of traffic. Whole pavers should be placed lation

first and then pieces cut cleanly to size. Alignment should be checked from time to time during the process, so that simple adjustments (either shifting the size of gaps or redoing single paver rows) can be made to assure a clean, consistent bond pattern throughout. Obstacles, such as manhole or water covers, should be prepared with square collars to avoid awkward cuts, or use a perimeter stacked bond border to move cuts away from the edges. Sailor borders are also used at the pavement borders to "frame" the pavement and to bring cuts away from the pavement edge.

A plate vibrator should be used to compact the pavers into place and initiate the process of interlock. To avoid shifting or breaking, the compactor plate should be at least two feet square and produce 3,000 to 5,000 pounds of centrifugal force. The compactor should have a rubber pad to avoid damaging the pavers. After the initial pass of the plate compactor, jointing sand is then spread into the spaces between the pavers. Sanding and compaction takes place again until the joints are full.

The brick pavement should be planned to lie flush with any adjacent pavement, and pavers abutting drains or gutters should be calculated to lie no more than 3/16 of an inch above the level of these drainage systems.

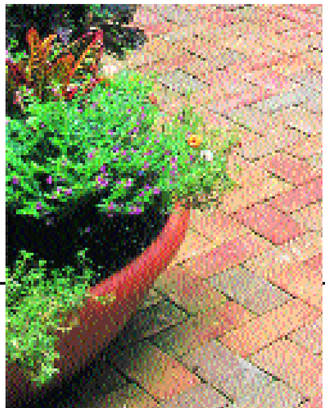
Maintenance an

Brick pavements are easy to maintain. Cleanup usually requires only a simple hosing down.

When a cleaner is deemed necessary, acid solutions should be avoided. Light brushing with plain water will remove most surface dirt. A commercial cleaner or a 50-50 solution of bleach and water will remove most moss or algae growth. In addition, time and weather will eliminate most efflorescence.

Snow and ice can be removed with normal hand equipment or motorized vehicles. Rotary brushes and snow blowers are preferred. Snowplow blades should be equipped with a rubber edge and set $^1/_4$ inch above the pavement. The use of rock salt is not recommended since it will cause efflorescence. Non-sodium de-icers that are environmentally compatible are available and the use of sand or cinders will provide some traction.

Coatings should not be applied in most climates, as they could trap moisture or salts that could damage the brick or make stains more difficult to remove. Evaporation of subsurface water may cause the coating to become cloudy. And in some areas, a joint sand stabilizer may be necessary to keep the sand in the joints, helping to keep system interlock. Products especially made for this situation should be used rather than all-purpose sealers.



d Cleaning

Summary

Brick manufacturers continue to expand pavement design possibilities. Many paver sizes and colors are available, as are special shapes such as squares and hexagons. Some pavement systems come designed in ornate patterns that integrate component pavers of different colors and shapes.

Offering a variety of styles, structural stability, and economic value, flexible brick pavements are anything but pedestrian. Ingenuity, proper planning and careful installation will almost always assure their success.

For more information regarding brick paving systems or any other brick applications, the Brick Industry Association can provide the architect or contractor with a wide variety of detailed publications. These include a *Design Guide for Vehicular Pavements* and the *Technical Notes* 14 Series on Brick Floors and Pavements.

Brick Industry Association

11490 Commerce Park Drive
Reston, VA 20191

(703) 620-0010
(703) 620-3928 fax

e-mail: brickinfo@bia.org
website: www.brickinfo.org