TECHNICAL NOTES on Brick Construction
The Brick Industry Association
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Technical Notes 29 - Brick in Landscape Architecture - Pedestrian Applications
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Abstract: This *Technical Notes* describes brick paving systems used in landscape design. Landscape architecture and its relationship to brick masonry is covered. Master planning and environmental aspects of landscape architecture are briefly discussed. Applications covered include patios, walks, steps and ramps. Materials and methods of construction of flexible and rigid paving applications, citing the most critical requirements, are outlined.

Key Words: landscape architecture, patios, pavements, ramps, steps, terraces.

INTRODUCTION

Landscape architecture is the planning and design of elements relating to the land, including trees, plants, paving, streets and sometimes structures. The design must take into account all of these elements and their relation to each other. Brick as a landscape material is an important design element. Brick paving applications can be used to create a pathway through the landscape, delineating pedestrian elements from natural elements. Since brick is made from the earth and is small in scale, it fits into many landscaping plans.

This *Technical Notes* covers the topic of brick as it relates to landscape architecture. It also covers environmental issues concerning the use of brick and brick paving systems in landscaping. Paving applications addressed include patios, walks, steps and ramps. Design, installation and material selections are discussed. Other installation practices that must be considered, but are not included in this *Technical Notes*, are edging, expansion joints and membranes. Other *Technical Notes* in this series cover garden walls and other miscellaneous landscape applications. Paving systems and related issues are discussed in more detail in the *Technical Notes* 14 Series [5,6].

LANDSCAPE ARCHITECTURE

The art of landscape architecture is more than the placement of trees and shrubs. Often it involves the development and planning of large areas within cities and suburban areas. This is typically organized through the development of a master plan. Alternately, landscaping may be on a much smaller scale, as in the design of a small garden. The landscape architect must always consider certain issues, including aesthetics, harmony, continuity/unity, accessibility, economy and other design parameters. Material and system selections are usually based on these issues.

Materials can be broadly classified as either landscape materials or hardscape materials. Landscape materials include trees, plants, grasses, soil and gravel. Hardscape materials include brick, stone, concrete and other hard materials. A comprehensive landscape plan usually combines both landscape and hardscape features.

Master Planning

The landscape architect plays a much larger role with all land development issues today than in the past. Buildings and their relationship and integration into the site have become increasingly important design issues. This may apply to entire subdivisions and cities as well. A master plan is usually developed to incorporate all elements into a comprehensive land development design. Master plans will dictate where open spaces should be located and locations of buildings, pavements and walks. Brick can play an important part in the development of master plans since it can be used as a common thread throughout an entire project. This includes walls, pavements, fountains, planters, fences, steps and other miscellaneous landscape uses. Continuity throughout the project can be achieved by using brick in many of these applications.

Environmental Issues

There is now more pressure than ever to consider the environmental effects of a particular landscape plan. A movement, often termed "sustainable development", considers the environmental impact of land development before, during and after design. Environmental issues, such as storm water runoff and the lack of water, are becoming more important as landscape architects look more closely at potentially threatening issues.

Sustainable Development. Sustainable development can be defined as development that meets the needs of the present without compromising the future. In the past, sites were often dramatically altered without adequate consideration of the environmental impact. As with all designs, compromises must be made to achieve the design requirements. Sustainable development takes into account the effects of materials used in the landscaping plan on the environment. The embodied energy and the effects of the manufacturing of the material on the environment are closely considered. Brick is a material made from clay and shale, some of the earth's most abundant materials. The energy used to make brick, which is termed its embodied energy, is less than that of concrete, steel and many other materials [3]. Since brick is inert, it does not pose any long-term environmental threats.

Water Issues. Environmental concerns have been raised regarding both storm water runoff and the lack of water in some areas. When many parts of the landscape are being covered by impermeable surfaces, storm water runoff becomes a larger problem. The amount of water that drains off of a shopping center parking lot, for example, can be quite large causing flooding or erosion. Thus, the size of storm sewers and catch basins must be increased in size accordingly, putting more stress on the infrastructure. Conversely, some areas of the country are so arid, they cannot support plant life.

Porous Pavements - Most hardscaping materials, such as concrete or asphalt, will not allow water back into the ground. This is also true of rigid (mortared) brick pavements and some flexible (mortarless) brick pavements over an impermeable base. These systems can have a negative effect in urban areas which include trees as a part of the urban landscape. Trees can die due to lack of water and nutrients when surrounded by impervious hardscapes. In an effort to provide water for trees, grates have been used, but their small size can inhibit proper tree growth. Soil and mulch have also been used around trees, but usually become compacted and allow rain to evaporate away too quickly. When water infiltration into the ground is desired, a pavement which allows water to percolate back into the ground should be used [4]. One alternative that can help water infiltration and reduce storm water runoff is the use of porous pavements.

A porous pavement allows water to filter through it, percolate back into the ground and replenish the ground water. In most cases, mortarless brick paving over an aggregate base can be constructed to allow water to percolate into the ground. However, to allow more percolation to occur, the pavement must have joints between the pavers at least 1/4 in. (6 mm) wide. The joints allow water to enter easily and permeate to the base. The base should be an open-graded aggregate, such as free- draining gravel or sand, to allow percolation. Although porous pavements allow storm water runoff to be directed back into the ground water system, it may go against usual pavement design practice. In a flexible brick pavement, it is desirable to have a dense base to resist loads from traffic above and from frost heave from below. Using an open-graded base may not provide the stable base that is needed.

To use an open-graded base under brick paving, some simple recommendations must be followed. The open-graded base must be compacted appropriately. Guidelines exist for the proper construction of open-graded bases [6]. A membrane, such as a geotextile or filter fabric membrane, must be placed between the sand setting bed and the open-graded base to avoid settling of the sand into the voids of the base. A geotextile may also be required between the base and the soil or subgrade to prevent soil from pumping up into the base. The size of the joints can be problematic when large amounts of water constantly run across the pavement. Jointing sand may wash out in areas when the joints are larger than 1/4 in. (6 mm). Another issue to consider is that interlock of the pavers will not be achieved when the joints are larger than 1/4 in. (6 mm). Interlock of the pavement occurs when the pavers are compacted into the sand setting bed and the entire pavement - i.e. pavers, setting bed, and base - lock together and act to withstand the loads as a single element. A flexible brick paving system can be designed for improved percolation, but interlock of the pavement cannot be expected when sand-filled joints are larger than 1/4 in. (6 mm).

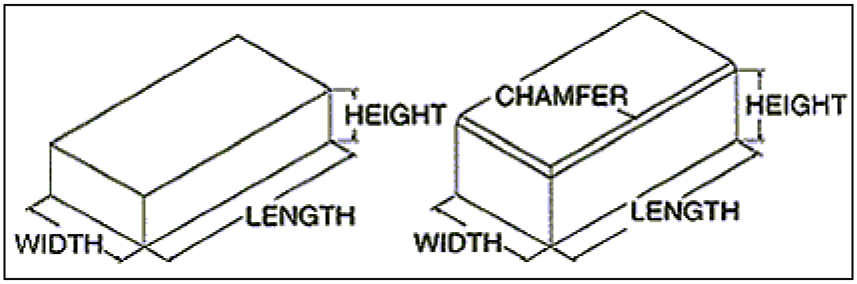
Xeriscapes - Xeriscapes are defined as water-efficient landscapes which not only require less water to grow vegetation, but have a reduced need for mowing, fertilizing and pesticide application. They may be used in certain areas of the country, such as parts of Southern California, Arizona and Nevada, where water supplies are low or unreliable. Instead of introducing planting areas that require large amounts of water, it may be prudent to use brick in the place of plants. In this manner, reliance on the local water system, expensive watering systems and plant maintenance can be reduced. Wildfires in arid regions of the country are another concern which may require the use of non-combustible materials adjacent to homes. Brush and shrubs can act as fuel sources for wildfires. Brick paving adjacent to the house can act as a fire break. To offset the use of all of the hardscape materials, patterns are laid in the pavement to give the impression of plantings. Obviously, this must fit in with the entire landscaping plan.

Aesthetics

One of the most important features that a landscape architect faces is that of appearance. The look of any design can evoke strong feelings, good or bad. So it is important that the aesthetics of the project be examined closely. As in all architecture, form, color and pattern are the vehicles for achieving a certain aesthetic appeal. Brick paving utilizes its variety of size, shape, color and pattern to conform to the chosen theme. Brick pavers are produced in a variety of sizes. The most common sizes are shown in Table 1.

TABLE 1
Typical Brick Paver Sizes[1]

Width, in. (mm)	Length, in. (mm)	Height, in. (mm)
4 (100)	8 (200)	Varies according to manufacturer and application, usually 1 1/4 (32), 2 1/4 (57), 2 5/8 (67) or 2 3/4 (70)
3 5/8 (92)	7 5/8 (194)	
3 1/2 (89)	7 1/2 (190)	
7 5/8 (194)	7 5/8 (194)	
8 (200)	8 (200)	



[1]Check with manufacturer for availability of chamfers.

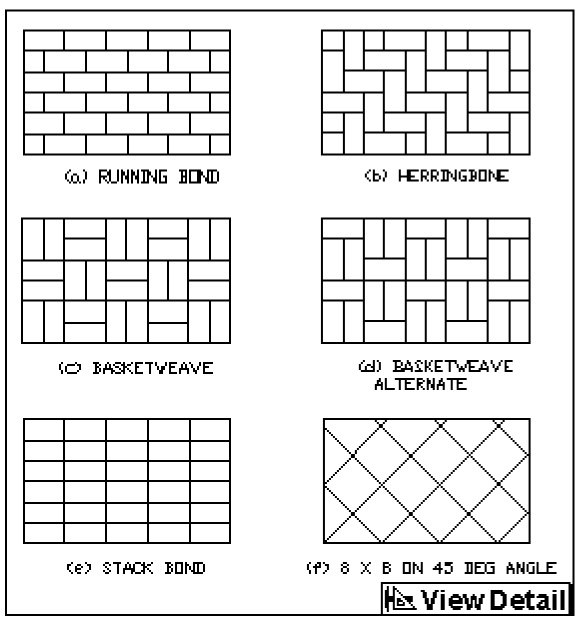
Alternative sizes and shapes of pavers can also be manufactured or cut from standard units into the desired shape. For example, radial brick are often used to create curves or circles in the pavement, as shown in Figure 1.

Special Brick Shapes

FIG. 1

The color of brick pavers range from buffs to dark browns, pinks to deep reds. The pavers can be a uniform color or there can be a range of colors. The color of brick will not fade over time. Different colors can be arranged within a pavement to achieve a truly dramatic look.

Almost any pattern is possible with brick. The pattern can be simple diagonals or more complicated cross or weave patterns. Different colored units can be used to create a flow pattern for pedestrian traffic. It may suggest a special theme used throughout the landscape plan. The more traditional brick paving patterns are shown in Fig. 2. Brick can also be cut to achieve a pattern; although in some cases, specially shaped pavers may be used.

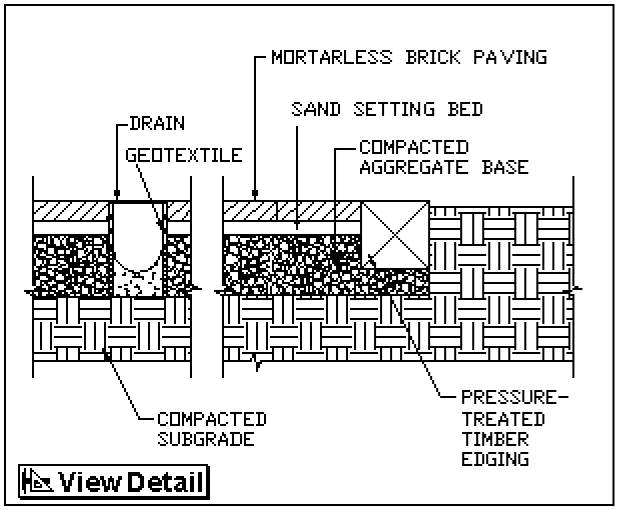


Brick Paving Patterns

FIG. 2

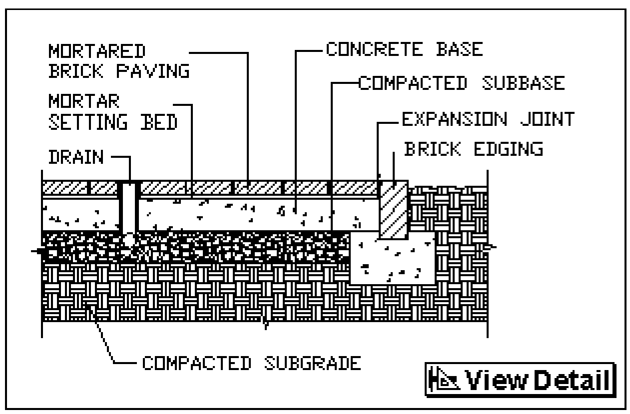
BRICK PAVING SYSTEMS

Brick paving can be classified by two basic systems; flexible and rigid. Flexible brick pavements usually consist of mortarless brick paving over a sand setting bed and an aggregate base. Rigid brick pavements consist of mortared brick paving over a concrete slab. Mortarless brick paving can be used over any base. Mortared brick paving must be supported by an adequate concrete slab or the mortar joints or pavers may crack if the base is not sufficiently rigid. Examples of flexible and rigid brick pavements are shown in Figs. 3 and 4, respectively.



Flexible Brick Paving

FIG. 3



Mortarted Brick Paving

FIG. 4

Although a flexible brick paving system is generally recommended, there are certain applications where rigid brick paving is desired. An example is brick steps, which requires the edges to be mortared together to keep the brick in place. The major advantages of using a flexible pavement include easier repairs to utilities beneath the pavement and usually lower installation costs.

The design of brick paving systems can be rather complex, depending on the size of the project. *Technical Notes* 14 Series discusses many of the design and construction parameters in more depth than in this *Technical Notes*. Only critical or unique information is contained here.

Patios and Walks

Some of the most widely used features of landscape design to which brick is adapted are patios and walks. Patios may be outdoor extensions of the indoor living space and supplement the activities of the occupant. Patios are often adjacent to living, family or dining rooms. Patios may be built as terraces, which are raised levels of earth supported on one or more sides by a wall or bank. A terrace is used to extend living space along a hillside.

Walks are often effectively used to provide an interesting and inviting entrance path to a garden or home. Walks may be used to define pedestrian travel routes and can provide geometric patterns in formal garden layouts. They can also serve as a path through a natural or garden setting.

Bases. The proper design and construction of the base is often the most critical element for long-term performance of the paving assembly. Insufficient base thickness or improperly compacted bases will lead to undulations (rutting) or cracking of the pavement. Appropriate base thickness depends on the type of loading and weathering it will receive. Most residential patios and terraces will only receive pedestrian traffic; therefore, the thickness may depend more on its resistance to frost heave. The minimum recommended base thickness is 4 in. (200 mm) for concrete, asphalt and aggregate bases. Thicker bases and the use of a subbase may be required in areas with poor soil conditions or soils that are constantly saturated. In these cases, the base should be increased in thickness based on local requirements.

Drainage. Drainage is another key design feature which affects long-term performance. Poor drainage will allow water to stand on the pavement and saturate the brick pavement. Problems resulting from poor drainage include deterioration of the paving, moss and algae growth and slippery pavements. Therefore, it is important to slope the pavement to keep water from collecting. Primary drainage of all pavements should occur on the surface. Drainage should occur away from buildings or other walls. For brick pavements, a slope of 1/8 to 1/4 in. per foot (1 to 2 mm per 100 mm) is recommended. Lesser slopes will allow water to accumulate. Steps and ramps must also be sloped to avoid standing water. Treads of steps should slope 1/8 to 1/4 in. per foot (1 to 2 mm per 100 mm). Cross-slopes of the pavement help drain water off of the pavement, but the slope should not exceed 3 percent. Flexible brick pavements may allow some water to percolate down into the ground. In this case, subsurface drains may be necessary to remove water from the system.

Steps and Ramps

Steps and ramps are used to connect different levels for easy access. Steps have traditionally been used to allow movement up and down steep slopes or within structures. The size and configuration of steps is governed by a combination of physical human dimensions and aesthetics. Ramps are used on gentle slopes and are used to provide access for the physically impaired. Since ramps have low slopes, they will require more space than steps. Brick has been used successfully in all configurations of steps and ramps mainly because it is a small element which permits numerous configurations. Model building codes often dictate certain criteria for steps and ramps such as riser-tread relationships and minimum slip resistance. Other design issues that should be considered include structural support of the steps or ramps and other safety issues. Steps should be a minimum width of 60 in. (1.5 m) for public spaces, or 42 in. (1.1 m) for private residences. There should be at least two, preferably three or more steps, in a stepped walkway, since single steps can be overlooked and lead to trips.

Step Riser - Tread Relationships. Riser-tread relationships have been studied for many years. Most steps are constrained to fit into a set elevation at the top and the bottom of the steps. For these steps, riser-tread relationships have been developed for safe and efficient use. In other areas, such as plazas, the tread dimension may not be constrained, which allows freedom of design. In these areas, riser and tread dimensions will be dictated by human dimensions and appearance.

Most local building codes mandate the minimum and maximum riser dimension and minimum tread dimension. The 7-11 rule is used most frequently; that is, maximum riser height is 7 in. (180 mm), while the minimum tread depth is 11 in. (280 mm). The riser must also be greater than 4 in. (100 mm) in height. Due to normal walking and gait, optimum riser-tread dimensions do exist. One formula for determining this relationship has been recommended for use [1]. It provides a general guideline for riser and tread dimensions.

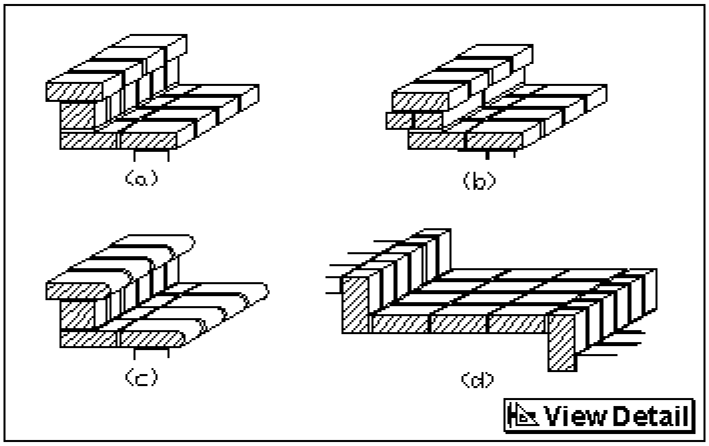
$$T \times R = 77.5 \quad (T \times R = 500, \text{ for SI units})$$

where:

T = tread width, in. (cm)

R = riser height, in. (cm)

In this equation, the riser is restricted between 4 in. (10 cm) and 7 in. (18 cm). Since brick is a small element, there are a variety of bonding patterns for the tread and riser. Figure 5 shows several examples of bonding arrangements with modular brick.



Step Configurations

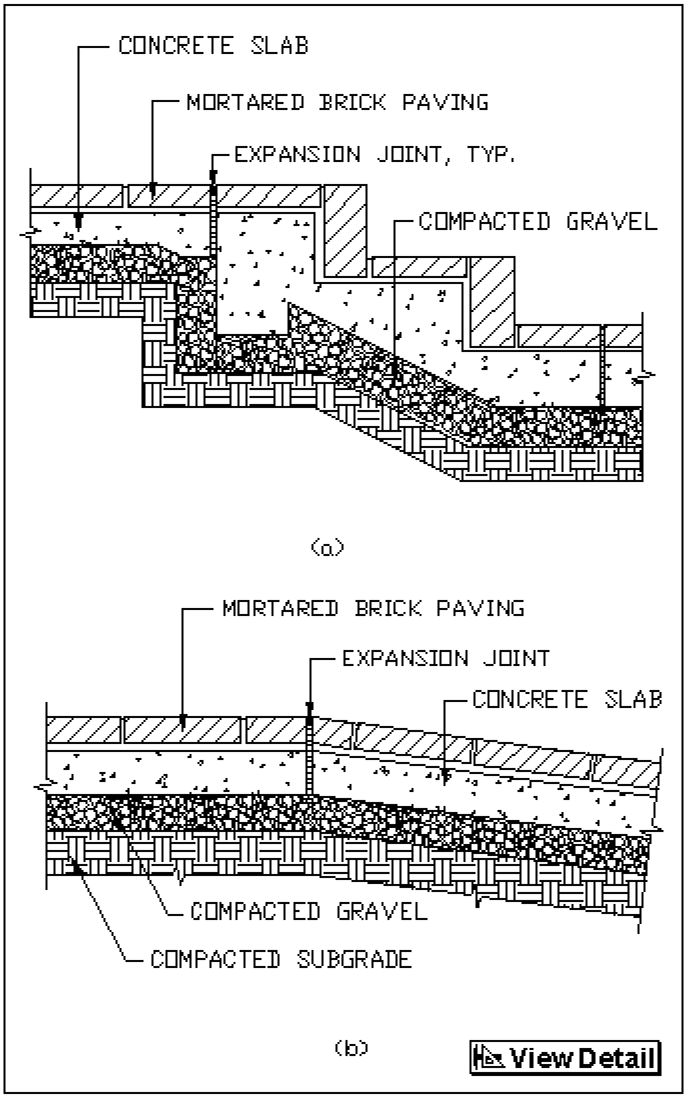
FIG. 5

Landings may be included in steps, especially when the cumulative height of steps is great. Building codes set the maximum height between landings at 12 ft (3.7 m); however, it is usually more desirable to limit the maximum height to 5 ft (1.5 m) between landings. The length of the landing should be long enough to allow easy cadence, which is about 5 ft (1.5 m) or a multiple of 5 ft (1.5 m).

Edge Details. For safety reasons, several issues relating to the edge of the steps should be considered. In most pedestrian applications, it may be beneficial to highlight the edge of the step by varying the color of the tread and riser brick, changing the bond pattern of the tread or by extending the tread slightly over the riser. These distinctions of the edge allow easy visual indication that a change is coming, which helps to avoid tripping. Extending the tread over the riser creates a shadow line highlighting the stairs and also allows the treads to be slightly deeper than if they were squared off. However, the maximum projection should be 1 1/2 in. (40 mm) to avoid catching the foot while stepping up. If a rounded tread is used, the leading edge should be a maximum 1/2 in. (13 mm) radius.

Ramps. The model building codes and other accessibility codes [2] usually limit the slope of ramps to no steeper than 1:12 in most applications. Greater slopes are allowed only if the total rise is less than 6 in. (150 mm). Slopes greater than those allowed by codes make it difficult for persons in wheelchairs to negotiate the ramp. The width of a ramp should be at least 3 ft (0.9 m) wide for one-way traffic and 5 ft (1.5 m) wide for two way traffic. In addition, landings should be provided every 30 ft (9 m) horizontally.

Support and Bonding. Brick steps and ramps are usually supported by a concrete base, but any material capable of supporting the brick properly could be used, if designed properly. Deflections or settlement of the support must be minimized to avoid cracking in the brickwork. Figure 6 shows a concrete support system for a step and ramp. Brick should be adequately bonded to the support or restrained around its perimeter to avoid loosening of units. Mortar is usually used to bond the brick to the concrete. This paving system is very effective when proper materials and installation are used. Dowels or ties into the mortar joints are not necessary since the mortar provides adequate bond. Newer types of adhesives are now being used to bond the brick directly to the concrete. These adhesives must be durable to withstand the severity of its environment. Adhesives can only be used when the concrete surface is fairly even and free of contaminants. Caulks and sealants are not appropriate for this purpose.



Stair and Ramp Sections

FIG. 6

Adequate footings should be designed for the step or ramp support. The depth of the footings should extend below the frost line. Since the paving assembly is supported on its own footing, an isolation joint should be used between the pavement and building and between the pavement and ramps or steps.

Safety. In addition to the required physical dimensions of the element, the slip resistance of the surface should also be considered. The static coefficient of friction is usually used to determine if a surface is considered slippery. There is no consensus minimum value for coefficient of friction; however, some codes are promoting minimum static coefficient of friction values of 0.6 for pavements and 0.8 for ramps [2]. Limiting the static coefficient of friction to these values is believed to make the surfaces safe and passable by both able-bodied pedestrians and the physically impaired. It is usually excessive water- ponding or the contamination of the pavement by other substances which cause most slips and falls. Brick usually has an adequate slip resistance, with higher coefficient of friction values achieved when a rough textured brick is used.

SELECTION OF MATERIALS

Pavements can be subjected to severe weather and abrasion; therefore, the materials used to construct them must be of superior quality. Most of the materials in a pavement must conform to ASTM standards. Following are recommendations for the selection of paving materials. Additional information on material selection can be found in *Technical Notes* 14 Series

Brick Pavers

Pavers must be able to withstand the weather and the abrasion of pedestrian traffic. Pavers should conform to the requirements of ASTM C 902 Specification for Pedestrian and Light Traffic Paving Brick. Units conforming to ASTM C 1272 Specification for Heavy Vehicular Paving Brick may be used, but are usually not necessary for most landscape applications, unless heavy vehicular traffic is expected. Heavy vehicular traffic is composed of high volumes of heavy vehicles on a pavement. Two of the more critical requirements of ASTM C 902, durability and abrasion, are discussed below. Other requirements, such as dimensional tolerances, chippage and warpage should also be considered.

Durability. The resistance of pavers to weathering is determined by the Class of the paver. The Class of the paver is based on the durability of the unit and is determined by compressive strength, cold water absorption and saturation coefficient of the unit. Class SX pavers are intended for use where the paver may be frozen while saturated with water. In exterior applications where freezing is not present, pavers should conform to Class MX or SX. Class NX pavers are acceptable for interior use where they are protected from freezing when wet. Alternate means of assessing durability of brick pavers are addressed in ASTM C 902 and *Technical Notes* 14A Revised.

Abrasion Resistance. Pavers must be able to resist the abrasive action of traffic. ASTM C 902 includes three abrasion classifications of pavers; Types I, II and III. Type I pavers are appropriate for areas receiving extensive abrasion, such as commercial driveways and entrances. Type II pavers are intended for exterior walkways and floors in restaurants and stores. Type III pavers are used for residential floors and patios. The paver Type is determined by its abrasion index, which is calculated by dividing the cold water absorption by the compressive strength and multiplying by 100. The resistance to abrasion can also be determined by a laboratory test, as outlined in ASTM C 902.

Setting Bed Materials

The setting bed, placed between the base and the brick pavers, functions as a leveling course for slight irregularities in the base and units. Setting bed materials include sand, mortar, asphalt and building felt.

Sand. Sand used as a setting bed should be a washed, well-graded angular sand with a maximum particle sized of 3/16 in. (4.8 mm). Sand should conform to ASTM C 33 Specification for Concrete Aggregates, usually referred to as concrete sand. Mason's sand can also be used as the setting bed material when the thickness of the setting bed is less than 1 in. (25 mm). Mason's sand should conform to ASTM C 144 Specification for Aggregates for Masonry Mortar. The thickness of the sand setting bed should be between 1/2 in. and 2 in. (13 mm and 50 mm).

Mortar. Mortar setting beds are used in mortared brick paving applications. Mortar should conform to ASTM C 270 Specification for Mortar for Unit Masonry or ANSI A118.4 Specification for Latex-Portland Cement Mortar, when a latex additive is used. For exterior mortared brick pavements, Type M mortar is preferred. Type M portland cement-lime mortar consists of 1 part portland cement, 1/4 part hydrated lime and 3 3/4 parts sand. Type S mortar can be used alternately. In severe freeze/thaw environments, mortars with better freeze/thaw resistance should be used. Two mortar properties that greatly influence freeze/thaw resistance are air content and water/cement ratio. An air content for paving mortars between approximately 10 percent and 15 percent is optimal. Increasing air content too much will reduce bond between the brick paver and mortar. To address the water/cement ratio, the mortar should be mixed with just enough water to make it workable. The thickness of the mortar setting bed should be between 3/8 in. and 1 in. (10 mm to 25 mm).

Asphalt. Asphalt setting beds typically consist of approximately 7 percent asphalt and 93 percent sand. The asphalt setting bed is used over a concrete or asphalt base. The thickness of the asphalt should be approximately 3/4 in. (20 mm).

Building Felt. Brick may be placed directly on a new or existing asphalt or concrete base. In these applications, building felt may serve as a cushion between the pavers and the base, which can accommodate small dimensional variations of the base and pavers. Two layers of No. 15 building felt or one layer of No. 30 building felt is appropriate.

Base Materials

Base materials consist of crushed aggregate, gravel, sand, asphalt and concrete. Asphalt and concrete bases often require an aggregate subbase. Steps and ramps usually are built on concrete bases, whereas patios and terraces may be supported on any of the base materials listed.

Aggregate Bases. Aggregate bases include crushed stone, gravel and sand. Heavier loading or areas subjected to frost heave may require crushed stone. Open-graded aggregate (gravel) is often used in areas of poor drainage, areas subjected to frost heave or when porous pavements are designed. The proper aggregate size depends on the depth of the layer and the size of the compaction equipment. Maximum aggregate size is usually 3/4 in. (20 mm) diameter.

In residential pedestrian applications, sand bases can be used when the subgrade compaction is ensured, when bearing on undisturbed earth and in areas where frost heave is not a consideration. Sand used as a base material should be a concrete sand conforming to ASTM C 33 and be clean and free of deleterious materials.

Concrete Bases. New or existing concrete bases may be used to support brick paving. New concrete should be installed following recommended concrete practices. Where mortar is used to bond brick pavers to the concrete, the concrete should have a rough textured finish. Caution should be used if brick is placed over an existing concrete slab. The existing concrete slab must be sound and any major cracks filled adequately with concrete or mortar.

Asphalt Bases. New or existing asphalt bases may used to support mortarless brick paving. Proper asphalt materials are generally determined by paving contractors or the asphalt plant and are beyond the scope of this *Technical Notes*. Asphalt bases should not be used to support mortared brick paving.

CONSTRUCTION

One of the most important factors in long-term pavement performance is proper installation. Critical elements include proper base compaction, proper edge restraints and full mortar joints, if used. There are numerous ways to install brick paving, and techniques tend to vary by region. The recommendations in this *Technical Notes* are based on experience and provide a minimum level of workmanship necessary for satisfactory performance. More information on construction of brick pavements may be found in *Technical Notes* 14 Series.

Base Preparation

Proper compaction of the subgrade (soil) and base is one of the most critical factors in pavement installation. Pavements rely on the strength of the base to adequately resist loads. Poorly compacted aggregate bases usually lead to undulations (rutting) or cracking of the pavement. Most patios, steps and ramps are built adjacent to a building or residence. These are often areas over backfill rather than undisturbed earth, making proper compaction even more critical. Compaction of the subgrade should be done with the largest equipment possible so that proper compaction is achieved. Once the subgrade is compacted, the base may be built on top. The base material should be spread and compacted in layers or lifts. The thickness of each layer must be consistent with the size of compaction equipment, but never exceed 4 in. (100 mm). Vibratory rollers may be necessary, although for most residential applications plate compactors provide enough force. Typical compaction criteria is 95 percent maximum density.

Mortar Installation

When brick are installed with mortar, standard bricklaying or tile setting procedures should be followed. The preferred method of mortar placement is with a trowel. The concrete base should be clean and slightly dampened, but surface dry prior to placing the mortar. Brick pavers should be buttered on the ends and shoved into the mortar setting bed. All joints intended to receive mortar should be solidly filled. The joints should be tooled with a metal jointer. A shallow concave joint profile is preferred for proper compaction of the joint and to keep water from ponding on the mortar joints.

CONCLUSION

This *Technical Notes* describes elements considered in landscape design including master planning and environmental aspects of landscape architecture. Design of pavements, steps and ramps is discussed. Materials and construction of these elements and the most critical requirements for each are outlined.

The information and suggestions contained in this *Technical Notes* are based on the available data and the experience of the engineering staff of the Brick Industry Association. The information contained herein must be used in conjunction with good technical judgment and a basic understanding of the properties of brick masonry. Final decisions on the use of the information contained in this *Technical Notes* are not within the purview of the Brick Industry Association and must rest with the project architect, engineer and owner.

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