Accessible Clay Brick Pavements

Abstract: Pavements composed of clay brick pavers must be able to accommodate many types of traffic, including pedestrians with physical disabilities. This *Technical Note* includes guidance related to the design, construction and maintenance of pavements constructed of brick pavers that will serve all people, including those with disabilities.

Key Words: accessible surfaces, accessibility, ADA, disabilities, pavements, segmental pavements, sidewalks.

SUMMARY OF RECOMMENDATIONS:

Design
- Select a paving system that is durable and is easy to maintain and repair
- Ensure that the base is designed and constructed properly to avoid differential settlement
- Minimize joint and chamfer widths to control vibration experienced by wheeled devices (see Figure 2)
- Select appropriate trees and plants for locations near brick pavements, and employ root barriers or other best management practices to accommodate them
- Consider permeable pavements that allow more rapid water runoff and allow air and water to reach tree roots
- Minimize curb cuts in accessible paths to provide more level surfaces
- Use truncated dome pavers/detectable warning surfaces where applicable
- Select bond pattern and orientation that minimizes wheelchair vibration

Paver Selection
- Select pavers that have top surfaces and edges that are planar
- When present, chamfers or rounded edges not wider than ¼ in. (6 mm) are recommended
- Select pavers with a surface that will provide adequate slip resistance when wet

Construction
- Construct pavements with smooth and level surfaces within the specified tolerances:
  - ±⅜ in. (10 mm) from level in 10 ft (3 m), noncumulative
  - ⅛ in. (3.2 mm) maximum vertical lippage for straight edged pavers; ¼ in. (6 mm) maximum vertical lippage for chamfered pavers
  - Maximum width of sand-filled joints: $^{3}/_{16}$ in. (4.8 mm)
  - Maximum width of mortar-filled joints: ½ in. (13 mm)

Maintenance
- Inspect and maintain pavements on a regular basis, but not less than once a year
- Refill sand in the joints in sand-set brick paving assemblies when necessary
- Remove snow and ice as quickly as possible using appropriate tools or machines
- Repair pavements that inhibit accessibility as soon as practical

INTRODUCTION

Clay pavers have been used in streets, sidewalks, paths and plazas for hundreds of years. They are chosen for their durability, long-lasting color, small scale, and ability to blend in with the surrounding area. While these are all desirable traits, more recent awareness of the needs of people with disabilities has refocused attention on other attributes of paving surfaces (Photo 1). People with disabilities make up a significant percentage of the population in the United States. People with limited mobility include those in wheelchairs or using crutches or other walking aids, as well as individuals who are blind or have low vision. With the enactment of the Americans with Disabilities Act in 1990, and the subsequent publication of guidelines by the U.S. Access Board, requirements for accessible surfaces have been established. Research and prolonged use has documented that segmental

Photo courtesy Stiles & Hart Brick Company

Photo 1
Tammy Lynn Center for Developmental Disabilities, Raleigh, North Carolina

clay paving systems can comply with provisions found within various accessibility guidelines. This *Technical Note* describes the ways that clay brick pavements can conform to accessibility requirements and be used as accessible routes.

While the information in this *Technical Note* is correct at the time of this writing, various updates to federal regulations are ongoing, so original sources should be checked for the most up-to-date information. In addition, there are various other requirements in the 2010 ADA Standards for Accessible Design (ADA Standards) [Ref. 1] that are not addressed here that could potentially impact the provisions covered in this *Technical Note*. This *Technical Note* should not be the only source used when designing an accessible pavement.

Misinformation about Clay Brick Pavements and Accessibility

It is important to maintain the proper perspective when evaluating existing brick paving systems that were designed and constructed prior to the advent of or without regard to ADA Standards. Such pavements were never intended to perform as accessible pavements. This is true for all pavement categories, including segmental, monolithic and other paving systems. Obviously, whether accessible or not, older paving systems should undergo maintenance or repairs to ensure that they meet both old and new performance requirements. Older pavements that have not received proper maintenance should not be expected to meet accessibility requirements.

Pavements using segmental pavers behave differently from monolithic slabs of concrete or other materials. It is often erroneously assumed that monolithic slabs are superior to segmental paver pavements because they have fewer joints; however, research shows that both types of pavements can be smooth enough to achieve accessibility requirements. In fact, the amount of work required for wheelchair users to cross segmental pavements may be less than for other pavement types [Refs. 2 and 6]. A frequent criticism of segmental pavements is that they have too many joints, which result in more vibrations to wheelchair users; however, vibration measurements conclude that the narrow joints in segmental pavements result in less severe vibrations than control joints in concrete slabs. Certainly larger joints, or pavers with large chamfers, can create a more irregular surface, but limiting chamfer size or joint size will result in the desired performance.

There is also a misconception that pavers normally become loose or misaligned over time, creating a tripping hazard. Pavers around street trees can become uneven over time due to growing roots forcing the pavers upward. This can be minimized with appropriate selection of plants or trees, root control and maintenance. Often, a segmental pavement will provide smoother surface transitions than the more abrupt changes in level that occur in monolithic concrete because the frequency of joints results in smaller incremental changes between pavers (compare Photo 2 and Photo 3). Pavements constructed with segmental pavers are much easier to repair than poured concrete, resulting in simpler and less costly maintenance.

Photo 2
Abrupt Changes in Level Caused by Tree Roots

Photo 3
Smoother Transition with Segmental Units

Research on Accessibility of Pavements Made with Clay Pavers

The clay and concrete paver industries, along with various federal agencies, funded a series of research projects [Refs. 2 and 6] to determine the effects of pavements constructed with pavers on people with disabilities. The research was conducted at the University of Pittsburgh and led by Dr. Rory A. Cooper, Director of the Human Engineering Research Laboratory. The research attempted to determine criteria for defining a pedestrian access route that does not require excessive propulsive work for people using wheelchairs, nor expose them to potentially harmful vibrations (Photo 4). While propelling a wheelchair, users encounter obstacles such as bumps, curb descents, and uneven surfaces. These obstacles cause vibrations on the wheelchair and, in turn, the wheelchair user, which through extended exposure can cause low-back pain, disc degeneration and other harmful effects to the body. Various paver designs were tested, including pavers with small chamfers, large chamfers and no chamfers. Two different bond patterns were also used as a variable. The following statement from the research [Ref. 6] summarizes the conclusions of the study:

> *"Based on the manual and power wheelchair results of this study, use of selected…pavers would be acceptable for any route traveled by individuals using wheelchair*[s]*. The results are as good as, and in some cases better, than that of a standard sidewalk surface. A* [chamfer width] *less than or equal to 6mm* [0.24 in.] *must be used for routes used by individuals using wheelchairs. Furthermore, a 90 degree herringbone pattern is preferred over the 45 degree pattern, while the 90 degree herringbone pattern is required for the 6mm* [0.24 in.] [chamfered] *pavers to maintain safe levels of vibration exposure."*

Photo 4
University of Pittsburgh Research

Pavers having chamfers not greater than ¼ in. (6 mm) wide allow the front wheel (5 in. [126 mm] diameter or larger) of a wheelchair to span the distance between the top surfaces of the pavers without creating undue stress on the wheelchair user. The joints created by pavers with chamfers larger than this may cause discomfort. This information can be used to distinguish pavements designed for accessibility from those that are not. Current research is under way to develop a rollability index similar to that used for roadways. This index will assist in measuring the roughness of a surface.

CHARACTERISTICS OF ACCESSIBLE PAVEMENTS

The ADA Standards establish minimum design requirements for public and private buildings and facilities that promote access for people with disabilities. The U.S. Access Board is also developing guidelines that cover disability access provisions for pedestrian areas along public rights-of-way. These Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) [Ref. 4], when published as a final rule, are anticipated to become the basis of enforceable standards issued by governmental agencies.

The ADA Standards and PROWAG mandate several surface profile requirements applicable to all pavement systems. The designer should be aware of maximum permissible gradients and other requirements that often are overlooked when focusing on pavement surface requirements.

In addition to planning and designing in accordance with these guidelines, all pavement types need regular maintenance programs capable of preserving the safe and serviceable condition of these routes. Specific requirements especially pertinent to clay pavers relate to surface properties, changes in level, joints and detectable warning surfaces.

Surface

The ADA Standards and PROWAG require an accessible surface to be firm, stable and slip resistant (see Photo 5). Smoothness of the entire pavement also may be an important criterion, because disabled pedestrians and wheelchair users may be more sensitive to trip hazards and vibrations. Properly designed, installed and maintained clay paver surfaces achieve the required smoothness. Even when properly designed, installed and maintained, all pavement systems may be subject to heaving and settlement of underlying soils that result in changes in level. Research has shown that the vibration on clay paver surfaces is comparable to or less than that of poured concrete and other common paving materials [Refs. 2 and 6]. Simple maintenance should be conducted on these surfaces to maintain their smoothness.

Photo 5
At-Grade Street Crossing with ADA-Compliant Surface Texture Changes

Changes in Level and Paver Lippage

Both the ADA Standards and PROWAG allow a change in level (surface discontinuity) up to ¼ in. (6 mm) (see Figure 1a) to be untreated. Each also permits a maximum change in level of ½ in. (13 mm) maximum, but the ADA Standards require this change in level to be sloped (beveled) not steeper than 1:2 (see Figure 1b). The PROWAG also requires a maximum slope (bevel) of 1:2 for this change in level but further mandates that the slope (bevel) be applied across the entire change in level (see Figure 1c).

With respect to pavers, changes in level (differences in elevation of the top surfaces of adjacent pavers) should be kept to a minimum through careful design and installation and should be maintained as part of a regular maintenance program. Changes in level can result from heaving or settling of the pavement base and more frequently occur at features that penetrate the paver layer, such as metal utility box frames and utility hole covers.

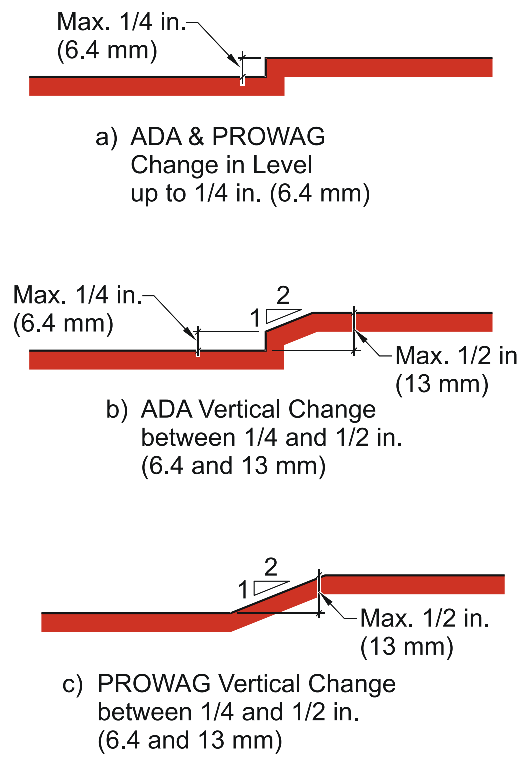

Figure 1
Requirements for Making Changes in Elevation

Joints

The ADA Standards do not specifically cover joint widths, but it does have requirements for openings in gratings, which should be considered due to their similarity. The PROWAG and ADA Standards include requirements for horizontal openings in walkway joints and gratings. Both documents state that openings in ground surfaces may not allow passage of a sphere more than ½ in. (13 mm) wide. Such an opening would be more than twice the typical width of joints between pavers in pavements with sand and bituminous setting beds that are typically 1/16 in. (1.6 mm) to 3/16 in. (4.8 mm) wide (Photo 6). Joints in

Photo 6
Typical Joint Size for Clay Pavers

permeable clay pavements are generally between ¼ in. (6 mm) and ⅜ in. (10 mm) wide. Joints between pavers in a mortar setting bed are generally ⅜ in. (9 mm) to ½ in. (13 mm) wide but are filled with mortar and thus are not generally considered openings.

Detectable Warning Surfaces

The PROWAG requires detectable warning surfaces between pedestrian and vehicular transitions. A detectable warning surface consists of a pattern of truncated domes sized to have a base diameter of at least 0.9 in. (23 mm) but not more than 1.4 in. (36 mm), a top diameter of a minimum of 50 percent to a maximum of 65 percent of the base diameter, and a height of 0.2 in. (5 mm). Clay pavers can be made with truncated domes in a variety of colors that conform to these requirements (Photo 7).

The ADA Standards require truncated domes to be placed on a square grid with a center-to-center spacing between 1.6 in. (41 mm) and 2.4 in. (61 mm), and a base-to-base spacing of 0.65 in. (17 mm) minimum, measured between the most adjacent domes. The PROWAG requires truncated domes to be placed in either a square or a radial grid pattern meeting the same dimensional layout requirements as set forth in the ADA Standards.

Photo courtesy Pine Hall Brick Company, Inc.

Photo 7
Detectable Warning Devices

The PROWAG also covers curb ramps and blended transitions, which are not covered in the ADA Standards. Curb ramps and blended transitions require detectable warning surfaces to extend 24 in. (610 mm) minimum in the direction of travel for their full width. Flares of curb ramps are not required to have a detectable warning surface. Both the ADA Standards and PROWAG require detectable warning surfaces to extend 24 in. (610 mm) from rail platform boarding edges. At pedestrian at-grade rail crossings, a detectable warning surface is required to be placed no less than 6 ft (1.8 m) and no more than 15 ft (4.6 m) from the centerline of the nearest rail. In addition, detectable warning surfaces are required to contrast visually with adjacent walking surfaces by using either light-on-dark or dark-on-light colors.

SPECIFICATION OF ACCESSIBLE PAVEMENTS

Selection of Appropriate Paving System

While creating a clear and smooth route for individuals with mobility impairments is an important consideration when choosing a pavement system, performance and maintenance requirements must also be considered. Any brick paving system as shown in *Technical Note* 14 can be used as an accessible walkway or surface, but special attention should be paid to the joints between the pavers and surface features such as uneven textures and larger chamfers, which may inhibit mobility.

Pavements designed as permeable pavements may have characteristics that appear to be in conflict with accessible pavements, since permeable pavements rely on larger joints to allow water to infiltrate the paving surface. In permeable pavements, void area is not the determinant to infiltration; rather it is the aggregate used between the pavers and the layers below that allows infiltration. Specific aggregates are used that can achieve optimal infiltration as well as joint filling. In addition, most clay pavers are manufactured with minimal chamfers, which have less impact on the overall joint width. Both accessible and permeable pavements can be achieved by following design requirements for each. As an alternative, a permeable pavement could be designed to surround an impermeable accessible pathway. Other *Technical Notes* in this series discuss permeable pavements.

Since maintenance of pavements occurs infrequently (or not at all), pavement designs that allow the surface to remain stable over its life should be considered. Often, pavements that are constructed with a sand setting bed

Photo courtesy Boral Brick, Inc.

Photo 8

Chamfered Pavers

Photo courtesy Glen-Gery Brick

Photo 9

Herringbone Pattern at the National Civil War Museum, Harrisburg, PA

are easier and less expensive to maintain. Those laid with mortar joints will require more maintenance due to the mortar having a shorter life span than the pavers. Since the base of the pavement has such a great effect on the stability of the pavement, it should be strong enough to resist infrequent overloading, prolonged saturation and/or severe freeze/thaw conditions. Refer to *Technical Note* 14 for discussion on brick paving assembly characteristics.

Surface Texture and Coefficient of Friction

The paver surface should also be considered in the selection of materials. Most wire-cut, pressed and molded pavers will provide a surface that does not inhibit the mobility of people with disabilities. Pavers that are heavily textured, such as tumbled pavers, may not provide suitable surfaces due to the increase in vibration for wheelchair users. Surfaces with higher coefficients of friction and slip resistance are also desired. While no generally accepted guidelines for the slip resistance of all walking surfaces under all conditions exists, advisory information suggests a static slip resistance value of 0.6 on horizontal surfaces and 0.8 on ramps. Clay pavers commonly have slightly roughened surfaces, such as wire-cut or sanded surfaces, which provide the desired slip resistance without detrimentally affecting the accessibility of the pavement [Ref. 3].

Chamfers and Lugs. Many clay pavers have chamfers (bevels) on their top edges (Photo 8). Some clay pavers also have lugs (spacers) on their sides to create uniform joint widths. The main purpose of chamfers is to reduce chippage on pavers and avoid direct contact between the top edges of adjacent pavers. Chamfers also create an interesting visual pattern and may help channel water off of the pavement surface. While chamfers and lugs can be desirable features on clay pavers, as their size increases, there is often an increase in the vibration experienced by wheelchair users as they roll across them. If the chamfer on each paver is equal to or less than ¼ in. (6 mm), then the resulting vibration should fall within the guidelines determined by the research mentioned previously [Refs. 2 and 6]. Similarly, the width of lugs should be considered so that recommended joint widths for various paving systems are not exceeded.

Bond Pattern. The bond pattern in which pavers are laid also has an impact on the vibration of wheelchairs. Patterns that result in joint lines parallel to the direction of travel generate the fewest vibrations. If pavers are laid in a herringbone pattern, which is typical of sand-set brick pavers, then less vibration is produced by a 90-degree herringbone as compared with a 45-degree herringbone pattern (Photo 9). The same can be said of a running bond pattern where the longitudinal joints are aligned with the direction of travel (Photo 10). When pavers with

Photo courtesy General Shale, Inc.

Photo 10

Stack Bond Pattern on Accessible Ramp

less than ¼ in. (6 mm) chamfers are used, research indicates that acceptable vibration levels are produced by any pattern.

Joints. Joints serve an important function in a segmental pavement; however, each profile has unique issues to consider. A mortared brick pavement can serve as an acceptable surface, but the mortar joints should be specified to be cut flush or to have a very shallow profile. This creates a smoother or more even surface. This is preferable for drainage as well, since water will flow more quickly off of a pavement with shallower joints.

Flexible paving requires a small amount of sand in between the pavers. Sand joints should be as small as possible, but not so small that sand cannot be swept into the joints. An appropriate sand joint size is between 1/16 in. (1.6 mm) and 3/16 in. (4.8 mm) wide. Sand-set pavers, often erroneously called "hand-tight" paving, should not have pavers directly touch one another with no sand filling the joints. This does not allow pavement interlock and promotes chipping. However, gaps wider than ½ in. (13 mm) may result in more noticeable vibration for the wheelchair user. Figure 2 shows appropriate paver joint configurations for accessible pavements. Although one wide joint in an entire field of brick paving may not be noticeable, joints that are consistently wider than recommended may result in an uneven surface due to shifting of pavers that have not developed sufficient interlock. Figure 3 provides a typical section of a pavement that can be used as an accessible pavement.

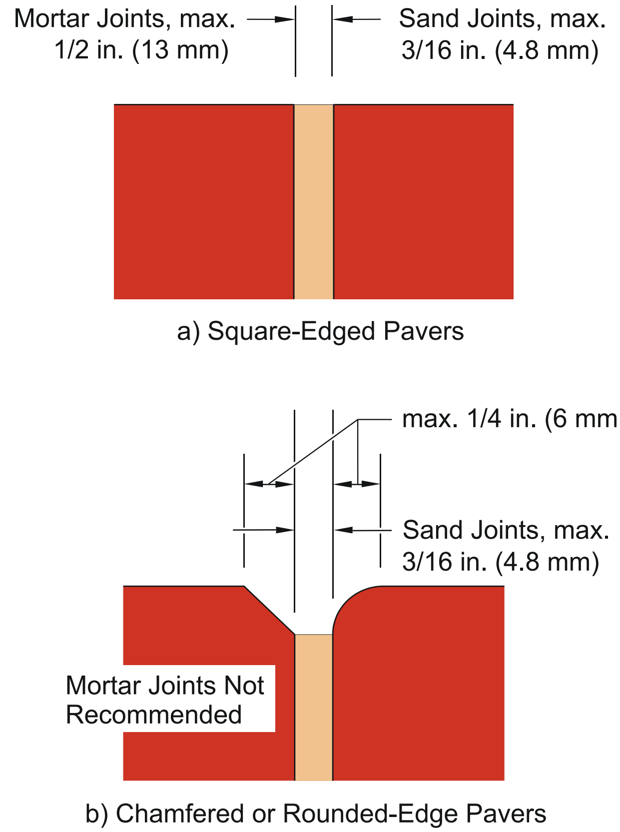

Figure 2

Recommended Paver/Joint Configurations for Accessible Pavements

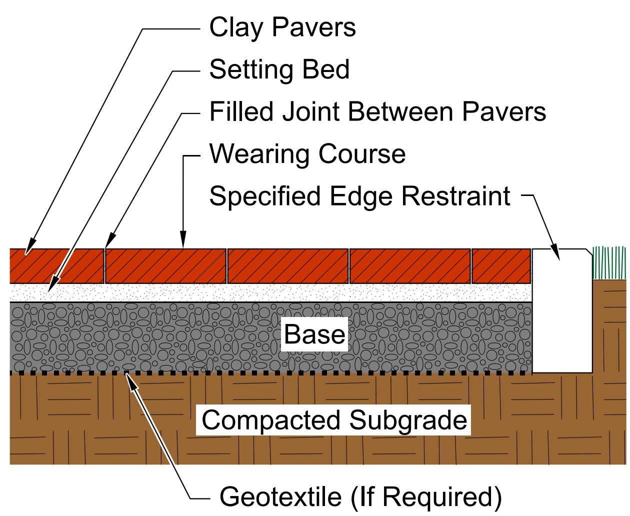

Figure 3

Typical Pavement Section

Street Trees and Utilities

Trees located within or along sidewalks provide many benefits to a community. While trees are a beautiful addition, their growth can create problems for the pavements surrounding them. In many cases, the roots of trees are what cause upheaval of a pavement (Photo 11). Tree roots can be cut back as they grow, but that harms the trees and may cause them to die.

Photo 11
Upheaval of Pavements Due to Tree Roots

First, consider specifying trees with less disruptive growth patterns beneath the surface, as well as above ground. Design or specify root barriers, or make the area surrounding the tree larger. Root barriers force the roots to grow down rather than spreading underneath the pavement. Not only do root barriers protect the surrounding pavement, but they also strengthen the tree by causing the roots to extend deeper into the soil. Larger soil areas allow the proper amount of water and air to reach the roots and allow the tree to grow into an area that is appropriate to its size. Various guides are available that provide design and implementation guidance for trees in urban areas, including preferred soil type around trees, size of tree grates and other information on coordinating these features with accessible routes [Ref. 5]. Permeable pavements are a potential alternative to tree grates, since they allow percolation yet can still function as an accessible path.

Below-grade service entrances, utility boxes, and other features that penetrate the surface can also disrupt a smooth brick pavement (Photo 12 and Photo 13). Two issues to consider are the change in level and the gap between the brick pavers and the metal box enclosing the unit. The same tolerances for installation of brick pavers as mentioned below can be used for these elements. Consideration should be given to utility units that have a transition or a beveled edge.

Curb Cuts

Curb cuts and driveway entrances create sidewalks that rise and fall along an accessible route (Photo 14). Keeping these to a minimum reduces tripping hazards and the amount of work required by wheelchair users. Design curb cuts with a longer transition or flared sides to avoid abrupt drops. The maximum slope ratio

Photo 12
Smooth Transition for Utility Structure

Photo 13
Abrupt Change in Level to Grate

Photo courtesy Whitacre Greer Company

Photo 14
Curb Cut and Pavers with Detectable Warning Surfaces

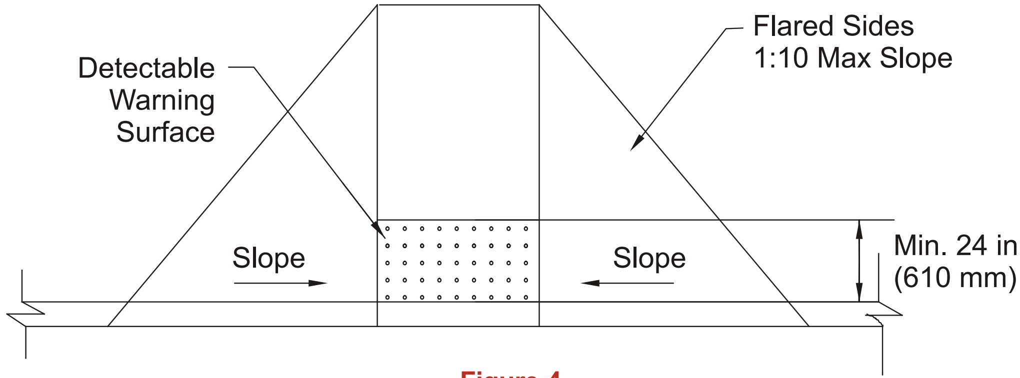

Figure 4

ADA Standards and PROWAG Requirements for Sides of Curb Ramps [Ref. 1]

of flared sides that complies with the ADA Standards and PROWAG is 1:10, as shown in Figure 4. Care must be used in planning the installation of pavers that transition between different elevations in a short distance to avoid unusual cuts or excess lippage between units. All tolerances for brick pavements apply at these locations as well. Curb cuts also require a detectable warning surface adjacent to the road. Brick pavers are available with the truncated domes that comply with the ADA Standards and PROWAG requirements. Consideration of materials that are permanent should take precedence over overlay materials that have a limited lifespan.

INSTALLATION REQUIREMENTS

Installation procedures can have an impact on the performance of the pavement. Pavements installed using recommended procedures will require less maintenance as the pavement ages. Information found in *Technical Notes* 14A, 14B and 14C for each of the pavement types will ensure that the minimum requirements are followed. The tolerances for pavements found in this *Technical Note* and others in this series conform to requirements found in the ADA Standards and other accessibility documents. Generally, the surface level of a pavement should not vary more than ±⅜ in. (10 mm) within a 10 ft (3 m) measurement. Lippage between two pavers or a paver and the surrounding elements should be no more than ⅛ in. (3 mm) for an accessible route (Photo 15). The maximum joint or gap between pavers or adjacent elements should be no more than ½ in. (13 mm). A smaller difference in height between two pavers decreases the chance of a tripping hazard and allows for a smoother pavement. As the width of joints increases, vibration generally becomes more severe, and pavers are more likely to shift, move or be lifted out of place.

Photo 15

Excessive Lippage Between Pavers

When individual units are not placed within the tolerance requirements, they can be removed and replaced in a manner that brings them into compliance with project or code requirements. Pavers set in sand are more easily replaced than those set in mortar or on a bituminous setting bed.

MAINTENANCE REQUIREMENTS

All pavements should be inspected and maintained on a regular basis. Some owners, public and private, often ignore these recommendations, resulting in small or localized failures that become larger problems as time passes, requiring more costly repairs. Seasonal maintenance procedures, such as snow removal, may also require immediate attention.

Maintenance

Inspection of paving surfaces should be conducted on a regular basis, but at least yearly. For public streets and sidewalks, members of the public are often the ones to alert public works officials to a problem. These issues should be dealt with as soon as possible, since localized problems tend to get worse over time. Two areas that should receive special attention are areas around penetrations, which may settle differently from the pavement, and other areas that are depressed or where sand loss from between the pavers is noticed.

If not designed and planted properly, street trees and their roots can cause consternation not only to users, but also to maintenance crews when they cause upheaval of the pavement. All paving systems, including segmental, monolithic and other paving systems, can be subject to pressure and upheaval from tree roots. While root barriers should be specified during initial design, it is possible to install them years after planting a tree; however, root damage is likely to affect the tree's health. Roots that are causing upheaval should be carefully cut away and the pavement reinstalled according to proper guidelines.

Excessive sand loss and subsequent movement of pavers is another common issue that if not properly addressed, may result in a more substantial pavement failure. When brick pavers set in sand are installed properly they interlock and create a firm, stable surface. Without the friction developed by sand in the joints, adjacent pavers can quickly lose interlock. Appropriate joint thicknesses, proper aggregates for joints, and compaction will keep sand in place in most cases. Resweeping of sand to fill the top surfaces of joints may be required on an infrequent basis. Joint sand stabilizers or polymeric sand may aid in preventing excessive sand loss, particularly on pavements subjected to vehicular traffic.

Snow removal

Snow removal is an important issue for all pedestrians, especially for the disabled. Prompt snow removal will aid in clearing a route and may allow melting to start to occur. Deicing chemicals may also be necessary to create a clear path. Permeable pavements typically do not require as much snow removal and de-icing than conventional pavements so their use should be considered.

Clearing snow from clay pavements can be undertaken using plows, snow blowers, shovels and brushes as used for other pavements. Care must be taken to ensure that the blades of the equipment do not scrape the pavement surface in a manner that might cause chipping or dislodging of pavers. Rubber or urethane blade edges can be used, or proper blade height can be maintained above the pavement surface using guide wheels. Any residual snow can be cleared with brushes.

SUMMARY

Clay pavers have served pedestrians in a variety of applications for hundreds of years. These systems can perform as accessible pavements when proper design, construction and maintenance requirements are followed. Design and construction recommendations for accessible clay brick pavements are essentially the same design and construction requirements for standard brick installations so no extra cost is usually involved. Regular inspection and maintenance of the pavement surface and surrounding elements will provide a smooth surface for decades to come.

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