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Pavements and Surface Materials

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Introduction

Pavements are composite materials that bear the weight of pedestrian and vehicular loads. Pavement thickness, width and type should vary based on the intended function of the paved area.

Pavement Thickness

Pavement thickness is determined by four factors: environment, traffic, base characteristics and the pavement material used.

Environmental factors such as moisture and temperature significantly affect pavement. For example, as soil moisture increases the load bearing capacity of the soil decreases and the soil can heave and swell. Temperature also effects the load bearing capacity of pavements. When the moisture in pavement freezes and thaws, it creates stress leading to pavement heaving. The detrimental effects of moisture can be reduced or eliminated by: keeping it from entering the pavement base, removing it before it has a chance to weaken the pavement or using moisture resistant pavement materials.

Traffic subjects pavement to wear and damage. The amount of wear depends on the weight and number of vehicles using the pavement over a given period of time. Road engineers estimate the pavement damage from the axle loads of the various vehicles expected to use the pavement over its designed life, usually 20 years. As a general principle, the heavier and more numerous the vehicles using the road, the thicker the pavement needed to support them.

For example, The Asphalt Institute recommends various asphalt pavement thicknesses to support various types of automobile traffic. The Institute suggests the following five "Traffic Classes," based on the number and weight of vehicles expected to use the road:

Traffic Class	Type of Road
1	Parking Lots, Driveways, Rural Roads
2	Residential Streets
3	Collector Roads
4	Arterial roads
5	Freeways, Expressways, Interstates

Based on the above classes, pavement thickness ranges from 3" for a Class 1 parking lot, to 10" or more for Class 5 freeways.

Sub grade strength has the greatest effect in determining pavement thickness. As a general rule, weaker sub grades require thicker asphalt layers to adequately bear different loads associated with different uses. The bearing capacity and permeability of the sub grade influences total pavement thickness. There are actually two or three separate layers or courses below the paved wearing surface including: the sub grade, sub base and base. The sub grade is either natural, undisturbed earth or imported, compacted till. The bearing capacity and permeability of the sub grade influences total pavement thickness. The sub base consists of a layer of clean course aggregate, such as gravel or crushed stone. Sub bases are installed where heavy-duty surfaces require an additional layer of base material. The base consists of a graded aggregate foundation that transfers the wearing surface load to the sub grade in a controlled manner. The base should also prevent the upward movement of water.

The **pavement material** or wearing surface, receives the traffic wear and transfers its load to the base, while at the same time serving as the base's protective cover. Pavements are classified as either flexible or rigid. Flexible pavements are resilient surfaces that distribute loads down to the sub base in a radiant manner. Flexible pavements generally have thin wearing surfaces and thick bases. Asphalt is an example of a flexible pavement. Hot mix asphalt has more strength than cold mixes therefore it can be laid in thinner layers. Rigid pavements distribute imposed loads over a broader area than do flexible pavements and therefore require thicker wearing surfaces and thinner bases. Reinforced concrete slabs and paver stone embedded in reinforced concrete are examples of rigid pavement.

The Asphalt Institute in College Park, Maryland has issued a "Asphalt Thickness and Design," manual that suggests that asphalt thickness for roads be based on the following three factors:
1. Traffic weight and number of vehicles that will use the road
2. Strength of proposed sub base, and,
3. Pavement material to be used.

Pavement Width

As with thickness, pavement width should vary based on its intended use. Interstate highways will obviously need to be much wider than local residential roads. Similarly, the parking lot serving a regional shopping center will be much larger than one for a neighborhood convenience store. A sidewalk in a low-density residential area can be narrower than one serving a central business district.

While the relationship of width to intended use seems so logical, many communities still have a "one design fits all occasions" approach to pavement widths. Pavement width standards are often found in local land use regulations. Zoning and subdivision regulations generally contain "minimum" width requirements for roads, driveways, sidewalks, parking stalls, loading areas, emergency access ways, alleys and multi-use trails. Developers often install pavement far exceeding "minimum" standards.

The over-paving of the developed landscape has well documented adverse environmental, social, and economic consequences. The direct adverse relationship between a watershed's imperviousness and its water quality is well established. As we pave the Earth's surface, we disrupt natural drainage and infiltration systems, drastically altering land and water as well as people and wildlife whose lives depend on the health of these resources. People are concerned that landscape design often pays more attention to the paved areas serving the automobile, than to green areas serving man and wildlife. Local officials are beginning to better understand the costs associated with the design, installation and maintenance of paved areas. It is one thing to require developers to install expansive roads, curb and curtain drain systems, it is another for municipalities to provide the resources to own and properly maintain these areas once they are built.

Pavement Material

Asphalt and concrete are the most common paving materials found in the developed landscape. However, there are other strong, durable pavements that can add variety to the built landscape and help reduce pavement's imperviousness. The following is a review of selected paving materials:

1. Asphault

Bituminous concrete or asphalt is composed of aggregates bound together with asphalt cement. The aggregate is heated and mixed with hot (275º f) asphalt cement then taken to the construction site where it is placed, as a wearing surface, over a base course. The asphalt is laid by hand or paving machine, then rolled to force the mixture to firmly set. It is then allowed to cool. Depending on: how it is constructed, the traffic it will bear, the climate it must endure, and the maintenance it receives, typical asphalt pavement has a life expectancy of 20 years before it needs resurfacing.

Bituminous surfaces when properly installed are: durable, can be used year round, drain quickly, are comparatively easy and inexpensive to maintain, resilient, hard, firm, easily marked, dust free, neat, non-glare and can be used for many different activities. The disadvantages of bituminous surfaces are their relatively high installation costs and their imperviousness.

Asphalt can be mixed with cork, sponge or rubber to create more resilient surfaces or with crushed stone to produce a hard or more porous surface.

Asphalt pavement is composed of the following two layers, the wearing course and the base course:

The Wearing Course transfers and distributes traffic loads to the base course. The wearing course is actually composed of two layers, a 1-1/4" to 1-1/2" surface layer and a 3" bonding layer. The bonding course penetrates voids in the sub base and binds the wearing course to the sub base aggregate. The thickness of the wearing course varies according to intended use, the materials used and the bearing strength of the sub base.
The Base Course thickness might range from 6" to 18" depending on the designed use and the bearing strength of material used. If the material has low bearing strength, sub base thickness is increased or stronger materials used.

The thinnest applications of asphalt involve the spreading of a liquid mix on gravel roads to provide water and dust proofing while at the other end of the thickness scale, some roads may require 10" or more of asphalt to support projected traffic. Liquid asphalt is also applied to existing pavement to renewed the wearing course, act as a sealer and to fill cracks. There is some debate as to how often asphalt needs to be sealed. For example, some contractors recommend asphalt driveways be sealed one year after installation, and four additional times over its 20 year life span. Others recommend that they should not be sealed at all, citing the need for asphalt to breathe.

Another application, commonly called "chipstone" or "chipseal" involves spreading new asphalt, waiting two months or so, and then applying a mixture of oil and stone. Chipseal can also be applied over existing pavement, using asphalt to fill in depressions and provide a surface coating, before covering with stone chips. Stone color can vary with salt and pepper mixes popular to provide a more rustic look. The stones can get displaced, but not as much as in a loose crushed stone application. Every five to seven years the chipstone surface should receive a new coat.

Pre molded asphalt blocks are also used for sidewalks, driveways, roads, plazas, piers and airport runways. The blocks range in thickness from 1-1/4" for a basic waterproofing surface to 3" roads and ramps.

Another asphalt surface, textured asphalt pavement involves imprinting softened asphalt with steel grid templates to produce a brick or cobblestone look. To install a textured surface, asphalt is laid on a base and allowed to semi harden. The surface is then softened with a heater and the steel template is pounded onto the surface to imprint the desired pattern. The template is raised and moved to the next paved section. A color coating can be added to the surface. Manufacturers recommend that new asphalt be laid for textured paving as old asphalt gets too polished with age to allow new asphalt to properly adhere.

Conventional hot mixes of asphalt are impervious to water as long as the total air void content is kept below 7 percent. Some mixtures often referred to as, “pop corn,” use larger sized aggregate to increase the air voids and thus make the pavement more porous. Porous asphalt pavements need to be washed with high-pressure sprays or vacuumed to keep soil particles from collecting in and clogging the voids. Porous mixtures have been used on parking lots, driveways, sidewalks, local roads and temporary roads and ramps.

2. Concrete

Concrete consists of binding material called cement, composed of lime, silica, alumina and gypsum, that is mixed with sand, aggregate and water. After curing concrete becomes as hard and impervious as stone. Steel rods or glass fibers are sometimes used to reinforce the strength of concrete mixtures. Concrete can be mixed in bulk and placed in forms to achieve any desired shape. The surface can finished with a variety of textures. Concrete surfaces can be used year round for multiple purposes. Concrete surface maintenance costs are very low.

The thickness of the wearing surface and gravel base of concrete sidewalks varies based on intended use. Common concrete sidewalk wearing surfaces range from 4" to 6" with gravel bases ranging from 4" to 8."

Concrete is also used to make precast paver stones of various shapes, sizes, finishes and colors. These pavers must meet industry standards of high comprehension strengths, of at least 8000 pounds per square inch, to resist breakage from freezing and traffic loads. Typical thickness range from 2-3/8" for use in sidewalks and residential driveways to 4" for pavements subject to vehicular traffic. Some pavers are designed to interlock forming an impervious surface while others are made to be porous. Interlocking concrete paving stones are laid in prepared beds of compacted soil, crushed stone and sand. The interlocking system withstands; snow plowing, shoveling or snow blowing. The chamfered joints between each paver eliminates the cracking often found in asphalt or concrete pavements and facilitate the removal of surface water helping to reduce nighttime glare and enhance skid resistance. As concrete pavers do not rely on continuity for structural integrity, cuts can easily be made for surface or underground utility repair. Herringbone patterns, the most effect-laying pattern for maintaining interlock, offer greater structural capacity and resistance to lateral movement. Therefore, herringbone patterns are recommended for areas subject to vehicular traffic. Restraints are used along the perimeter of the pavers or where there is a change in the use of pavement material to hold the pavers tightly together and help prevent spreading as a result of traffic forces. Concrete pavers come in many colors, shapes and patterns that can be used to mark traffic and parking lanes and pedestrian walkways.

3. Brick

Brick from kiln-fired clay or shale has been used as paving for thousands of years. The Romans used brick to build their roads and since the colonial era, brick has been used in America for pathways, sidewalks and as a building material. Until the mid-20s brick was the most popular street paving material in America, thereafter, asphalt and concrete were widely used. Brick is a popular paving material because it is easy to produce, easy to use in small, hard to reach areas, can be used with other paving materials, is flexible, and is readily available in a variety of shapes and colors. Bricks come in all sizes. A survey conducted in 1973 by the brick industry association showed approximately 40 different size brick were being manufactured. Brick texture can range from a highly finished smooth glaze to rough finishes. Brick can be colored and installed in many different patterns, such as herringbone and basket weave. Brick is graded by its' weather resistance, measured by porosity. When properly installed, brick pavement is stable and durable, however, it is generally more costly to install than bulk paving materials such as concrete and asphalt. In northern climates there is concern that the bricks may create an uneven surface making snow plowing difficult.

Paver bricks, specially made for outdoor and street use, are different from those used on historic brick walks and streets in that they have a slip resistant surface and are very dense to resist freeze/thaw damage. Abrasion and weight can destroy brick not made for outdoor use. Modern outdoor bricks range in thickness from 3/4" to 2-1/2," with 1-5/8" and 2-1/4" the most popular thickness.

There are three basic types of brick paving systems: flexible brick over a flexible base, flexible brick over a rigid or semi rigid base and rigid brick on a rigid concrete base.

Flexible brick paving on flexible or semi rigid bases is not subject to cracking as are rigid pavements. This is especially important in regions where frost heaves and soil swelling occur. Brick laid mortarless in sand allows storm water to infiltrate the ground. Less skill is needed to lay brick in sand than mortared brick and individual bricks can be removed allowing for easy surface repair or access to subsurface utilities. Also the brick pavement can be immediately open to traffic, following the repair, as no hardening or curing time is needed as with asphalt or concrete. Sand quality is critical to the performance of flexible brick paving especially where heavy traffic loads and weights are planned. Sand manufactured from crushed stone may break down under the weight of heavy trucks or buses, natural silica sand has proven resistant to such wear. In some instances elastic coatings are applied on the surface to keep sand from moving between the bricks. However, surface coatings may reduce the porosity of the mortarless system.

Sometimes bricks are laid in gravel or crushed stone as opposed to sand. If a porous surface is desired, care must be taken to provide a sub base and joints that do not join the bricks to form an interlocking impervious cover.

Semi rigid systems consist of bricks set in a bituminous bed laid over an asphalt or concrete base. This system is popular in urban areas as it can be laid over an existing base. Semi rigid systems may be more durable than flexible systems, but they may cost more.

Rigid brick paving systems have bricks set in mortar, laid over a mortar bed, that rests on a concrete slab. Used where water must drain from the surface or where mortared joints are desired for aesthetic reasons, this system requires maintenance as the mortar deteriorates. Thinner paver bricks can be used for walks when they are set in a mortar bed.

4. Stone

Stone is a durable paving surface that is available in either natural or synthetic form. Natural paving stone is graded based on its' hardness, porosity and abrasion resistance. It is available either in cut or uncut form in various degrees of smoothness.

Cut stone is available as either roughly squared, unfinished blocks or as uniformly trimmed, highly polished tiles. Common cut stone used for paving include blue or flagstone, marble, slate, granite blocks, cobblestones and Belgium blocks. Quarries can offer stone cut to measure and sell it by the square face, by its' thickness, or by unit price.

Examples of uncut or rubble stone, are broken quarry rock and river stone available in varying degrees of smoothness. Crushed stone of various sizes and hardness is used as sub-base for other surface materials, surface pavement or ground cover. When mixed with asphalt or concrete, crushed stone or aggregate is used in the wearing and base coarse of roads, drives, parking lots and sidewalks. Larger stones are mixed with asphalt or concrete when a rougher or more porous surface is desired.

While providing a slightly irregular surface, crushed stone can be used where a porous material is desired for roads, driveways, paths or parking lots with light traffic. It is also used as a durable, decorative ground cover and to reduce erosion and promote infiltration in areas receiving roof and surface runoff. Crushed stone is commonly used for residential driveways particularly where a country look is desired or the driveway is long. Typical driveway stone sizes range from 1/4" to 2" sizes, with pea size (3/8") the most popular because it is the easiest to walk on. Stone colors can ranges from bright white to black, depending on local characteristics.

Synthetic stone made of concrete mixtures is available in a variety of shapes, colors and textures. It can be made to closely resemble natural stone and often costs less than the real thing.

Stone, as with brick, can be set in a sand or concrete bed. If a pervious surface is desired, the stone should be laid on a smooth bed of sand that in turn is placed over a level and compacted cinder or gravel base. If sand is used, it should be brushed over the stone to form a grout, tamped and watered.

Crushed stone can be placed in plastic grid pavers that are laid over a base designed to accept and filter runoff and support heavy vehicular weight. If an impervious surface is required, the stone is laid over a concrete bed that is reinforced with steel rods or welded wire fabric. The concrete bed rests on a level gravel base.

The advantages of crushed stone are its relatively low installation cost, high porosity and enhancement of community character. Crushed stone also has some disadvantages including: dust generation and weed growth, rutting from tires, displacement of stone during snow plowing, stones getting caught in snow blowers and lawn mowers and need to periodically replenish displaced stones.

5. Tile

Tiles are baked clay of various shapes, colors and finishes. Tile is often graded on its' weather resistance. Tile can be glazed or unglazed. Glazing increases tile's imperviousness. Tile's small unit size makes it easy to work with, particularly where space is limited or hard to reach. When used as a paving surface, tile is laid similar to brick and stone.

6. Wood

Wood and wood products are used in the construction of decks, walks and steps. At one time, wood was used to surface roads, resulting in what was commonly known as "plank roads." Wood is strong and durable for its weight. Wood used outdoors must be; non-splintering, stiff, strong and resistant to decay, wear and warp. Woods with many of these characteristics include; white oak, Douglas fir, redwood, cedar, southern pine and various tropical hardwoods. To help prevent short order rot, wood can be pressure treated to increase its resistance to decay from insects and weather. However, there is some concern that commonly used wood preservatives, at certain stages of their life cycle, may be harmful. For example, the copper, in many pressure treating compounds and surface applied preservatives, is toxic to aquatic organisms. For this reason, extreme care should be taken in the use of wood pressure treated with copper for decking, walks or support columns in or near wetlands.

In addition to wood boards or logs used to make decks and planked walks, landscape timbers and railroad ties are used as steps and in paths. An interesting use of wood in walks is 6" thick, wood disks of cypress; redwood, chestnut or locust set in sand, gravel or concrete. Other wood products used as surface materials include shredded bark and wood chips of various sizes and colors.

7. Earth Materials

Earth materials used for paving include sand, gravel, soil, granular products, and turf. The volume of earth materials is determined by its state in the earth moving process. For example a cubic yard of gravel as it lies in its natural, undisturbed state usually swells to 1.25 cubic yards after it has been disturbed by excavation. The same quantity of gravel decreases in volume to about .90 cubic yards after it has been compacted by machinery on site.

Sand is often used as a sub base for other paving material such as brick and paver blocks. Depending on how the paving material is laid in the sand and the sub base used, sand surfaces can be porous or impervious. There are problems using sand as a surface material as it can generate dust and has a tendency to become rutted when used extensively by heavy vehicles in wet weather.

Gravel has been used for years as a road and path surface. In the “Design Guide for Rural Roads,” prepared in 1998 by the Dutchess Land Conservancy, Inc., 16' wide gravel roads are suggested for residential areas with lots of five acres or greater and traffic is less than 100 vehicles per day. The Conservancy also suggests 12' wide gravel roads serving no more than four residential lots with traffic less than 25 vehicle per day. The Design Guide also lists the advantages and disadvantages of gravel roads. Advantages of gravel roads include: less costly to construct than paved roads, easier to maintain as they require less equipment and equipment used is easier and less expensive to operate, surface damage is easier and less expansive to correct and they discourage speeding and preserve the area's rural character. Disadvantages include: they generate dust, require more frequent maintenance, can become impassable with frequent snow or rain and create greater wear and tear on vehicles than paved roads.

A suggested design of a gravel road is a 4" layer of high quality gravel or crushed stone over an 18" to 24" bed of porous compacted fill. Gravel roads can be designed to be porous but unless properly designed and maintained, porous gravel roads can become compacted and their voids clogged with particles creating a surface as impervious as asphalt or concrete. Some communities allow gravel roads only if they are privately owned and maintained.

Soil, while not commonly used as a surface material by itself, can be bound with various stabilizers to decrease its muddy or dusty qualities and to harden it. Used motor oil was once sprayed onto dirt roads to act as a soil stabilizer. The most common form of stabilized soil is soil cement, a mixture of existing soil and 5 to 16 percent Portland cement. No aggregate or sand is used, so costs are less than those of concrete or asphalt are. The surface looks like local soil, but is hard with a compressive strength up to 1500 pounds per square inch. Soil cement is usually created by spreading dry cement over the ground and tilling to a depth of 4 " to 6," thoroughly mixing soil and cement. The mixture is wetted, compacted and cured under plastic sheeting. The National Park Service uses soil cement as the surface material on trails that are handicapped accessible. It has also been successfully used for road base courses, road and trail surfaces, pond liners and as an inexpensive riprap alternative.

Granular surfacing such as crushed shells, decomposed granite, crusher fines and crushed brick offer a traditional paving surface that is easy to construct and maintain. As these surfaces have historically been used on walks and roads, they are especially appropriate for sites where historic preservation or a period or regional look is desired. As they use local materials, granular surfaces naturally blend into the site helping to preserve a sense of local character and identity. For example, along coastal areas crushed shells are used for informal paving and in Tidewater Virginia on country roads. Shells are cleaned and crushed to sizes of 1" or ¼". Sometimes shells are mixed 2:1 with limestone dust or sand, placed 4" deep over filter fabric, machine tamped and wetted until firmly compacted.

Turf is the upper layer of soil bound together by grass and plant roots to form a mat. The advantages of turf as a surface material are its appearance, resiliency, porosity and smoothness. Turf is difficult to maintain in areas of high use and it may require time and care to restore itself after heavy utilization. During wet periods it may become rutted and unusable. During dry periods, compacted turf can become dry and hard as concrete. It also needs watering, mowing, fertilization and protection from insects and plant diseases. Improper use of fertilizers and pesticides can result in water pollution. Unless proper care is taken, plowing snow off turf surfaces can destroy the vegetative cover. When turf is used as the wearing surface, reinforced base applications provide support for vehicle weight while allowing infiltration of storm water through the grass, top soil and specially designed sub base. (See porous pavements).

8. Synthetics

There are many types of synthetic surfacing materials on the market. Most have been used at recreation facilities. Examples include, sponge, sponge rubber, rubber mats, plastics, cork and various combinations of these with a binder coating material, such as asphalt. Synthetics have been used on running tracks, as a grass substitute on athletic playing fields and as a cushioned base for playgrounds. Synthetics require little maintenance, are pleasant to look at, have high resiliency, come in a variety of colors, are nonabrasive and can be used year round.

Another synthetic product that can be used for decking, walks, play structure flooring, boardwalks, steps and landscape timbers, is recycled plastic lumber. In the United States approximately 20 million tons of plastic are disposed of each year. Plastic lumber is a product developed to provide a market for the large amount of available, recycled plastic. Plastic lumber is either made of pure plastic resins or plastic mixed with wood fibers or fiberglass. A relatively new product without a long history of use, 100% plastic lumber, has some shortcomings including: lower structural strength than wood, softening and expanding when heated, and slippery when wet. The wood-plastic composites have greater strength, greater stiffness and less expansion than the all-plastic products. The benefits of plastic lumber are resistance to rot and insect damage, lack of harmful chemicals and ease of maintenance. At the present time most recycled plastic lumber costs two to three times as much as pressure treated lumber.

9. Porous Pavements

Plastic Grid Pavers feature a system of 100 percent recycled molded, interlocking plastic grids that support a strong, attractive, porous surface of 100 percent grass or crushed stone. Some systems have hollow rings or honeycombs attached to a base, others have open cells without bases. Other systems designed for crushed stone, have a fabric base that prevents the stone from moving down to the sub base. The plastic grids are flexible, allowing use on uneven sites without grading. The grid rings or cells transfer surface loads to the underlying base course material. This prevents surface rutting, compaction of grass roots, and displacement of soil or stone due to traffic. The grids, not the grass or stone, absorb vehicle weights of well over 100,000 pounds. This system is environmentally friendly in that it:
1. uses only recycled plastic, keeping it out of local landfills;
2. promotes infiltration which recharges the water table, reduces surface runoff, helps prevent flooding and reduces non-point source pollution; 3. Reduces the imperviousness of development and
4. Minimizes site disturbances, especially on erosion prone slopes.

Manufactures recommend their use for paved areas, including sidewalks, parking areas, golf cart paths, residential driveways, fire lanes, emergency access roads

Plastic grid pavers, using grass as the surface material, are installed by first preparing a porous base course of compact sandy gravel as determined by local engineers. To ensure base course porosity, it should be hosed and the water observed for complete drainage. Next, a fertilizer and soil polymer mix is spread over the base course. The grass paver units are then placed rings up, directly over the growth mixture and interlocked as needed. The plastic pavers can be cut to any desired shape with a knife or pruning shears. The rings are then filled to the top with sand, then grass seed and mulch is added. Sod can be applied over the sand filled rings as an alternative to grass seed and mulch. After installation the grass or sod should be protected until root systems are well established. The surface is then maintained as a grass lawn.

When crushed stone is used instead of grass, a heavier plastic grid is used.

Plastic grid pavers do not require curbs, curtain drains, detention or retention ponds or any other associated drainage facility making them competitively priced with asphalt and concrete paving when their required associated drainage facilities are cost factored.

Cement Grid Pavers are similar to plastic grids described above but made of concrete rather than plastic.

Concrete Grid Pavement first appeared in the early 1960s when concrete building blocks were placed in the ground, hollow side up, to handle overflow parking at a cultural center near Stuttgart, Germany. Since then concrete grids have been used for embankment stabilization and as ditch liners. However, a significant application of this technology is as a pavement specifically as it is used in: driveways, parking areas, shoulders along airstrips and highways, roadway medians, boat launching ramps, emergency access roads, fire lanes, sidewalks, sidewalk borders, grassed rooftops, pool decks and, patios. There are two types of concrete grid pavers: lattice and castellated. Lattice pavers produce a flat, continuous, patterned, concrete surface when installed. Castellated grid pavers feature protruding cement knobs on their surface that make the grass surface appear continuous when installed. Unlike plastic grid pavers, concrete pavers are heavy, ranging in weight from 45 to 90 pounds. The percentage of open area associated with concrete pavers range from 20 percent to 50 percent.

Whether grass or crushed stone is used in the grids, depends on the expected intensity and duration of use and maintenance capability. As most grasses require about five hours of daily sunlight, grass should be used in areas of less intense use such as over flow parking and fire lanes. For heavily used areas and areas that will be continually covered by vehicles during the day, crushed stone should be used. Solid concrete pavers can be used to delineate parking spaces including those that are handicapped accessible, pedestrian paths and bicycle parking areas. Concrete grid pavers with grass require the same maintenance as lawns including, watering, mowing, weed removal, and fertilization. If the grass can not be properly maintained, then crush stone should be used. Crushed stone is also recommended if the sediment from the site or adjacent areas is expected to wash into the grids.

Snow can be plowed from the grids if the plow blade is set slightly above their surface. Deicing compounds and salt should not be applied to grass, as they will kill it. If individual grid units are damaged from soil or base settlement they can be easily removed and replaced.
Two designs for the base areas under concrete grid paving are suggested, dense graded or open graded aggregate. The choice for base design depends on the amount of infiltration and storage of storm water desired.

Dense Graded Base installations typically consist of a sub grade of existing compacted soil, a layer of geotextile in poorly drained areas, compacted crushed stone, 1" to 1½" of bedding sand and the cement grids filled with either grass or aggregate. A minimum of 8" of compacted crushed stone is suggested for emergency fire lanes, driveways and parking lots. Thicker bases may be needed when extremely heavy vehicles are expected to use the surface, the soil sub grade is weak, has high clay or silt content, or is wet. However, for residential uses in sandy, well-drained soils a base may not be needed as the grids and bedding sand can be placed directly on the compacted sandy soil. When grass is used, it should not be exposed to tire wear until it is well established, typically 3 to 4 weeks after application.

When maximum infiltration, partial pollutant treatment and storm water storage is sought, an open graded base is suggested, otherwise a dense graded base can be used. When concrete grid pavers with 60 percent solid area are placed over a 12" open graded sub base with 40 percent void space, they can infiltrate 5" of rain per hour before becoming saturated. Thicker bases can store greater rainfall amounts. In view of their drainage capability grid pavers should be considered as representing a 100 percent pervious area as opposed to just the area defined by its openings. Areas with high water tables, impermeable soil layers or shallow depth to bedrock may not be suitable as an infiltration area with an open graded base. Care should be taken to assess the bearing capacity of the soil to withstand vehicular loads when saturated. Also, manufactures suggest that infiltration areas with concrete grids should be used to drain areas less than five acres and targeted to drain 2 to 10 year storms.

Research shows that concrete grid pavements designed as infiltration areas over an open graded base can substantially reduce nonpoint source pollutants in storm water. A key determinant of pollution reduction capability of infiltration systems is the soil found in the base course. For instance, clay soils have been found to be particularly effective pollutant filters. Unfortunately, many clay soils do not have high infiltration rates or strong bearing capacities, when saturated, to be used under infiltration areas subjected to heavy vehicle loads.

Any infiltration area can become clogged with sediments thereby decreasing storage capacity and infiltration capability. One way to avoid clogging is to prevent sediment from flowing into the infiltration system during construction or use. Another method is to treat the runoff before it enters the infiltration area. Both methods will help extend the useful life of the system and reduce removal and replacement costs. Also, concrete grid pavers are not recommended in places where grease and oil loads are high. Filter areas such as settling basins should be used to remove grease and oil before they enter the grid system.

Stabilized Grass Root Zone Systems address the problem of turf and its root zone being compressed by vehicle weight, or heavy play. The compaction destroys soil voids containing oxygen and water necessary for healthy turf. Stabilized turf systems blend pieces of polypropylene mesh, about the size of a playing card, with soil or a grass, growing medium. The mesh pieces interlock, with each other and root zone particles, creating a stable structure. As the grass roots develop they entwine with the mesh to provide a deep, anchored, root system supporting a tough, stable, springy turf surface. The mesh elements in the soil produce high aeration for enhanced oxygen levels and improved infiltration. The mesh elements act as springs, whose flexing action creates and maintains voids holdings water and oxygen necessary for healthy roots and turf surfaces.

Stabilized turf systems are most often used as a playing surface at athletic facilities mainly because spectators and players enjoy the look and feel of healthy turf. It provides a strong, damage resistant surface that drains rapidly, withstands heavy use and recovers fast. Athletes enjoy it because it provides consistent traction and is highly resilient, capable of absorbing impact from falls. In addition, stabilized turf can be used for overflow parking lots, airstrips, heavy used visitor attractions, emergency access areas and playgrounds. It resists compaction and rutting even when the surface is saturated. One manufacturer claims its stabilized turf system increases the vehicle load bearing capacity of natural turf areas by up to 500% while others claim a 40 ton truck can be driven across or parked on the turf surface without leaving any noticeable tire marks.

Turf Reinforcement Mats are synthetic or natural, permanent or temporary, blankets or mats that reinforce turf areas designed for erosion control on steep slopes, shorelines, and stream banks. They are also used as an alternative to rock riprap to line drainage ditches and open channels. Synthetic turf reinforcement mats are commonly referred to as "geotextiles." Typical installation guidelines for geotextiles include: grade and compact area, prepare a 3" seedbed above the final grade, add lime and fertilizer as needed, apply turf reinforced mat directly on soil, apply seed and ¾ " of fine top soil to the mat and water as needed.

A review of literature from several manufacturers of geotextile turf reinforcement mats, mentions they can support lightweight rubber-tired construction equipment but no tracked equipment or sharp turns should be used on the mat. Whether this is only during the installation phase or permanently is not clear.

Degradable erosion control blankets are flexible erosion control products designed to hold seeds and soil in place until vegetation is established. The blankets are designed to protect the soil surface from water and wind erosion while offering partial shade and heat storage to accelerate vegetative development. The blanket is designed so the various fibers used in its construction degrade and become part of the soil. Some "roll type" erosion control blankets are made of natural products such as straw, excelsior, coconut and jute others of synthetics such as polypropylene. Some blankets are porous allowing turf roots to adhere to open areas in the weave, other are made impervious and puncture resistant so they can serve as pond liners or landfill caps.

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