NCMA TEK

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CONCRETE GRID PAVEMENTS

TEK 11-3
Pavers (2001)

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INTRODUCTION

Concrete grid pavements, like those shown in Figure 1, emerged from Europe in the 1960s as a method of providing a grass surface capable of surviving vehicular traffic. The surface was developed as an alternative to runoff and heat-producing parking surfaces of asphalt and poured concrete. Grid pavements were further developed to reduce erosion along lakes, drainage ditches, streams and rivers.

Uses for concrete grid pavements include:

- Primary and overflow parking areas
- Multi-use open areas
- Driveways
- Airfield runway and taxiway shoulders
- Highway shoulders
- Medians and median cross overs
- Trailer parks
- Boat launching ramps
- Emergency access roads, fire lanes adjacent to buildings
- Ditch liners
- Stream bank and lakeside erosion protection

Figure 1—Concrete Grid Pavement With Grass

TYPES OF CONCRETE GRID PAVEMENTS

There are several configurations of concrete grids, all of which can be classified into two categories: lattice and castellated (Figure 2). Lattice pavers have a flat grid-like appearance where the concrete forms a continuous pattern when installed. Castellated grid pavers are distinguished by concrete knobs that protrude slightly through the soil surface.

Length and width dimensions vary between 1 to 2 ft (305 to 610 mm). Thicknesses range from a minimum of 3$^{1}/_{8}$ in. (80 mm) to 4$^{1}/_{2}$ in. (114 mm), and weights range from 45 to 90 lb (20 to 41 kg).

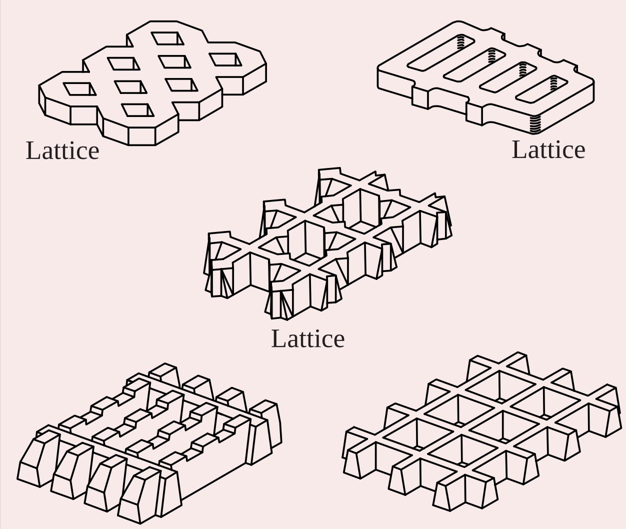

Figure 2—Types of Grid Pavement Units

PAVEMENT DESIGN AND INSTALLATION GUIDELINES

A typical grid pavement installation consists of a soil subgrade, a gravel base, a layer of bedding sand and the grid pavers. Topsoil and grass, or stone aggregate is placed in the openings.

The intensity of use by vehicles over the life of the pavement must be carefully assessed when selecting between grass or stone aggregate. Grass generally needs at least five hours of light each day if it is to survive. Cars parked on the grass every day for extended periods of time will block sunlight, killing the grass beneath. If parking is continuous, aggregate should be used in the openings instead of topsoil and grass. Aggregate should be used if regular watering and maintenance of the grass is not anticipated; since grass may die. Aggregate should also be used if oil drippings from parked cars is expected to be excessive. For intermittently used lots, overflow lots, or fire lanes, grass is recommended.

Soil Subgrade

The soil subgrade should be uniformly compacted to at least 95% of its optimum density prior to placing the gravel, sand and the grids.

Aggregate Base

Aggregate used for road bases is acceptable for use with concrete grids. The fines (aggregates smaller than the No. 50 sieve) can be omitted if additional water permeability is desired. If fines are omitted, then filter cloth will be required between the sand and aggregate to prevent migration of sand into the base.

The compacted aggregate base should extend beyond the edge of the grids a minimum of 6 in. (152 mm) where possible. The thickness of the base depends on the loads and the strength of the soil subbase. For residential uses on adequately drained soil, the base can be omitted and the grids placed directly on the sand layer, as shown in Figure 3. For heavy vehicular loads such as those from fire trucks, or repeated loads from cars, a minimum of 8 in. (203 mm) of compacted aggregate road base is recommended, shown in Figure 4.

Filter cloth is recommended for use with soils having a low California Bearing Ratio (CBR) (i.e., less than 4%), those with high clay and silt contents, soils in high water table areas, and soils in low lying areas subject to flooding. The filter cloth is placed over the compacted subgrade and should be fine enough to prevent migration of soil into the aggregate base. Woven fabrics are preferred over nonwoven materials when the cloth is placed directly under the sand layer in installations subject to traffic.

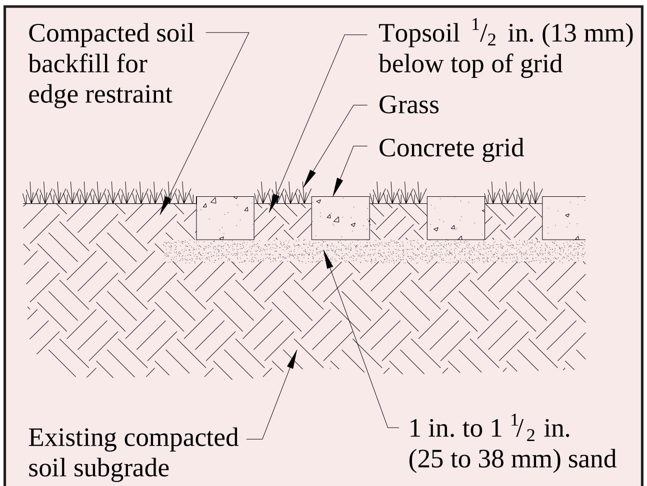

Figure 3—Grids and Sand on Compacted Soil Subgrade

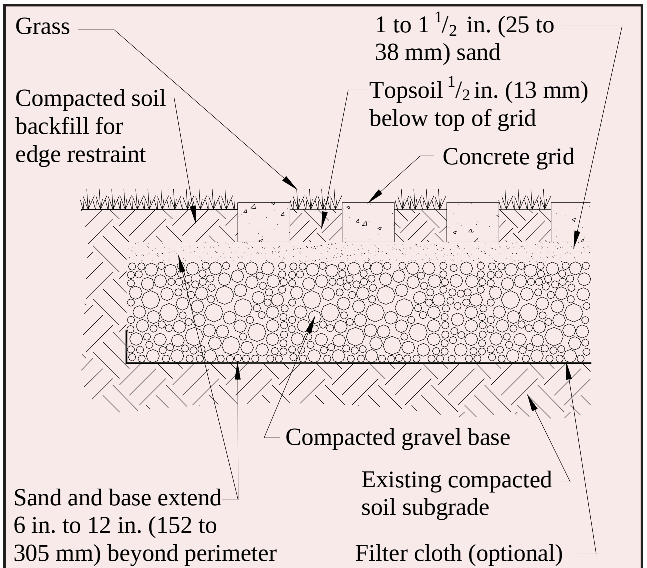

Figure 4—Grids and Sand on Compacted Gravel Base

Figure 5—Screeded Bedding Sand

Concrete grids allow water into the gravel base. However, excess amounts of water can weaken the base and subject it to the degradation of freeze-thaw cycles. Removal of excess water from bases over poorly drained soils should be provided by the use of drain pipes. Water can be drained to a storm sewer or stream. If drainage from soils of low permeability is impractical, bases subject to regular vehicular traffic can be stabilized with 4 to 6 percent (by weight) of cement.

Bedding Sand

Grading requirements for the sand should conform to *Standard Specification for Concrete Aggregates*, ASTM C 33 (ref. 8) for concrete sand. The sand layer should be between 1 and 1$^1/_2$ in. (25 and 38 mm) thick. Masonry sand should not be used. The sand should be screeded, as shown in Figure 5, to proper elevations and have a uniform moisture content (not saturated) prior to placing the grids. To maintain a level bedding surface, the screeded sand should not be disturbed.

Placement of Grids

The grids should be placed with a minimum joint spacing of 1/16 in. (2 mm). If the grids touch, they may chip and spall upon repetitive loading.

Vibration of Grids Into the Sand

A high frequency (3,500-5,000 cycles per second), low amplitude plate vibrator should be used to seat the units into the bedding sand. A rubber mat may be attached to the vibrator to protect the grids from cracking and chipping. Plywood sheets placed on the grids can be used for protection if a rubber mat is not available.

At the end of each day, the grids placed that day should be vibrated. If bedding sand is left exposed, it should be covered with plastic to protect it from rain, since rainfall settles the exposed sand and prevents the grids from pressing into the sand when vibrated.

Topsoil Placement

Grass seed and fertilizer can be mixed with the topsoil or broadcast directly on the surface and swept into the openings and joints. The grids should be vibrated again after the voids are full. The final level of the topsoil should be 1/2 to 3/4 in. (13 to 19 mm) below the top surface of the concrete grids. This provides some protection from tires to the grass as it grows.

Edge Restraints

Edge restraints are necessary for most grid pavement applications. Steel, aluminum, plastic, or wood edge restraints are used in situations where automobile tires could loosen the edge units and damage the continuity of the pavement. Installations that receive only occasional traffic may not require edge restraints. For these applications, the topsoil adjacent to the pavement can be compacted against the perimeter of the units, 6 to 12 in. (152 to 305 mm) from the edge. *Edge Restraints for Concrete Pavers* (ref. 2) provides further guidance on edge restraints.

Grass Selection

The durability of turf grass depends on a variety of factors including the species, proper installation of the topsoil, sod or seed, the frequency of traffic, and the climate. Research of grass in grid pavements has shown that Merion Kentucky bluegrass, Kentucky 31 tall fescue, and Manhattan perennial ryegrass have a high tolerance to wear, a high potential for recuperation from damage, and a low tendency toward thatch buildup (ref. 5). Turfgrass specialists should be consulted for further recommendations.

Application rates for grass seed should be reduced to take into consideration the presence of the concrete surface. Sod plugs can be used as an alternative to seed. Sediment from adjacent areas should be prevented from washing into the voids during and after establishment of the grass. The sediment will clog the topsoil and prevent the grass from growing.

Figure 6—Solid Interlocking Pavers Used for Pedestrian Walks and Parking Spaces

Straw can be applied to protect the grass while it is growing. The grass should not be subjected to vehicular traffic until it is well established.

Integration With Solid Pavers

Spaces in parking lots can be marked with solid concrete pavers. Pedestrian paths should be paved with solid pavers to make walking more comfortable. Figure 6 shows solid pavers used to mark parking spaces and for walkways.

Maintenance

The grass should be cut, watered and fertilized as with any other area of grass. The care of the grass should not be

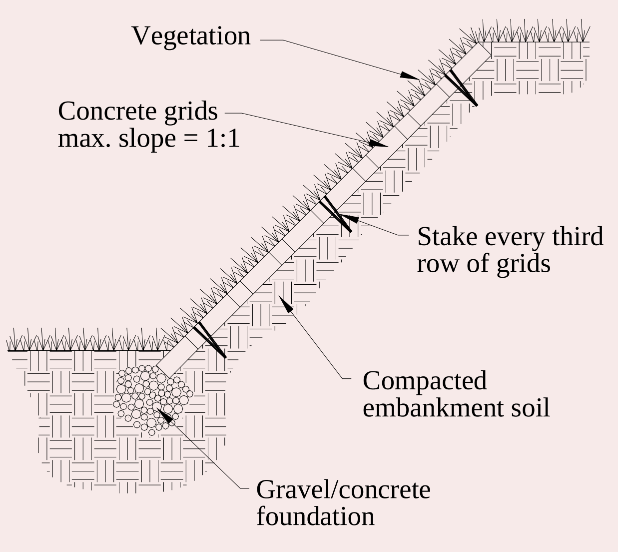

Figure 7—Grid Installation on an Embankment

neglected, as it is difficult to reestablish grass in compacted or polluted soil without removing and replacing the soil in each opening.

Snow can be plowed from concrete grids if the plow blade is set slightly above the surface of the grids. Rotary brushes for snow removal are not recommended. Deicing salts should never be used where there is grass, as the salt will kill the grass.

DESIGN FOR ON-SITE STORMWATER MANAGEMENT

Many municipalities have ordinances that regulate the quantity and rate of stormwater drainage into sewers and streams. Concrete grid pavements are one of several techniques for reducing the rate and volume of drainage from a site. Concrete grids can reduce or eliminate storm sewers and drainage appurtenances such as inlets, curbs, and grates, thereby reducing costs.

For drainage calculations using the Rational Method, an average runoff coefficient of 0.3 can be used for grids with established grass (ref. 6). This coefficient is substantially lower than the 0.9 to 1.00 for conventional asphalt and concrete pavements, and is more typical of coefficients for unpaved grass surfaces. No. 57 gravel is recommended for the base construction for stormwater infiltration and storage.

Grid pavements detain stormwater and allow for partial treatment of pollutants in the water. Because of this, grids can improve water quality by reducing sediment and pollutants that enter lakes and streams (refs. 1,3)

In addition to abating runoff, concrete grids generate lower temperatures than asphalt. Asphalt and other man-made surfaces hold heat in the summer and aggravate heat and air pollution in cities. Research has shown that areas with grid pavements have 2 to 4 °F (1 to 2 °C) lower local air temperatures than similar areas with asphalt pavements and 4 to 6 °F (2 to 4 °C) lower radiometric than asphalt (ref. 6). Lower temperatures can mean more comfortable microclimates for pedestrians in urban surroundings.

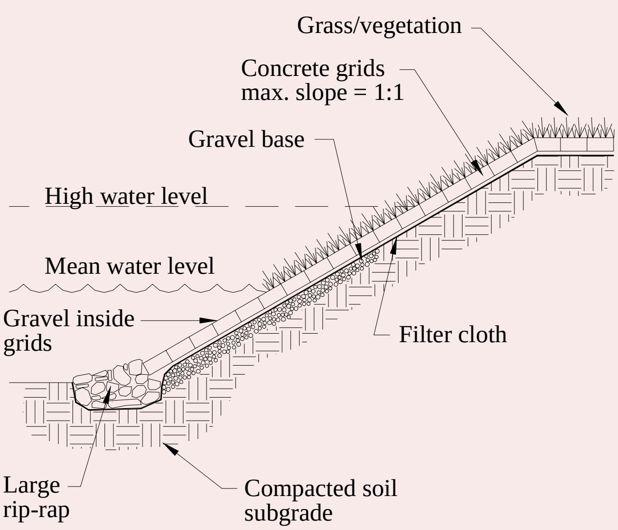

Figure 8—Typical Cross Section for Streambank or Lakeside Stabilization

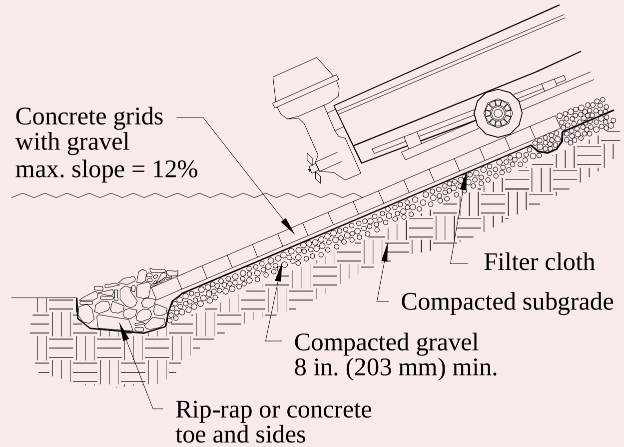

Figure 9—Typical Cross Section for Boat Ramp

DESIGN GUIDELINES FOR EROSION CONTROL

Embankments

Concrete grids have been successfully used to control the erosion of embankments, providing immediate stabilization until grass or other vegetation is established. The recommended maximum angle for embankment stabilization is 70°. Grids can be placed directly on graded and compacted soil, working from the bottom to the top of the embankment. For slopes over 45°, the grids should be staked every third row to secure them while vegetation is becoming established, as shown in Figure 7. Stakes can be plastic or steel.

Streambanks and Lakesides

Research by the U.S. Army Corps of Engineers has demonstrated the efficacy of grids for streambank stabilization (ref. 4), where grids were shown to be a cost-effective alternative to 17 in. (432 mm) stone rip-rap. Grids with gravel in the openings reduced shear stress against the finer soil, as well as acting to hold it in place. Grids can also accommodate riparian plants that further stabilize the soil.

Concrete grids are recommended for stream velocities of no greater than 11 ft/s (3.3 m/s). The maximum bank slope for grids should be 45°. For grid pavements, Manning's roughness coefficient, "*n*", has been estimated by the U.S. Army Corps of Engineers to be on the order of 0.024-0.026 (ref. 4).

The streambank should be graded and compacted prior to placing the grids. A minimum 4 in. (102 mm) thick gravel layer is often placed on streambanks in order to prevent erosion. A layer of filter fabric should be placed prior to installing the grids and should be anchored with large gravel at the "toe" (bottom) and sides of the installation (Figure 8).

Gravel should be placed in the voids of the grids if the stream is continually flowing. Topsoil and grass can be used in installations or areas not subject to frequent inundation, such as drainage ditches. The upstream, or starting edge of the grids should be protected with gravel so that stream debris does not break or lift the leading grids.

Concrete grids also make excellent boat ramps in parks and recreation facilities. They can be installed without partitioning the area and removing the water prior to construction. The design and construction guidelines above for streambanks and lakesides should be followed, except that 8 to 10 in. (203 to 254 mm) of gravel should be placed beneath the grids (Figure 9).

SPECIFICATION

Standard Specification for Concrete Grid Paving Units, ASTM C 1319 (ref. 9) governs concrete grid paving units for vehicular traffic, parking areas, soil stabilization, and revetments. The Standard covers units up to 24 in. long by 24 in. wide (610 x 610 mm), with a minimum nominal thickness of $3^1/_8$ in. (80 mm).

Standard C 1319 sets forth requirements covering materials, strength, absorption, durability, dimensions, appearance, and testing. When particular features such as weight classification, higher compressive strength, surface texture, finish, or color are desired, these properties should be specified separately by the purchaser. Local grid paver manufacturers should be consulted as to the availability of units having the desired features.

Physical Requirements

At the time of delivery to the work site, the units must conform to the physical requirements in Table 1 for minimum compressive strength, maximum water absorption, minimum net area, and minimum web width.

When units will be subjected to freeze-thaw cycles, it should be demonstrated by proven field performance that the units have adequate durability for the intended use. As used in the Standard, "proven field performance" is demonstrated when units similar in composition and made with the same manufacturing process as the units to be supplied maintain the physical requirements in Table 1 after three years of use. The units used to demonstrate proven field performance shall have been exposed to the same general type of environment, temperature range, and traffic volume as is expected for the unit supplied to the purchaser.

Permissible Variations in Dimensions

Length or width of units must be within $\pm^1/_8$ in. (3 mm) from approved samples. Similarly, heights of units must be within $\pm^1/_8$ in. (3 mm) from the specified standard dimensions. These dimensions are verified using *Standard Test Methods of Sampling and Testing Concrete Masonry Units*, ASTM C 140 (ref. 7).

Visual Inspection

All units are required to be free of defects that would interfere with the proper placing of the unit or impair the strength or permanence of the construction.

Sampling and Testing

The Standard provides for the purchaser, or the purchaser's authorized representative, to inspect and sample the units at the place of manufacture from lots ready for delivery. Units are sampled and tested in accordance with ASTM C 140, *Standard Test Methods of Sampling and Testing Concrete Masonry Units* (ref. 7), except that the coupon method for determining compressive strength shall not be used.

Rejection

If the samples tested from a shipment fail to conform to the specified requirements, the manufacturer may sort it, and a new sample be selected by the purchaser from the retained lot. This new sample is tested at the expense of the manufacturer. In cases where the second set of specimens also fails to conform to the test requirements, the entire lot shall be rejected.

Unless otherwise specified, the costs of tests are usually borne by the purchaser if the units conform to the specified requirements, and by the seller if the units fail to conform.

Table 1—Physical Requirements

Compressive strength net area min. psi (MPa)		Water absorption max., lb/ft^3 (kg/m^3)	Net area min., %	Web width, in. (mm)	
Avg. of 3 units	Individual unit	Avg. of 3 units		Min.[a]	Avg.[b]
5,000 (35)	4,500 (31)	10 (160)	50	1.00 (25)	1.25 (32)

[a] measured at the thinnest point

[b] average of measurements along the height of the web

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