

Impact of Porous Paving Upon Runoff Calculations

Many designers ask us for the runoff coefficient for our Grasspave² and Gravelpave² porous pavement systems. This number is also known as the “C” factor in the Rational Formula used to calculate runoff volumes within a small watershed. The formula is: $Q = CiA$, where Q is the peak runoff in cubic feet per second, i is the rainfall intensity in inches per hour, and A is the watershed area in acres. The closest “C” factor representative of our porous paving systems would be 0.10 to 0.15 -for lawn, well drained (sandy soil) on 2% to 7% slope.

We believe that the rational method is quick, but can be a course projection for small construction sites (less than 10 acres). We feel it would be beneficial to also look more closely at way water responds to a porous pavement cross section, especially in regard to dramatic increases in time of concentration, additional subsurface storage, and infiltration capabilities. The following information should provide a new perspective to traditional stormwater impact analysis, and perhaps a method to reevaluate and modify existing stormwater management codes and design guidelines.

Definition of Porous Paving -

While many paving surfaces could be considered “porous” , including weathered and severely cracked asphalt, we shall define porous paving as that specifically designed and constructed to encourage rapid infiltration and percolation of rainfall and stormwater through the entire pavement cross-section, and maintain this function over many decades, while directly supporting traffic loads.

Pavements Included

Grasspave²
Gravelpave²
Geoblock[^]
Grassy Pavers[^]
Grass Road Pavers[^]

Pavements Excluded

Porous Asphalt*
Porous Concrete*
Interlocking Pavers w/sand joints
Concrete/Grass Blocks

*Excluded when placed over impervious base course material.

[^]Provided base course is porous and cells are filled with primarily sand.

Importance of Porous Base Course -

Designing for porosity in base course and materials to fill structural elements means that attention must be paid to the sieve analysis of potential sources. Largest particle size is determined by size of the smallest opening of the structural cell and whether grass roots are involved. For instance, if a structural paving cell is 2” across, and there is a restricted opening at the bottom of the cell measuring 1.5” dia., then the largest aggregate size allowed for the base course should be 3/4” dia., to allow at least 50% of the opening area to be available for grass roots and air/water access.

The critical minimum particle size is material able to pass a #200 screen (clay and silt). If this material exceeds 5% of the base course mixture, percolation rates will

begin to be reduced, and grass roots will not be able to find enough air and water for growth.

Most state highway or transportation departments have not yet begun to develop standard specifications for porous base course mixtures. If one had to design one with commonly available materials, we would suggest a mixture of 2/3 crushed drainage rock (1" to 3/4" dia) with 1/3 sand (clean concrete or masons sand). When compacted to 95%, this mixture will provide excellent load bearing support, and a root zone compatible environment. Void content of this mixture should be about 35 - 40%, which is also potential storage volume for stormwater.

Importance of Porous Wearing Course -

Infiltration and percolation through the surface layer, also known as wearing course, is just as important as having a porous base course, if not more important. If water cannot enter the surface, storage potential of the base course can never be realized.

Equally important is the necessity to maintain porosity over the life of the pavement. Many sources of fine materials having potential to impede water movement by filling voids of porous media exist, including: wind blown dust; suspended sediment in water; leaf litter; and even erodable materials from vehicles such as tire dust, brake dust, rust, etc.

Grass surfaces (sand filled cells) can filter and absorb these deposits into the root zone, without greatly effecting infiltration. However, as wind or water borne deposits accumulate, they may eventually need to be removed by power brooming or lifting with sod cutting equipment, set to ride above the top of the cell structure.

Non-grass porous surfaces will usually be some form of fine gravel material and not be able to keep fine sediment at the surface. Filtration ability becomes a factor of particle size and mixture of the cell fill material. In the case of unbound stone fill, complete removal of the stone from cells by vacuum may be necessary if infiltration becomes impeded. Stone held with binder (similar to porous asphalt or concrete) may be able to be flushed with high volume or high pressure water spray, or cleansed by vacuum.

Impact Upon Runoff Coefficients -

Properly designed and constructed porous pavements will not generate any runoff until the voids within the cross section are filled. Infiltration rates of sand and sandy/gravel materials are so rapid that water will go down until it meets resistance of a less permeable material, such as sub soils, liners, or water held from previous rainfall, runoff or irrigation.

In the case of grass pavements, we use an available void factor of only 25% to allow for space occupied by root systems and moisture held for plant benefit. While roots occupy space, they also act as express conduits for water movement, so root mass/void space relationships are not simple.

For other porous (non grass) surfaces, we use a void factor of 35%. As an example, with 1" high Gravelpave2 over an 8" deep sandy gravel base, 35% times 9" equals 3.15", which is the amount of rainfall that could be held if the section were dry and did not have to also receive runoff from adjacent surfaces. This quantity

would thus accept the majority of storms of one hour or less duration across the United States, before surface runoff would begin.

How do we determine the runoff coefficient? To determine a runoff factor for a grass driveway, we could use as an example: a 1" deep Grasspave2 wearing course over a 5" deep sandy gravel base. This 6" deep section times 25% void equals 1.5" - the depth of rainfall that could be received and stored before runoff begins. C factor is equal to zero for the first 1.5" of rainfall.

For a grass paved firelane, we might have 1" deep Grasspave2 over a 12" deep sandy gravel base, which would equal 3.25" of storage value (13" x 25%). C factor is equal to zero for the first 3.25" of rainfall.

For a gravel paved truck loading area, we might have 1" deep Gravelpave2 over a 12" deep sandy gravel base, which would equal 4.55" of storage value (13" x 35%). C factor is equal to zero for the first 4.55" of rainfall.

The following chart may give some idea of how these numbers relate to likely rainfall intensity rates in the United States. For local code requirements and design guidelines, refer to local rainfall data.

Rainfall Rates - Excessive Storms
US Weather Service 1904-1934

Duration	<u>5 min</u>	<u>10 min</u>	<u>15 min</u>	<u>30 min</u>	<u>60 min</u>	<u>90 min</u>	<u>120 min</u>
Precip-inches	0.85	1.2	1.4	1.74	2.15	2.46	2.97

Time of Concentration -

Once the storage potential of a porous pavement section is met, water will begin to flow across the pavement surface as runoff, or form a surface pond, depending upon gradients. By the time this happens, most intense rainfall storms will have passed and on-site storage or detention requirements will have been met. Time of concentration factors have turned into hours instead of minutes.

Rainfall or storms that last over several days create a different demand. Porous subsoils can allow water to enter and pass almost as quickly as it falls, so little runoff is seen, even over days. Impervious or slow to percolate subsoils will create a saturation effect in the porous pavement section, necessitating additional storage in surface ponds, or better subsurface empondments, such as our Rainstore3 system.

The time factor related to when water will reach community drainage facilities, saturate ground water aquifers, is critical to community stormwater management plans. Porous pavements can play a major role in reducing potential for flooding, and must become an important tool for all future development.