Permeable paving as an application input to reduce damage from heavy rainwater

Assist. Prof. Dr. Sherif El Sayed El Said Mohamed

Assistant Professor at the Faculty of Architecture and Planning, Department of Architecture, Qassim University, Qassim, Kingdom of Saudi Arabia

sh.mohamed@qu.edu.sa

Abstract:

Egypt and many other countries in the Arab world are among the countries with little rain in general, but the large number of climate changes in the world have doubled the possibilities of heavy rains, which resulted in what looks like torrential rains during the winter season more than once in the past few years, so that they have become a threat that is expected to occur every year. On the other hand, there was no interest in taking advantage of this wasted natural water, and therefore it is assumed that ways to face it and also benefit from it should be developed. One of the effective solutions is the use of permeable paving systems, in order to reduce damages resulting from heavy rainwater and floods, especially after the spread and recurrence of this phenomenon in many countries of the Arab world. For these systems to be effective, porous asphalt must be designed to have sufficient structural capacity to accommodate projected vehicle loads, to manage rainwater flow into the subsoil, as well as wastewater drainage operations. When heavy rains come, more of it ends up accumulating on impermeable concrete surfaces such as parking lots, driveways, sidewalks and streets rather than leaking through the soil. This leads to an imbalance in the natural ecosystem, which results in a group of problems including erosion, floods, groundwater, and river pollution, as well as the flow of water from the farmland across the surface of the impermeable pavement will lead to the passage of death to capture everything on its surface, starting like oils spilled grease, and chemical fertilizers. Therefore, this paper describes the best practices used to design and build permeable paving systems, which are considered one of the best applications in general use as indicated by the results of this research, as they are a major contributor to effective rainwater management. With a focus on the lessons learned from construction, whether on narrow or express roads, sidewalks, and parking lots, in addition to studying the engineering characteristics of each type, structural characteristics, and durability, as well as reviewing all the environmental benefits resulting from this, especially the material aspect that some consider the main factor, which may prevent this from being achieved.

Keywords:

Permeable Pavement, Porous Asphalt, Pervious Concrete, Heavy rain.

Research objective:

Many urban areas now suffer from the problem of unexpected torrential rain water during the winter season, and the roads and streets are not ready to absorb, as the design of these roads is not good or in other words not prepared to absorb this huge amount of water. Therefore, the research aims to shed light on one of the most effective methods of managing torrential rainwater, which has increased in use in many countries of the world, which is permeable paving

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systems, as that water is well managed by allowing it to penetrate through a set of treated and prepared layers down to the lower soil layers, or to the channels and drainage channels connected to them. On the other hand, the research aims to present low-cost enforceable regulations as one of the most important determinants that prevent their implementation in many countries, especially the third world countries.

Research problem:
The solutions provided to drain the torrential rainwater, which are taking place in many countries of the world, especially the Arab world, are temporary solutions for several reasons, including that the main goal is to try to prevent the recurrence of the event, so that the presenter is temporary and quick. Correct geometric premise. On the other hand, easy traditional solutions are always sought, due to the reluctance to assume responsibility - due to the difficulty of implementation. As a result, new, more efficient and effective solutions must be implemented, such as lean paving systems (this will be discussed and analysed).

Research scope:
It should be noted that there are three types of water drainage. The first includes household water drainage, the second is rainwater drainage, and the third is flood drainage. Usually, work does not falter in household water drainage pipes, but work stumbles in the pipes to drain rain water, as well as the drainage of floods falter, and this is the real problem, and therefore the research will only study the second type (drainage of heavy rainwater) in an attempt to find appropriate solutions to reduce from the damage caused by heavy rain water.

Research Methodology:
The research follows the inductive approach, by presenting all types of permeable floors, which are applied in many countries of the world now, and include: Porous Asphalt, Precious Concrete, Permeable Interlocking Concrete Pavements (PICPs), In addition to Grid Pavements and Pervious Pavers, identifying the advantages and disadvantages of these systems, then studying the design considerations that must be followed to determine the thickness of the porous layers of the pavements, with a full and accurate description of the components and properties of these layers. On the other hand, all stages of construction and implementation, as well as related maintenance processes, are explained, leading to the most important results of this study, and coming up with the most important recommendations that must be followed when designing and implementing such systems.

1. Permeable Pavement Systems
They are advanced and multi-functional systems, so it is not only necessary to provide a strong treated surface for roads, whether they have traffic densities, pathways, or parking spaces only; They are designed to manage and treat torrential runoff. These systems consist of a graduated mixture that has the ability to absorb rainwater falling on its surface and then transfer it to a porous base made of graded gravel from which the water then moves to the natural ground underneath - if this is so possible, or it is drained laterally to an adjacent basin or channel (Figure 1).

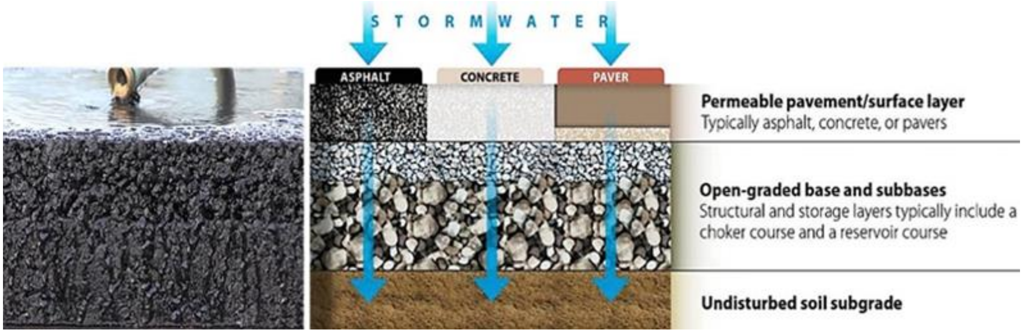

Figure (1): Right (a general cross section of the implemented pavement), left (a sector for the permeable paving system during the test). Source: Right, ACRP Research report 178, Guidance for usage of permeable pavement, Left, Permeable pavement guide helps practitioners avoid pitfalls, 2019.

1/1 Porous Asphalt

Its first use appeared in Australia in 1973, and in Japan in 1987 (1). Porous asphalt is an evolution of road surfacing technology that allows water to enter asphalt mixtures through continuous air voids. Porous asphalt pavements comprise one or more layers of porous asphalt, below which are several treatment layers and an assembled sub-base tank (Figure 2). Where the depth of the building layer is determined according to the structural load and expected rainwater requirements. Under the porous asphalt, an aggregate layer is laid (passing through the sieve hole No. 4), resulting in a porous mixture that allows water to pass through interconnected voids. Additives are also used to improve the durability and reduce the likelihood of asphalt drying.

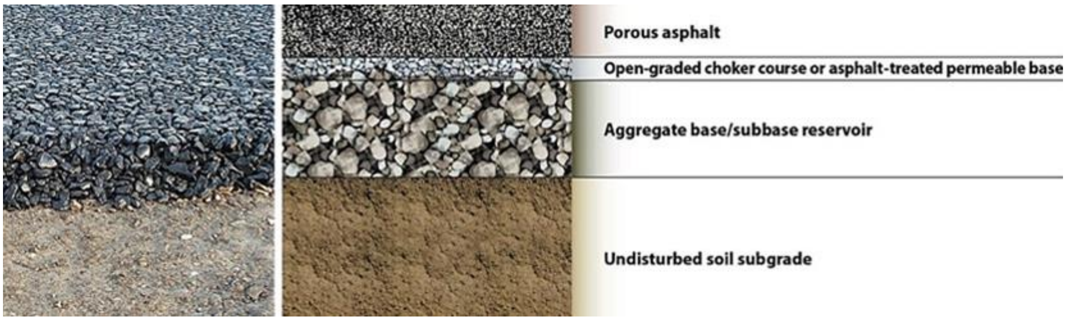

Figure (2): Right (cross section showing paving layers using porous asphalt), left (porous asphalt during implementation). Source: Right, ACRP Research report 178, Guidance for usage of permeable pavement, Left, Porous Asphalt Pavement, City of New Berlin, 2017.

1/2 Pervious Concrete

The preceding concrete consists of a hydraulic cement bonding system (such as Portland cement), combined with open graded aggregates to produce a solid and durable paving layer. Former concrete is usually placed over a stone layer (or a treated base layer) and a bulk bed / or sub-base tank (Figure 3). The former concrete pavement usually contains 15% to 25% of interconnected empty space, and the surface permeability according to GPC is 300 to 2000 inch / hour (2).

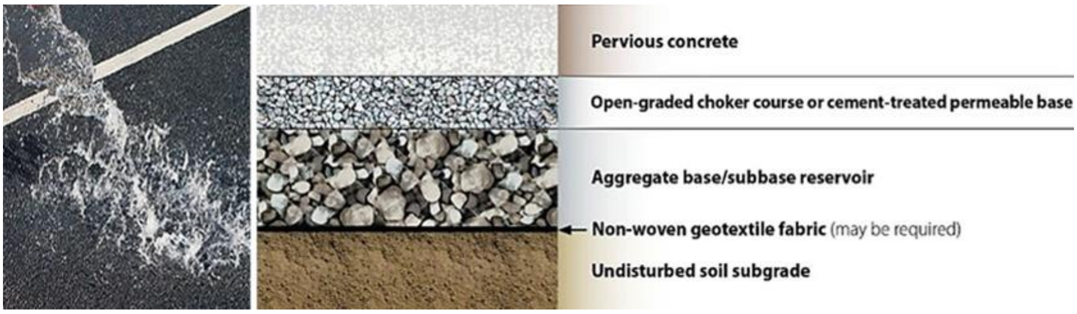

Figure (3): Right (cross section showing previous concrete paving layers), left (previous concrete while exposed to water). Source: Right, ACRP Research report 178, Guidance for usage of permeable pavement, Left, Pervious Concrete Pavement Grey Color, Water Permeable Concrete for Paving Walking ways.

1/3 Permeable Interlocking Concrete Pavements (PICPs)

Permeable interlocking concrete piers consist of concrete curb and pavers - forming voids and connections through which rain water permeates by flowing into the stone layers below, and a combined base/ or a tank with a sub-base (Figure 4). Joints usually constitute from 5% to 15% of the pavement surface area, thus reaching the global system surface permeability from 400 to 600 inch/hour, and permeable interlocking concrete pavements often include small-sized bulk treatment bed layers below the pavement surface and above the stone layer to ensure flat surface for sidewalks [3].

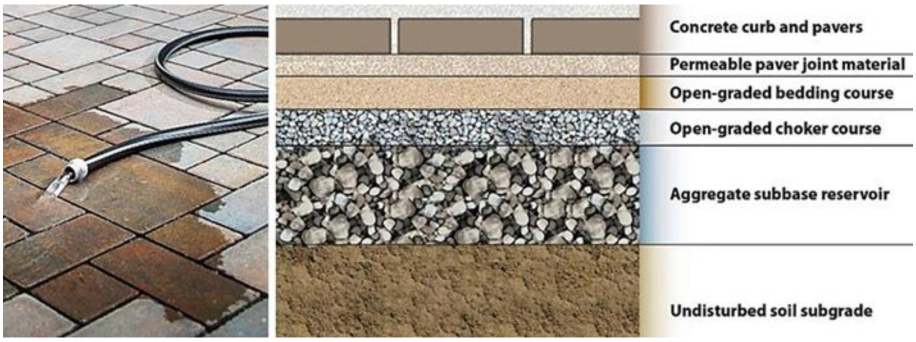

Figure (4): Right (permeable interlocking concrete pavement layers), left (permeable interlocking concrete pavement during exposure to water). Source: Right, ACRP Research report 178, Guidance for usage of permeable pavement, Left, Right Tool for the Right Job: Managing Storm water, 2018.

1/4 Other systems

1/4/1 Grid Pavements

The grid paving system consists of concrete or plastic grid paving units with thicknesses that can accommodate aggregates, topsoil, or grass (Figure 5). Where the surface void area ranges from 20% to 75%. Concrete and plastic mesh pavements usually have a sand bed grouped below the mesh pavement surface and above the stone bed to ensure a flat surface of the pavement [2].

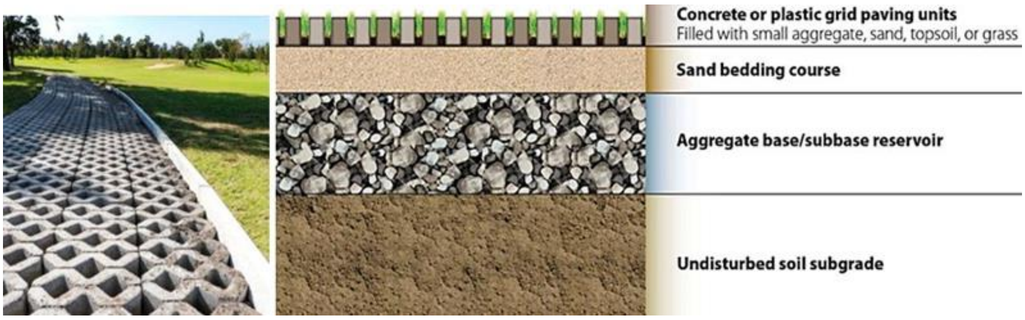

Figure (5): Right (a cross section showing the paving layers using the grid paving method), left (implementing the grid paving). Source: Right, ACRP Research report 178, Guidance for usage of permeable pavement, Left, Permeable or open grid concrete paving, 2019.

1/4/2 Previous Pavers

Previous flooring consisted of a paving unit usually made of a group of smaller sized stones grouped together by cement or polymer. These floors differ from the PICP-permeable concrete pavement systems, and the difference is that the paving floors themselves are permeable, and therefore permeability is related to the entire paving surface and is not limited to the open connections between them.

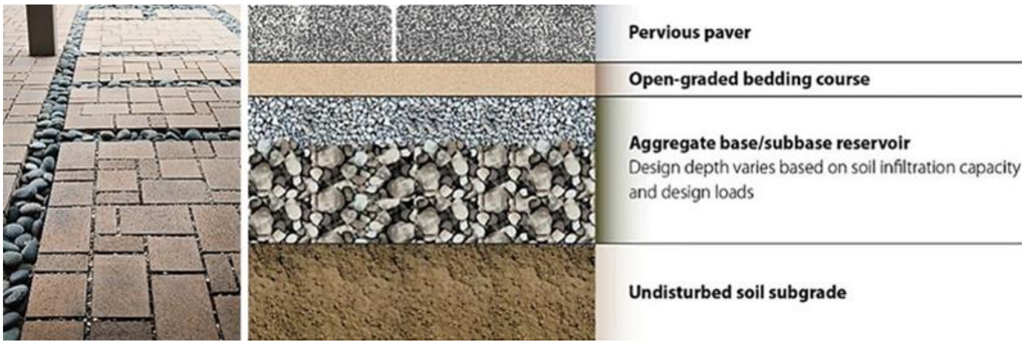

Figure (6): Right (A cross section showing the paving layers using the net paving method), left, (implementing the grid paving). Source: Right, ACRP Research report 178, Guidance for usage of permeable pavement, Left, Permeable or open grid concrete paving, 2019.

2. Permeable Pavement Advantages

- Effective rainwater management technology,
- Valid for all types of roads,
- Environmentally friendly systems,
- Reducing the impact of Splash and spray, Aquaplaning,
- Reducing light reflection and glare,
- Noise reduction,
- Skid Resistance, and
- Rut-resistance.

3. Permeable Pavement Advantages

- Cost
- Aging and Stripping
- Chemical spills
- Reducing Porosity

4. Design considerations

Three considerations are required when determining pavement thicknesses of pavements: site considerations (to ensure that the site is acceptable), hydrological design (to ensure that porous paving meets potential rainwater runoff requirements), and finally, structural design (to ensure that porous pavement has capacity to withstand the expected traffic load forces).

5. Construction sequence

- The subsurface infiltration bed is excavated under the porous pavement without heavy pressing equipment, fine grading is done by hand.
- Earthen berms (if used) must be left between seepage layers in place during drilling. These berms do not require pressure if their stability is verified during construction.
- Non-woven geotextile is applied immediately after fine sorting.
- The uniform graded aggregate is placed in the base as the storage medium.
- Porous asphalt shall be laid in the same way as conventional asphalt.
- The finished surface is similar to conventional asphalt until it rains. As it begins to absorb water until the surface is completely dry.

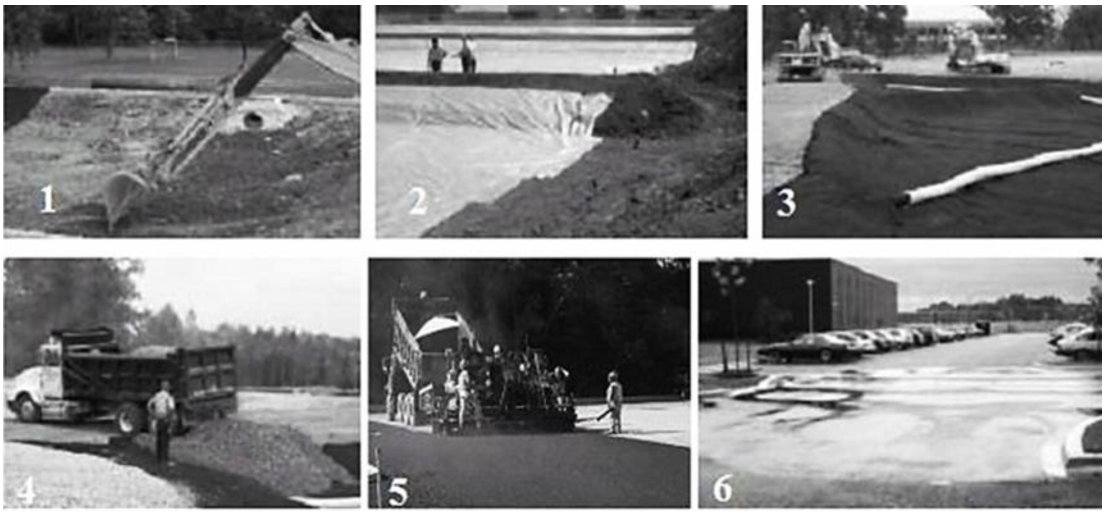

Figure (7): Construction sequence for porous asphalt pavements.
Source: Porous asphalt: the right choice for porous pavements. Hot Mix Asphalt Technology, 2003

6. Maintenance of permeable paving systems

Due to the open nature of the surfaces of permeable paving systems, they will over time become clogged with sediments and debris reducing the rate of their infiltration. Where the rate of decrease depends on the sources of sediment deposit. The gradual occlusion of the surface layer can have the benefit of capturing some suspended solids, otherwise it will be deposited at the sub-base and / or discharged into the substrate, and with normal maintenance, sediments that are captured near the surface can be removed more easily than sediments that accumulate at the base [(4)].

7. Results

From the previous study we can say that permeable paving systems are a major contributor to effective rainwater management. It is through them that best practices are applied to capture, stored and leaked rain and storm water. Thus, we can achieve a reduction in rainwater drainage, in addition to improving water quality, including reducing suspended solids and also reducing chemical pollutants. However, although it is an effective tool, when designed and built it must be carefully applied, for structural and hydrological quality standards as mentioned previously, to ensure that it provides cost-effective solutions over the life of its design and operation.

8. Recommendations

In order to increase the effective life of the pavement, the following is recommended:

- Do not use conventional oil, aerosol-based paving markers, or Latex.
- Never apply a sealing layer to porous asphalt.
- Limit parking of vehicles that may leak engine oils and lubricants on the sidewalk.
- Limit activities that increase the possibility of clogging the pavement surface.
- Where possible reduce the frequent use of heavy compounds for porous methods, for example,
- It is forbidden for vehicles to stop or wait on the porous roads, or to allow them to drive at fixed and announced times such as (from midnight until 6 AM), ... etc.
- Avoid excessive use of trimmers - dicing chemicals.
- Use caution when cleaning streets, as permeable paving systems consist of a surface with joints and /or openings.
- Allow free movement of water to penetrate the system. This is why it is forbidden to remove the filler joints of the paving surfaces.

9. References

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