Course Name: Building Materials as a Cornerstone to Sustainability

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Lecture 04

Permeable Concrete

Dear students, I am back with yet another interesting material, an advanced building material called permeable concrete. Now what is permeable concrete? Large aggregates are used in the production of pervious concrete with little or no fine aggregates. Water can then pass through the concrete slab since the concrete paste has coated the particles. Parking lots, places with little traffic, residential streets, pedestrian pathways and greenhouses are among the typical applications for pervious concrete. It is a significant application of sustainable construction and one of the numerous minimal impact development strategies that builders employ in order to preserve the purity of water. So this is a unique kind of concrete which is highly porous and it is used for concrete flat work applications.

This concrete can reduce runoff from the site and permit groundwater recharge by allowing water from precipitation and other sources to pass through it directly. So, as I have said some of the applications or uses where it can be used is parking lots, places with less traffic, residential streets, pedestrian pathways and greenhouses. Let us look at what is a permeable concrete. Now as a low impact development technique, permeable concrete has gained popularity as a way to lower the negative environmental effects of infrastructure operations and construction.

So, PCs can be, permeable concrete can be utilized as a green infrastructure solution to complement or replace traditional grey infrastructure, particularly for parking surfaces and roadways with minimal truck traffic or heavy vehicle traffic, low speed and low weight vehicles preferably. Now, a type of concrete pavement which features an open network of pores to allow infiltration of stormwater through the pavement into the base or sub layers is known as pervious concrete pavement or PCP in a short form. Let us understand more about this concrete in terms of its permeability and then its environmental benefits. So, reduced stormwater runoff is one major advantage of this concrete. So, by filtering rainwater into the ground, permeable concrete significantly reduces the risk of flooding and erosion, protecting natural waterways and infrastructure.

The second one is it is replenishing the groundwater. Rainwater does not simply disappear. It replenishes vital groundwater reserves, ensuring a healthy water cycle and supporting the ecosystems. And the third one is improved water quality. So, as water percolates through the concrete, natural filtration processes remove pollutants, contributing to cleaner waterways and reducing the need for expensive treatment methods.

This can reduce the heat island effect. and how conventional concrete absorbs and radiates heat, contributing to the urban heat island effect. Permeable concrete, with its lighter color and open and porous structure, allows heat to dissipate, promoting cooler, more comfortable urban environments. It also has enhanced aesthetics. So the naturally textured surface of permeable concrete adds visual interest to landscapes, creating a more inviting and natural feel.

There are potential cost savings. And how so? While the initial cost may be higher, permeable concrete can reduce long-term maintenance needs by minimizing stormwater infrastructure requirements. It can also act as a natural filter enabling that contraption required to filter the stormwater or the rainwater. Let us see the properties of permeable concrete. The properties of permeable concrete are different when fresh and when hardened, similar to typical concrete.

When fresh, the fresh properties are the plastic pervious concrete mixture is stiff compared to traditional concrete. When placed and compacted, the aggregates are tightly adhered to one another and exhibit the characteristic open matrix. So concrete working time is typically reduced for previous concrete mixtures. Usually one hour between mixing and placing is all that is recommended. This can be altered using stabilizers and retarders.

as it is an evolving and upcoming material, one needs to be more careful in understanding its properties because this is an upcoming material and probably you people are the one who would experiment more with this material and take it forward. Let us look at the properties of this material. Now once the concrete is hardened, the properties alter. First is the density. The density of pervious concrete depends on the properties and proportions of the material that is used and on the compaction procedures used in placement.

In-place densities in the order of 1600 to 2000 kg per meter cube are common, which is in the upper range of lightweight concrete. Compressive strength Pervious concrete mixtures can develop compressive strengths in the range of 3 MPa to 30 MPa which is

suitable for a wide range of applications. The third property is its shrinkage. Drying shrinkage values in the order of 0.002 have been reported, roughly half that of conventional concrete mixture.

Because of this lower shrinkage and the surface texture, many pervious concretes are made without control joints and allowed to crack randomly. So, let us see the potential uses of previous concrete. Pervious concrete can be used for many purposes such as the low volume pavements that is pavements on which there is not too much of load such as trucks or tractors and so on. It can be used in residential roads, alleys, and driveways. It can also be used for sidewalks and pathways, especially because these do not carry very heavy loads, and this can also function as a stormwater drain.

This can be used in parking areas which are basically large areas open to sky and therefore have a potential for catchment. Permeable concrete can be used in patios. They can be used in artificial reefs. These can also be used for slope stabilization. in lining of wells so that wherever the aquifer cuts across the well there is seepage of water inside the well.

Instead, if one were to line the well with a material, say, concrete, then even if there is an aquifer that passes through the well, it will not benefit from tapping the water. These can be used for tree grates in sidewalks, and therefore we would not need to water the tree because when it rains, water would percolate and the tree would be able to hold the water. Then it can be used in foundations or floors for greenhouses, for fish hatcheries and aquatic centers, and also in zoos. These can be used for hydraulic structures and in swimming pool decks so that water that splashes on the deck percolates and seeps inside. These can be used in pavement edge drains.

They can be used for sea walls as a noise barrier. and also for walls including load bearing walls. So, previous concrete has a lot of usage as well as advantages. Now, let us look at the mixing and construction of permeable concrete. Mixing and construction is very important in incorporating permeable concrete.

A strong and durable permeable concrete can be realized by using a small amount of fine aggregate, adding polypropylene fibers, using a slightly higher water-cement ratio, increasing compaction that is lower porosity Introducing entrained air and increasing paste volume, replacing some Portland cement with fly ash or silica fume or using a latex admixture. Cement may be replaced by about 10 to 30 percent of fly ash, 20 to 50 percent of blast furnace slag and 5 percent of silica fume. The addition of fine aggregate will decrease the porosity and increase its strength. So, you can see that this material can also be a green material in two ways. First is by tapping water that falls on its surface and

ensuring that there is no runoff to a place where the water cannot be used.

So, this can percolate inside and help us in groundwater recharge. Also, in the manufacture of permeable concrete, we can use typical industrial waste such as fly ash or blast furnace slag, and this can make the concrete a green product. So let us look at the transportation. Now a previous pavement mixture should be discharged completely within one hour and after initial mixing. The use of retarding chemical admixtures or hydration-stabilizing admixtures may extend discharge time to one and a half hours or more.

If we look at placement and consolidation, the previous concrete mixture cannot be pumped, making site access an important planning consideration. Prior to placement, the subbase preparation and forms should be double checked. Placement should be continuous, and spreading should be rapid. Mechanical vibrating, laser screeds, and manual screeds are commonly used. Although manual screeds can cause tears and cracks in the surface if the mixture is very stiff,.

Consolidation is generally accomplished by rolling over the concrete with a steel roller, which compacts the concrete to the height of the forms. Because of rapid hardening and high evaporation rates, delays in consolidation can cause problems. Curing. Now, as pervious concrete pavements do not bleed, they can have a high propensity for plastic shrinkage cracking. Curing for pervious slabs and pavements begins before the concrete is placed.

The subgrade must be moistened to prevent it from absorbing the moisture from the concrete. Fog misting followed by plastic sheeting is the recommended curing procedure. Normally this is carried out for 7 days. Let us look at the innovative uses of permeable concrete. The permeable concrete is used in many ways relating to groundwater runoff reduction, urban heat island mitigation, parking etc.

The property of the concrete to pass water can be used in roof ponds in hot dry climate. Roof pond is an advanced passive technique that is used in hot, dry climates to enhance indoor thermal performance. The permeable concrete slab can be placed upon the roof RCC element with breathing space in between for water to be stored. The advantages of permeable concrete is the roof pond will have partial shade. Hence, the water in the daytime can also be kept still and would have a low evaporation rate.

As the slab water will have concrete slab above, the roof will be usable and functional. The drainage system below the surface will allow the water to be changed periodically. Let us look at the advantages of using permeable concrete. Usage of permeable concrete

has many advantages and sustainable benefits too. Now it is claimed that the high flow rate of water through a permeable concrete pavement allows capture of rainfall, thus reducing stormwater runoff, recharging groundwater, and supporting sustainable construction through controlling rainwater on site and addressing stormwater runoff issues.

It also helps in controlling the amount of contaminants in waterways through reducing or eliminating runoff and allowing treatment of pollution. Such treatment normally occurs as a result of capturing initial rainfall and allowing it to percolate into the ground, thus allowing soil chemistry and biology to treat the polluted water in a natural manner. Less absorption of solar radiation happens because of the light color of concrete pavement as compared with darker materials and less storage of heat because of the relatively open pore structure of permeable concrete. A permeable concrete pavement and its sub-base may provide enough water storage capacity to eliminate the need for retention ponds, swales and other precipitation runoff contaminant strategies in order to contain these, thus leading to more efficient land use. It is also lightweight and has low shrinkage properties.

So there are so many advantages of using permeable concrete, ranging from environmental in terms of water conservation and environmental conservation to sustainability, and therefore one needs to start incorporating permeable concrete more in the day-to-day architecture. Now, permeable concrete also comes with its limitations. So, there are some limitations that are associated with the use of permeable concrete. Their long-term behavior is still not known or well understood. This must be studied for us to use this concrete extensively.

For that we have to start using this concrete. It is important to do careful planning and execution of construction details. This concrete can clog under certain circumstances with muddy runoff. If the soil gets now fixed into the pores then it can no longer function as a permeable concrete. Let us look at a small case study where this has been used, permeable concrete has been used.

So, we shall now look at a case study which is in Minnesota, US. The city of Shoreview replaced 9,000 square feet of asphalt roads with 7 inches of pervious concrete, over 18 inches of coarse-grade aggregate base near the Owasso Lake, which is highly drainable sand serving as the base. This was done on the neighbourhood of Woodbridge on low traffic roads. About twice each year for five years, researchers tested sound absorption, water infiltration and ride quality one day after the pavement had been vacuumed. In 2015, they replaced these tests without vacuuming the day before.

It is important to vacuum these roads twice a year as they may get blocked by organic matter or even mud and soil. Now, the previous pavement performed very well in filtering stormwater. By 2012, at least 1.3 acre feet of water had filtered through the pavement and ground, and in 2015, nearly 2 acre feet of water had filtered through the surface, all of which would otherwise have run directly into Lake Owasso. Water filtration and sound absorption rates were higher than traditional concrete, although rates declined over time because organic material continued to clog the pavement pores despite vacuuming twice a year.

So, this shows that it is very important to vacuum this concrete not necessarily twice a year, but even periodically. Especially in tropical countries and developing countries like India, it is very important to vacuum this in order to ensure that the pore remains open and the surface functions as a pervious pavement of porous concrete. Nevertheless, this one study showed that previous concrete is a very effective strategy from a sustainable point of view and an environmental point of view. More usage of this material is demanded in day-to-day architecture. With this, I stop this class as we have seen an advanced building material called porous concrete or permeable concrete.

We will meet next class with another topic. Thank you.