Pervious Concrete: Solution for Low Cost Construction

Neetu B. Yadav, Jayesh A. Shah, Rushabh A. Shah

***Abstract*— Pervious concrete is known as No fines, gap graded or porous concrete. This concrete is a mixture of Cement, Corse Aggregate and with or without sand. Pervious concrete has an interconnected pore structure that freely allows the passage of water to flow through. This concrete is being used as paving material to solve or reduce the storm water runoff to the drainage system and minimize water logging problems. This paper covers some of the main properties and major uses of pervious concrete and its ecofriendly benefits. This concrete proves to be very beneficial if it utilize to its full extent in various flat work applications in India.**

***Key Words* – Eco-Friendly, Low Cost Construction, Pervious Concrete, Storm Water Management.**

I. INTRODUCTION

As urbanization increases in India and many parts of the world the problem of water logging and requirement of drainage is also increase. This is partly due to impervious nature of the bituminous and concrete pavements. Pervious concrete which has an open cell helps significantly to provide high permeability due to its interconnected pores. Pervious concrete (also called porous concrete, permeable concrete and no fines concrete) is a special type of Concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge. Pervious concrete is made using large aggregates with little to no fine aggregates. Pervious concrete has been used in the United State for over 30 years. Pervious concrete was first used in the 1800s in Europe as pavement surfacing and load bearing walls. Cost efficiency was the main motive due to a decreased amount of sand. It became popular again in the 1920s for two story homes in Scotland and England. It became increasingly viable in Europe after the Second World War due to the scarcity of cement. India is facing a typical problem of ground water table falling at a fast rate due to reduced recharge of rainwater into subsoil and unplanned water withdrawal for agriculture and industry by pumping. NFC if adopted for construction of pavements, platform/walkways, parking lots designed for lighter load. It can become a component of rainwater harvesting schemes being prepared by Government of India on a Priority basis. It also reduces the runoff from the pavement areas hence reduce load on drainage systems.

II. PROPERTIES OF PERVIOUS CONCRETE

Density and porosity

The density of pervious concrete depends on the properties and proportions of the materials used, and on the compaction procedures used in placement. In place densities on the order of 1600 kg/m^3 to 2000 kg/m^3 are common, which is in the upper range of lightweight concretes. The porosity of pervious concrete largely depends on aggregate size.

Permeability

The flow rate through pervious concrete depends on the materials and placing operations Typical flow rates for water through pervious concrete are 288 in. /hr, 120 L /m^2/min, or 0.2 cm/s to 770 in. /hr, 320 L /m^2/min, or 0.54 cm/s, with rates up to 1650 in. /hr, 700 /m^2/min,1.2 cm/s and higher having been measured in the laboratory.

Compressive strength

Pervious concrete mixtures can develop compressive strengths in the range 3.5 MPa to 28 MPa, which is suitable for a wide range of applications. Typical values are about 17 MPa. As with any concrete, the properties and combinations of specific materials, as well as placement techniques and environmental conditions, will dictate the actual in-place strength.

Flexural strength

Flexural strength in pervious concretes generally ranges between about 1 MPa and 3.8 MPa Many factors influence the flexural strength, particularly degree of compaction, porosity, and the aggregate: cement (A/C) ratio. However, the typical application constructed with pervious concrete does not require the measurement of flexural strength for design.

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Shrinkage

Drying shrinkage of pervious concrete develops sooner, but is much less than conventional concrete. Specific values will depend on the mixtures and materials used, the material's low paste and mortar content is a possible explanation. Roughly 50% to 80% of shrinkage occurs in the first 10 days, compared to 20% to 30% in the same period for conventional concrete. Because of this lower shrinkage and the surface texture, many pervious concretes are made without control joints and allowed to crack randomly.

Durability

1) Freeze-thaw resistance:

Freeze-thaw resistance of pervious concrete in the field appears to depend on the saturation. The typical deterioration of concrete exposed to freeze-thaw conditions is random cracking, surface scaling and joint deterioration due to cracking. The first two are primarily due to lack of adequately entrained air in the concrete mass or the surface layer, respectively, and the latter phenomenon is primarily related to non-durable aggregate.

2) Sulfate resistance:

Aggressive chemicals in soils or water, such as acids and sulfates, are a concern to conventional concrete and pervious concrete alike, and the mechanisms for attack are similar. However, the open structure of pervious concrete may make it more susceptible to attack over a larger area. Pervious concretes can be used in areas of high-sulfate soils and groundwater if isolated from them. Placing the pervious concrete over a 6-in. (150-mm) layer of 1-in. (25-mm) maximum top size aggregate provides a pavement base, storm water storage, and isolation for the pervious concrete.

3) Abrasion resistance:

Because of the rougher surface texture and open structure of pervious concrete, abrasion and raveling of aggregate particles can be a problem, particularly where snowplows are used to clear pavements. This is one reason why applications such as highways generally are not suitable for pervious concretes.

III. MAINTENANCE

Maintenance is easy if the Pervious Concrete is properly installed. It starts with a properly installed base. The base must be free of debris, roots from nearby trees must be professionally pruned to prevent uplift and compaction must be uniformly 94% or greater. Placement of the pervious mix must be choreographed to be of-loaded by conveyor, spread, screed vibrated within precision placed steel forms and roller-compacted, all within 15-20 minutes. Any shortcuts here will produce a pavement that will be difficult or impossible to maintain.

Source:
http://www.perviousconcrete.com/maintenance.htm

IV. PREVENTION

Some critics claim that Pervious gets clogged with oil and debris. It can if not given minimum attention. Some common sense procedures will keep it performing indefinitely. All pavements require some maintenance depending on traffic and location. Pervious concrete usually requires much less but inspection and some attention will keep it working for many years. Any well maintained parking area needs some cleaning. When needed by Pervious Concrete, clean with parking lot vacuums or vacuum sweepers. Sweepers without vacuums do not remove sand from its open cells.

- Any well maintained parking area needs some cleaning. When needed by Pervious Concrete, clean with parking lot vacuums or vacuum sweepers. Sweepers without vacuums do not remove sand from its open cells. Material removed by sweepers should be disposed of as controlled waste. This is true of such material from any vehicle pavement.
- Concrete stain removers can be used if needed. Acid-based cleaners should not be used since they will attack Portland cement and limestone aggregate.
- Pressure washing is an acceptable procedure to remove mold or algae. Do not paint Pervious Concrete. It will become Impervious.
- In heavy traffic areas such as drive-through and gas stations, oil-eating microbes may be included in pavement cleaning. Oil-eating microbes are now available in commercial pavement cleaning products. For best results they should be applied in a liquid carrier and soaked through the pervious concrete to the soil below extreme heat will kill them.

Source:
www.perviousconcrete.com/maintenance_prevention.

V. ENVIRONMENTAL BENEFITS CHECKLIST

- Allows storm water to infiltrate into the ground to replenish ground water aquifers.
- Retains storm water so that retention ponds are not needed for parking lots.
- Keeps pavement surfaces dry even in wet situations, such as greenhouses.
- Allows parking lots to be ice-free in freeze/thaw areas since snow melt immediately drains off the surface.
- Allows water and air to get to the roots of trees within a parking area.
- Aerobic bacteria that develop within the pavement and base can break down oil and remove other pollutants from the water that washes off the surface.
- Light reflectivity is higher than with asphalt surfaces, reducing any heat island effect.
- Allows a project to claim LEED® points. (Leadership in Energy and Environmental Design is a rating system developed by the U.S. Green Building Council to evaluate the environmental performance of a building.)
- Can collect irrigation and retain water to be used for irrigation.

VI. ECONOMIC BENEFITS OF PERVIOUS CONCRETE

- A parking lot properly constructed from pervious concrete has a life span ten times as long as an asphalt lot, thereby providing excellent long term benefits. It is true that the initial costs for pervious pavement may be slightly higher due to the preparation of the sub-base, but those who look long term will realize the economic benefits.
- As far as the material goes, pervious concrete is installed in a thicker quantity than conventional concrete, usually six-inches (15 cm.) vs. four-inches (10 cm.). However, one must look beyond the costs per square foot, at the product that overall system. Pervious concrete is a sustainable saves money in the long run for the following reasons:
- Lower installation costs due to the elimination of costly curbs, gutters, storm drain outlets and retention basins that cost two to three times more to construct than pervious. Less money will be needed for labor, construction and maintenance of ponds, pumps, drainage pipes and other storm water management systems.
- Allows for the use of existing storm sewer systems for new developments.
- Increase land utilization since there is no need to purchase additional land for large retention ponds and other filtering systems. Land developers can get a better return on investment with efficient land use that does not have to allow for large detention ponds since the pavement itself acts as a detention area.
- Lower life-cycle costs equal to that of conventional concrete that if properly constructed will last for 20 to 40 years. Pervious requires fewer repairs than asphalt, and can be recycled once it has reached its lifecycle.
- Recent reports from multiple regions around the U.S. indicate that the cost for asphalt binder has recently increased as much as 50% and more, resulting in dramatic cost increases for asphalt pavement.
- Easy maintenance that consists primarily of prevention of clogging through pressure washing and power vacuuming.
- Supports local economies by having its mix design adapt to different regions, making use of available materials for coarse aggregates. Since time is a critical factor after the batching, local companies are used for transportation and materials.

VII. DISADVANTAGES

- Runoff from adjacent areas onto pervious concrete needs to be prevented.
- The parking areas are generally limited to auto parking and occasional trucks.
- If reinforcement is required, epoxy coated bars should be used.
- Concrete is variable in permeability; over vibration significantly reduces permeability.
- It is still a new material that requires acceptance from cities and states.

VIII. APPLICATIONS

Pervious concrete has been used in a wide range of applications, including:

- Pervious pavement for parking lots
- Rigid drainage layers under exterior mall areas.
- Greenhouse floors to keep the floor free of standing water.
- Structural wall applications where lightweight or better thermal insulation characteristics, or both, are required.
- Pavements, walls, and floors where better acoustic

absorption characteristics are desired.

- Base course for city streets, county roads, driveways, and airports.
- Surface course for parking lots, tennis courts, zoo areas, and animal barns and stalls.
- Bridge embankments.
- Swimming pool decks.
- Beach structures and seawalls.

IX. CONCLUSION

Pervious concrete is a cost-effective and environmentally friendly solution to support sustainable construction. Its ability to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete to play a significant role. Pervious concrete is a smart sustainable option with very high potential. Pervious concrete is an ideal solution to control storm water, re-charging of ground water, flood control at downstream and sustainable land management. Due to its low cost construction, if it gets utilized in Indian context then it proves to be very beneficial to solve environmental issues and water logging problems which are the major issues in India. Pervious concrete is the brightest star in the green building movements, according to past research history. It really a jump starts for our hurting industry right now, if we can do research to improve its basic properties then it has much bright start for its application in India.

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