Properties of Pervious Concrete Pavement with fly ash inRoadways

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***Abstract*:**

The experimental investigation is mainly focused on the development cost effective concrete containing fly ash in pervious concrete pavement.In the thermal power stations huge quantity of fly ash were generating as a by-product material after burning coal. Many researchers stated that fly ash is a beneficial supplementary binding material for concrete and it is influences many properties of concrete in both fresh and harden state concrete. Pervious concrete is a unique and effective way to capture storm water and allow it to seep into the ground, thus recharging groundwater, reducing storm water runoff. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swales and other storm water management devices. The installation of pervious concrete pavement solved various environmental issues such as reduction in the discharge, which makes the life at major cities miserable. This investigation focused on various pervious concrete treatments determining optimum strength, voids and infiltration. The results of an experiment on the compressive strength and water purification properties of porous concrete are reported in this paper.

Keywords: *Pervious concrete, permeability, compressive strength, discharge, runoff, storm water*.

Introduction:

Concrete is a construction material composed of cement, as well as other cementation materials such as fly ash, slag cement, coarse aggregate, fine aggregate and chemical admixtures. The porous concrete does not have fine aggregate in the mixture. The porous concrete increases the potential for excess surface runoff, which can lead to downstream flooding, bank erosion and transport of pollutants into potable water supplies. The use of Portland Cement Pervious Concrete may reduce flooding risk, recharge ground water, reduce storm water runoff, reduce noise when in contact with vehicle tires and prevent glare and skidding during rainy season by allowing water to infiltrate freely through its pores.

Fly ash is a by-product material obtained after burning coal / lignite in thermal power stations. Nearly 150 million tonnes of fly ash are being generated from the thermal power stations per annum in India and 700 million tonnes worldwide. Thermal power stations face major problems in dumping and disposal of fly ash [Dirk, 2011]. Fly ash is disposed of in either a wet or a dry state. Fly ash often contains heavy metals, namely Ni, Cd, Sb, As, Cr, Pb, etc. That may results in diseases such as respiratory problems, lung cancer, Anaemia and Skin cancer [Manas, 2011]. Fly ash consists of fine particles, the typical size of which is less than 90 micrometers. It is removed from the flowing gas using the force of an induced electrostatic charge inside the electrostatic precipitator. In the thermal power stations, dumping and disposal of fly ash require huge land spaces. If fly ash is disposed of in the land, during the rainy season, it leaches out and contaminates the ground water, which leads to the pollution of the surrounding land [Dirk, 2011].

In this experiment, the sustainable Urban Drainage System is provided. The pervious pavement, composed of a surface layer and a base layer were made. It can be applied to both the footpath and the vehicle road. It is an environment friendly pavement material. The pervious concrete is also called as porous concrete or no fine concrete because of the absence of fine aggregate. This pervious concrete is only suitable for pavements, it cannot be used for structural members.

The strength and porosity of pervious concrete depends upon the shape and size on the aggregates, the grade of cement and water cement ratio. Then the compressive strength of pervious concrete cubes is compared with of compressive strength of M30 grade of concrete cubes. The compression strength results are compared and the charts are made.

Properties of materials:

Properties of the materials used in this study were found in the laboratory and are discussed below.

Cement:

The ordinary Portland 53 grade cement according to as per IS 12269:1987 was used as a binding material in this experimental work. The properties of cement were tested in the laboratory and the values are given in Table 1.

Table1. Physical Properties of Cement

S.NO	Description	Values obtained
1	Normal consistency	28%
2	Initial setting time	40min
3	Final setting time	350min
4	Specific gravity	3.15

Fly ash:

Fly ash collected from the Ennore thermal power plant and the properties were conformed with IS 3812:2003, used as a supplementary binding material through the study. The specific gravity of fly ash was found as 2.17 in laboratory.

Coarse aggregate:

Coarse aggregate of size varying from 8mm to 10mm is used for preparing the pervious concrete cubes. The aggregate of size less than 8mm increases the strength of pervious concrete but the permeability will be very less. The specific gravity found as 2.8 used as per IS 383:1970.

Water:

Water plays a vital role in concrete while mixing a water cement ratio of 0.45 is used in this experimental study. This initiates the reaction between cement and aggregate. Ordinary tap water is used for mixing.

Composition of Pervious Concrete:

(i) Pervious concrete layer:

The pervious concrete layer is the top most layer of this system. It is in direct contact with traffic and the surroundings. This layer consists of small coarse aggregate, cementationmaterial and water this layer should be strong enough to withstand the traffic and durable enough to resist various types of weather conditions the thickness of the pervious concrete layer is shown in Figure 1.

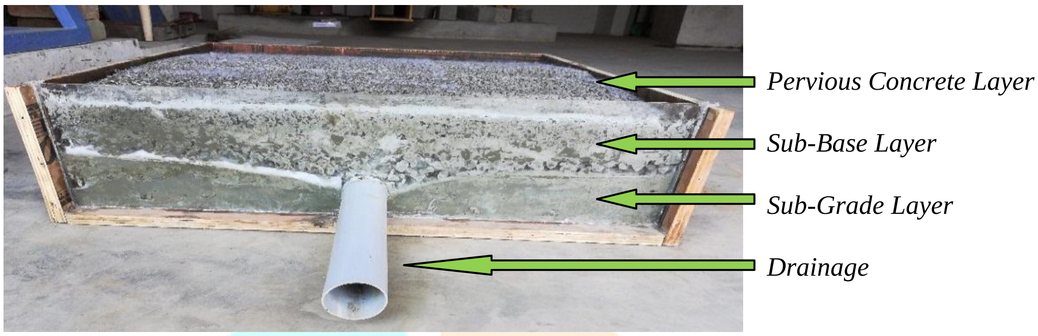

Fig.1. Cross Section of Model Pervious Concrete Pavement

Compaction Methods:

Roller compaction: this is the simplest compaction technique done using steel rollers is shown in figure 2. After the initial strike off, the concrete is rolled with heavy steel rollers to ensure proper compaction. It may be done in perpendicular directions to give plainness and smoothness of concrete.

Fig.2. Model Rolling Compaction and geo-textile sheet for Pervious Concrete Pavement

Curing:

The pervious concrete layer is placed on a pre-wet sub-base, it provides additional moisture for curing. The pervious concrete itself contains a lot of air voids, the exposed surface area that provides for the evaporation of mixing water. It is necessary to protect the concrete being placed as soon as possible to prevent excessive moisture loss. Here, the geo-textile sheet is used to prevent the moisture loss. Also the model curing process is shown in **figure 2**. This plastic sheet is placed over the surface immediately after the concrete is compacted. This will reduce the moisture loss and extend the hydration time necessary for concrete materials to achieve the required properties.

Experimental Investigation:

Mix proportioning:

As per the guidelines given in IS 10262:2009 arrived mixture proportion of M30 grade concrete. Pervious concrete uses the same materials as conventional concrete, except that there is usually little or no fine aggregate. The quantity, proportions, and mixing techniques affect many properties of pervious concrete, in particular the voids structure and strength. Usually single sized coarse aggregate up to 20mmsize aggregates provides smoother surface that may be better suited for some application such as pedestrian pathways.Although the coarse aggregate size 6mm to20mm are used, the most common being12mm fairly uniform size is used. The aggregates may be rounded like gravel or angular like crushed stone. A water –to-cementing material (W/CM)ratio of 0.35 was generally used. The absorption and moisture content of the aggregate on the day of mixing were determined and used to correct the mixing water.Table 2.

Table 2. Mix Design proportions

Materials	Proportions (kg/m^3)
Cementious materials	270-415
Coarse aggregate	1190-1480
Fine aggregate	Nill
Water Cement Ratio	0.27-0.34

Casting of specimens:

150x150x150mm concrete cube specimens were casted to study quality and strength of concrete at curing age of 7,14, 28 days. 150mmØ X 300mm length cylinder were casted to study the split tensile strength. Based on the material proportions for corresponding mixtures, concrete were made and casted the specimens after 24 hours, specimens are demolded from mould, then kept in the curing with geo-textile sheet. Curing process was carried out up to the required curing age. At the age of testing, specimens were taken out from dried state in room temperature and tested the specimens. Specimens were tested as per procedure given in IS 516:1959.

Results and discussion:

Compressive strength:

At the age of 7, 14 and 28 days in each mixtures three specimens are tested at respective curing age in the compression machine. The average compressive strength of concrete specimens are calculated and plotted the graph and given in Fig. 3

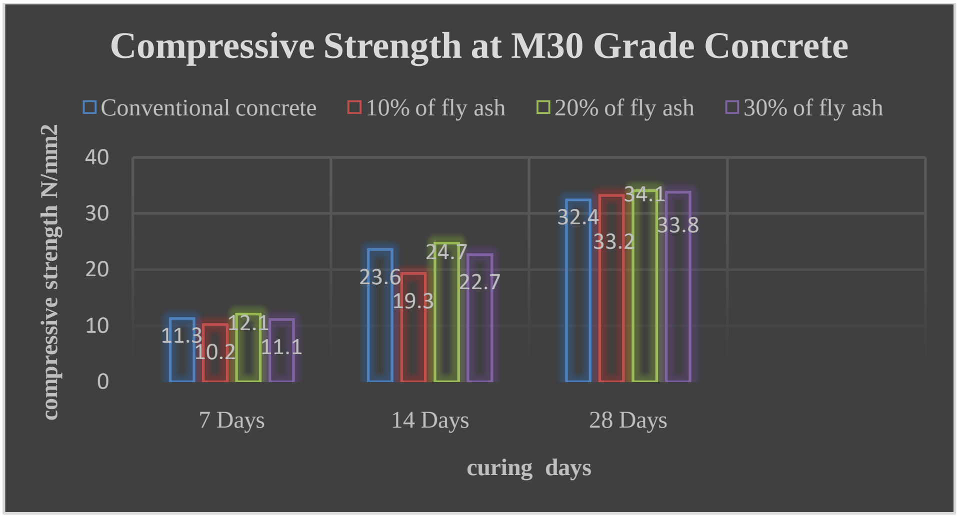

Fig.3. Compressive strength of concrete mixtures at different curing ages.

The 28th day compressive strength of control concrete were kept as benchmark and measured the percentage gained by control concrete and replacement concrete mixtures at different curing ages and the % are given in Table 3.

Table 3. Percentage of strength gained by concrete mixtures with respect to 28 days

Mixture ID	% of strength gained by concrete mixtures		
	7 days	14 days	28 days
CC	37.66	78.66	108.00
Mix 1	34.00	64.43	110.66
Mix 2	40.33	82.33	113.66
Mix 3	37.00	75.66	112.66

The control concrete and replacement mixtures achieved target strength at 28 days were observed from Table 2. The enhancement strength may be due to packing effect between the materials and ongoing pozzlanic reaction [Jatuphon et al. 2005].Increasing of the curing age of concrete specimens, strength were increased up to 34.1 N/mm^2 at 28 days and the % of increment in strength as 113.66% compared with strength of control concrete at 28 days.

Split tensile strength:

Table 4 also gives the result of splitting tensile strength at 14 and 28 days measured on standard cured specimens of the concrete contains 10%, 20%, 30% of fly ash. At 28 days, Conventional concrete achieved 2.41 N/mm^2. The replacement of cement with fly ash concrete mixtures Mix 2 and Mix 3,Mix 4 achieved 2.43, 2.48and 2.42 N/mm^2 respectively. Increased the curing age of specimens and achieved 2.48 N/mm^2 by Mix 3 concrete.

Table 4. Tensile strength of concrete at 28 and 56 days curing.

Mix ID	Splitting Tensile Strength in (N/mm^2)		Hydraulic conductivity in (m/sec)	
	7 days	28 days	7 days	28 days
CC	1.64	2.41	0.0060	0.0082
Mix 2	1.68	2.43	0.0065	0.0092
Mix 3	2.10	2.48	0.0098	0.0098
Mix 4	1.69	2.42	0.0096	0.0096

Hydraulic Conductivity test:

Permeability is a measure of the ability of a material (typically unconsolidated material) to transmit fluids. The permeability can be determined by percolation rate. The time needed for percolation of known volume of water through the sample is measured and the coefficient of permeability can be tabulated in table 4. The result analysis of Percolation water through the pervious concrete is shown in figure 4.

$$k = [\frac{A}{t}]$$

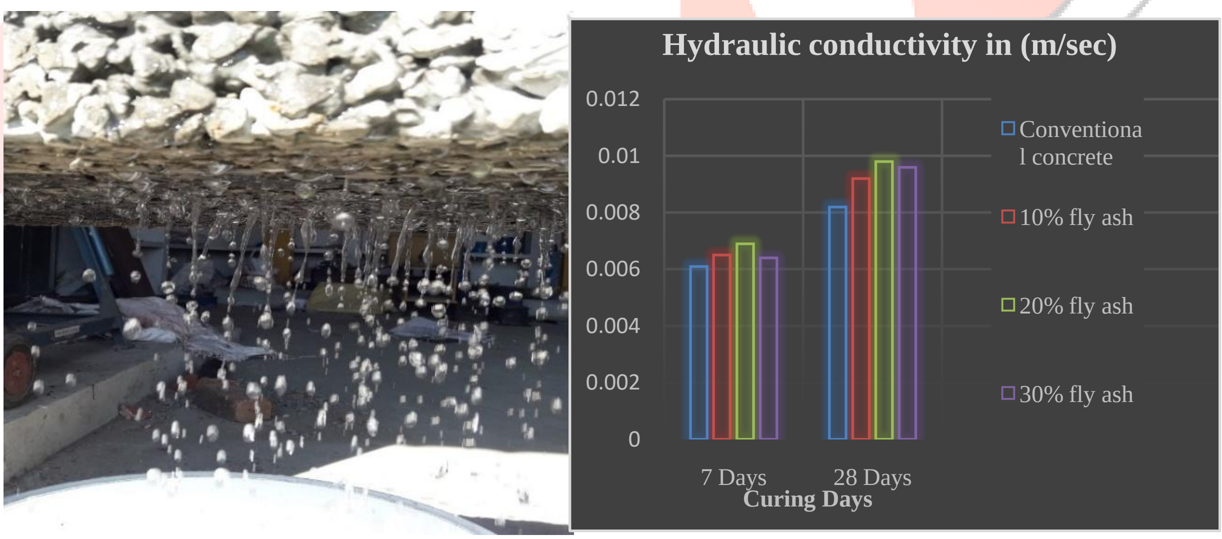

Fig.4. Percolation of water through the Pervious Concrete.

Conclusion:

From the above discussions, the following conclusions are made.

- The pervious concrete layer reduces the need for storm sewers and increases the permeable area. It improves the quality of landscaping.

- Based on the experimental investigation it is found that the replacement of fly ash for cement has increased the compressive strength, split tensile strength for 10%, 20%, 30% replacements.
- The replacement of fly ash for cement has increased the hydraulic conductivity (permeability) of pervious concrete, especially the replacement of fly ash at 20% increases the permeable in this cases.
- It shows that with 20% replacement of cement with fly ash gives strength up to13.3% higher than normal pervious concrete.
- These pervious concrete layers are eco-friendly with Environment, which recharges the ground water level and reduces the risk of flooding.

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