Pervious Concrete

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***Abstract*—Pervious concrete is a form of lightweight porous concrete, obtained by eliminating the sand from the normal concrete mix. The advantages of this type of concrete are lower density, lower cost due to lower cement content, lower thermal conductivity, relatively low drying shrinkage, no segregation and capillary movement of water. It has better insulating characteristics than conventional concrete because of the presence of large voids. In the present study M15 pervious concrete is designed by ACI522R -10 design code. The effect of w/c ratio and aggregate size on the strength of pervious concrete are studied. It is revealed that the compressive strength increases as the water/cement ratio decreases up to optimum w/c ratio and with increase in volume of paste.**

IndexTerms*— Pervious concrete, mix proportioning, compressive strength, coefficient of permeability *(keywords)

I. INTRODUCTION

Pervious concrete (also called porous concrete, permeable concrete, no fines concrete and porous pavement) is a special type of concrete with a high porosity used for concrete flat applications 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. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. Pervious concrete is traditionally used in parking areas, areas with light traffic, residential streets, pedestrian walkways, and green houses. It is an important application for sustainable construction and is one of many low impact development techniques used by builders to protect water quality. The basic ingredients of pervious cement concrete mix are not very different from the conventional cement concrete mix, except in the proportion of ingredients. The main ingredients are cementations material, water, aggregate and if required, admixtures. The initial use of porous concrete was in the United Kingdom in 1852 with the construction of two residential houses and a sea groaned. Cost efficiency seems to have been the primary reason for its earliest usage due to the limited amount of cement used. It was not until 1923 when porous concrete surfaced as a viable construction material.

II. MATERIALS

PORTLAND CEMENT

Cement Ordinary Portland cement, 53Grade was used for casting all the Specimens. Different types of cement have different water requirements to produce pastes of standard consistence. Different types of cement also will produce concrete have a different rates of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used. It is also important to ensure compatibility of the chemical and mineral admixtures with cement.

COARSE AGGREGATE

Coarse aggregates are particles of gravel or crushed stone retained on the 10 mm sieve and ranging up to 150 mm. The most commonly used maximum aggregate size is 20 mm. Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm. Crushed granite aggregate with specific gravity of 2.77 and passing through 4.75 mm sieve and will be used for casting all specimens. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

WATER

Casting and curing of specimens were done with the potable water that is available in the college premises.

NEED OF PERVIOUS CONCRETE

In rural areas larger amount of rainwater ends up falling on impervious surfaces such as parking lots, driveways, sidewalks, and streets rather than soaking into the soil. This creates an imbalance in the natural ecosystem and leads to a host of problems including erosion, floods, ground water level depletion and pollution of rivers, as rainwater rushing across pavement surfaces picks up everything from oil and grease spills to de-icing salts and chemical fertilizers.

A simple solution to avoid these problems is to stop constructing impervious surfaces that block natural water infiltration into the soil. Rather than building them with conventional concrete, we should be switching to Pervious Concrete or Porous Pavement, a material that offers the inherent durability and low life-cycle costs of a typical concrete pavement while retaining storm water runoff and replenishing local watershed systems. Instead of preventing infiltration of water into the soil, pervious pavement assists the process by capturing rainwater in a network of voids and allowing it to percolate into the underlying soil.

III. BENEFITS OF PERVIOUS CONCRETE:

- It reduces the storm water runoff
- Eliminates the need for detention ponds and other costly storm water management practices
- Mitigates surface runoff
- Replenishes the aquifers and water table
- Allows more efficient land development
- Prevents water from entering into the stream and also prevents it from being polluted

IV. APPLICATIONS OF PERVIOUS CONCRETE:

- Pervious Concrete as a Road pavement
- Low-volume pavements
- Sidewalks and pathways
- Residential roads and driveways
- Parking lots
- Noise barriers
- Slope stabilization
- Hydraulic structures
- Swimming pool decks
- Tennis courts

V. OBJECTIVES OF PERVIOUS CONCRETE

- The main objective of this investigation is to develop a strong and durable pervious cement concrete (PCC) mix using different types of fine aggregates with varying the quantity of fine aggregates. In addition, it is also aimed to compare the properties of these PCC mixes.
- The properties of PCC mixes investigated are compressive strength, flexural strength, abrasion resistance, permeability, and clogging potential.
- To design the concrete mix for pervious concrete with and without fine aggregate.
- The main objective is to investigate the performance characteristics of pervious concrete such as porosity, compressive strength, infiltration rate (or) permeability.

VI. PERVIOUS CONCRETE PROPERTIES

Properties of Pervious Concrete

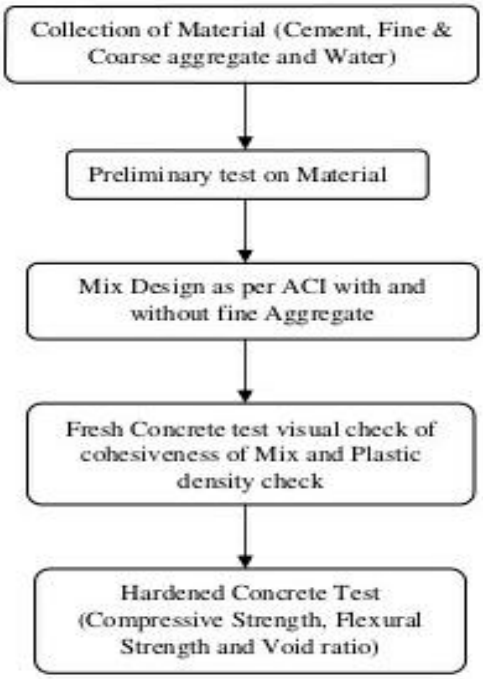
PERVIOUS CONCRETE PROPERTIES		
FRESH CONCRETE	**HARDENED PROPERTIES** ➢ Density &porosity ➢ Permeability ➢ Compressive strength ➢ Shrinkage ➢ Flexural strength	**DURABILITY** ➢ Freezethaw resistance ➢ Abrasion resistance ➢ Sulfate resistance

VII. METHODOLOGY FOR PERVIOUS CONCRETE

The main objective of the research is to develop a cost effective storm water management technology to prevent runoff and to recharge the ground water table. Muscat the capital city of Sultanate of Oman is located in an arid region where the rain fall is very low and ground water table is deep need to conserve, whatever minimum rainfall it receives. This can be achieved by covering the secondary roads.

After identification of problem and setting the objectives of the research, the research methodology has carefully design to achieve these objectives.

- Collection and study of literature pertaining to the dissertation work.
- Determine the engineering properties of pervious concrete and compare them with conventional concrete.
- Cast various trial mixes with varying percentages of pervious concrete and compare for the compressive strength.
- Prepare test samples with the percentage value and test these samples for the various pavements properties.
- To comment on the suitability and limitations of pervious concrete with conventional concrete in construction of pavements.



Flow chart: Methodology of pervious concrete

VIII. LIST OF TESTS ON MATERIALS

TEST ON CEMENT

- Specific gravity
- Normal consistency
- Fineness of cement
- Initial setting time
- Final setting time
- Bulk density of cement

TEST ON SOIL

- CBR test

TEST ON COARSE AGGREGATE

- Specific Gravity
- Water absorption
- Bulk density of coarse aggregate
- Abrasion test
- Impact test
- Aggregate Crushing strength
- Abrasion test

IX. MIX DESIGN AS PER ACI 522R-10 (WITHOUT FINE AGGREGATE)

NO-FINES CONCRETE

No-fines concrete is a simple form of light weight concrete obtained by eliminating the finer fractions of aggregate in a normal concrete mix. The total omission of fine aggregate in the mix will result in a system of uniformly distributed voids through out the mass of concrete, generally reducing the density of the resulting material. The main advantages of using no fines concrete are the high degree of thermal insulation, speedy construction, low density and shrinkage. No fines concrete is not prone to seggregation and it can be dropped from a considerable height, facilitating the use of high lifts. Due to absence of large surface area of sand particles that would have to be coated with cement paste, the cement in a no fines concrete mix my be a little as 70-130 kg per cc of concrete, resulting in comparatively lower costs.

The density of no fines concrete depends on the grading of coarse aggregate used and is generally in the range of 6-75 percent of that of normal concrete. The aggregate generally use in 10 to 20 mm material, although the other sizes may be used. If light weight aggregate is used, densities as low as 70 kg per cubic meter can be obtained. Various types of aggregates like, crushed rock, gravel, blast furnace slag and clinker have all be used successfully to produce no fines concrete. The use of crushed rock generally results in higher strengths than when gravel aggregates are used in the mixes.

STRENGTH CHARACTERISTICS

The compressive strength no fines concrete mainly depends on its density. The strength varies generally between 70 kg per centimeters square for density of 1900kg per cubic meter-140kg per centimeter square for a density of 2100kg per cc at 28 days. The strength continues to increase after 28 days in a manner similar to that of normal concrete. In the case of no fines concrete mixes, water cement ratio is not the main controlling factor and for a given aggregate cement ratio, there is an optimum water cement ratio, yielding the highest strength. This trend can be clearly identified in the data of McIntosh, Bottom and Muir as show in the figure in which aggregate cement ratios ranging from 6-10 by volume are covered. The corresponding water cement ratios varying from 0.37-0.45 by weight, while the density of concrete varies from 1940-2100kg per cubic meter for aggregate cement ratios in the range from 10-6 by volume.

The optimum water cement ratio touching the peaks of the aggregate cement ratio curves is useful in the proportioning no fines concrete mixes. A water cement ratio higher than the optimum will result in the seggregation of the aggregate particles while lower values adversely affect the workability of the mix resulting in improper compaction.

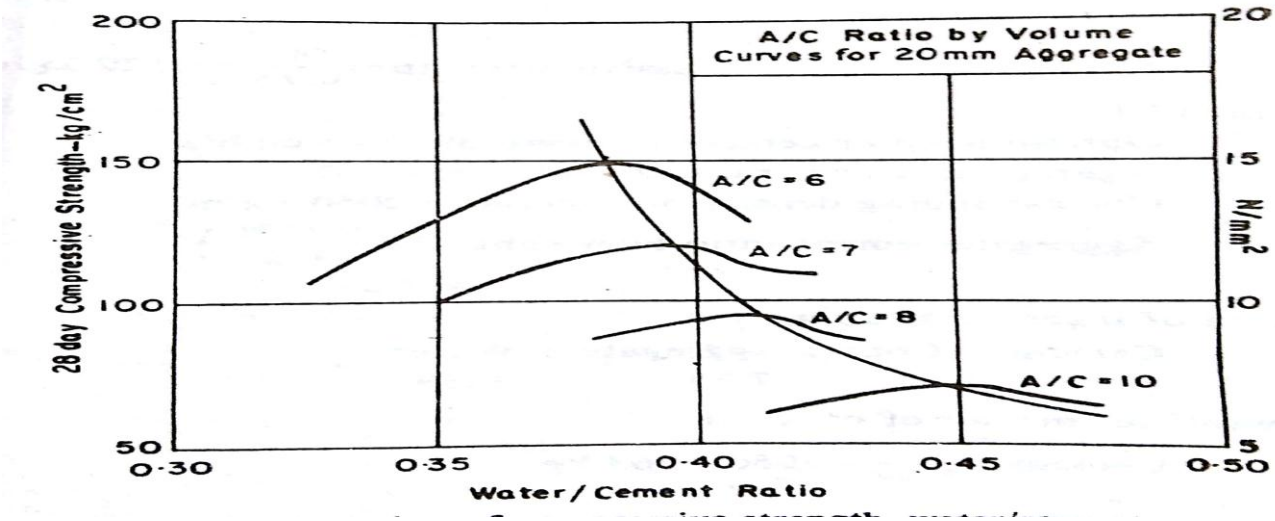
MIX PROPORTIONING

The design of no fines concrete mixes is based on the required strength at a particular age. The relations between the water and aggregate cement ratios and strength as shown in figure are useful in this regard. The proportions are governed more by the necessity to achieve a cellular structure and coat each aggregate particle with cement grout than by a high strength requirement. Trial mixes are made using the estimated proportions of ingredients and suitable adjustments necessary to produce the required workability and strength are incorporated. If the workability is to low, it may be necessary to increase cement content and or the water cement ratio. On the other hand, if the workability is too high and bleeding occurs, the water cement ratio or the richness of mix is reduced. Normally gravel and crushed rocks do not absorb a significant percentage of water in the mix. However, if, light weight aggregates are used to produce no fines concrete, it is rather difficult to predict the optimum water cement ratio since they absorb as much as 10-20 percent of water (by weight) in 24 hours. In such cases the optimum combination of ingredients in the mix should be decided by trial mixes followed by tests.

MIX DESIGN AS PER (ACI 522R-10)

DESIGN

Size of coarse aggregate: 12-20mm
Control factor: 0.75 (Assumed)
Bulk density of cement: 1328kg/m^3
Bulk density of coarse aggregate: 1335kg/m^3
Average 28 days compression strength,
=150/0.75
=200kg/m^3
Water cement ratio: 0.37 to 0.45
Aggregate cement ratio: 6 to 10
Density of concrete: 2500kg/m^3
Aggregate cement ratio by weight,
= (6*1335) / (1328)
= 6.03



Relation of compressive strength, water/cement ratio and aggregate /cement ratio or no-fines concrete

PROPORTION:

Cement: Coarse Aggregate: Water
1 : 6.03 : 0.4

X. COMPRESSIVE STRENGTH

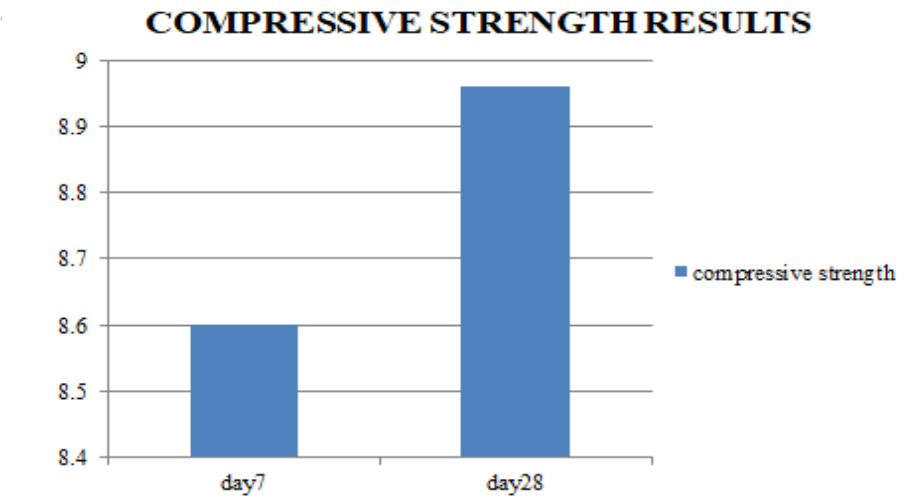
- Once it is placed, the pervious concrete shall remain covered and undisturbed for seven (7) days.
- The covering should be a water proof polyethylene sheeting with a minimum thickness.
- This curing period is essential for adequate strength and durability.

Compressive strength for 7days:

Area	Load(KN)	Compressive strength(N/mm²)
0.15*0.15	200	8.8
0.15*0.15	190	8.4
0.15*0.15	195	8.6

Compressive strength for 28days:

Area	Load(KN)	Compressive strength(N/mm²)
0.15*0.15	200	8.8
0.15*0.15	210	9.3
0.15*0.15	200	8.8



XI. ADVANTAGES OF PERVIOUS CONCRETE

- Recharge of local aquifer.
- Water budget retention and pollution removal.
- Less need for storm sewer.
- Green building alternative suitable for many applications.
- Natural run-off allows rainwater to drain directly to sub-base.
- Reduced construction requirements for drainage structures.
- Reduced pollution prevents environmental damage.
- Protects streams and lakes and allows local vegetation to thrive.

XII. DISADVANTAGES OF PERVIOUS CONCRETE

- Extended curing time.
- Limited use in heavy vehicle traffic areas.
- Frequent maintenance is required.
- Compressive strength is low.
- Special care in expansive soils and high ground water conditions.

XIII. CONCLUSION

Pervious concrete allows water to pass through the concrete which eliminates storm water run-off. Pervious concrete is the relatively new concrete for the pavement construction in rural areas having cost benefits and pervious concrete extensively used worldwide because of their environmental benefits, hydraulic properties. Pervious concrete strength is low and permeability is very high compared to conventional concrete. Here, pervious concrete mix is designed without sand and adding silica fume as an admixture using ACI 522R-10 code, the mechanical strength of the concrete is increased to an extent.

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