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Experimental Study of Pervious Concrete using M-Sand

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Abstract : Pervious concrete – which has been widely used all over the world to reduce the amount of runoff water due to rain and improve the water quality in pavements and parking lots, but its use in India is not in wide range but due to its reduced strength due to high porosity, pervious concrete is unfair able for highway pavements[2,4]. This paper reports an experimental investigation on the development of pervious concrete providing the optimal combination of strength and water permeability. Pervious concrete pavement is an environmentally friendly paving material that allows water to drain directly through the pavement structure and infiltrate into the sub grade[1]. By reducing runoff, pervious concrete pavement decreases the demand on the storm water management system. Pervious concrete trial mixes with different size of aggregate, with and without fine aggregates. Tested for its mechanical properties such as compressive strength, water permeability, and porosity. Pervious concrete is a porous concrete which allows water and air to pass through it. In this study, the pervious concrete is obtained by removing the fine aggregate wholly (0%), 5%, 10% and 15% of replacing coarse aggregate with M sand. The pervious concrete specimen of cube size of 150mm x 150mm x 150mm and they were cured in water for the period of 7, 14, 28 days. The compressive strength test and permeability is done in laboratory after curing. Then the compressive strength of pervious concrete is compared the compressive strength of M20grade of concrete.
Keywords : Pervious Concrete, M Sand, Compressive Strength, Permeability.

1.0 Introduction

A large amount of rainwater ends up falling on impervious surfaces such as parking lots, drive ways, sidewalks, and streets rather than soaking into the soil[4]. Pervious Concrete is a mixture of Cement, Coarse Aggregate and water. Now a day's special concrete is more preferred in the construction industry. The pervious concrete is otherwise called as porous concrete or no fine concrete because of the absence of fine aggregate. Pervious concrete is an innovative material which is a mixture of coarse aggregate, cement, water and little to no sand. This innovative material sometimes called as No Fines Concrete also. Absence of sand or fine aggregate permit the properly placed pervious concrete to have about 15 to 30% of void space, the pores can range from 0.08 to 0.32 inches (2 to 8mm), which permit water to pass through without causing any damage to the matrix of the porous concrete.

Pervious concrete is a special high porosity concrete used for flatwork applications that allows water from precipitation and other sources to pass through, thereby reducing the runoff from a site and recharging ground water levels[5,7]. There are a number of alternate names for porous concrete including permeable concrete, porous pavement, and pervious concrete. All of the names basically mean the same thing which is porous concrete. Porous concrete is made by mixing large aggregate material with mortar, creating lots of voids in the cast concrete. When water lands on the concrete, it flows through the voids and go to the ground below. Pervious concrete is an important application for sustainable construction.

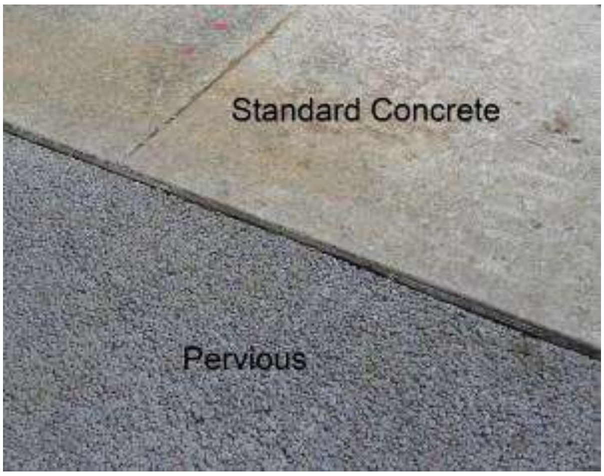


Figure 1. Samples of Standard Concrete & Pervious Concrete

Pervious concrete also naturally filters water from rainfall or storm and can reduce pollutant loads entering into streams, ponds and rivers. So in this way it helps in ground water recharge. Pervious concrete has very high permeability that drains water quickly. Pervious concrete is lightweight concrete having weight 1600 to 1900 kg/m3[2].(ijraset)

1.1 Pervious Concrete

Pervious concrete is a porous concrete paving material which permits rain and storm water runoff to percolate through it rather than flood surrounding areas or storm drains. It is usually admixture of 3/8" to 1/2" average diameter aggregate, Portland cement, other cementations' materials, admixtures and water. Pervious concrete typically describes a near-zero-slump, open-graded material consisting of Portland cement, coarse aggregate, little or no fine aggregate, and water. This concrete is high porosity and allows draining freely unlike dense, high strength of concrete. The high porosity is achieved by the absence or very low content of fine aggregates. Pervious concrete has water to cementations materials ratio of o.28 to 0.40 with a void content of 18 to 35%. Pervious concrete is also known as no-fines concrete, gap graded concrete or porous concrete. In normal concrete, the fine aggregates typically fill in the voids between coarse aggregates. But in pervious concrete fine aggregate is non-existent or present in very small amounts.

1.2 Manufactured Sand

Manufactured Sand is sand produced from crushing of granite stones in required grading to be used for construction purposes as a replacement for river sand.

Figure 2.M sand

1.2.1 Properties of Manufactured Sand used for construction are:

1. Higher Strength of concrete:

The manufactured sand has required gradation of fines, physical properties such as shape, smooth surface textures and consistency which makes it the best sand suitable for construction. These physical properties of sand provides greater strength to the concrete by reducing segregation, bleeding, honeycombing, voids and capillary.Thus required grade of sand for the given purpose helps the concrete fill voids between coarse aggregates and makes concrete more compact and dense, thus increasing the strength of concrete.

2. Durability of concrete:

Since manufactured sand (M-Sand) is processed from selected quality of granite, it has the balanced physical and chemical properties for construction of concrete structures. This property of M-Sand helps the concrete structures withstand extreme environmental conditions and prevents the corrosion of reinforcement steel by reducing permeability, moisture ingress, increasing the durability of concrete structures.

3. Workability of concrete:

Size, shape, texture play an important role in workability of concrete. With more surface area of sand, the demand for cement and water increases to bond the sand with coarse aggregates.

The control over these physical properties of manufacturing sand make the concrete require less amount of water and provide higher workable concrete. The less use of water also helps in increasing the strength of concrete, less effort for mixing and placement of concrete, and thus increases productivity of construction activities at site.

4. Less Construction Defects:

Construction defects during placement and post-concreting such as segregation, bleeding, honeycombing, voids and capillarity in concrete gets reduced by the use of M-Sand as it has optimum initial and final setting time as well as excellent fineness.

5. Economy:

As discussed above, since usage of M-Sand has increased durability, higher strength, and reduction in segregation, permeability, increased workability, decreased post-concrete defects, it proves to be economical as a construction material replacing river sand.It can also save transportation cost of river sand in many cases.

6. Eco-Friendly:

Usage of manufactured sand prevents dredging of river beds to get river sand which may lead to environmental disaster like ground water depletion, water scarcity, threat to the safety of bridges, dams etc. to make M-Sands more eco-friendly than river sand.

2.0 Application of Pervious Concrete

This type of pervious concrete pavement can be used for pavements on Light weight vehicles are passing, driveways, sidewalks, footpaths, parking place for light motor vehicles, Tennis courts, Tree grate, Swimming pool decks, garden walkway, and Pavement edge drains. This may be used as inverted filter in hydraulic structures at downstream side.

2.1 Advantages

- Decreasing flooding possibilities, especially in urban areas
- Recharging the groundwater level
- Reducing puddles on the road
- Improving water quality through percolation
- Heat absorption

- Supporting vegetation growth
- Dust free environment

2.2 Disadvantages

- Low strength due to high porosity
- High maintenance requirement
- Limited use as a load bearing unit due to its low strength
- Strength is less as compared to impervious concrete pavement

2.3 Maintenance

Over time, sand, dirt, vegetation, and other debris can collect in pervious concrete's voids and reduce its porosity, which can negatively affect the functionality of the system. Thus, periodic maintenance may be needed to remove surface debris and restore infiltration capacity. Two common maintenance methods are pressure washing and power vacuuming (ACI 2010).

3.0 Aim of the Study

The aim of this study is to evaluate the structural performance of pervious concrete in civil engineering construction. To achieve this, the effects of varying the aggregate size on the porosity, compressive strength and specific gravity of pervious concrete were studied. The study covers the simple use of pervious concrete as pavement material in the construction of pedestrian walkways and parking lots.

3.1 Objective and Scope

The objective of the present study was to investigate available laboratory test methods for evaluating abrasion and raveling resistance of PCPC. The tests considered the fresh concrete and harden concrete. Fresh concrete is considered the slump cone test. The harden concrete is considered to be compressive strength, porosity, infiltration and permeability test.

In recent times many studies have been carried out on no fines concrete. The objective of the present study is to check the performance of no fines concrete on various sizes of aggregates. Concrete is the most important material for construction purposes and cement is the most expensive ingredient in it. The name of no fines concrete itself explains that the fine aggregate has been omitted in this kind of concrete. Due to the absence of fine aggregate in no fines concrete, there is a high percentage of void space which results in high permeability. The unit weight, drying shrinkage and hydrostatic pressure for no fines concrete is less compared to conventional concrete. Due to the less cement content in no fines concrete, the cost of the overall project reduces. No fines concrete also helps in the reduction of urban heat island effect due to its light color. In this project cubes of 150 mmxl50 mm x 150 mm size are caste with two categories of (10mm & 20mm) coarse aggregates. The cubes are tested and their corresponding Compressive strengths and densities are noted.

3.2 Review of Literature

Development of Mix Proportion for Functional and Durable Pervious Concrete

(Wang, K.1, Schaefer, V. R.2, Kevern, J. T.3, and Suleiman, M.T.4)

Portland cement pervious concrete (PCPC) mixes made with various types and amounts of aggregates, cementitious materials, fibers, and chemical admixtures were evaluated. Porosity, water permeability, strength, and freezing-thawing durability of the concrete were tested. The results indicated that the PCPC made with single-sized coarse aggregates generally had high permeability but not adequate strength. Addition of a small amount of fine sand (approximate 7% by weight of total aggregate) to the mixes significantly improved the concrete strength and freezing-thawing resistance while maintaining adequate water permeability. Addition of a small amount of fiber to the mixes increased the concrete strength, freezing-thawing resistance as well as void content. Based on these results, performance-based criteria are discussed for proportioning functional and durable PCPC mixes

Evaluation of Structural Performance of Pervious Concrete in Construction

(S.O. Ajamu1, A.A. Jimoh2, J.R. Oluremi1)

Aggregate/cement ratio of 6:1, 8:1 and 10:1 respectively were used to produce three different batches of fresh concrete using18.75mm aggregate size and same ratios were used for 9.375mm coarse aggregate size to produce another three different batches. In each case, aggregate/cement ratio of 6:1 gave the highest compressive strength compared to other aggregate/cement ratio of 8:1 and 10:1. The highest compressive strength obtained was 8.2 N/mm2 and 10.8 N/mm2respectively for 18.75 mm and 9.375mm coarse aggregate sizes. These values fall within the values stipulated by ACI 552R-10 (2.8 N/mm2-28 N/mm2). It was found that the aggregate/cement ratio of 10:1 produced pervious concrete of higher co-efficient of permeability of 3.12x10-3 cm/sec and 3.89x10-3cm/sec for aggregate size 9.375mm and 18.75mm respectively

An Innovative No-Fines Concrete Pavement Model

(Sirile Eathakoti1, Navya Gundu2, Markandeya Raju Ponnada)[8]

In this paper, an innovative model that can transport water percolated into the pavement has been suggested in this direction. Different combinations of Cement, water and Course aggregate with different maximum size and gradation were adopted for trial mixes to arrive at M20 grade concrete.M20 grade concrete is achieved with a w/c ratio of 0.45, Course aggregate of nominal size 20 mm and with a cement to Course aggregate ratio of 1:4. Its density and flexural strength were observed to be 21 kN/m3and 35 kg/cm2respectively.A pavement slab suitable for low traffic volume roads is designed as per IRC SP62: 2004 which allows storage of water upto 125 lit./m3of concrete pavement giving time for infiltration thereby reducing the runoff and recharging the ground water or sufficient time for transport of it. A perforated pipe can be provided at center of the pavement above sub-base such that it collects the water stored in concrete and drains it to the required treatment plant or a recharge pit. This however needs further investigation and trials before practical implementation

Strengthening of Pervious Concrete for High Load Road Application; a Review

(Dr. R.R. Singh, Er. A.S. Sidhu)

Due to the significantly reduced strength associated with the high porosity, pervious concrete mixtures currently cannot be used in highway pavement structures. This paper provides the review of improving the mechanical properties of pervious concrete through different factors i.e. using additives, using different type and size of aggregates, different w/c ratios; without considerable effect on permeability. This review paper aims at looking for a vision to introduce pervious concrete with optimum Mechanical properties for using in Highways as an alternative for storm water mitigation and increasing the ground water level.

Feasibility of Porous Pavement: A Case Study at Hatkeshwar Area of Ahmedabad City

(1.Parmar Manisha, 2.Dr. A. M. Jain)[7]

For this study Hatkeshwar area of Ahmedabad city has been selected with the specific road network nearby to the Narol -Naroda corridor link joining CTM cross road to karnavati bunglows. The above road network has the history of the accumulation of water in the area during the monsoon season for long duration. To study the above objective the rainfall data for the area during the different day, month is collected. The volume data is the other important aspect for identifying the low volume road. The quality of soil sub grade is the other data, which is collected for determining the thickness of porous asphalt concrete at this road network. The soil quality is also useful in order to identify suitability of disposal of the seepage ground water nearby to the stream/artificial drainage link

Studies on Applicability of Pervious Concrete for Pavements

(Biji .U.I 1, M. Rajeswari 2, Dhaarani. K. K 3, Karthikai Raja. K 4)

The paper determines the possibility of achieving maximum compression strength and permeability in concrete by replacing fine aggregate with coarse aggregate and cement along with the addition of admixture in order to increase the permeability of concrete. In this study, the pervious concrete is obtained by removing the fine aggregate wholly (0%) and partially as 10% and 20% replacing the coarse aggregate. From the results, we came to know that, the mix M3 with 20% fine aggregate yields good compressive strength and flexural strength. The permeability rate is higher for mix M1 with 0% fine aggregate. The mix M2 with 10% fine aggregate yields good compressive strength and flexural strength.

An Experimental study on pervious concrete as a pavement layer

(K. Nagababu, E. V. RaghavaRao, D. Satheesh)[9]

This paper explains in detail about the use of pervious concrete as pavement material. In this study, we considered mix proportion of pervious concrete from reference mix of M40 in that by changing the fine aggregate content to 0-18% by replacement method. i.e. the fine aggregate volume is replaced by coarse aggregate volume in mix proportion, there will be no change in volume of aggregate hence we had difficulty in finding volume of cement paste occupying volume of voids, because volume of aggregate and volume of cement paste will be constant in proportions , therefore we found relationship of varying fines with permeability, porosity(without cement paste), failure load and compressive strength. As it satisfies the criteria of using it of sub-base for concrete pavement as permeable and dry lean concrete sub base.

Pervious Concrete: New Era For Rural Road Pavement

(Darshan S. Shah 1, Prof. JayeshkumarPitroda 2 Prof.J.J.Bhavsar 3)

In rural area cost consideration is the primary factor which must be kept in mind. So that in rural areas costly storm water management practices is not applicable. Pervious concrete pavement is unique and effective means to meet growing environmental demands. By capturing rainwater and allowing it to seep into the ground. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swell, and other costly storm water management devices. From the above case study we conclude that there is a considerable saving in amount about 29 Rs / m3 or 193 Rs / m2 or 18 Rs / feet2 for construction of 1m * 1m * 0.15m size pavement. 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 and durability properties.

3.3 Methodology

The methodology adopted and material characterization and design mix is carried out is presented in the form of flow chart and parameters studied.

- Collection Of Materials
- Physical Test On Materials
- Casting Of Sample
- Test For Fresh And Harden Concrete
- Fresh Concrete Test
    - Slump Cone Test
- Harden Concrete Tests
    - Compressive Strength (For 7, 14, 28 Days)
    - Permeability Test

3.4 Factors to be Considered for Designing Pervious Pavement

Pervious concrete used in road pavement systems must be designed to support the intended **Traffic Load**and contribute positively to the site specific **Storm Water Management Strategy**. The designer selects the appropriate material properties, the appropriate pavement thickness, and other characteristics needed to meet the hydrological requirements (permeability, volume of voids, amount of rainfall expected, underlying soil properties) and anticipated traffic loads simultaneously.

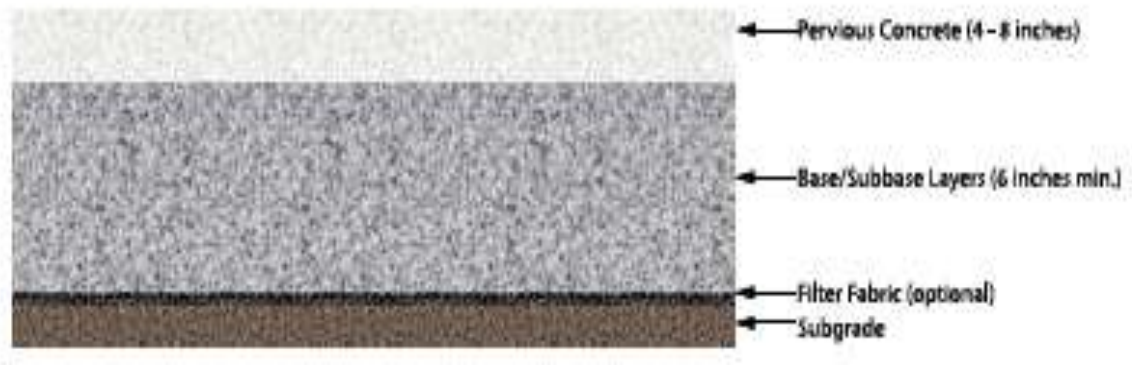


Figure 3.Typical pervious concrete pavement cross section (tech brief, FHWA-HIF-13-006)

3.5 Cost of Porous Pavement:

The cost of pervious asphalts and stone recharge beds may be higher than standard dense-grade asphalt surfaces due mainly to the amount of materials required for the stone recharge bed. This cost difference however, is offset by the savings in the area of land required by surface storm water retention basins or underground storm water containment systems.

3.6 Guidelines for Installation of pervious Concrete:

- Pervious concrete pavement shall be installed by certified contractors only
- Once it is placed, the pervious concrete shall remain covered and undisturbed for seven (7) days. The covering should be a waterproof Polyethylene sheeting with a minimum thickness of 6 mm. This curing period is essential for adequate strength and durability
- The use of signage is encouraged during the seven day period to minimize the potential damage to the curing concrete occurring from pedestrian traffic.

3.7 Construction Techniques

An experienced installer is vital to the success of pervious concrete pavements. As with any concrete pavement, proper sub grade preparation is important. The sub grade should be properly compacted to provide a uniform and stable surface. When pervious pavement is placed directly on sandy or gravelly soils it is recommended to compact the sub grade to 92 to 96% of the maximum density. Typically pervious concrete has water to Cementations Materials (w/cm) ratio of 0.28 to 0.40 with a void content of 15 to 25%.

A properly proportioned mixture gives the mixture a wet -metallic appearance or sheen. Curing should begin within 20 minutes of concrete discharge and continue through 7 days. Plastic sheeting is the standard method of curing, however, this contributes to a substantial amount of waste sent to landfills.

3.8 Materials Required

Ordinary Portland cement (C 53 grade) conforming to the requirements of IS 12269 (ASTM C 150-85A) was used in the study. Manufactured sand was used as fine aggregate and crushed angular granite stone was used as coarse aggregate. Coarse aggregate with combined grading of 50% of 20mm size and 50% of 10mm size aggregate is used.

3.9 Testing of Materials

Cement

Ordinary Portland cement was used for the project work. Following are the result obtained after testing cement.

Table 1 Summary of test results of Cement

S.No	Properties	Result
1	Standard Consistency	33%
2	Initial Setting Time	45 min
3	Final Setting Time	185 min
4	Fineness	1.55
5	Specific Gravity	3.13

Fine aggregate

Natural manufactured sand is used to fine aggregate are used to project work. Following are the result obtained after testing fine aggregate.

Table 2 Summary of test results of Fine aggregate

S.No	Properties	Result
1	Type	Natural
2	Particle Shape	Rounded
3	Grading Zone	Zone – II
4	Fineness Modulus	2.6
5	Specific Gravity	2.81

Coarse aggregate

Natural coarse aggregate which were locally available were used in the project work. Following are the result obtained after testing of coarse aggregate.

Table 3 Summary of test results of Coarse aggregate

S.No	Properties	Result
1	Type	Natural
2	Particle Shape	Angular
3	Water absorption	0.5%
4	Fineness Modulus	6.27
5	Specific Gravity	2.66

4.0 Mix Design

a) Grade designation = M_{20}
b) Type of cement = OPC 53 grade IS 1269
c) Maximum nominal size of aggregate = 20mm
d) Minimum cement content = 310kg/m^3
e) Minimum water cement ratio = 0.35
f) Workability = 0mm (no slump)
g) Exposure condition = Normal
h) Method of concrete placing = Hand
i) Degree of supervision = Good

j) Type of aggregate = Crushed angular aggregate
k) Maximum cement content = 540kg/m³
l) Chemical admixture type = Nil

Test Data for Materials

1) Cement used = OPC 53 grade
2) Specific gravity of cement = 3.13
3) Chemical admixture = Nil
4) Specific gravity of coarse aggregate = 2.66
5) Specific gravity for fine aggregate = 2.81

Target Strength For Mix Proportion

f´ck = Fck+1.65S

Where
f´ck = Target average compressive strength 28 days
Fck = Characteristic compressive strength 28 days
S = Standard deviation IS 456-T-8
Target mean strength = 20 + (1.65×4)
= 26.6N/mm²

Selection of W/C Ratio

T-8 IS 456
Maximum w/c ratio = 0.55
Adopt w/c ratio = 0.35
0.35 < 0.55

Selection of Water Content

From T-2
Maximum water content
for 20mm aggregate = 186 lit
Calculation of cement content w/c ratio = 0.35
186 / 0.35 = 541.43 kg/m³

Mix Calulation

a) Volume of concrete = 1m³

b) Volume of cement content = mass of cement / sp .of cement×100

= 541.43/3.13×1/1000

= 0.1698 m³

c) Volume of water = mass of water/sp .of water×1/100

= 186/1×1/1000

= 0.186 m³

d) Volume of all fine aggregate

e = [a-(b + c)]

= [1-(0.169+0.186)]

= 0.645 m^3

e) Mass of coarse aggregate

= e × volume of coarse aggregate × specific gravity of coarse aggregate × 1000

= 0.645×0.62×2.66×1000

= 1063.73 kg

f) Mass of fine aggregate

= e × volume of fine aggregate × specific gravity of fine aggregate × 1000

= 0.645×2.81×0.3×1000

= 543.73 kg

Ratio 1: 3.02: 0.35

Material requirement m_{20}

Cement	= 531.43 kg/m^3
Fine aggregate	= 543.73 kg/m^3
Coarse aggregate	= 1063.73 kg/m^3
Water	= 0.704 lit
Water-cement ratio	= 0.35

For one cube,

Size of cube = 0.15m × 0.15m × 0.15m
Volume = $3.375\times10^{-3}m^3$
= volume × unit weight
= $3.375 \times 10^{-3} \times 2400$
= 8.1 kg
Mix proportion
1: 1.02: 2
= 4.02

Cement quantity for one cube = 1/4.02 × 8.1

= 2.01 kg
Coarse aggregate for one cube = 3.02/4.02
= 6.085 kg
Water for one cube = 2.01×0.35 = 0.7040
= 0.704 lit

4.1 Mix Proportioning

The basic mix proportion for no-fine concrete is binder materials, coarse aggregate and water 1.0:3.02 :0.35 respectively. Mix 1 contained 100% Coarse aggregate. Mix 2 had 95% of the coarse aggregate and 5% M Sand by weight. Mix 3 had 90% of the Coarse aggregate and 10% M Sand aggregate by weight. Mix 4, 85% of the coarse aggregate and 15% of the M Sand aggregate weight. Four mixes corresponding to two aggregate sizes are proportioned by the absolute volume method. A total of 4 mixes were studied. Water/binder ratio of 0.35 and theoretical void content of 20% was used for all no-fine concrete mixes.

Table 4 Summary of mix proportioning

.No	Mixo	W/C Ratio	Cement	Coarse Aggregate	M-Sand
1	Mix-1	0.35	100%	100%	Not used
2	Mix-2	0.35	100%	95%	5%
3	Mix-3	0.35	100%	90%	10%
4	Mix-4	0.35	100%	85%	15%

4.2 Mixing of Concrete, Casting and Curing of Test Specimens

Mixing was done by hand mixing. Initially the dry mix constituents of the mix namely cement, M Sand and coarse aggregate was mixed for two minutes in the mixer and then the water were added and mixing continued for another 2 minutes. The total mixing time was kept at 4 minutes until a homogeneous mixture was obtained. Compaction was achieved by hand using the standard tamping rod ensuring the filling of the mold in layers with appropriate blows and also ensuring the same method followed for all the mixes. All specimens were de molded after 24 hours and stored in water until the age of testing.

4.3 Test Methods

Fresh No-fine concretes were tested for slump which is a quick measure of workability. However the hardened concrete was tested for compressive strength discussed below.

4.3.1 Slump Test

The slump test was done in accordance with the IS 1199-1959.As the No-fine concrete falls under the category of no slump concrete therefore it shows poor workability. However the slump of the No-fine concrete has no correlation with its workability.

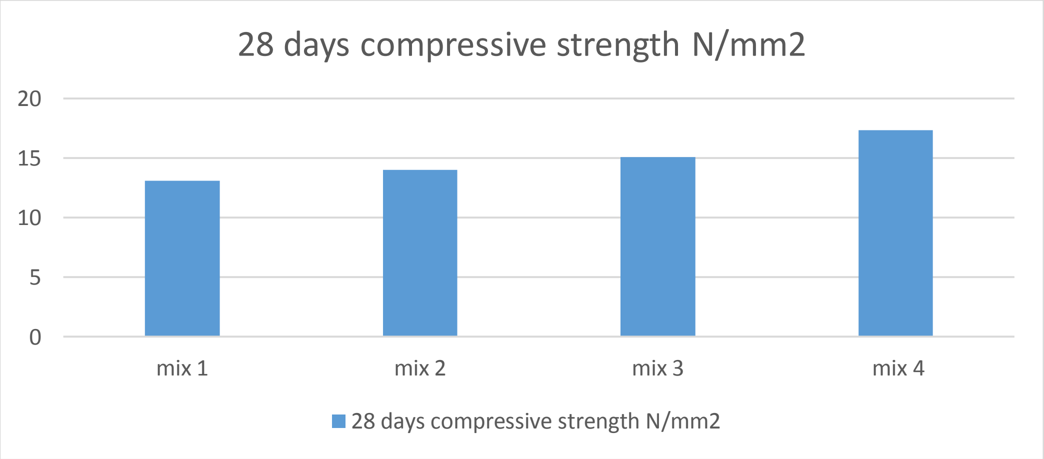
4.3.2 Compressive Strength Test

Compressive strength test was performed according to ASTM C 39. Cubes of specimen of size 150 mm x 150 mm x 150 mm were prepared for each mix. After 24 hours the specimens were de molded and cured in water for 7, 14, & 28 days until testing. For specimens with uneven surfaces, capping was used to minimize the effect of stress concentration. The compressive strength reported is the average of three results obtained from three identical cubes.

Figure 4. Compressive strength

Table 5 Compressive strength for 28 days

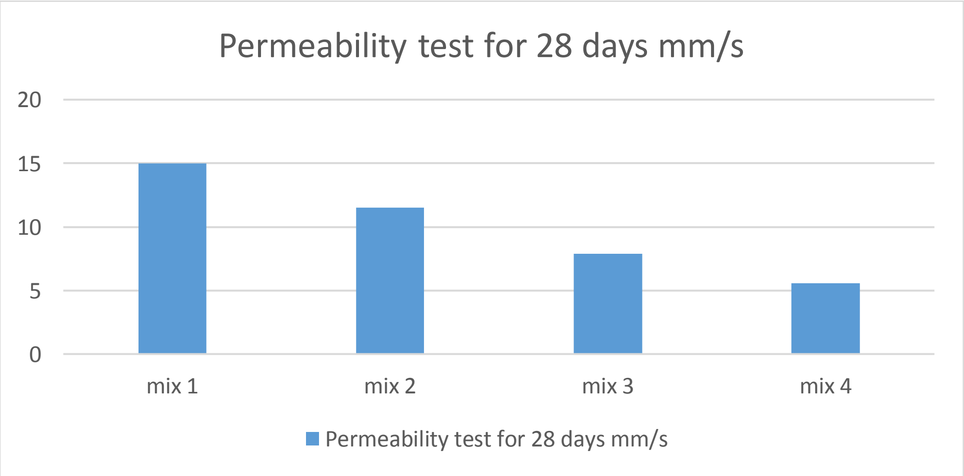
MIXES	Trial 1	Trial 2	Trial 3	Average N / mm^2
M1	13.06	13.02	13.24	13.1
M2	13.78	14.13	14.08	14.0
M3	14.89	15.20	15.24	15.11
M4	17.51	17.28	17.20	17.33



4.3.3 Permeability Test

Table 6 Permeability test for 28 days

MIXES	SEC	mm / sec
M1	1	15
M2	1.3	11.53
M3	1.9	7.89
M4	2.7	5.56



5.0 Conclusion

Table shows the permeability and compressive strength for all the four concrete mixes.

- The permeability Varies as the aggregate size increases but shows a decreasing trend when some fines were added to it.
- The concrete has zero slump value as the concrete completely collapse when the mould of frustum of cone is raised vertically. Similar variations in concrete strength were obtained when tested after 28-days.
- The compressive strength of No-fine concrete largely depends upon the size of coarseaggregate used in the concrete mix and the percentage of M sand used in the mix.
- Lower value of compressive strength and high permeability was obtained for 0% mix. However the inclusion of M sand results in comparatively good strength but low permeability.
- 15% replacement of M sand is acceptable for better strength and permeability.

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