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Utilization of waste foundry sand, demolished aggregate and waste plastic in making pervious concrete

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Abstract - *Pervious concrete is a special type of concrete that allows the water to freely pass through it. Normally it has a low strength because of its weak bonding between coarse aggregate and cement paste. In the present work an attempt has been made to replace the coarse aggregate by natural sand and waste foundry sand at 10% intervals starting from 0% up to 60% separately and also in place of natural coarse aggregate demolished aggregate is used. In experimental work four sets of specimens were casted having combinations of natural coarse aggregate and natural sand, natural coarse aggregate and waste foundry sand, demolished aggregate and natural sand, demolished aggregate and waste foundry sand. In all the mixes 2% of waste plastic is added by volume fraction method. The specimens were casted with water cement ratio 0.37 in the M25 grade concrete. The laboratory tests were conducted after 28 days of curing period for the various mechanical properties such as slump test for the workability, compressive strength, split tensile strength, flexural strength and permeability test.*

Key Words: *Waste plastic, Compressive strength, Split tensile strength, Flexural strength, Permeability.*

1. INTRODUCTION.

Increased urbanization over the past years has altered the natural water balance of ecosystem and has become the major environmental issue nowadays. However, the reality is urbanization will continue. Pervious concrete is found to be an effective measure to mitigate the adverse impact of urbanization on the environment and to develop a more eco-friendly infrastructure. Pervious concrete also called as porous concrete, permeable concrete, gap-graded concrete or no fines concrete. It is a special type of concrete with high water porosity. Its void content ranges between 18 to 35% [1]. This type of concrete is mainly used for flat work applications that allow water and air to pass through it, there by reducing the runoff from different areas, reducing the load on storm water drains, ground water recharge and maintaining the earth's temperature for the sustainable development.

1.1 Waste Foundry Sand (WFS).

Waste Foundry Sand (WFS) is a discarded material coming from the ferrous and nonferrous metal casting industry [2]. There are about 35000 foundries in the world with annual production of 69 million metric tons of castings per annum. It is estimated that around 7000 foundries are operating all over India. The foundry units in India are mostly located in clusters like Howrah, Rajkot, Agra, Jamnagar, Belagavi, Kolhapur, Coimbatore and Hyderabad with number of units ranging from 100 to 700 foundry units [3]. According to survey and as per registration there are about 142 foundries in Belagavi city. Majority of foundries are located in Udyambag, Machhe & Honaga industrial areas with total output of 60000 tons of castings per annum. Foundries produce different types of wastes like waste sand, slug, waste water, waste chemicals and particulate emissions. Among all these wastes, waste foundry sand generated in large quantity. Nearly 500 tonnes of waste foundry sand is generated from the Belagavi foundries every day. Only 50 tonnes is reclaimed every day in the reclamation unit at Santibastwad village near Belagavi. Disposal of waste foundry sand has become a major environmental problem due to scarcity of landfills and ever increasing land cost. As this waste foundry sand is dumped in low lying areas in and around Belagavi city, it may affect the ground water resources polluting them by leaching heavy metals especially during wet seasons.

1.2 Demolished aggregate (DA).

Nowadays Construction and Demolition (C&D) waste constitutes a major portion of the total solid waste production all over the world. Discarding C&D waste without any pre-treatment provokes a considerable burden to the environment, which pollutes soil, water as well as air, includes aesthetic degradation, reduced property values and landscape destruction. Preservation of the environment and conservation of the rapidly diminishing natural resources should be the essence of sustainable development. Rapid urbanization and industrial development poses a serious problem of demolished aggregate disposal, whereas on the other hand, there is a critical shortage of natural aggregates for production of fresh concrete. One of the best ways to solve these problems is to use this demolished aggregate in making concrete [4].

1.3 Waste plastic.

Due to the increase in generation of plastic, the waste plastic is also becoming a major component in solid waste. After food and paper waste, plastic waste is the third major constituent in Municipal Solid Waste (MSW)

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generated by towns and cities. This increase has turned into a major challenge for local authorities, responsible for solid waste management and sanitation. Due to lack of Integrated Solid Waste Management (ISWM), most of the plastic waste is neither collected properly nor disposed of in appropriate manner to avoid its negative impacts on environment and public health and also the waste plastics are causing littering and choking of sewerage system. Due to extremely long periods required for natural decomposition, waste plastic is often the most visible component in waste dumps and open landfills [5]. A possible application is to utilize these waste plastic fibers in concrete. In the present work 2% of waste plastic is added by volume fraction method in all combinations.

2. Experimental work.

In the experimental work four sets of specimens were casted namely;

1. Natural Coarse Aggregate (NCA) and Natural Sand (NS) with addition of 2% of waste plastic.
2. Natural Coarse Aggregate (NCA) and Waste Foundry Sand (WFS) with addition of 2% of waste plastic.
3. Demolished Aggregate (DA) and Natural Sand (NS) with addition of 2% of waste plastic.
4. Demolished Aggregate (DA) and Waste Foundry Sand (WFS) with addition of 2% of waste plastic.

2.1 Materials used.

The materials used in this experimental work are, Ordinary Portland Cement (43 grade) conforming to IS 8112-1982 [6] Natural Sand conforming to zone-II, Natural Coarse Aggregate having maximum size 20mm, Waste Foundry Sand, Demolished Aggregates having maximum size 20mm, waste plastic fiber, potable water and CONPLAST SP-430 super-plasticizer. The physical properties of materials used are given below in Table 1 to 4.

Properties	Value
Specific Gravity	3.1
Fineness	440.75m^2/kg
Initial setting time	45 minutes
Final setting time	425minutes

Table 1: Physical properties of OPC 43 grade.

Type	Natural Sand (Zone II)	Waste Foundry Sand (WFS)
Specific gravity	2.57	2.47
Total water absorption in %	0.45	1.15
Fineness modulus	2.29	1.91

Table 2: Physical properties NS and WFS.

Properties	Value
Size of fibers	3/50mm
Bulk Density	348kg/m^3
Color	Different colors
Water absorption in %	0

Table 3: Physical properties of waste plastic fibers.

Type	Natural Coarse Aggregate(NCA)	Demolished Aggregate(DA)
Specific gravity	2.85	2.15
Water absorption in %	0.6	6.35
Surface Moisture content	0.35	3.34
Bulk density kg/m^3	1524.2	1344.45

Table 4: Physical properties of NCA and DA.

Water(Lit)	Cement	Coarse aggregate(Kg)
98.5	266.16	1735.36
The super plasticizer was added at a dosage of 0.5 - 2% by weight of cement in all the mixes.		

Table 5: Mix proportions per cubic meter of M25 grade controlled concrete.

2.2 Methodology.

Cement, coarse aggregate and water were taken in the ratio of 1:6.52:0.37 corresponding to M25 grade pervious concrete.

1. In the first set Natural Coarse Aggregate was replaced by Natural Sand from 0 to 60% at an interval of 10% with the addition of waste plastic at 2%.
2. In second set Natural Coarse Aggregate was replaced by Waste Foundry Sand from 0 to 60% at an interval of 10% and 2% of waste plastic was added.
3. In the third set Demolished Aggregate was replaced by Natural Sand from 0 to 60% at an interval of 10% with addition of waste plastic at 2%.
4. In the fourth set Demolished Aggregate was replaced by Waste Foundry Sand from 0 to 60% at an interval of 10% with addition of 2% of waste plastic.

All the ingredients were dry mixed homogeneously and then required quantity of water and super-plasticizer were added.

2.3 Specimen preparation.

Concrete cube specimens (150mm x 150mm x 150mm) were cast for finding its compressive strength. The cylindrical specimens (diameter of 150mm and length-300mm) were cast to determine the split tensile strength of pervious concrete. The beam specimens (100mm x 100mm x 500mm) were cast to determine the flexural strength. All the specimens were casted as per IS: 516-1959 [6]. For the permeability test cube specimens of (150mm x 150mm x 150mm) were cast. Permeability of pervious mixes was determined by using variable head method. All the specimens were tested after 28 days curing period. [7]

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3. RESULTS AND DISCUSSIONS.

3.1 Compressive strength.

Compressive strength of cube specimens were calculated by using following equation,

$f = P/A$ (MPa)

Where, f = Compressive strength of specimen (MPa)
P = Maximum load applied to the specimen
A = Cross sectional area of the specimen.

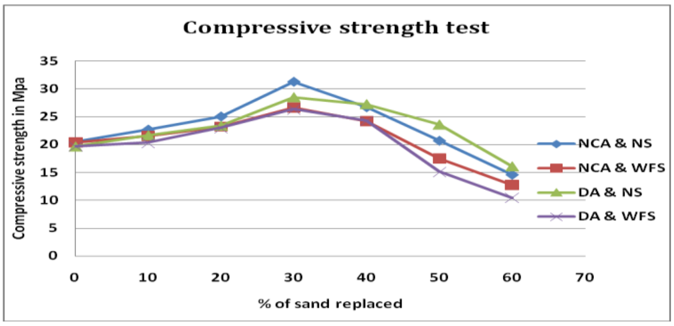

Fig 1: Variation in compressive strength of pervious concrete at different percentages of fine aggregate replacing coarse aggregate for all the 4 combinations.

From the Fig. 1 it can be observed that there is an increase in compressive strength at every 10% replacement of fine aggregate till 30%, after 30% there is continuous reduction in compressive strength for all the 4 combinations. Among the 4 sets the highest compressive strength observed is 31.24MPa at 30% Natural Coarse Aggregate replacement by Natural Sand in pervious concrete with addition of 2% of waste plastic fibers.

3.2 Split tensile strength.

Split tensile strength of cylinder specimens were calculated by using following equation,

$f = 2P/ \pi DL$ (MPa)

Where, f = Split tensile strength of specimen (MPa),
P = Maximum load applied to the specimen,
D = Diameter of the cylindrical specimen,
L = Length of the cylindrical specimen.

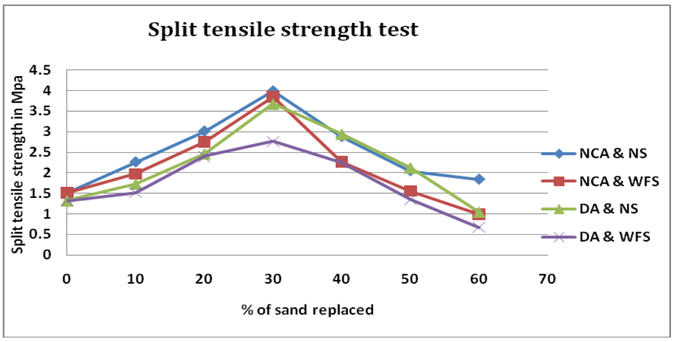

Fig 2: Variation in tensile strength of pervious concrete at different percentages of fine aggregate replacing coarse aggregate for all the 4 combinations.

From the Fig. 2 it can be observed that there is an increase in tensile strength at every 10% replacement of fine aggregate till 30%, after 30% there is a continuous reduction in tensile strength for all the 4 combinations. Among all the the 4 combinations the highest tensile strength obtained is 3.99 MPa at 30% Natural Coarse Aggregate replacement by Natural Sand in pervious concrete with addition of 2% of waste plastic.

3.3 Flexural strength.

Flexural strength of beam specimens were calculated by using the following equation,

$f = PL/bd^2$ (MPa)

Where, f = Flexural strength of specimen (MPa),
P = Failure load,
L = Effective span of the beam,
b = breadth of the beam,
d = depth of the beam.

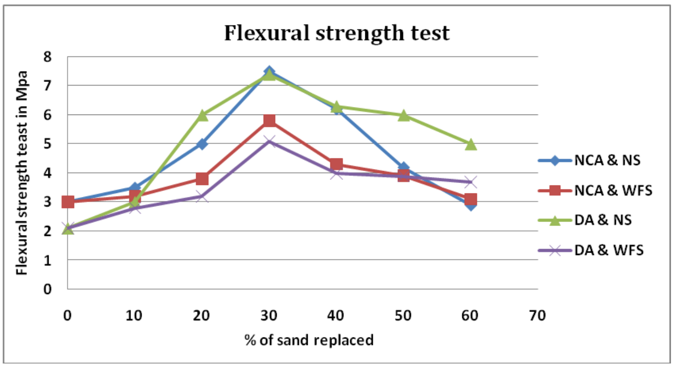

Fig 3: Variation in flexural strength of pervious concrete at different percentages of fine aggregate replacing coarse aggregate for all the 4 combinations.

From the Fig. 3 it can be observed that there is an increase in flexural strength at every 10% replacement of fine aggregate till 30%, after 30% there is continuous reduction in flexural strength for all the 4 combinations. Among all the 4 combinations the highest flexural strength observed is 7.6 MPa at 30% Natural Coarse Aggregate replacement by Natural Sand in pervious concrete with addition of 2% of waste plastic fibers.

3.4 Permeability.

Results of permeability tests for the pervious concrete are shown in Table 6 to 9. Pervious concrete with DA containing 0% of NS and DA containing 0%WFS with 2% of waste plastic has more permeability when compared to other combinations. Permeability of pervious concrete mainly depends upon the size of coarse aggregate as well as the addition of fine aggregate in different percentages. However permeability decreases with increase in fine aggregate content due to clogging of voids. It is evident from the table 8 that permeability values for all the 4 combinations at 1ml head ranges between 0.46 cm/sec to 0.6 cm/sec which is sufficient enough for a drainage layer for pavement [8].

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% of fine aggregate replaced	Percolation rate in cm/sec			
	15ml head	10ml head	5ml head	1ml head
0	0.0082	0.0140	0.1184	0.4640
10	0.0072	0.0132	0.1120	0.3380
20	0.0060	0.0086	0.0610	0.2200
30	0.0000	0.000	0.0000	0.0000

Table 6: Percolation rate of NCA and NS with 2% waste plastic fibers at different heads.

% of fine aggregate replaced	Percolation rate in cm/sec			
	15ml head	10ml head	5ml head	1ml head
0	0.0082	0.0140	0.1184	0.4640
10	0.0070	0.0112	0.0830	0.3000
20	0.0053	0.0076	0.0500	0.1600
30	0.0000	0.0000	0.0000	0.0000

Table 7: Percolation rate of NCA and WFS with 2% waste plastic fibers at different heads.

% of fine aggregate replaced	Percolation rate in cm/sec			
	15ml head	10ml head	5ml head	1ml head
0	0.0100	0.0710	0.1520	0.6000
10	0.0070	0.0500	0.0800	0.3000
20	0.0057	0.0180	0.0600	0.1000
30	0.0000	0.0000	0.0000	0.0000

Table 8: Percolation rate of DA and NS with 2% waste plastic fibers at different heads.

% of fine aggregate replaced	Percolation rate in cm/sec			
	15ml head	10ml head	5ml head	1ml head
0	0.0100	0.0710	0.1520	0.6000
10	0.0054	0.0202	0.0610	0.1810
20	0.0042	0.0184	0.0370	0.0727
30	0.0000	0.0000	0.0000	0.0000

Table 9: Percolation rate of DA and WFS with 2% waste plastic fibers at different heads.

By comparing the results obtained from permeability test, among all the 4 sets of cube specimens casted, the highest percolation rate observed is 0.01 cm/sec for 15ml head, 0.071 cm/sec for 10ml head, 0.152 cm/sec for 5ml head and 0.6 cm/sec at 1ml head for 0% replacement of fine aggregate in pervious concrete containing DA with 2% of waste plastic fibers. The lowest percolation rate observed is 0.0053 cm/sec for 15ml head, 0.0076 cm/sec for 10ml head, 0.05 cm/sec for 5ml head and 0.16 cm/sec for 1ml head at 20% replacement of fine aggregate in pervious concrete containing NCA and WFS with 2% of waste plastic fibers. In all the combination the percolation has stopped at 30% replacement of fine aggregate mainly due to the filling up of most of the voids.

4 CONCLUSIONS.

The present study illustrates the percentage of fine aggregate replaced, which influences mechanical properties and behavior of pervious concrete.

The following conclusions can be drawn from this study:

1. Belagavi city is one among the foundry clusters of India. There about 142 foundries in Belagavi city. Every day 500 tonnes of WFS is generated by Belagavi foundries, which are being dumped indiscriminately in low lying areas of Udyambag, Machhe and Honaga industrial areas of Belagavi city. This leads to environmental pollution, especially the ground water pollution due to heavy metals present in it.

2. By utilizing the WFS, DA and waste plastic fibers in pervious concrete the negative impact on environment can be reduced considerably. If these waste materials are mixed with the pervious concrete then it will ultimately become the part of the structure eliminating the disposal problem.

3. Comparing the results obtained from compressive strength test, among all the four sets of cube specimens casted, the highest compressive strength observed is 31.24MPa at 30% NCA replacement by NS in pervious concrete, containing NCA and NS with addition of 2% of waste plastic. The lowest compressive strength observed among all the four sets of the cube specimens casted is at 60% of WFS replacement containing DA and WFS is 10.44MPa.

4. Comparing the results obtained from tensile strength test, among all the four sets of cylinder specimens casted, the highest tensile strength observed is 3.99MPa at 30% NCA replacement by NS in pervious concrete, containing NCA and NS with addition of 2% of waste plastic. The lowest tensile strength observed among all the four sets of the cylinders casted is at 60% of WFS replacement containing DA and WFS is 0.68MPa.

5. Comparing the results obtained from flexural strength test, among all the four sets of beams casted, the highest compressive strength observed is 7.6MPa at 30% NCA replacement by NS in pervious concrete, containing NCA and NS with addition of 2% of waste plastic. The lowest flexural strength observed among all the four sets of the beams casted is at 60% of WFS replacement containing DA and WFS is 1.7MPa.

6. By comparing the results obtained from percolation test, among all the four sets of cubes casted, the highest percolation rate observed is 0.6 cm/sec for DA with 0% of NS and DA with 0% of WFS with 2% of waste plastic.

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7. It is observed the best strength results obtained at 30% replacement of NCA by NS with 2% of waste plastic fiber and the least strength results were obtained at 60% replacement of DA by WFS.

8. Since Government of Karnataka has banned sand mining and stone crushing activities, the shortage of fresh sand and aggregate can be minimized by utilizing these wastes in making the pervious concrete. Hence environmental pollution as well as over exploitation of sand and aggregate can be minimized.

REFERENCES

[1] Karthik H Obla (Aug 2010) *Pervious concrete- An overview.* The Indian concrete journal.

[2] Rafat Siddique and Gurpreet Singh (2011) *Utilization of waste foundry sand (WFS) in concrete manufacturing,* Resources, Conservation and Recycling 55 pp 885– 892

[3] Diagnostic study of foundry cluster of Belgaum. (http://www.msmefoundation.org/)

[4] Tsoumani. A.A, Barkoula. N.M and Matikas.T.E, (Nov 2014). *Recycled aggregates as structural material*, Symbiosis conference.

[5] Converting waste plastics into a resource. Assessment Guidelines. (http://www.unep.or.jp/Ietc)

[6] IS 8112:1989 Indian standard 43 grade ordinary Portland cement- specification (First revision).

[7] IS 516-1959 Indian standard methods of tests for strength of concrete. (Incorporating Amendment Nos. 1 & 2). UDC 666.97: 620.17. (Reaffirmed 1999) Edition1.2 (1991-07).

[8] Uma Maguesvari.M and Narasimha.V.L (2013), *Studies on characterization of Pervious concrete for pavement Applications*. Elseveir. Procedia- social and Behavioral Sciences 104198-207.

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