OPEN ACCESS

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Development of Sustainable Concrete Using Alternative Building Materials By Replacing Industrial Waste Steel Slag for Aggregates

A. Vijayakumar, J. Raja Murugadoss, S. Praveen

Abstract: ***It has now been found that industrial solid waste management is a major worldwide concern. Because of its heavy price effects, which cause economic and other environmental risks, most industries are not interested in the therapy and secure disposal of these waste. The disposal of waste foundry sand and slag is of main significance due to the trivial amount produced from the foundries throughout the world. Steel slag is a waste product produced during steel production. This waste has disposed of in the form of landfills, which creates enormous pollution of the soil. As a result, the need to use these waste is very essential due to increased demand to protect the usual environment, mainly in fields where it is built up. Consequently, replacing of natural aggregates with foundry slag would lead in considerable environmental advantages. In addition, paver blocks that are commonly used in building are inferior to burnt clay bricks in structure. In this project, therefore, normal fine and coarse aggregate should be substituted by foundry slag and foundry sand in the paver block. Several studies will be used to perform the studies, including compressive strength testing, tensile strength testing and flexure strength testing. Foundry waste is gathered from Foundries around Coimbatore.***

Keywords: ***Foundry slag, Foundry sand, Paver block, Compressive, Tensile and Flexure test.***

I. INTRODUCTION

Concrete is an extremely versatile building material used in nearly every aspect of the infrastructure of developed nations. Concrete comprises of fine and coarse aggregates that make up 60 to 70% of the concrete, and the remaining components are water and cement, the binding material that solidifies and holds the mixture together. This has put increasing demand on the limited supply of natural aggregates, with such a large portion of concrete consisting of aggregates. This increase in demand led in numerous innovations and reuse of materials that would have been considered waste materials and disposed of in landfills. With only so many resources available for use and limited landfill space, it is very important to find ways to reuse and recycle products otherwise disposed of. Metal slag is a residual component of the steel making method and is a material once considered a waste material disposed of in landfills.

II. LITERATURE REVIEW

A. *Foundry Slag in Concrete*

Assessed by 0 percent, 10 percent, 20 percent, 30 percent and 40 percent the effect of steel slag as a partial replacement for fine Aggregate. The sample was evaluated after 14 and 28 days of water healing. Replacing excellent aggregate for 14 and 28 days of water healing with steel slag outcomes in variations in compressive strength [1]. The 30% substitutes were desirable fine aggregate substitutes with steel slag. The impact of blast furnace slag on the mechanical characteristics of concrete was also explored when fine aggregates were substituted by blast furnace slag in various cube percentages. From this research it was found that up to 25 percent of furnace slag can be used as an option to fine concrete aggregate [2]. The compressive strength decreases as the proportion of blast furnace slag increases. Analyzed [3] waste material was replaced by coarse aggregate substitute and concrete block preparation. The concrete grade M35 was achieved using conventional Indian techniques. It seeks to study the impact of furnace slag as a partial substitution with varying proportion of coarse aggregate. Compared to the standard blend, the strength of concrete comprising 60 percent furnace slag was high. Investigates mild steel slag which has highest content in concrete mixture, was used as replacement for aggregate or stone. Benefits can therefore be accomplished through the use of mild steel slag rather than natural aggregates. Compressive power and the other experiments showed that mild steel slag exceeded natural aggregates. High strength and long lasting low-cost concrete blocks [4]. Presented that the concrete with steel slag by-products was a cost effective and advantageous material for pavement construction. By improving pavement performance considerably, high resistance to abrasion and Strength of 40-60MPa can be achieved. This study work was designed to use EAF slag aggregates and LF slag as binder as an alternative combination for industrial concrete pavement building. It showed a substantial rise in the mechanical strength of the concrete generated by using slag compared to calcareous aggregates [5,6]. By using coarse LF slag aggregates, the compressive and flexural resistance is improved by more than 40% relative to the reference concrete with coarse calcareous aggregates.

Revised Manuscript Received on October 30, 2019.
* Correspondence Author
A. Vijayakumar*, Civil Engineering, GMR Institute of Technology, Srikakulam, Andhra Pradesh, India.
J. Raja Murugadoss, Civil Engineering, GMR Institute of Technology, Srikakulam, Andhra Pradesh, India.
S. Praveen, Civil Engineering, GMR Institute of Technology, Srikakulam, Andhra Pradesh, India.

B. *Foundry Sand in Concrete*

Studied [6,7] the production of high-strength commercially accessible strong masonry blocks so that they can be used in load-bearing constructions and fine aggregate substitution in these blocks with foundry sand waste. Good outcomes were discovered for all practical reasons when replacing fine aggregate with waste foundry sand by about 20 to 30 percent. Block resistance and optimum proportion of waste sand substitute were discovered to rise from 20 to 30 percent. Discussed [7,8] that the foundry sand was partial replaced with fine aggregate in the Geopolymer paver block to assess the change in the compressive strength of the separate blocks. Different percentage such as 0%, 20%, 40%, 60%, 80% and 100% were partially replaced by fine aggregate. The outcome achieved shows that replacing foundry sand reduces Geopolymer paver block's compressive strength. Slightly elevated compressive strength was achieved when up to 60 percent fine sand replacement was discovered to be optimal by foundry sand. Reviewed [9, 10] and provided an overview of the use of waste foundry sand in concrete. The effect of WFS is described on concrete properties such as compressive strength, dividing tensile strength, elasticity modulus, freezing-thawing resistance, and shrinkage. It displays reduced unit weight, greater water absorption, and greater percentage of void compared to conventional concrete sand. Results of strength characteristics show that waste foundry sand can be used very conveniently to make concrete and building products of excellent quality.

III. OBJECTIVE OF THE RESEARCH

1. This research aims to determine concrete's mechanical characteristics in paver block by replacing concrete components with industrial by-products.
2. To discover the best proportion of foundry slag and foundry sand by replacing natural coarse and fine aggregates respectively in paver block.
3. Replacing conventional coarse and fine aggregates with a 25%, 50%, 75% and 100% foundry waste.

IV. EXPERIMENTAL PROGRAM

A. *Materials*

Concrete is generally produced up of four primary components, namely coarse aggregate, fine aggregate, cement, and water. They all play a specific role in making concrete strong and durable.

B. *Ordinary Portland cement (OPC)*

Ordinary Portland cement (43 degree) has been used. It was tested according to the IS: 8112-1989 Indian Standard Specifications.

C. *Fine Aggregate*

Fine aggregate is smaller sand filler as per Indian standard, any aggregate that is larger than 4.75 mm is good. It should have graded mixture confirming any standard for radiation shielding such as ASTM, BIS or Indian Standard, fine aggregate consisting of fine steel shot and crushed iron ore.

D. *Coarse Aggregate*

Coarse aggregate is categorized as such if the particle's smallest size exceeds 4.75 mm and the highest size is 10 mm (as per IS: 383-1970). Coarse aggregate properties affect the final strength of hardened concrete and its confrontation with disintegration, weathering and other damaging impacts.

E. *Water*

No strain or deposit shall be produced on the ground by water used for healing. The existence in water of iron compound and tannic acid is objectionable to curing As per Indian IS standard: 3025. Sea water should not be used to mix or heal because it includes chloride.

F. *Foundry Slag*

Foundry slags are produced by metal casting processes at metal foundries through product components. Metal casting is a metal forming method used in the production of metal components ranging from blocks and pistons for automotive engines to plumbing fixtures to precision components for aircraft. Before casting, which consists of fluxing agents and impurities, the foundry slag is separated from the molten metal.

G. *Foundry Sand*

Foundry sand, which is standardized silica sand of high quality, can be used to make the molds and core for the casting of ferrous and nonferrous metals. It consists primarily of silica sand, covered by a thin film of burnt coal, residue and dust. It can be used as a partial replacement of cement or fine aggregates or as a full fine aggregate replacement and as a complement for achieving separate concrete features. The use of concrete sand foundry will enhance concrete strength and other aspects of durability.

H. *Mix Design*

The mix ratio in this research is 1:6 (one part of cement and six components of coarse aggregate [as per IS 2185 (Part 1): 2005]. All samples were prepared in accordance with IS15658:2006, IS: 456-2000 and IS: 10262-2002 Indian Standard Specification. The material characteristics needed for different experiments have been evaluated. The blend layout was performed for concrete grade M30 and was performed as per IS: 10262-2009. The mixing ratio of Natural and Fine aggregate replacement generated by 25%, 50%, 75% and 100% of M-Sand, Foundry sand and slag shown in Table 1.

V. TEST RESULTS

The physical properties of cement, fine aggregate and coarse aggregate are shown in Table 2 to Table 4.

Table - I: Mix Design for Combinations

% of Foundry wastes	C	F.A	Foundry Sand (Kg)	C.A	Foundry Slag (Kg)
0	35	70	0	140	0
25	35	52.5	17.5	105	35
50	35	35	35	70	70
75	35	17.5	52.5	35	105
100	35	0	70	0	140

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-6, August, 2019

Table – II: Physical Properties of Cement

Properties	*Limits*	*Results*
Consistency	26-33%	31%
Initial Setting Time	30 min	35 min
Final Setting Time	10 hours	10 hours
Specific Gravity	3.12-3.19	3.14
Fineness	10%	2.06%

Table - III: Physical Properties of Fine Aggregate

Physical Properties	*Foundry Sand*	*M - Sand*
Specific Gravity	2.42	2.12
Water Absorption	0.45%	3.25%
Shear Strength	0.00792 N/mm^2	0.0196 N/mm^2
Moisture Content	9.2%	7.58%
Fineness Modulus	1.6	2.66
Plastic Index	Non-Plastic	Non-Plastic

Table - IV: Physical Properties of Coarse Aggregate

Property	*Results for Coarse Aggregate*	*Results for Foundry Slag*
Specific Gravity	2.12	2.76
Water Absorption	3.25%	10%
Flakiness Index	14.17%	26.30%
Elongation Index	20.8%	38.88%
Impact Strength	43.95%	8.3%
Crushing Strength	37.75%	2.95%
Abrasion Value	3.19%	25%

A. Casting and Curing of Paver Block

The sample specimen was casted in moulds of rubber. The materials are mixed by machine mixing. Two pieces are put in moulds after blending concrete and each layer is compacted using a table vibrator. After 24 hours the samples were de-molded and placed for healing tank until samples were tested.

B. Compressive Strength of Paver Block

The samples were screened for compressive strength at the end of 7, 14 and 28 days. Three samples were screened for each blend ratio at 7, 14 and 28 days. The findings of the 7-day compressive strength exam are shown in Table 5. Table 6 and Table 7 indicate a 14-day and 28-day compressive strength test outcome. Figure 1 indicates the graphical representation of the dumble shape's compressive strength and Figure 2 demonstrates the graphical representation of the delta shape's compressive strength.

Table - V: Compressive Strength Test Result for 7 Days

Shape	**Dumble**		**Delta**	
% of Foundry Waste	**Avg. Load (Kg)**	**Compressive Strength (N/mm^2)**	**Avg. Load (Kg)**	**Compressive Strength (N/mm^2)**
0%	626	26.08	854	22.46
25%	931	38.79	1304	34.29
50%	675	28.31	1465	38.53
75%	649	27.04	1251	32.90
100%	930	38.75	1026	26.98

Table - VI: Compressive Strength Test Result for 14 Days

Shape	**Dumble**		**Delta**	
% of Foundry Waste	**Avg. Load (Kg)**	**Compressive Strength (N/mm^2)**	**Avg. Load (Kg)**	**Compressive Strength (N/mm^2)**
0%	935	38.95	1369	36.71
25%	697	39.04	1629	42.84
50%	918	38.25	1935	50.89
75%	490	29.41	1067	38.06
100%	837	44.88	1249	32.85

Table - VII: Compressive Strength Test Result for 28 Days

Shape	**Dumble**		**Delta**	
% of Foundry Waste	**Avg. Load (Kg)**	**Compressive Strength (N/mm^2)**	**Avg. Load (Kg)**	**Compressive Strength (N/mm^2)**
0%	1298	54.08	1664	43.76
25%	713	39.71	1676	44.08
50%	1127	46.96	1958	51.49
75%	527	31.96	1736	45.65
100%	917	48.21	1549	40.73

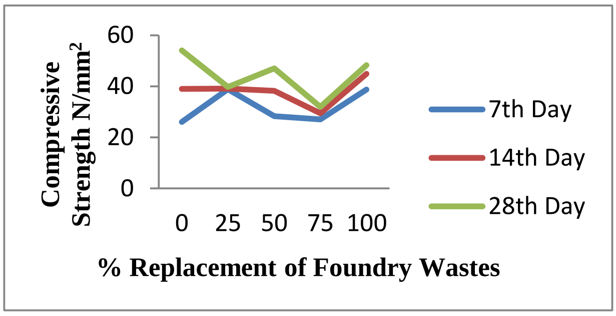

Fig.1. Compressive Strength of Dumble Shape

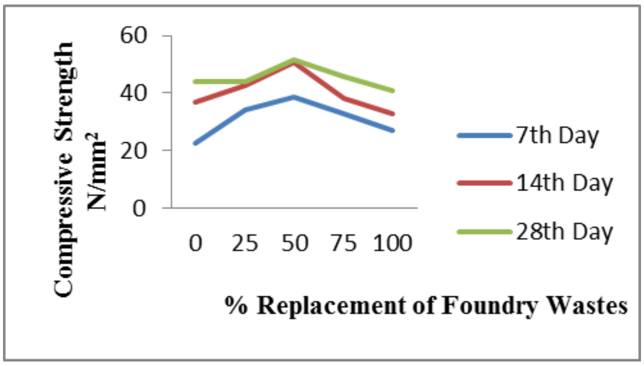

Fig.2. Compressive Strength of Delta Shape

C. Tensile Strength Test

Testing takes place after 28 days, the days are measured when the water is added to the dry components. The splitting section shall be selected, the test carried out in parallel and symmetrical with the edges along the longest splitting section of the specimen. The outcome of the tensile strength test is shown in Table 8. Figure.3 demonstrates the graphic depiction of the paver block's tensile strength.

Table - VIII: Tensile Strength Test Result for 28 Days

Shape	**Dumble**		**Delta**	
% of Foundry Waste	**Avg. Load (Kg)**	**Tensile Strength (N/mm^2)**	**Avg. Load (Kg)**	**Tensile Strength (N/mm^2)**
0%	63	3.93	45	2.45
25%	71	4.43	36	1.96
50%	75	4.68	39	2.12

75%	60	3.74	38	2.06
100%	47	2.93	37	2.01

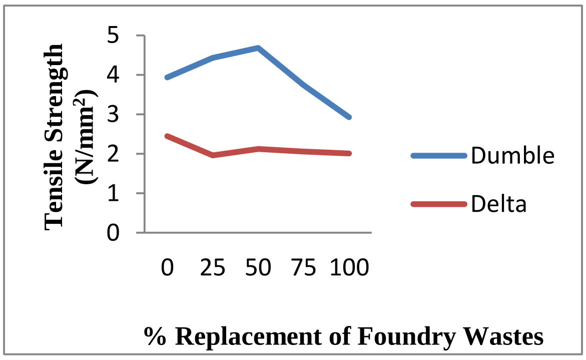

Fig.3. Tensile Strength of Paver Block

D. Flexural Strength Test

The load shall be introduced as a simple beam loading midway between the supporting rollers from the top of the specimen through a roller placed between them. Without shock, the load must be introduced and continually increased at a uniform pace of 6kN / min. The peak load applied to the closest N shall be registered, which will increase the load until the specimen fails. The outcome of the 28-day flexural resistance exam is shown in Table 9. Figure 4 shows the graphical representation for flexural strength of paver block.

Table - IX: Flexural Strength Test Result for 28 Days

Shape	Dumble		Delta	
% of Foundry Waste	Avg. Load (Kg)	Flexural Strength (N/mm^2)	Avg. Load (Kg)	Flexural Strength (N/mm^2)
0%	15	4.92	17	5.27
25%	10	3.28	22	6.81
50%	12	3.93	19	5.89
75%	11	3.61	17	5.26
100%	11	3.61	16	4.96

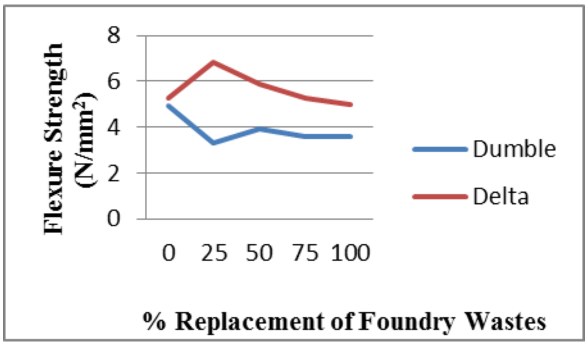

Fig.4. Flexural Strength of Paver Block

E. Water Absorption Test for Paver Block

Water Absorption Test Result for Dumble and Delta Shape is shown in Table 10.

Table IX: Water Absorption Test Result for Dumble and Delta Shape

Foundry Waste (%)	Water Absorption (%)	
	Dumble Shape	Delta Shape
0	4	3
25	5	5
50	5	5
75	7	5
100	6	6

VI. CONCLUSION

1. From this experiment, although we have compressive strength of 48.21 N / mm^2 and 40.73 N / mm^2 for dumble and delta forms with 100 percent fine and coarse aggregate substitute. It is useful for general use, such as footpath, parking, and public pedestrian and light car routes.
2. Up to 100 percent replacement by foundry sand and foundry slag of fine and coarse aggregate provides optimum strength over 28 days as specified compressive strength.
It was observed that coarse aggregate and fine aggregate were totally substituted by foundry slag and foundry sand showing marginal rises in the strength of split tensile and flexural strength.
3. From this experimental learning, it is suggested that complete substitution of fine and coarse aggregate with foundry waste produces outstanding outcomes. Using waste material can solve problems of lack of fine and coarse aggregate in distinct construction sites and reduce environmental problems connected with aggregate mining and suggest the best option for waste disposal as well as using waste aggregates and lowering concrete production expenses.
4. Using Foundry waste as a natural coarse and fine aggregate provides optimum results from this project. So we proposed 100 percent replacement of natural coarse and fine aggregate by foundry waste as per IS:15658-2006 would be satisfactory. It is also suggested that the replacement of foundry wastes should be used in RC construction work.

REFERENCES

1. Pruthviraj L. Kadam, Nanasaheb Mahadik Polytechnic Institute Peth. (MH) Tal. Walwa, Dist. Sangli. “Effect of partial replacement of fine aggregate by steel slag and its impact on compressive strength of concrete”, International Journal of Scientific & Engineering Research, Volume 7, Issue 2, 2016.
2. Vrunda D.Thaware, Pawnar,Wardha MH. “Replacement of fine aggregate with blast furnace slag in concrete”, IORD Journal of Science & Technology, Volume 2, Issue 6, pp 27 – 32, 2016.
3. Subramani,G.Ravi, “Experimental Investigation of Coarse Aggregate with Steel Slag in Concrete”, IOSR Journal of Engineering, Vol. 05, Issue 05, pp. 2278-8719, 2015.
4. Gokul, S. Suganthan, R. Venkatram and K. Karthikeyan “Mild Steel Slag as a Potential Replacement For Concrete Aggregate”, International Journal of Current Research, Vol. 4, Issue, 11, pp.106-109, 2012.
5. Eleftherios Anastasiou, “High Performance Concrete for Pavements With steel Slag Aggregate”. https://www.researchgate.net/publication/255965203_High_Performance_Concrete_For_Pavements_With_Steel_Slag_Aggregate,2010.
6. Mahima Ganeshan, Dr. Sreevidya V, Salim P.M., “Waste Foundry Sand as a Replacement for Fine Aggregate in High Strength Solid Masonry Blocks”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, Issue 5, 2016.
7. Kewal, Sajay K.Sharma and Himmi Guptha, “Foundry Sand Based Geopolymer Concrete”, Journal of Today’s Ideas – Tomorrow’s Technologies, Vol. 3, No. 2, pp. 129–144, 2015
8. Rafat Siddique, Gurpreet Singh, “Utilization of waste foundry sand (WFS) in concrete manufacturing”, Resources Conservation and Recycling, 55, 885– 892, 2011.
9. Priyanka A. Jadhav, Dilip K. Kulkarni, “Effect of replacement of natural sand by manufactured sand on the properties of cement mortar”, International Journal of Civil and Structural Engineering, Volume 3, No 3, 2013.

10. M.Adams Joe, A.Maria Rajesh, P.Brightson, M.Prem Anand, “Experimental Investigation on the Effect of M-Sand In High Performance Concrete”, American Journal of Engineering Research (AJER), Vol.-02, Issue-12, pp-46-51.
11. B.V.Venkatarama Reddy, “Suitability of manufactured sand (M-Sand) as fine aggregate in mortars and concrete (CSIC project: CP 6597/0505/11-330 dated 5 th July 2011.
12. Borge Johannes Wigum and Svein Willy Danielsen, “Production and Utilisation of M-Sand”, SINTEF Building and Infrastructure, 2009.

AUTHORS PROFILE

Dr. A. Vijayakumar is working as a Professor in Civil Engineering at GMR Institute of Technology, Rajam-532127, Andhra Pradesh. His area of interest in Seismic Strengthening of RC Structures. He published more than 30 international and national journal publications.

Dr. J. Raja Murugadoss is working as a Professor in Civil Engineering at GMR Institute of Technology, Rajam-532127, Andhra Pradesh. His area of interest in research is fibre reinforced cementitious composites and concrete technology. He published more than 50 international and national journal publications.

Mr. S. Praveen is working as Assistant Professor in Civil Engineering at GMR Institute of Technology, Rajam-532127, Andhra Pradesh. His area of interest in research is Construction Engineering and Management. He published more than 20 international and national journal publications.