UTILIZATION OF WASTE FOUNDRY SAND IN CONVENTIONAL CONCRETE

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***Abstract*: Concrete is one of the most vital and common materials used in the construction field. The current area of research in the concrete was introducing waste foundry sand (WFS) in the ordinary concrete. Waste foundry sand is the by-product of metal casting industries which causes environmental problems because of its improper disposal. An experimental investigation was carried out on concrete containing waste foundry sand (WFS) in the range of 0%, 10%, 20%, 30%, and 40% by weight for M-40 grade concrete. Concrete was produced, tested and compared with conventional concrete in plastic state as well as in harden state for workability, compressive strength & split tensile strength. These tests were carried out on standard cube, cylinder for 7 , 28 and 91 days to determine the properties of concrete. Key words: Industrial Waste, Waste Foundry Sand (WFS), Eco friendly, Compressive Strength, Split Tensile Strength and Workability.**

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.

***Keywords*: Compressive strength, Split tensile strength, Flexural strength, Permeability**

1. INTRODUCTION

The recycling of waste materials implies a significant reduction in amounts, destined to disposal by land filling, which enhances the achievement of recycling rates established by law, leads to a reduction in the use of non-renewable resources and produces a positive outcome on the environment. Additionally, in several places, conventional building materials may prove to be too expensive and insufficient to face the worldwide growing need for housing development. Accordingly, the use of waste as alternative material may help to meet the above shortages. The mixing of wastes with inert fractions to produce construction materials should be done to improve functionality rather than merely to dilute wastes. As natural resource raw materials become more costly with ever higher global demand caused by developing nations undergoing economic expansion, the incentive to explore and locate low cost, environmentally beneficial alternative uses of production by-products becomes an ever more near term goal. Recycling involves processing used materials into new products in order to prevent the waste of potentially useful materials, reduce energy usage, reduce air and water pollution by reducing the need for conventional waste disposal, lower greenhouse gas emission as compared to virgin production. Several types of by-products and waste materials are generated. Each of these specific wastes has special effects on the properties of cement-based materials. The utilization of such materials in concrete not only makes it economical but also do help in reducing disposal problems. Nowadays, the engineers are interested in “green concrete” defining the closeness of structural concrete elements to the sustainable environment with less greenhouse gas emission and preserving non-renewable resources.

The term “industrial sands” refers to any sand-like material that is a by-product of industrial processes. Many, if not properly handled, may be harmful or strenuous to the environment. It includes manufactured sands or natural sands that have been used in some face of industrial operations. There are a number of different types of industrial sands, including filter sands, quarry settling pond sands and foundry sands. Foundry sand is high quality silica sand with uniform physical characteristics which is a by-product of ferrous and non-ferrous metal casting industries, where sand has been used as a moulding material because of its thermal conductivity. This sand normally uses a small amount of bentonite clay to act as the binder material. Chemical binders are also used to create sand cores. Depending upon the geometry of the casting, sand cores are inserted into the mould cavity to form internal passages for the molten metal. Once the metal has been solidified, the casting is separated from the moulding and core sands, in the shakeout process. In the casting process, moulding sands are recycled and reused multiple times. After many times, it loses its characteristics especially the cleanliness and the uniformity, becoming unsuitable in the manufacturing process and then thrown out.

2. SCOPE:

The present work concerns the investigation of WFS utilization effect on concretes. The aims are to establish the amount of used foundry sand that can be added in the mixture without too heavy penalizations, principally in terms of workability, mechanical performances (i.e. compressive strength and tensile strength) . This research was conducted to investigate the performance of fresh and hardened concrete containing waste foundry sands as a replacement of fine aggregate. A control concrete mix was proportioned to achieve a 7-days and 28-day compressive, tensile and flexural strength of 30 MPa. Other concrete mixes were proportioned to replace 20% and 40% & 60% of regular concrete sand with used foundry sand by weight.

3. OBJECTIVES:

1. To economize the cost of construction without compromising with quality.
2. To investigate the utilization of Used Foundry Sand as Fine aggregate and influence of WFS on the Strength on concrete made with different replacement levels.
3. To check the effect of Used Foundry Sand on properties of fresh concrete & compressive strength, split tensile strength and flexural strength.
4. To check the suitability of Used Foundry Sand as an alternative construction material.

4. NEED OF THE PROJECT:

The most critical problem we are facing now a day is the deficiency of artificial resources for the construction purpose. The reason behind this is the ban of on extraction of sand ordered by the government. To solve this problem, we are using the solid waste from industries as a replacement material for fine aggregate i.e. used foundry sand.

4.1 SCENARIO OF CONCRETE PRODUCTION IN THE WORLD:

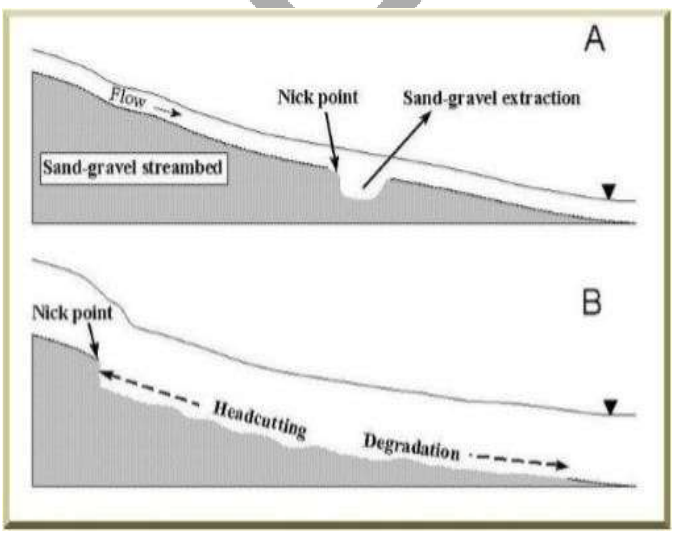
Worldwide, over ten billion tons of concrete are being produced each year. In the United States, the annual production of over 500 million tons implies about two tons for each man, woman, and child. Such volumes require vast amounts of natural resources for aggregate and cement production. Indian cement industry is the second largest in the world with an installed capacity of 500 million tonnes and presently each RMC plant approximately produces 40 to 45 million cubic meters of ready-mix concrete which make India second highest concrete producer in the world.

4.2 SCENARIO OF WASTE FOUNDRY SAND PRODUCTION IN THE WORLD:

Waste Foundry Sand (WFS) is a discarded material coming from the ferrous and nonferrous metal casting industry. There are about 50000 foundries in the world with an 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 a number of units ranging from 100 to 700 foundry units. The share of Iron foundries is the maximum i.e. almost 56%, followed by steel with 14% and then the non-ferrous ones with 30% which produce a total amount of 10 million tonnes of foundry sand each year in India as per the census of world casting production-2017.

4.3 SAND MINING:

Along with above, there are many problems associated with sand mining from the river. Excessive instream sand-and-gravel mining causes the degradation of rivers. Instream mining lowers the stream bottom, which may lead to bank erosion. Depletion of sand in the streambed and along coastal areas causes the deepening of rivers and estuaries, and the enlargement of river mouths and coastal inlets. It may also lead to saline-water intrusion from the nearby sea. Excessive instream sand mining is a threat to bridges, river banks, and nearby structures. Sand mining also affects the adjoining groundwater system and the uses that local people make of the river.



4. LITERATURE REVIEW

4.1. **Bavita Bhardwaj et.al** According to her, several studies have been conducted to investigate the effect of addition of waste foundry sand as partial and complete replacement of regular sand in concrete. It has been found suitable to be used as partial replacement of sand in structural grade concrete. A number of properties have been reviewed in the current paper, the results observed from the various studies depict that replacement of foundry sand to a certain extent enhance the durability as well as strength properties of the concrete but simultaneously decreases the slump value with the increase of replacement level of waste foundry sand.

4.2.**Maria Auxiliadora et.al** Aimed to characterize and analyse the use of a very fine sand, referred here as waste foundry exhaust sand, WFES, from Waste Foundry Sand from the foundry of pieces in the automotive industry in conventional concrete production partially replacing the fine aggregate. The test on the physical properties such as size classification, specific gravity and density were carried out according to the Brazilian standards to obtain the mixture. The chemical characterization of the leachate solution of the waste was assessed to identify the presence of heavy metals. The waste was classified as non-inert and non-hazardous and physically adequate for use in conventional concrete.

4.3.**Thiruvenkitam Manoharan et.al** His investigations were carried out to evaluate the mechanical, durability and micro-structural properties of M20 concrete at the age of 7, 28 and 91 day. XRD (X-ray Diffraction), EDX (Energy Dispersive X-ray) and opticalmicroscopic imaging analysis were performed to identify the presence of various compounds and micro cracks in the concrete with WFS. The study shows that, WFS is compatible for the replacement of fine aggregate in concrete. He also stated that, mechanical and durability properties for different grade of concrete can be the future concern.

4.4 **Francesca Tittarelli1 et.al** Waste foundry sand (WFS) is a discarded material coming from ferrous (iron and steel) and nonferrous (copper, aluminium, and brass) metalcasting industry to create moulds and cores. About 1 ton of foundry sand for each ton of iron or steel casting produced is used. Typically, suppliers of the automotive industry and its parts are the major generators of foundry sand (about 95% of the estimated WFS). Moulding sands are manufactured using virgin silica sands with the addition of binding agents (e.g., bentonite clay and organic resins). Silica sand is mainly used because of its thermal conductivity. It can absorb and transmit heat while allowing the gases generated during the thermal degradation of binders to pass through the grains. As a moulding material, the sand is compacted and shaped according to the mould pattern that is going to be produced, as well as to create cavities. In the casting process, moulding sands are recycled and reused multiple times. At the end of the casting process, the moulds or cores are broken apart to retrieve the pieces and to be further reclaimed. Before reuse, silica sand needs to be cleaned by means of screening systems and magnetic separators to segregate reusable sand from other wastes and to separate particles of varying sizes. Although WFS is partially a recycled material itself, as successfully recycled and reused through many production cycles, after many times it loses its characteristics of cleanliness and uniformity. The sand grains begin to break down from heat and mechanical abrasion; thus, new sand must be continually added to the system to maintain proper tolerances and prevent casting defects. When WFS becomes unsuitable in the manufacturing process, the sand removed from the system, known as discarded, spent, waste, or WFS, is commonly disposed of at foundry landfills or at offsite municipal landfills.

4.5.**N.Gurumoorthy et.al** This paper presents the results of an experimental investigation carried out to evaluate the micro structural and mechanical properties of concrete mixtures in which fine aggregate (river sand) was partially replaced with TWFS. Test results indicated a marginal increase in the strength properties and good micro structural properties of plain concrete by the inclusion of TWFS as partial replacement of fine aggregate (sand). This will pave the way for making good quality concrete and disposing of the Used Foundry Sand safely without disturbing the environment. Used Foundry Sand (WFS) is the high-quality silica sand by-product from the production of both ferrous and nonferrous metal casting industry. The WFS from ferrous metal casting industry contains more iron content. Inclusion of WFS without proper treatment in concrete will reduce the binding and strength properties. In order to minimize the iron content, the WFS was treated with acid. While treating with acid, the silica in foundry sand has been enriched. This is called as Treated Used Foundry Sand (TWFS). In Treated Used Foundry Sand, silica content is about 80% when treated with 5% HCl. Mechanical properties of concrete mixtures increase with the increase in the percentage of TWFS content. TWFS concrete mixtures show enhanced mechanical properties (compressive strength, splitting tensile strength and flexural strength) with respect to age for all the percentage of replacement.

4.6.**M Nithya et.al** Properties of concrete containing waste foundry sand for partial replacement of fine aggregate in concrete. Her study demonstrated that the feasibility of waste foundry sand in concrete as a substitute for fine aggregate by evaluating the durability properties of concrete. The durability evaluation in terms of acid resistance and alkalinity has shown relative supremacy over conventional concrete mix. Concrete produce with WFS suffered similar losses in weight and compressive strength as compared to ordinary concrete when subjected to sulphuric acid attack.

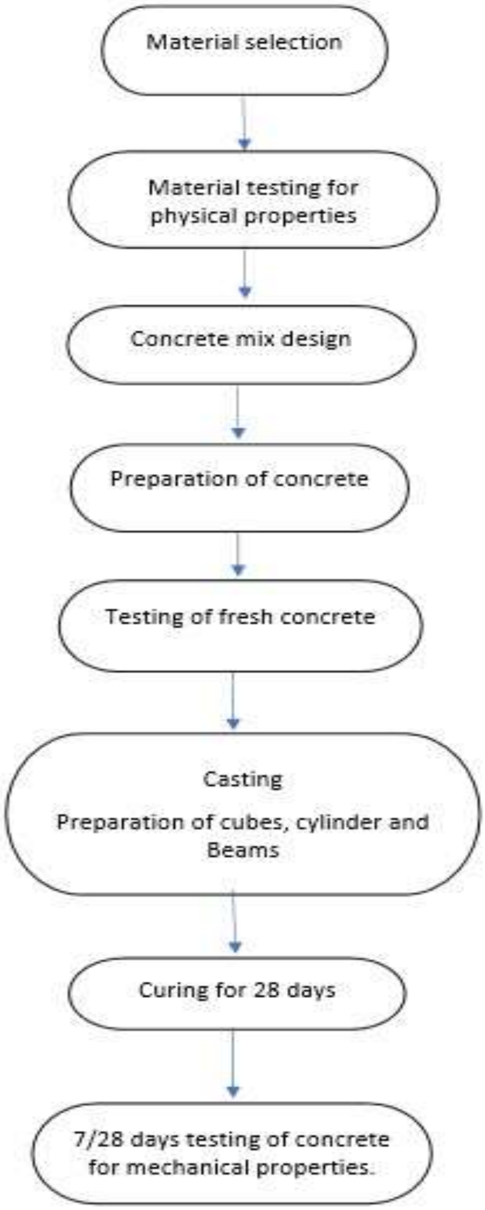
4.7.**Vipul D. Prajapati et.al** India has an approximate road network of over 4,000,000 kilometres. These roads are a mix of modern highways and narrow, unpaved roads, and are undergoing drastic improvement. Nowadays, India has changed with major efforts to modernize the country's road infrastructure. Road Transport is vital to India's economy. It enables the country's transportation sector to contribute more than 4 percent of India’s gross domestic product, in comparison to railways that contributed nearly 1 percent. Road transport has not gained in importance over the years despite significant barriers and inefficiencies in inter-state freight and passenger movement compared to railways and air. The government of India considers road network as critical to the country's development, social integration and security needs of the country. Bitumen and concrete are used in road construction as the two major types of materials in the country. It is most essential to develop profitable construction materials from used foundry sand. The innovative use of used foundry sand in concrete formulations as a fine aggregate replacement material was tested as an alternative to traditional concrete. The fine aggregate has been replaced by used foundry sand accordingly in the range of 0%, 10%, 30% & 40% by weight for M-20 grade concrete.

5. METHODOLOGY

Strength is one among the most important properties of concrete since the first consideration in structural design is that the structural members must be capable of carrying the imposed loads. The mix of concrete used in this study is M30. Concrete mix with 0% waste material is the control mix and water-cement ratio adopted is 0.5 in accordance with the Indian Standards specification IS 10262 - 2009. A design mix proportions of 1: 1.86: 2.89: 0.5 was investigated for the research. The percentages of replacements are 20%, 40% and 60% by weight of fine aggregate. Tests were performed for compressive strength, flexural strength and split tensile strength of concrete for all replacement levels of fine aggregate at different curing period (7 days and 28 days). Besides, the physical and chemical properties of the foundry sand are also studied.

Before casting, different tests are carried out on foundry sand, river sand to find out physical properties for further work. The test includes a water absorption test, sp. gravity test, etc. The replacement of fine aggregate is done in three sets by weight.

The study will lead to possible innovative utilization of foundry sand in the construction of concrete apart from its present use in a landfill application. The use of waste foundry sand, it could be feasible, will not only provide for its better utilization but also will help in conserving the precious natural resource of natural sand.



6. MATERIALS:

CEMENT:

Cement is an extremely good material having adhesive and cohesive properties which provide a binding medium for discrete ingredients. It is obtained from burning together in a definite portion a mixture of naturally occurring argillaceous and calcareous material to partial fusion at high temperature (about 1450ºc). Cement in concrete acts as a binding material that hardens after the addition of water. It plays an important role in the construction sector.

Physical properties of Cement (OPC) 53 grade	Result
Specific gravity	3.15
Standard consistency (%)	31.6%
Initial setting time (min)	210 min
Final setting time (min)	250 min
Compressive strength N/mm2 at 28 days	52 N/mm2

(A) Properties Of (OPC) Cement

Oxide	Percentage
Lime, CaO	3.15
Silica, SiO2	20
Alumina, Al2O3	6
Iron oxide, Fe2O3	3
Magnesia, MgO	2

(B) -Chemical properties of cement

In this stud, the Ordinary Portland Cement (OPC) of 53 Grade (Birla Cement) is used according to IS: 1489-1991. Various tests were performed on cement they are Soundness test, Consistency test, Initial and final setting time.

AGGREGATE:

Aggregate is a natural deposit of sand and gravel and also give structure to the concrete. It occupies almost 60% to 80% of volume in concrete and hence shows influence on various properties such as workability, strength, durability, and economy of concrete. To increase the density of concrete aggregate is frequently use in different sizes. Aggregate acts as reinforcement and introduces strength to the overall composite material. Aggregate is also used as a base material for roads, railroads and under foundation due to its good strength.

1. Fine aggregate:

Fine aggregate is defined as aggregate whose size is 4.75 mm and less and having not more than 5 percentage of coarser material. Sand is a loose, fragmented, naturally occurring material consisting of very small particles of decomposed rocks, corals, or shells. Sand is used to providing bulk, strength, and other properties to construction materials like asphalt and concrete. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. Artificial sand with 4.75mm maximum size is used as per IS 383-1970. It satisfied all the requirements. Results are given in the table.

(A)- Physical properties of fine aggregate

2. Course aggregate:

The aggregate having size more than 4.75 mm is termed as coarse aggregate. The graded coarse aggregate is described by its nominal size i.e. 40mm, 20mm, 16mm, 12.5mm, etc. 80mm size is the maximum size that could be conveniently used for making concrete. In this study coarse aggregate is confirmed to IS 383. The Flakiness and Elongation Index were maintained well below 15%.

MATERIAL TESTING:

All tests are carried out as per the IS 2386(part-II, III)-1963.Following tests are conducted to find out physical properties of fine aggregate, coarse aggregate and foundry sand.

SIEVE ANALYSIS:

The main purpose of Sieve analysis of aggregates is to determine the particle size distribution of the coarse and fine aggregates. From the result of sieve analysis, fineness modulus has found out for fine and coarse aggregate. The fineness modulus is only a numerical index of fineness, giving some idea of the mean size of the particles in the entire body of the aggregate. For the fine aggregate standard sieve size used are 4.75mm, 2.36 mm, 1.18 mm, 600 µm,425µm, 300µm, 150µm, 75µm while for coarse aggregate standard sieve size are 40mm, 20mm, 10mm, 4.75mm, 2.36mm, 1.18mm, 600µ, 150µ.

(A) -Sieve analysis of fine aggregate.

Sieve Aperture	Weight Retained(g)	Cumulative Weight Retained (gm)	Cumulative Weight Retained (%)	Passing (%)
4.75	16	16	1.45	98.5
2.36	306	322	29.27	70.27
1.18	356	678	61.63	38.36
0.6	136	841	76.45	23.54
0.3	106	947	86.09	13.90
0.15	79	1026	93.27	6.73
Pan	74	1100	100	0

From the above table, grading zone of aggregate,

<table>
<tr><th>Properties</th><th>Value</th></tr>
<tr><td>Sp. Gravity</td><td>2.70</td></tr>
<tr><td><table>
<tr><th>% Passing</th><th>Zone I</th><th>Zone II</th><th>Zone III</th></tr>
<tr><td>98.5</td><td>90-100</td><td>90-100</td><td>90-100</td></tr>
<tr><td>70.27</td><td>60-95</td><td>75-100</td><td>85-100</td></tr>
<tr><td>38.36</td><td>30-70</td><td>55-90</td><td>75-100</td></tr>
<tr><td>23.54</td><td>15-34</td><td>35-59</td><td>60-79</td></tr>
<tr><td>13.90</td><td>5-20</td><td>8-30</td><td>12-40</td></tr>
</table>Bulk density</td><td>1560 kg/m3</td></tr>
<tr><td>Fineness modulus</td><td>3.48</td></tr>
<tr><td>Water absorption</td><td>1</td></tr>
</table>

7. CALCULATION

CONCRETE MIX DESIGN:

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of the ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

The compressive strength of hardened concrete which is generally considered to be an index of its other properties depends upon many factors, e.g. quality and quantity of cement, water, and aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant, and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible. From a technical point of view, the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to the evolution of high heat of hydration in mass concrete which may cause cracking.

The actual cost of concrete is related to the cost of materials required for producing a minimum mean strength called characteristic strength that is specified by the designer of the structure. This depends on the quality control measures, but there is no doubt that the quality control adds to the cost of concrete. The extent of quality control is often an economic compromise and depends on the size and type of job. The cost of labour depends on the workability of mix, e.g., a concrete mix of inadequate workability may result in a high cost of labour to obtain a degree of compaction with available equipment.

REQUIREMENTS OF CONCRETE MIX DESIGN:

The requirements which form the basis of selection and proportioning of mix ingredients are:

a) The minimum compressive strength required for structural consideration.
b) The adequate workability is necessary for full compaction with the compacting equipment available.
c) Maximum water-cement ratio and/or maximum cement content to give adequate durability for the particular site conditions.
d) Maximum cement content to avoid shrinkage cracking due to temperature cycle in mass concrete.

CONCRETE MIX DESIGN OF M30 BY I.S CODE METHOD (IS 10262-2009):
Stipulations for proportioning:

1. Grade designation : M30
2. Type of cement : OPC 53 grade conforming to IS 12269
3. Maximum nominal size of aggregate : 20 mm
4. Minimum cement content : 320 kg/m3
5. Maximum water-cement ratio : 0.55
6. Workability : 100-120 mm (Slump)
7. Exposure condition : Moderate (For Reinforced Concrete)
8. Degree of supervision : Very Good.
9. Type of aggregate : Crushed angular aggregate.
10. Maximum cement content : 450 kg/m3
11. Chemical admixture type : None

Step 1 : Determining the target mean strength for mix proportioning

Step 2: Selection of water-cement ratio

Step 3: Selection of water content

Step 4: Calculation of cement content

Step 5: Proportion of volume of coarse aggregate and fine aggregate content

Step 6: Estimation of concrete mix proportion

Step-7: Concrete mix proportions

Step-8: Mix proportion ratio:

8. SPECIFICATIONS AND TESTING

PREPARATION OF CONCRETE:

All cement, sand (natural or foundry), and coarse aggregate 20mm and 10mm respectively are measured with the Digital balance. The water is measured with measuring cylinder of capacity 1 litre and measuring jars of capacity 1000ml. The quantity of ingredient is decided as per the ratio 1:1.86:2.89. A sufficient quantity of material has been measured to prepare mould specifically cubes, cylinder, beam.

MIXING OF CONCRETE:

The ingredients were mixed by hand. The ingredients were thoroughly mixed over the floor after sprinkling them with water. The sand, cement, and aggregate were measured accurately with an equal mix design proportion and were mixed in a dry state for normal concrete. The dry concrete mix was then thoroughly and uniformly mixed till uniform and homogeneous mixing of all the ingredients in the dry mix was observed. The designed quantity of water was then added gradually to the dry mix so that it gives a plastic mix of the required workability and w/c ratio. According to the specifications, the mix was turned 3 times so that the uniform concrete was obtained. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens. Four batches have been made with changing waste foundry sand percentage as 0%, 20%, 40%, 60%.

WORKABILITY OF CONCRETE:

At every batch of mixing the concrete slump is measured and recorded with a slump cone apparatus as per relevant IS. Workability is measured in terms of a slump.

PLACING OF CONCRETE:

Sr. No.	W/C ratio	Foundry sand percentage %	Height of mould H1 (mm)	Height of subsided concrete, H2 (mm)	Slump H1-H2 (mm)
1	0.5	0	300	215	85
2	0.5	20	300	217	82
3	0.5	40	300	222	78
4	0.5	60	300	240	60

The fresh concrete was placed in the moulds by trowel. It was ensured that the representative volume was filled evenly in all the specimens to avoid segregation, accumulation of aggregates, etc. Before placing concrete, the moulds are cleaned and oiled from inside for smooth remoulding. Concrete is mixed thoroughly and placed in the mould in three layers and compacted by electrically operated Table vibrator with suitable fixing frame. It is vibrated till concrete woes out of the mould. The vibration is continued till cement slurry just ooze out on the surface of moulds. Care is taken of cement slurry not to spill over, due to vibration and segregation. While placing concretes, the compaction in vertical position was given with the help of tamping rod to avoid gaps in the mould.

FINISHING OF CONCRETE:

After removing from vibrating table, the moulds were kept on the ground for finishing and covering up for any leftover position. The concrete is worked with a trowel to give uniform surface. Care is taken not to add any extra cement, water or cement mortar for achieving the good surface finish. The additional concrete is chopped off from the top surface of the mould for avoiding over sizes etc. Identification marks are given on the specimens by embossing over the surface after initial drying.

DEMOULDING AND CURING OF SPECIMENS:

The plain cement concrete specimens are demoulded carefully after 24 hours of casting wet concrete and kept in water tank for curing of 7 days and 28 days.

6.1. SLUMP CONE TEST:

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. The test is popular due to the simplicity of apparatus used and simple procedure. The slump test is used to ensure uniformity for different loads of concrete under field conditions.

COMPRESSIVE STRENGTH TEST:

Compressive strength tests were performed on compression testing machine of 2,000 KN capacity. The compressive strength for different replacement levels of foundry sand contents is carried out at the end of 7 days and 28 days. Three cubes of 150*150*150 mm from each batch were subjected to this test. Overall twenty-four number of cubes are subjected to compressive strength test. The comparative study was made on properties of concrete after percentage replacement of fine aggregate by waste foundry sand in the range of 0%, 20%, 40% and 60%. The compressive strength of specimen was calculated by the following formula:

Pc – Failure load in compression, KN.

A – Loaded area of cube, Sq.mm.

(A)-Ultimate load at 7 and 28 days.

Foundry sand Percentage %	Ultimate load at 7 days (KN)			Ultimate load at 28 days (KN)		
	Trial No.-01	Trial No.-02	Trial No.-03	Trial No.-01	Trial No.-02	Trial No.-03
0%	460	460	470	700	710	690
20%	510	500	510	780	780	770
40%	570	580	570	850	860	840
60%	390	390	400	610	600	600

SPLIT TENSILE STRENGTH:

The split tensile strength for different replacement levels of foundry sand contents is carried out at the end of 7 days and 28 days. Four cylinders of 150mm diameter x300mm height from each batch were subjected to this test. Overall sixteen number of cylinders are subjected to split tensile strength test. The comparative study was made on properties of concrete after percentage replacement of fine aggregate by waste foundry sand in the range of 0%, 20%, 40%, and 60%.The split tensile strength is calculated by the following formula, $ft= 2P/\pi LD$ Where, ft – Tensile Strength of Concrete N/mm2

P – Maximum load in, N

L – Length of the Specimen, mm

D – Diameter of the specimen, mm

Ultimate load at 7 and 28 days.

Foundry sand percentage %	Ultimate load at 7 days (KN)		Ultimate load at 28 days(KN)	
	Trial No.1	Trial No.2	Trial No.1	Trial No.2
0%	190	200	280	270
20%	210	220	300	290
40%	230	240	320	330
60%	160	170	210	200

9. CONCLUSION

Based on above study the following conclusions are made regarding the properties and behaviour of concrete on partial replacement of fine aggregate by waste foundry sand-

It was noticed that workability (slump) of concrete decreases as percentage of foundry sand. This maybe most likely because of the presence of clayey type fine substances in the WFS, high water absorption, and fineness which are compelling in diminishing fresh concrete fluidity.

1. Compressive strength, split tensile strength and flexural strength of concrete specimens increased, with increase in fine aggregate replacement by foundry sand, providing maximum strength at 40 % replacement on 7 and 28 days, and beyond that the strength parameters showed a decline in their respective values.
2. Maximum compressive strength is gained at 40% replacement of fine aggregate which is higher than normal concrete strength (M30) by 21.44%. (From table 6.2 D)
3. Beyond 40% replacement (60%) shows the decrement in compressive strength by 13.79%. (From table 6.2 D)
4. The variation in split tensile strength and flexural strength followed the similar trend as observed in compressive strength with a maximum increment by
18.20% and 19.10%. (From table 6.3 D)

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