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EVALUATING THE STRENGTH OF CONCRETE USING FOUNDRY SAND AS PARTIAL REPLACEMENT FOR FINE AGGREGATE

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ABSTRACT

This study is a summary of the various experiments, discussions for the given project topic "Evaluating The Strength Of Concrete Using Foundry Sand As Partial Replacement For Fine Aggregate". With highlights on the effect of foundry sand on the strength of concrete and its effect when used in constructions. Also, the detailed discussions of the experiment carried out in the project. The use of concrete is widespread in the construction industry due to its durability, strength, and versatility. The primary components of concrete are cement, water, and aggregates, with fine and coarse aggregates typically used to ensure the desired properties of the final product. Fine aggregates provide the necessary filling and binding properties to cement, making it an essential component in concrete production. The cost of sand used as a fine aggregate is increasing, and the environmental impact of sand mining is becoming more apparent, leading to the search for alternative sources of sand. Foundry sand is a by-product of the manufacturing process of metallic castings, and its disposal has become a significant environmental challenge. Recycling foundry sand as a partial replacement for fine aggregate in concrete could be an innovative solution to this challenge.This project aims to evaluate the strength of concrete produced using foundry sand as a partial replacement for fine aggregate. The research will explore the characteristics of the foundry sand, including its fineness modulus, specific gravity, and absorption capacity, and compare them with the properties of natural sand. The study will also analyze the effect of varying replacement percentages

Key words: Evaluating, Strength ,Concrete, Foundry Sand , Fine Aggregate

Introduction

According to Wikipedia, concrete is a composite material composed of fine and coarse aggregate bonded together with a fluid cement (cement paste) that hardens (cures) over time. Concrete is the second-most-used substance in the world after water, and is the most widely used building material. Its usage worldwide, ton for ton, is twice that of steel, wood, plastics, and aluminum combined. Globally, the ready-mix concrete industry, the largest segment of the concrete market, is projected to exceed $600 billion in revenue by 2025. This widespread use results in a number of environmental impacts. Most notably, the production process for cement produces large volumes of greenhouse gas emissions, leading to net 8% of global emissions. Other environmental concerns include widespread illegal sand mining, impacts on the surrounding environment such as increased surface runoff or urban heat island effect, and potential public health implications from toxic ingredients. Significant research and development are being done to try to reduce the emissions or make concrete a source of carbon sequestration, and increase recycled and secondary raw materials content into the mix to achieve a circular economy. Concrete is expected to be a key material for structures resilient to climate disasters, as well as a solution to mitigate the pollution of other industries, capturing wastes such as coal fly ash or bauxite tailings and residue.

Foundry sand also known as molding sand is sand that when moistened and compressed or oiled or heated tends to pack well and hold its shape. It is used in the process of sand casting for preparing the mold cavity. Foundry sand also has the name “green sand”, the name comes from the fact that the sand mold is not set, it is still in the green or uncured state even when the metal is poured into the mold. Foundry sand or green sand is usually 10% bentonite clay. On a molecular level, thin clay contains an absorbent mixture of silica and aluminum and commonly also has potassium, sodium, or calcium. Calcium bentonite is the most commonly used clay in the green casting process. Molding sand is prepared in a screw mixer if organic binders are to be used. Binder preparations are added to the sand and the mixer evenly distributes the resin over the sand grains. Samples are taken and tested for strength to ensure the mix is correct. Foundry sand is prepared in a muller, a mixer with large wheels that does not destroy the properties of bentonite clay. Samples are taken and tested for compression strength, and additions of water, carbon, and clay are made if not up to specification. Other samples are taken and tested on a regular basis for Loss on Ignition (LOI) and Permeability (Kapranos, 2014).

Used foundry sand (UFS) is a discarded material coming from the ferrous (iron and steel) and nonferrous (copper, aluminum, and brass) metal-casting industry to create molds and cores. About 1 ton of foundry sand for each ton of iron or steel casting produced is used (Siddique and Noumowec, 2008). Typically, suppliers of the automotive industry and its parts are the major generators of foundry sand (about 95% of the estimated UFS). Foundry sand has been used as a substitute for fine aggregate in asphalt paving mixes. It has also been used as a fine aggregate substitute in flowable (or controlled density) fill applications.

Foundry sand can be obtained directly from foundries, most of which are located in midwestern states, including Illinois, Wisconsin, Michigan, Ohio, and Pennsylvania. Foundry sand, prior to use, is a uniformly graded material. The spent material, however, often contains metal from the casting and oversized mold and core material containing the partially degraded binder. Spent foundry sand may also contain some leachable contaminants, including heavy metals and phenols that are absorbed by the sand during the molding process and casting operations. Phenols are formed through high-temperature thermal decomposition and rearrangement of organic binders during the metal pouring process. The presence of heavy metals is of greater concern in nonferrous foundry sands generated from nonferrous foundries. Spent foundry sand from brass or bronze foundries, in particular, may contain high concentrations of cadmium, lead, copper, nickel, and zinc.

MATERIALS AND METHODS

This study undertook some experiments investigation in order to promote a good understanding of the effect of foundry sand as a partial replacement for fine aggregate on the strength of concrete. The tests were done on eight samples of the fine aggregate, the coarse aggregate sample, the green concrete (wet concrete) and the hardened concrete. The topic drew most of its references from some people who have worked on related topics or experiments in times past.

MATERIALS:

The materials which were used in the experimental investigation for this study are as follows:

i. Water
ii. Cement (binder)
iii. Sharp sand
iv. Foundry sand

v. Granite (coarse aggregate)

EXPERIMENTS

The following are the different tests that will be done and also the procedures intended to be followed in order to get an optimum result.

WATER ABSORPTION RATE (WAR)

This is a test which is used to determine the rate of absorption of water by concrete made out of hydraulic cement, this is done by measuring the increase in mass of a specimen or mass of concrete resulting from the absorption of water as a function of time after the specimen has been immersed in water for a certain period of time.

MATERIALS

i. Cement
ii. Water
iii. Sharp sand
iv. Foundry sand
v. Coarse aggregate (granite)

APPARATUS

i. Curing tank
ii. Mold (for concrete cubes)
iii. Weighing balance

PROCEDURE

1. I mixed the materials for concrete and when mixed I place them in different molds
2. I left the for a certain amount of time to dry
3. I then measured each mold and then placed them in the curing tank
4. After the first seven days, I went back to the lab where I took the weight of the submerged concrete and after that I subtracted the weight from the measured weight before curing (W2-W1)
5. I repeated step four for days 14, and 28 respectively.
6. After this I was able to determine my water absorption rate

Figure 3.4: Curing tank

COMPRESSIVE STRENGTH TEST

Compressive strength test is a mechanical test measuring the maximum amount of compressive load a material can bear before fracturing. The test piece, usually in the form of a cube, prism, or cylinder, is compressed between the platens of a compression-testing machine by a gradually applied load.

Out of other tests that can be performed on a concrete, this particular test is of the utmost importance because it gives an idea about all the characteristics of concrete. By this test one can judge whether concrete is properly done or not.

MATERIALS

i. Concrete cube

APPARATUS

i. Compressive strength test apparatus
ii. Weights of different masses

PROCEDURE

1. I removed the specimen from water after specified curing time and wiped out excess water from the surface after I took the weight
2. I cleaned and set the bearing surface of the test machine

3. I aligned the specimen centrally on the base plate of the machine and the I rotated the movable portion gently by hand so that it touches the top surface of the specimen
4. I then applied the load gradually without shock and continuously till the specimen fails
5. Finally, I recorded the maximum load and noted any form of unusual features in the type of failure
6. I repeated procedure 1 to 5 for days 14, and 28

Fig 3.5 Compressive strength test machine

FLEXURAL STRENGTH TEST

This method is similar to AASHTO T 177 as it covers the procedure for determining the flexural strength of concrete by the use of a simple beam with center point loading.

This test method covers the determination of the flexural strength of concrete by the use of a simple beam with third-point loading.

I will be using this test to determine the flexural strength and rigidity of each hardened concrete bar made from different aggregate sizes.

It therefore follows that this test will be used to predict

MATERIALS

i. Concrete beam

APPARATUS

i. Weighing balance
ii. Compressive strength test machine
iii. Weights of various masses
iv. Curing tank

PROCEDURE

1. I removed the concrete beam from the curing tank after specified curing time and wiped out excess water from the surface after taking its weight
2. I then cleaned and set the bearing surface of the testing machine
3. I aligned the beam centrally on the base plate of the machine and then I rotated the movable portion gently by hand so that it touches the top surface of the specimen
4. I then applied the load gradually without shock and continuously till the specimen fails
5. Finally, I recorded the maximum load and noted any form of unusual features in the type of failure

I repeated procedures 1 to 5 for days 14, and 28 respectively

RESULTS AND ANALYSIS

this study, shows results in tabulated, observations and recommendations will be made based on the final results gotten from the experimental exercises which has initially been carried out in the laboratory, graphs will also be plotted to efficiently prove the real relevance and effect of the experimental exercise.

FLEXURAL STRENGTH (Ft), COMPRESSIVE STRENGTH (Fcu) AND WATER ABSORPTION RATE (WAR)

Below are the tables showing the results gotten from the flexural tensile strength (Ft) test, water absorption rate (WAR) and compressive strength (Fcu) test carried out on both the concrete cubes and beam samples for the curing ages ranging from seven (7) to twenty-eight (28) days. The graphs of all the results are plotted against each replacement percentages in order to note the strength progress for each structural component modelled from each replacement percentages by the curing days.

TABLE 4.1 COMPRESSIVE STRENGTH (Fcu) AND FLEXURAL TENSILE STRENGTH (Ft) TEST RESULT FOR SEVEN (7) DAYS

FOR CONCRETE CUBES

REPLACEMENT PRECENTAGES	AGE (DAYS)	WEIGTH (kg)	WEIGTH 2 (kg)	DENSITY (kg/m^3)	CRUSHED LOAD (kN)	Fcu (N/mm^2)		WAR
0%	7	2.41	2.690	2690	133	13.0		0.28
0%	7	2.45	2.72	2720	121	12.0		0.27
0%	7	2.51	2.79	2790	136	11.0		0.28
20%	7	2.223	2.530	2530	54	5.0		0.307
20%	7	2.34	2.62	2620	77	7.0		0.28
20%	7	2.38	2.74	2740	69	6.0		0.36
40%	7	2.51	2.830	2830	95	9.0		0.32
40%	7	2.46	2.91	2910	102	10.0		0.45
40%	7	2.58	2.76	2760	113	11.0		0.18
60%	7	2.14	2.350	2350	112	11.0		0.21
60%	7	2.20	2.47	2470	123	12.0		0.27
60%	7	2.26	2.51	2510	135	13.0		0.25

FOR CONCRETE BEAMS

REPLACEMENT PRECENTAGES	AGE (DAYS)	WEIGTH (kg)	WEIGTH 2 (kg)	DENSITY (kg/m^3)	CRUSHED LOAD (kN)	Ft (N/mm^2)		WAR
0%	7	9.82	10.79	168.59	23	5.0		0.97
0%	7	10.04	10.86	170.16	26	6.0		0.82
0%	7	10.32	10.91	170.47	27	8.0		0.59
20%	7	9.77	10.42	162.81	22	5.0		0.65
20%	7	9.89	10.46	163.44	28	9.0		0.57
20%	7	9.95	10.61	165.78	24	5.0		0.66
40%	7	9.12	9.36	146.25	20	4.0		0.24
40%	7	9.23	9.49	148.28	22	4.0		0.26
40%	7	9.30	9.55	149.22	27	7.0		0.25
60%	7	10.14	10.45	163.28	18	3.0		0.31
60%	7	10.22	10.62	165.94	19	3.0		0.40
60%	7	10.02	10.39	162.34	21	4.0		0.37

TABLE 4.2 COMPRESSIVE STRENGTH (Fcu) AND FLEXURAL TENSILE STRENGTH (Ft) TEST RESULT FOR FOURTEEN (14) DAYS

FOR CONCRETE CUBES

REPLACEMENT PERCENTAGES	AGE (DAYS)	WEIGTH (Kg)	WEIGTH 2 (Kg)	DENSITY (Kg/m^3)	CRUSHED LOAD (kN)	Fcu (N/mm^2)		WAR
0%	14	2.31	2.55	2550	63	6.0		0.24
0%	14	2.12	2.64	2640	78	7.0		0.52
0%	14	2.26	2.45	2450	75	7.0		0.19
20%	14	2.24	2.68	2680	89	17.0		0.44
20%	14	2.36	2.76	2760	93	18.0		0.40
20%	14	2.41	2.89	2890	81	16.0		0.48
40%	14	2.15	2.54	2540	51	10.0		0.39
40%	14	2.21	2.67	2670	59	10.0		0.46
40%	14	2.34	2.94	2940	63	11.0		0.60
60%	14	2.53	2.74	2740	64	12.0		0.21
60%	14	2.26	2.73	2730	71	13.0		0.47
60%	14	2.64	2.99	2990	63	12.0		0.35

FOR CONCRETE BEAMS

REPLACEMENT PRECENTAGES	AGE (DAYS)	WEIGTH (kg)	WEIGTH 2 (kg)	DENSITY (kg/m^3)	CRUSHED LOAD (kN)	Ft (N/mm^2)		WAR
0%	14	9.69	10.20	159.38	44	4.0		0.60
0%	14	9.76	10.45	163.28	48	4.0		0.69
0%	14	9.83	10.58	165.31	54	5.0		0.75
20%	14	11.17	12.02	187.81	65	6.0		0.85
20%	14	10.86	11.68	182.50	74	7.0		0.82
20%	14	10.79	11.32	176.88	71	7.0		0.53
40%	14	9.84	10.69	167.03	76	7.0		0.85
40%	14	9.99	10.87	169.84	81	8.0		0.88
40%	14	10.12	10.79	168.59	72	7.0		0.67
60%	14	9.73	10.69	167.03	37	3.0		0.96
60%	14	10.22	10.71	167.34	45	4.0		0.49

60%	14	9.87	10.69	167.03	39	3.0		0.82

TABLE 4.3 COMPRESSIVE STRENGTH (Fcu) AND FLEXURAL TENSILE STRENGTH (Ft) TEST RESULT FOR TWENTY-EIGTH (28) DAYS

FOR CONCRETE CUBES

REPLACEMENT PERCENTAGES	AGE (DAYS)	WEIGTH (Kg)	WEIGTH 2 (Kg)	DENSITY (Kg/m^3)	CRUSHED LOAD (kN)	Fcu (N/mm^2)		WAR
0%	28	2.31	2.70	2700	151	15.0		0.39
0%	28	2.29	2.67	2670	145	14.0		0.38
0%	28	2.27	2.78	2780	160	16.0		0.51
20%	28	2.45	2.64	2640	106	10.0		0.19
20%	28	2.41	2.73	2730	112	11.0		0.32
20%	28	2.36	2.81	2810	124	12.0		0.45
40%	28	2.20	2.33	2330	95	9.0		0.13
40%	28	2.34	2.56	2560	97	9.0		0.22
40%	28	2.46	2.63	2630	104	10.0		0.17
60%	28	2.16	2.24	2240	78	7.0		0.08
60%	28	2.22	2.61	2610	84	8.0		0.39
60%	28	2.40	2.56	2560	82	8.0		0.16

FOR CONCRETE BEAMS

REPLACEMENT PRECENTAGES	AGE (DAYS)	WEIGTH (kg)	WEIGTH 2 (kg)	DENSITY (kg/m^3)	CRUSHED LOAD (kN)	Ft (N/mm^2)		WAR
0%	28	10.77	11.06	172.81	56	11.0		0.29
0%	28	10.63	11.16	174.38	65	12.0		0.53
0%	28	10.81	11.02	172.19	61	12.0		0.21
20%	28	10.23	10.67	166.72	36	7.0		0.44
20%	28	10.31	10.69	167.03	44	9.0		0.38
20%	28	10.43	10.73	167.66	45	9.0		0.30
40%	28	10.68	11.00	171.88	40	8.0		0.32
40%	28	10.55	10.89	170.16	38	6.0		0.34
40%	28	10.61	11.14	174.06	49	7.0		0.53
60%	28	10.02	10.59	165.47	31	6.0		0.57
60%	28	10.11	10.67	166.72	35	6.0		0.56
60%	28	10.25	10.60	165.63	40	7.0		0.35

RECOMMENDATION

The following are my recommendations after the above tests were carried out:

1. All materials if to be used in the future for building constructions should be used well with the right mix ratio as well as the right replacement percentage(s)
2. Tests should be carried out before the use on a building construction to avoid building collapse and maybe loss of lives
3. All building construction materials like sand, cement, aggregates, reinforcement bars and particularly the partial replacement aggreagate to be used for structural components such as beams, columns and slabs should be properly tested before commencement of any construction
4. Government should exercise leadership in protecting and enhancing the quality of all the buildins by encouraging and enforcing regular maintenance so as to protect human life and properties
5. Government should quickly enforce a National Building Regulation for the elimination or considerable reduction of the unwanted and continuous collapse of buildings in Nigeria and quick response committee for investigating incidents of building collapsed should be formed.

CONCLUSION

In conclusion, the conducted study was able to identify the various curing ages with different foundry sand replacement percentages in the concrete cubes and beams and the tests carried out shows the varying strength in each of the cubes and beams tested along with a tabular format drawn to showing the different tests and their effect on each tested cubes.

It is therefore advised to carefully choose the best mix ratio and replacement percentage(s) if the partial replacement material (foundry sand) is to used in building constructions in the near future to avoid critical damage to the environment and loss of lives if the required replacement percentage is not used. As seen over the years in previous cases where the wrong mix ratio was used, the effect and results of that wrong mix use should be avoided by all means.

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