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AN EXPERIMENTAL STUDY ON STRENGTH AND DURABILITY CHARACTERISTICS OF HIGH STRENGTH CONCRETE MADE WITH PARTIAL REPLACEMENT OF CAST- OFF AGGREGATE

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Abstract:
Investigate on the convention of waste production materials is extremely significant due to the equipment waste is steadily growing with the improved of residents and increasing of town development. Virgin aggregate need to mine but cast-off aggregate can ignore this process.
Whenever cast off aggregate is applied, water content in the concrete mix has to be monitored carefully due to the water absorption capacity of cast off aggregate will vary.
The study was carried out in two parts one is fresh and mechanical property of concrete and second one includes durability of concrete. In first part includes workability test, compressive test, direct tensile test, flexural strength and modulus of flexibility test. In the second part includes RCPT and Sorpitivity test.
There were total of six batches of concrete mixes, consists of each 10% increase of cast-off aggregate substitute from 0% to 50. Based on the fresh concrete property results it was concluded that the workability of concrete significantly reduced as the amount of cast off aggregate increased. This was evaluated during normal slump test and compacting factor test Based on the observations and experimental work it was concluded that although the values of strength results of cast - off aggregate is lower than the natural aggregate, they are still within the useable range and by limiting the replacement ratio, the desirable strength can be easily obtained using cast - off aggregate concrete also.

Key Words: Cast off Aggregates, OPC 53grade, sulphate assault, chloride assault, various tests.

Introduction:

Construction aggregates make up more than 80 percent of the total aggregate market and are used mainly for building constructions and pavements. With the construction activities increasing tremendously, and we falling short of construction aggregates it has become necessary to find an alternate source for the material. Projections for building material requirement of the housing sector indicate a shortage of aggregates to the extent of about 55,000 million cu. m. An additional 750 million cu. m aggregates would be required for achieving the targets of the road sector.
At this stage the concept of using cast - off aggregate has proved to be a good alternative. When structures made of concrete are demolished or renovated, concrete recycling is an increasingly common method of utilizing the rubble.
Research has going on long time, more than 30 years, to exploit the use of cast - off materials as construction and demolition waste in new construction materials as e.g. in concrete. For instance, designers do not know what proportion of cast – off aggregate should be specified in different concrete grades.
The use of cast - off construction rubble as aggregate for concrete is not a new idea. The first large scale use of demolition rubble as aggregate occurred after the second world war. At that time there was a lot of rebuilding in Germany, and large amounts of demolition rubble lying around in the form of bombed and shelled buildings, which needed to be cleaned up. This naturally led to the rubble being used as aggregate in the rebuilding process. In 1951, a German Standard, DIN 4163, „Concrete made with broken brick. Specification for production and use‟, was published. This indicates that there was enough recycling of rubble into concrete to necessitate some level of control over its production.
A review of overseas literature carried out as part of this project, shows that research into using cast - off concrete rubble as aggregate for new concrete began in earnest in the mid to late 1970‟s. Work was carried out in both North America and Europe. The main reasons generally given for carrying out the research were
A shortage of readily available, high grade conventional aggregates. Environmental concerns, including lack of landfill sites for disposal of demolition rubble, and the environmental impact of transporting conventional aggregates greater and greater distances Economic concerns, which parallel the environmental concerns. As aggregate supplies and rubble disposal sites become scarcer, the cost of these services increases, making recycling a cost-effective option.

Review of literature:

Strength characteristics of concrete with recycled aggregate by ***N.K. Deshpande Dr.S.S. Kulkarni and H.Pachpande***
The objective of the subject is to utilize recycled aggregates in concrete, using IS 10262:2009 for designing the concrete with grade M25. A comparison with control mix mainly their compressive strength, split tensile strength and flexural strength will allow assessing the suitability of using recycled aggregate in concrete was studied.

Experimental study on recycled aggregate concrete by ***G. Mural Gabriela Rajang, G.J. Janaki, N. Shift Jajan2 and R. Ramie sir.***

The objective of the subject is that the use of recycled aggregate weakens the quality of recycled aggregate concrete which limits its application. Strength properties of the treated and untreated coarse aggregate were compared. The results indicated that the compressive, flexure and split tensile strength of recycle aggregate is found to be less than the natural aggregate.

Recycled Aggregate Characterization by ***D. N. Parekh and Dr. C. D. Modhera.***
This paper reports the basic properties of recycled fine aggregate and recycled course aggregate. It also compares these properties with natural aggregates. Basic changes in all aggregate properties were determined and their effects on concreting work were discussed at length. Similarly, the properties of recycled aggregate concrete were also determined and explained here. Basic concrete properties like compressive strength, flexural strength, workability etc. are explained here for different combinations of recycled aggregate with natural aggregate. Use of recycled aggregate has been found useful for pavement construction. Reasons, of use of recycled aggregate concrete in pavement construction, with technical proofs are explained here in detail. Individual performance of recycled fine aggregate in concrete, use of silica fumes in recycled aggregate concrete, use of fly ash in recycled aggregate concrete etc. are shown with experimental reasons.

A techno-economical study on recycled aggregate concrete by ***Prof. Chetna M Vyas and Prof. Dr. Darshana R Bhatt.***

The main aim of this thesis is to determine the characteristic strength of recycled aggregates will gives a better understanding on the properties of concrete with recycled aggregates, as an alternative material to coarse aggregate in structural concrete by cost. The scope of this project is to determine and compare the strength and cost of concrete by using different percentage of recycled aggregates. strength at There were total of six

Objective:

To study the material properties of cast-off aggregates To set up the blend for M60 grade cement and locate the most extreme conceivable swap proportion for this evaluation according to IS code

- To assess the quality properties like compressive quality, split elasticity and flexural quality of reused total cement
- To assess the strength properties like water assimilation, sulfate assault, chloride assault, corrosive assault of reused total cement

Materials Used:

1 .Portland cement i.e. 53 grade
2. Fine aggregate i.e. sand
3. Coarse aggregate i.e. recycled aggregate
4. Water.

Cement:

Cement is a material, generally in powder form, that can be made into a paste usually by the addition of water and, when melded or poured, will set into a solid mass. The colour of the cement is iron oxide. In the absence of impurities, the colour would be white, but neither the colour nor the specific gravity is a test of quality.

Fine Aggregate or sand

Fine aggregate / sand is grains of mineral matter obtained from the disintegration of rocks. It is from gravel only by the size of the grains or particles but is distinct from clays which contain organic materials. Sands that have been sorted out and separated from the organic material by the action of currents of water Much of the earth"s surface is sandy, and these sands are usually quartz and other siliceous materials. The most using fine aggregates are silica sands, often above 98% pure. Beach sands usually have smooth, spherical to overload particles from the abrasive action of waves and tides and are free of organic matter.

Sand is sold by the cubic yard (0.76 m3) or ton (0.91 metric ton) but is always shipped by weight.

Standard sand is a silica sand used in making concrete and cement tests. The fine aggregate obtained from river bed of Keel, clear from all sorts of organic impurities was used in this experimental program.

Coarse Aggregate:

Coarse aggregate is the crushed stone it is used to making concrete. The parentl stone is quarried, crushed, and graded. generally the crushed stone used is granite, limestone, and trap rock. The last is a term used to designate basalt, gabbro, diorite, and other dark- collared, fine-grained igneous rocks. Graded crushed stone usually consists of sharp edges broken rock. The sizes are from 0.25 to 2.5 in (0.64 to 6.35 cm), although larger sizes may be used for massive concrete aggregate. crushed granite broken angular shaped was used as coarse aggregate. The maximum size of coarse aggregate was 20 mm and specific gravity of 2.78. the parenet granite and igneous rock has even texture and consisting largely of quartz and feldspar with often small amounts of mica and other minerals. There are many varieties. Granite is hard and compact, and it takes a fine polish, showing the beauty of the crystals. Granite is the important building stone. Granite is extremely durable, and since it does not absorb moisture, as limestone and sandstone do, it does not weather or crack as these stones do. The colour of the course aggregate is reddish, greenish, or gravy. granite may have a black or dark-green background with pink, yellowish, and reddish.The density is 2,723 kg/m3, the specific gravity 2.72, and the crushing strength 158 to 220 MPa.

Water:

Water should be free from acids, oils, alkalis, vegetables or other organic Impurities. Soft waters also produce weaker concrete. Water has two functions in a concrete mix. water reacts chemically with the cement to form a cement paste in which the inert aggregates are Secondly, it acts as a lubricant in the mixture of fine aggregates and cement.

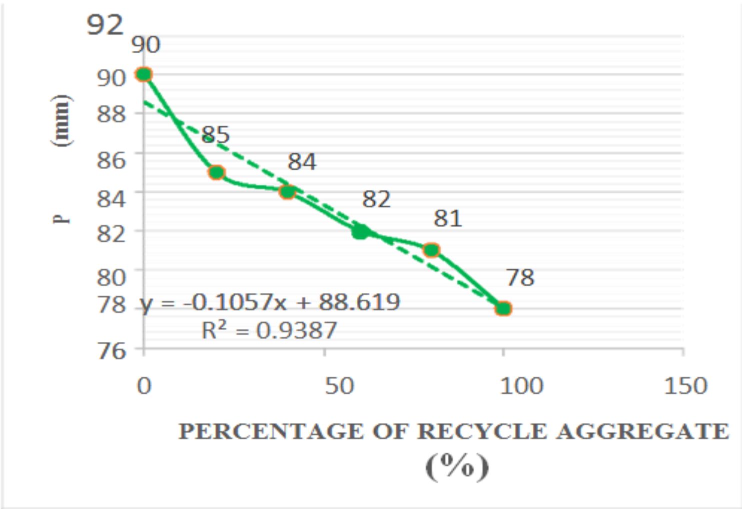
TESTS RESULTS AND ANALYSIS:

SLUMP TEST RESULT AND ANALYSIS

The slump test indicates a falling movement of workability when the proportion of cast-off aggregate enlarged. Table 5.1 below shows the average slump recorded during the test.

Table:The slump result for each batch of mix concrete

Percentage of Cast off Aggregate (%)	**Slump (mm)**
0% cast off aggregate	89
10% cast off aggregate	84
20% cast off aggregate	83
30% cast off aggregate	81
40% cast off aggregate	80
50% cast off aggregate	78



Fig; Graphical demonstration of slump altitude.

The average slumps that obtained for 50% cast off aggregate was 78 mm.

COMPACTING FACTOR TEST:
when the percentage of cast off aggregate increased.

Table:The compacting factor ratio for each of mix concrete

Percentage Cast off Aggregate (%)	Partially Compacted	Fully Compacted	Compacting Factor Ratio
0% cast off aggregate	25.06	25.08	1.000
10% cast off aggregate	24.30	24.44	0.998
20% cast off aggregate	25.52	25.70	0.997
30% cast off	25.19	25.31	0.995

Aggregate	50% cast off aggregate	23.76	24.53	0.969
	40% cast off aggregate	24.64	24.96	0.987

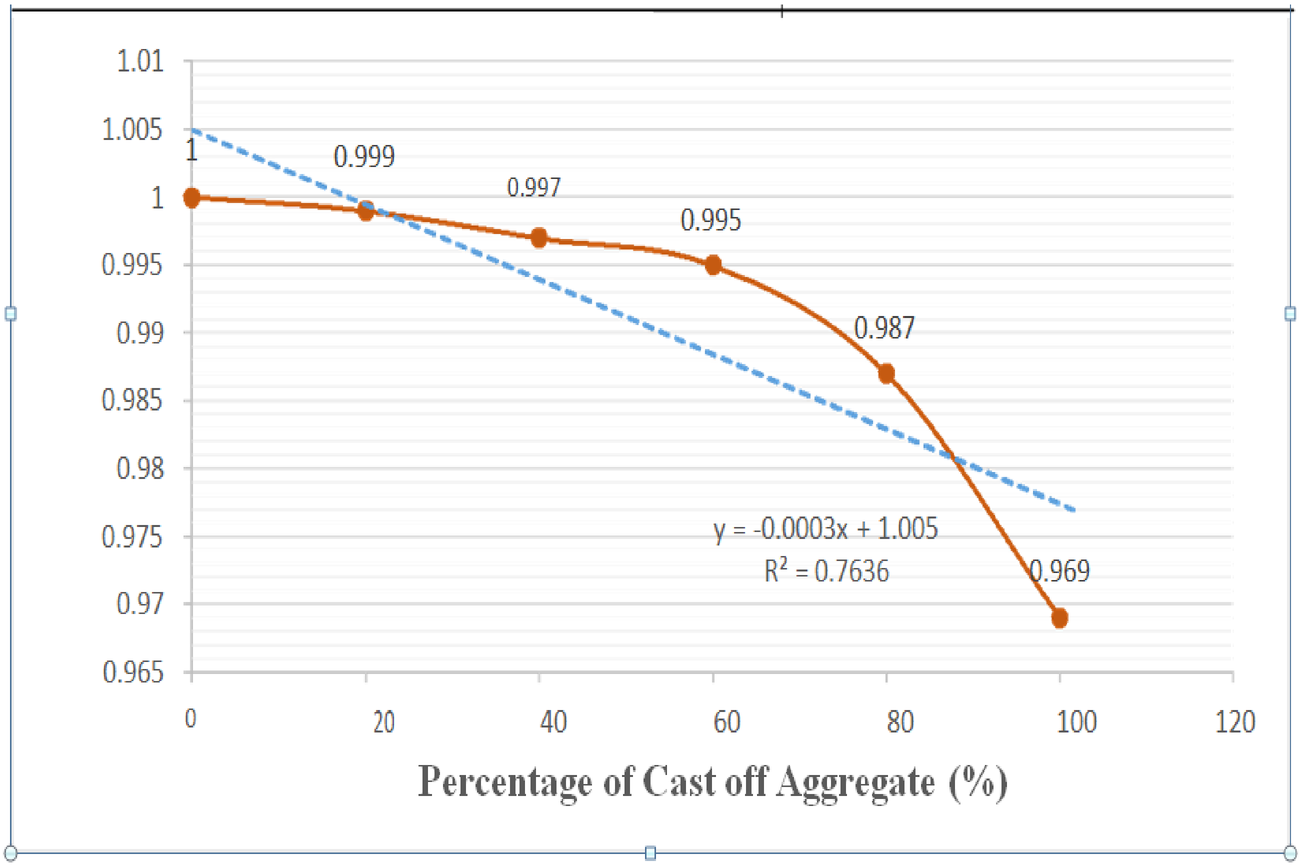


Figure: Graph showing the result of Compacting Factor Ratio

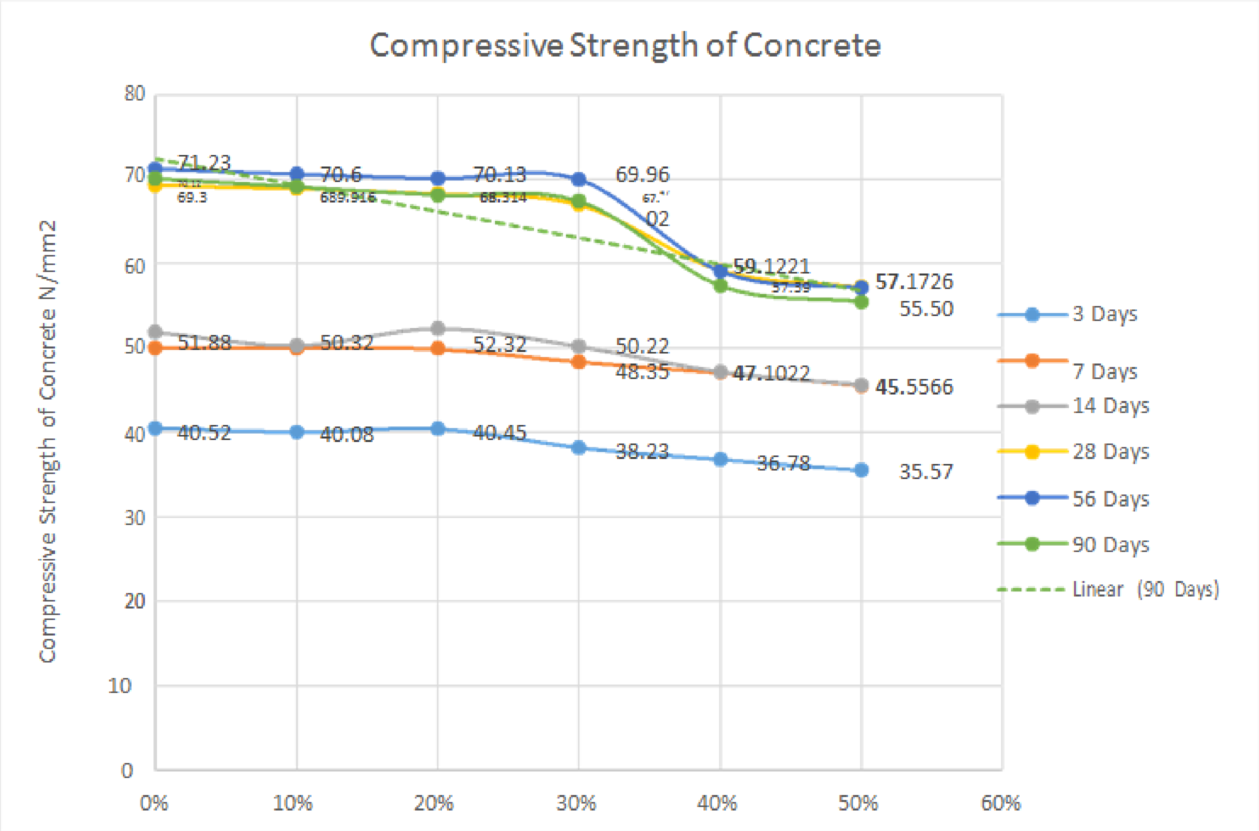
From the result obtained, we can say that the workability is getting lower due to the increasing of cast off aggregate used.

COMPRESSION TEST:

The below figures gives a comparison of compressive strength developed with age for different replacement ratios of cast - off aggregate concrete. It can be concluded from the graph that for both natural aggregate concrete and cast - off aggregate concrete the compressive strength progressively increases with age of concrete as seen in the graph.

Also, it can be seen that the strength development in cast - off aggregate concrete is less than that of natural aggregate concrete at all age and the reduction in strength increases with increase in the replacement of natural aggregate by cast - off aggregate.

From the graphs and test results it can also be concluded that though with increase in replacement of natural aggregates there is a decrease in the strength development, replacement up to 30% by cast - off aggregates is found to be usable as it crosses the target strength of 67MPa at 28 days,56 days and 96 days.



	0%	10%	20%	30%	40%	50%
3 Days	40.52	40.08	40.45	38.23	36.78	35.57
7 Days	49.99	49.95	49.93	48.35	47.10	45.55
14 Days	51.88	50.32	52.32	50.22	47.22	45.66
28 Days	69.30	68.90	68.30	67.02	59.21	57.26
56 Days	71.23	70.60	70.13	69.96	59.12	57.17
90 Days	70.12	69.16	68.14	67.47	57.39	55.50

Figure: 28-day compressive strength developed with age for different replacement ratios of cast - off aggregate concrete

SPLIT TENSILE STRENGTH RESULT AND ANALYSIS:

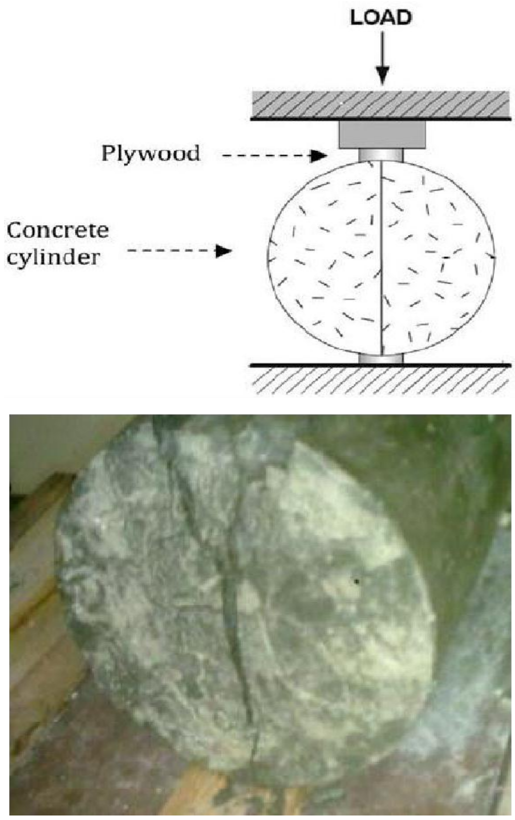


Figure: Specimen after being subjected to split tensile strength

The results of the split tensile strength test are given below and the conclusions drawn from the test are explained by the graphs.

From the below table& figure it can be concluded that the split tensile strength for both natural and cast - off aggregate concrete increases with age. The maximum strength achieved is of that for natural aggregate concrete being 3.15 N/mm^2. The maximum tensile strength developed in cast - off aggregate concrete is for 10% replacement cast - off aggregate concrete with strength of 3.09 N/mm^2. The least strength developed is that for 50% replacement cast - off aggregate concrete having strength of 2.39N/mm^2.

Table: Split tensile strength results of concrete

S. No	Percentage Replacement	7 Days Split Tensile Strength	28 Days Split Tensile Strength
1	0	3.21	5.59
2	10	3.09	5.19
3	20	2.89	4.79
4	30	2.61	4.37
5	40	2.41	4.09
6	50	2.39	4.07

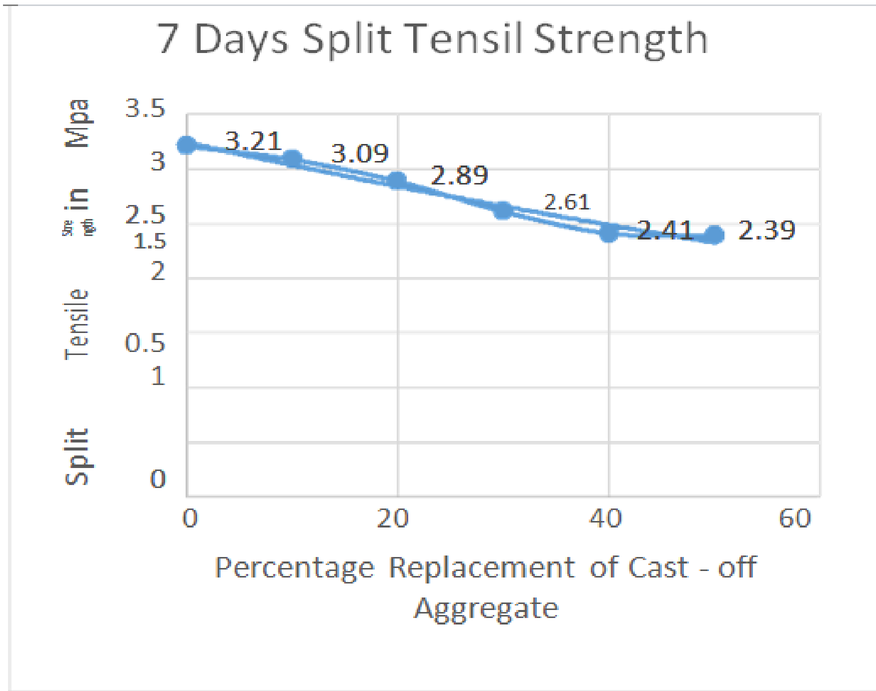


Figure: 7 day split tensile strength on concrete

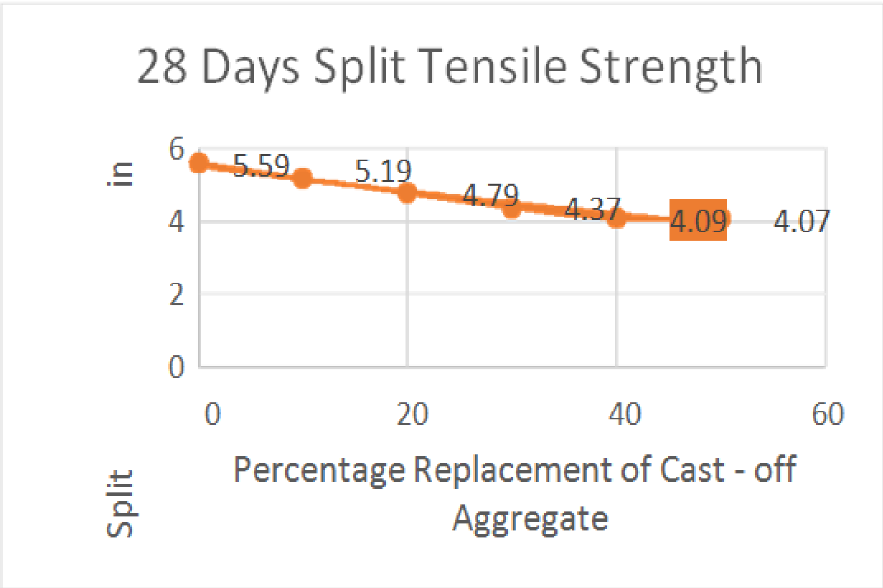
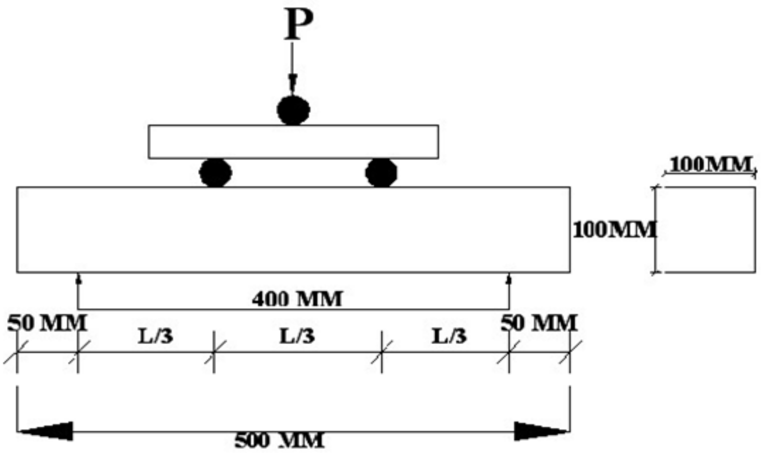


Figure: 28day split tensile strength on concrete

From the above figure it can be concluded that the split tensile strength increases with age for both the type of concrete but the maximum strength developed is for that of natural aggregate with a strength development of 5.59 N/mm^2. The maximum developed tensile strength for cast - off aggregate concrete is for that of 10% replacement being 5.19 N/mm^2 and the least tensile strength developed is of that with 50% replacement with strength of 4.07N/mm^2

FLEXURE TEST RESULTS:

The flexure test indicates a decreasing trend of flexure strength when the percentage of cast - off aggregate is increased.

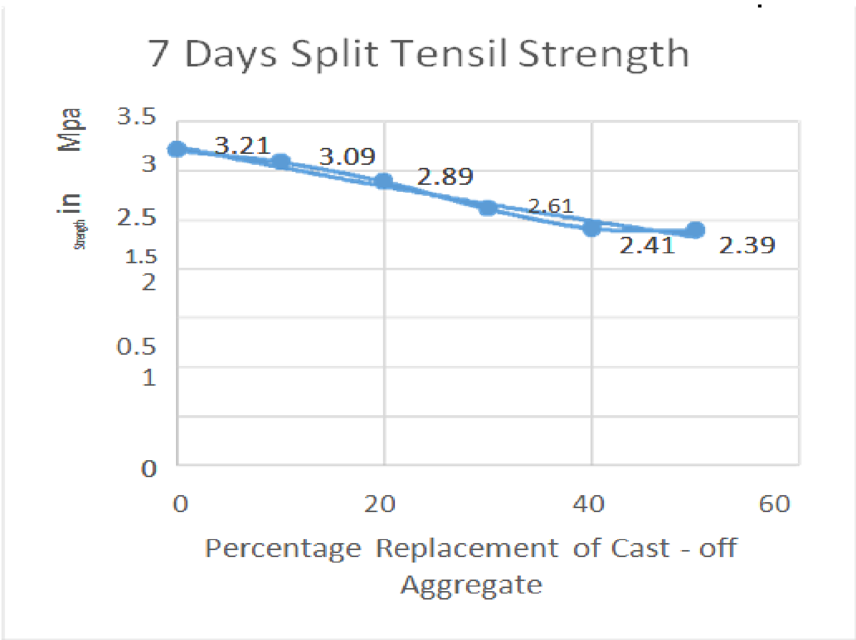


TWO POINT LOADING SETUP IN FLEXURE TEST

Figure: Specimen subjected to flexure test

Table: Flexure test results on concrete

S. No	% of Cast – off Aggregate	No of Divisions	Flexure Strength (N/Mm^2)
1	0	348	4.83
2	10	336	4.69
3	20	330	4.59
4	30	280	3.90
5	40	252	3.49
6	50	248	3.32



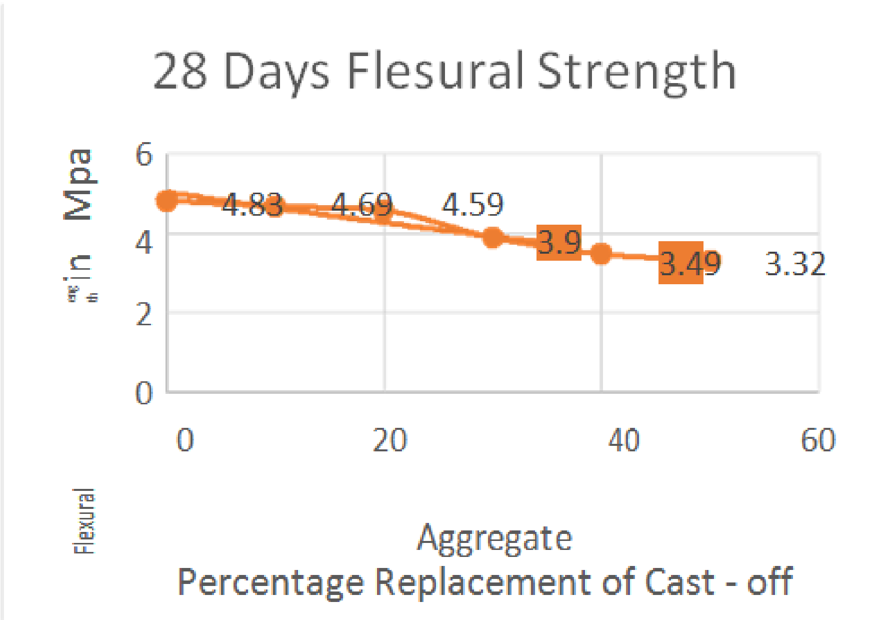


Figure: 28-day flexure strength of concrete

Flexure strength results from the above figure shows similar trend as that of compressive strength and split tensile strength. With increase in replacement of cast - off aggregates the strength gained reduces. Maximum strength developed is for natural aggregate concrete with strength of 4.83 N/mm^2. The maximum flexural strength developed in cast - off aggregate concrete is again for a replacement of 10% being 4.69 N/mm^2 and the least strength developed is with 40% replacement being 3.32N/mm^2.

MODULUS OF ELASTICITY TEST:

Modulus of elasticity test indicates a decreasing modulus of elasticity value when the percentage of cast off aggregate increased.

Table: The results obtained from different percentage of cast off aggregate replacement.

S. No	Percentage of cast off aggregate	Modulus of elasticity (MPa)
1	0%	44303
2	10%	42413
3	20%	41435
4	30%	39256
5	40%	38956
6	50%	37928

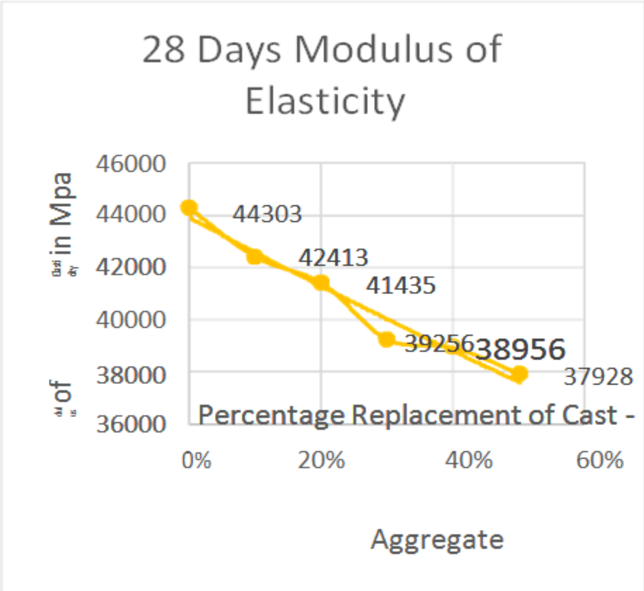


Figure: Variation of Modulus of Elasticity

Figure indicate shows the variation of modulus of elasticity of concrete specimens with the increasing of 10% of cast off aggregate. It shows a decreasing trend occurs when the percentage of cast off aggregate increasing. Consequently, specimens made with cast off aggregate have less modulus of elasticity value than the specimens made with all-natural aggregate.

From the experimental results, the modulus of elasticity of full natural aggregate specimens was 44303 MPa, while the modulus of elasticity of 50% cast off aggregate specimens was 37928 MPa. It indicates a drop of 6375 MPa,

DURABLE PROPERTIES:

RAPID CHLORIDE PERMEABLITY TEST:

Table shows that results of this experiment in this experiment the chloride passes through the concrete sample which taken at the curing periods 28 days, this passing chloride shows that the permeability of the concrete, the charge passed through coulombs values are taken from the equipment display, and this value are compared with the standard values which are mentioned by ASTM C1202.
As observed the highest charge passed through the sample which is replacement with cast - off aggregates 50% (3645), and the lowest value passed through the sample which is replaced by the cast - off aggregates with 30% (2011). Finally, all values are shown that moderate values when compared with the table according to ASTM C1202

SORPITIVITY:

Table shows that the results of the sorptivity experiment, as the results the values of sorptivity it is reported that the values of sorptivity of the concrete is highest at the replacement of the cast - off aggregates 20% and the water absorption rate is also observed as the more, and lowest value reported at the replacement of cast - off aggregates 30%.

The values of sorptivity and water absorption is same as normal conventional concrete at the replacement levels of copper slag are RS 10% and RS 30%

Table: RCPT VALUES OF CONCRETE

Specimen Designation	Charge Passed Through in Coulombs (C)	Chloride Permeability Results as Per ASTM C 1202
RA 0%	2100	**MODERATE**
RA 10%	2287	**MODERATE**
RA 20%	2564	**MODERATE**
RA 30%	2675	**MODERATE**
RA 40%	2928	**MODERATE**
RA 50%	3245	**HIGH**

TABLE 5.8 SORPITIVITY VALUES

Specimen Designation	Sorptivity Value ($x 10^{-6}$) mm/ $min^{0.5}$	Absorption Rate I = S.t ½ mm
RA 0%	4.50	101.62
RA 10%	4.60	100.14
RA 20%	5.36	111.23
RA 30%	4.55	124.20
RA 40%	6.28	125.61
RA 50%	7.28	132.61

CONCLUSIONS:

Based on experimental investigation the following conclusions are drawn:

- ✓ average slumps that obtained for 50% cast-off aggregate was 78mm.
- ✓ The highest compacting ratio is 1.00 at 0% and average compacting ratio between 0% and 80% cast off aggregate is 0.996.
- ✓ The The compressive strength of 50% cast - off aggregate concrete is 17.05 % lower than that of natural aggregate concrete while that of 10% cast - off aggregate concrete is just 0.58 % lower than that of natural aggregate concrete.
- ✓ The maximum compressive strength obtained at 0% is 69.30N/mm2 for 28 days.
- ✓ Replacement up to 30% by cast-off aggregate is found to be usable as it crosses the target strength of 67Mpa at 28 days, 56 days and 96 days.
- ✓ The same above conclusions follow for split tensile strength and flexural strength of concrete.
- ✓ Hence from the strength results, 30% replacement is considered as optimum and two sets of cubes- one of natural aggregate and other of 30% replacement cast - off aggregate were casted for durability tests for a period of 28 days.
- ✓ In case of water absorption, the cast - off aggregate exhibit higher water absorption values as compared to natural aggregate. This is due to the presence of attached mortar present in the aggregates. The greater is the attached mortar, the more is the water absorption in the concrete.

From the above observations it can be concluded that although the values of strength results of cast - off aggre gate is lower than the natural aggregate, they are still within the useable range and by limiting the replacement ratio, the desirable strength can be easily obtained using cast - off aggregate concrete also

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