EXPERIMENTAL INVESTIGATION ON CONCRETE WITH DIFFERENT WASTE STONE AGGREGATE AS A REPLACEMENT OF COARSE AGGREGATE

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Abstract: Booming construction activities impose heavy demand on the construction material especially on the components of concrete. Advancements in technology get better not only human comforts but also harm the environment. Use of waste stone as an aggregate in construction industry has become popular and safe now. At present construction industry is in need of finding cost effective material to enhance the strength of concrete. The effect of natural stone aggregate (NSA), Shabath stone aggregate (SSA), granite stone aggregate (GSA) and ceramic tile stone aggregate (TSA) were investigated. Experimental investigation was done using M30 mix and tests were carried out as per recommended procedures by relevant codes. The compressive strength, split tensile strength, flexural strength and durability of concrete has been studied in this research.

As a construction material, concrete is not considered to be environment friendly due to its unpleasant effects on the environment. However, it remains to be a most commonly used construction material. This creature the current situation, the concrete industry has to conform to sustainable development, predicting the future of concrete and developing essential strategies concerning this issue. For instance, better durability and more efficient use of concrete should be aimed at. Indeed, today, aggregates make up nearly 50 to 80% of concrete volume. Put differently, if the concrete industry fails to utilize substitute aggregates in the future, around 8 to 12 billion tons of natural aggregates will be addicted as of year 2010. The main aim of this experimental work is to study the experimental investigation on concrete with different waste stone aggregate as a partial replacement of coarse aggregate in comparison with the physical and mechanical characteristics of normal aggregates and different waste stone aggregates. The experimental investigation has been carried out to study the effects on compressive strength, split tensile strength and flexural strength on concrete. The obtained results is been compared with strength and durability of different waste stone concrete and it is been tabulated.

General

Concrete is a manufactured product, essentially consisting of cement, aggregates, water and admixture(s). Among these, aggregates, i.e. inert granular materials such as sand, crushed stone or gravel form the major part. Traditionally aggregates have been readily available at economic price. However, in recent years the wisdom of our continued wholesale extraction and use of aggregates from natural resources has been questioned at an international level. This is mainly because of the depletion of quality primary aggregates and greater awareness of environmental protection.

The Indian construction industry consumes about 400 million tons (MT) of concrete every year and it is expected that this may reach a billion ton in less than a decade. All the materials required to produce such huge quantities of concrete come from the earth's crust, thus deflecting its resources every year creating ecological strains. On the other hand human activities on earth produce solid wastes in considerable quantities to the extent of over 2500 MT per year, including industrial wastes, agricultural wastes and wastes from rural and urban societies. Recent technological development has shown that these materials are valuable inorganic and organic resources and can produce various useful products. Amongst the solid wastes, the most prominent are fly ash; blast furnace slag, rice husk ash, and silica fume and demolished construction waste stone materials. During the 20th century there was an increase in the consumption of mineral admixtures by the cement and concrete industries. This increasing demand for cement and concrete is met by partial cement replacement. Substantial energy and cost saving can result when industrial by – products are used as a partial replacement for the energy intense Portland cement. The current cement production rate of the world, which is approximately 1.2 billion tons per year, is expected to grow exponentially to about 3.5 billion tons per year by 2015. Most of the increase in cement demand will be met by the use of supplementary cementing materials, as each ton of Portland cement clinker production is associated with a similar amount of CO2 emission. Under service conditions, concretes are subjected to different stresses depending upon their location and usage. Depending upon the exposure conditions, the durability of the exposed concrete is determined and the service life is defined accordingly. The term High Performance Concrete (HPC) is not universally defined and it has different definitions given by different authorities. The American concrete institute defines high performance concrete as "concrete that meets special performance and uniformity requirement that cannot always be obtained by using conventional ingredients, normal mixing procedure and typical curing practices". These requirements may include the following enhancements like ease of placement and consolidation without affecting strength, long term mechanical properties, high early strength, toughness, volume stability and longer life in severe environment. To summaries, high performance concretes should have at least one outstanding property, viz, compressive strength, workability, enhanced resistance to chemical or mechanical stresses, lower permeability, durability etc. high performance concrete has been used in various structures all over world since last two decades. In India, high performance concrete is about a decade old with major applications in construction work at nuclear power plants. Recently a few infrastructure projects have also seen specific application of high performance concrete. The development of high performance concrete has brought about the essential need for admixtures, both chemical and mineral, to improve the performance of concrete.

Properties of concrete:

Concrete is a composite construction material composed primarily of aggregate, cement and water. There are many formulations that have varied properties. The aggregate is generally coarse gravel or crushed rocks such as limestone, or granite, along with a fine aggregate such as sand. The cement, commonly Portland cement, and other cementations materials such as fly ash and slag cement, serve as a binder for the aggregate. Various chemical admixtures are also added to achieve varied properties.

Chemical properties of different waste stone aggregates

CONSTITUENT	SHABATH COMPOSITION (%)	GRANITE COMPOSITION (%)	CERAMIC TILE COMPOSITION (%)
Aluminum Oxide	1 – 5	1 – 8	1 – 3
Calcium Oxide	40 - 52	49 - 61	38 - 48
Iron Oxide	10 – 13	14 – 19	8– 11
Magnesium Oxide	5 - 10	8 - 14	3 - 7
Manganese Oxide	6 – 9	8 – 12	4 – 6
Phosphorus Oxide	0.5 – 1	0.7 – 1.1	0.3 – 1
Silica	24 - 28	70 - 75	22 - 24

Objectives and Scope of work

The main objective of this study is to use the different waste stone aggregate in concrete. The construction industry is already facing a scarcity of materials, from natural resources, such as sand and stone aggregate, and most of the source materials such as cement are highly energy intensive. Therefore the utilization of waste materials will go a long way in promoting sustainable development of the construction industry. So avoid the situation, the less load bearing structure can be constructed with help of waste stone aggregate. Thus there is the dual advantage of safe disposal of the waste as well as their effective utilization for the sustainable development of the construction industry.

Scope of work

To study the properties of concrete with partial replacing of different waste stone aggregate on concrete.

a) To investigate the flexural strength, cracking & deflection of Specimen.
b) To develop mixes for reference concrete and assess its properties in hardened state.
c) To utilization of different waste stone aggregate in concrete.
d) To experimentally establish full physical characterization of waste stone aggregate in comparison with coarse aggregate.
e) To determine the mechanical properties of concrete using with different waste stone aggregate.
f) To compare the strength behavior of waste stone aggregate with reference concrete.
g) To study the durability testing on concrete specimen.
h) The material is easily available and it is an eco friendly.
i) The cost of material is cheaper than normal coarse aggregate.

Experimental investigations

Processing of different waste stone aggregates

Different waste stone aggregates are Shabath stone aggregates (SSA), Granite stone aggregates (GSA), and Ceramic Tile stone aggregates (TSA) was collected from dismantled buildings. The waste stone aggregates are used as the substitute for coarse aggregate. They have been cut manually using with hand hammer into the required size of aggregates and then sieved

Table: sieve analysis of ceramic tile stone aggregate

SL. NO	SIEVE SIZE IN MM	WEIGHT RETAINED	PERCENTAGE OF WEIGHT RETAINED	CUMULATIVE PERCENTAGE RETAINED	PERCENTAGE OF PASSING
1	20	320	6.4	6.4	93.6
2	10	4440	88.8	95.2	4.8
3	4.75	225	4.5	99.7	0.3
4	Pan	15	0.3	100	0
		5000			98.7

through the batch of broken aggregates into separating of sizes 40mm, 20mm, 12.5mm and 10mm and aggregates retained in 20mmsieves are taken as coarse aggregate conforming to the regarding of IS383-1970[6].

Source of waste :

For the main purpose of different waste stone aggregate concrete in the form of specimens of about 2 tones were obtained. The concrete specimens are of M30 grade with variable strength, behavior and durability of concrete.

Materials used in present work

The materials used in the present experimental investigation are

a. Cement – OPC – 53 grade (ultra tech) conforming to IS12269-1987.
b. Fine aggregate – sand (IS383-1970).
c. Natural stone coarse aggregate (NSA) - 20mm (IS383-1970).
d. Shabath stone aggregate (SSA) - 20mm
e. Granite stone aggregate (GSA) - 20mm
f. Ceramic Tile stone aggregate (TSA) – 20mm
g. Clean portable water conforming to IS 456-2000

Mechanical properties of aggregates

a) Crushing value
b) Impact value

The procedure for conduct of each of the above test and the results of the test are covered in detail in the following sections

Table: sieve analysis of fine aggregate

SL. NO	SIEVE SIZE IN MM	WEIGHT RETAINED(G)	% OF WEIGHT RETAINED(G)	CUMULATIVE PERCENTAGE RETAINED(G)	% OF PASSING(G)
1	4.75	70	3.5	3.5	96.5
2	2.36	160	8	11.5	88.5
3	1.18	755	37.75	49.25	50.75
4	600 µ	540	27.2	76.45	23.55
5	300 µ	330	16.5	92.95	7.05
6	150 µ	95	4.75	97.7	2.3
7	PAN	46	2.3	100	0
		2000			268.25

As per IS 383-1970, the fine aggregate falls under the Zone II.

Fineness modulus = 2.68

Table: sieve analysis of Shabath stone aggregate

SL NO	SIEVE SIZE IN MM	WEIGHT RETAINED(G)	% OF WEIGHT RETAINED(G)	CUMULATIVE PERCENTAGE RETAINED(G)	% OF PASSING(G)
1	20	2525	50.5	50.5	49.5
2	10	2250	45	95.5	4.5
3	4.75	185	3.7	99.2	0.8
4	Pan	40	0.8	100	0
		5000			54.8

Table: sieve analysis of Shabath stone aggregate

SL NO	SIEVE SIZE IN MM	WEIGHT RETAINED(G)	% OF WEIGHT RETAINED(G)	CUMULATIVE PERCENTAGE RETAINED(G)	% OF PASSING(G)
1	20	2525	50.5	50.5	49.5
2	10	2250	45	95.5	4.5
3	4.75	185	3.7	99.2	0.8
4	Pan	40	0.8	100	0
		5000			54.8

Table: sieve analysis of granite stone aggregate

SL NO	SIEVE SIZE IN MM	WEIGHT RETAINED(G)	% OF WEIGHT RETAINED(G)	CUMULATIVE PERCENTAGE RETAINED(G)	% OF PASSING(G)
1	20	85	1.7	1.7	98.3
2	10	3245	64.9	66.6	33.4
3	4.75	680	13.6	80.2	19.8
4	Pan	990	19.8	100	0
		5000			151.5

Table: sieve analysis of ceramic tile stone aggregate

SL NO	SIEVE SIZE IN MM	WEIGHT RETAINED	PERCENTAGE OF WEIGHT RETAINED	CUMULATIVE PERCENTAGE RETAINED	PERCENTAGE OF PASSING
1	20	320	6.4	6.4	93.6
2	10	4440	88.8	95.2	4.8
3	4.75	225	4.5	99.7	0.3
4	Pan	15	0.3	100	0
		5000			98.7

Table: Aggregate impact value

SL NO	CONTENT	COARSE AGGREGATE
1.	Weight of aggregate taken (W_1)g	1005
2	Weight of aggregate left over(W_2)g	366
3	Weight of aggregate in the cup(W_1-W_2)g	639
4	Weight of aggregate passing 12.5mm and retain 10mm (W_3)g	82
5	Aggregate impact value	**12.83%**

Table: Impact value for different waste stone aggregate

SL NO	CONTENT	SHABATH STONE AGGREGATE	GRANITE STONE AGGREGATE	CERAMIC TILE STONE AGGREGATE
1.	Weight of aggregate taken (W_1)g	1004	1006	1001
2	Weight of aggregate left over(W_2)g	382	358	373
3	Weight of aggregate in the cup(W_1-W_2)g	618	648	628
4	Weight of aggregate passing 12.5mm and retain 10mm (W_3)g	73	84	51
5	Aggregate impact value	*11.81%*	*12.96%*	*8.1%*

Table: Bulk densities for different waste stone aggregates

SL.NO	AGGREGATES	BULK DENSITY KG/M³
1.	Shabath stone aggregates	1535.33
2.	Granite stone aggregates	1600. 62
3.	Ceramic tile stone aggregates	1196.60

Table: mix detail

MATERIAL	QUANTITY PER M³ IN KG
Cement	511.1 kg
Fine aggregate	641.70 kg
Coarse aggregate	1038.35 kg
Water – Cement ratio	0.37

0.37: 1: 1.25: 2

Table: percentage of replacement for different waste stone aggregates

AGGREGATES	0%	25%	50%	75%
Shabath stone	1038.35kg	269.34kg	538.68kg	808.02kg
Granite stone	1038.35kg	258.28kg	514.56kg	781.65kg
Ceramic Tile	1038.35kg	(20%)186.53kg	(40%)373.06kg	(60%)560kg

Table: compressive strength for 7 days cubes average test results

SL.NO	PERCENTAGES OF AGGREGATES	COMPRESSIVE STRENGTH(MPA)
1.	Controller	27.85
2.	Shabath Stone 25%	26.60
3.	Shabath Stone50%	25.03
4.	Shabath Stone75%	26.66
5.	Granite Stone25%	26.67
6.	Granite Stone50%	27.25
7.	Granite Stone75%	29.27
8.	Ceramic Tile Stone20%	18.53
9.	Ceramic Tile Stone40%	15.71
10.	Ceramic Tile Stone60%	13.75

Table: compressive strength for 28 days cubes average test results

SL.NO	PERCENTAGES OF AGGREGATES	COMPRESSIVE STRENGTH(MPA)
1.	Controller	38.20
2.	Shabath Stone 25%	34.52
3.	Shabath Stone50%	31.39
4.	Shabath Stone75%	32.89
5.	Granite Stone25%	35.91
6.	Granite Stone50%	38.02
7.	Granite Stone75%	39.85
8.	Ceramic Tile Stone20%	31.87
9.	Ceramic Tile Stone40%	26.82
10.	Ceramic Tile Stone60%	21.91

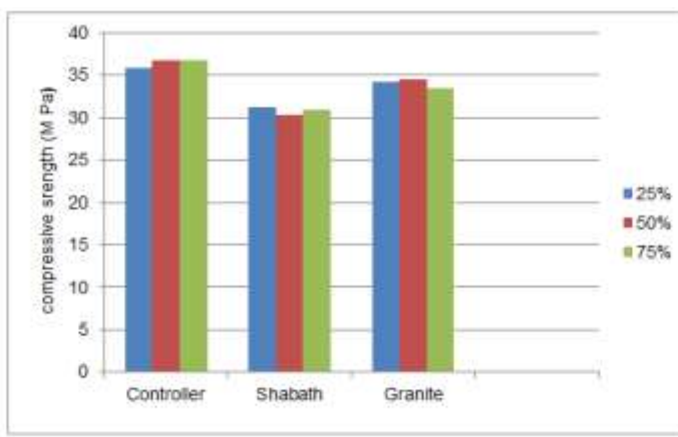

Figure: comparison of compressive strength with different waste stone aggregate

RESULTS AND DISCUSSIONS:

COMPRESSIVE STRENGTH OF CONCRETE :

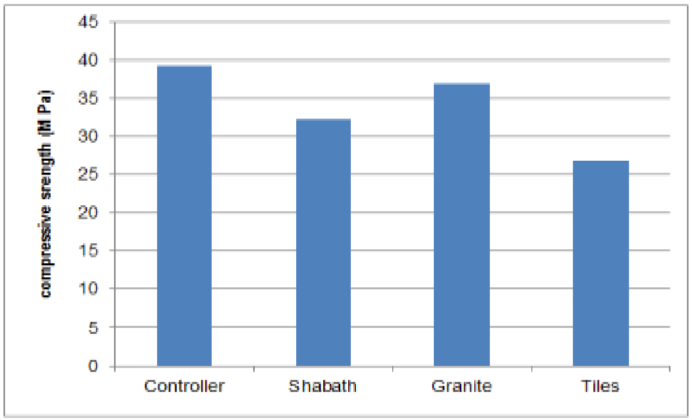

Figure: comparison of Average compressive strength with different waste stone aggregate

SPLIT TENSILE STRENGTH OF CONCRETE:

Table: split tensile strength for 28 days cylinder average test results

SL.NO	PERCENTAGES OF AGGREGATES	SPLIT TENSILE STRENGTH(MPA)
1.	Controller	5.1
2.	Shabath Stone 25%	4.38
3.	Shabath Stone50%	4.69
4.	Shabath Stone75%	4.81
5.	Granite Stone25%	4.98
6.	Granite Stone50%	5.15
7.	Granite Stone75%	5.26
8.	Ceramic Tile Stone20%	3.96
9.	Ceramic Tile Stone40%	3.14
10.	Ceramic Tile Stone60%	2.89

FLEXURAL STRENGTH OF CONCRETE:

Table: Flexural strength for 28 days prisms average test results

SL.NO	PERCENTAGES OF AGGREGATES	FLEXURAL STRENGTH(MPA)
1.	Controller	10.42
2.	Shabath Stone 25%	8.45
3.	Shabath Stone50%	9.13
4.	Shabath Stone75%	10.02
5.	Granite Stone25%	10.25
6.	Granite Stone50%	10.52
7.	Granite Stone75%	10.48
8.	Ceramic Tile Stone20%	8.15
9.	Ceramic Tile Stone40%	6.53
10.	Ceramic Tile Stone60%	4.82

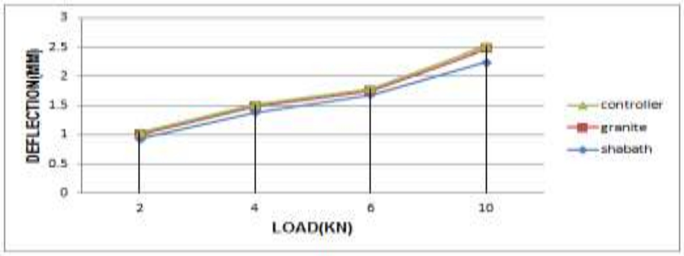

Figure: load with deflection curve of flexural strength

DURABILITY STRENGTH OF CONCRETE:

Table: Durability (RCPT) test for 28 days cylinder average test results

SL.NO	SPECIMEN	TOP (mA)	MIDDLE(mA)	BOTTOM(mA)
1.	Controller	112	119	117
2.	Shabath Stone 25%	123	138	128
3.	Shabath Stone50%	126	136	129
4.	Shabath Stone75%	119	133	131
5.	Granite Stone25%	113	124	121
6.	Granite Stone50%	114	126	123
7.	Granite Stone75%	116	129	124
8.	Ceramic Tile Stone20%	127	134	128
9.	Ceramic Tile Stone40%	129	139	133
10.	Ceramic Tile Stone60%	131	141	137

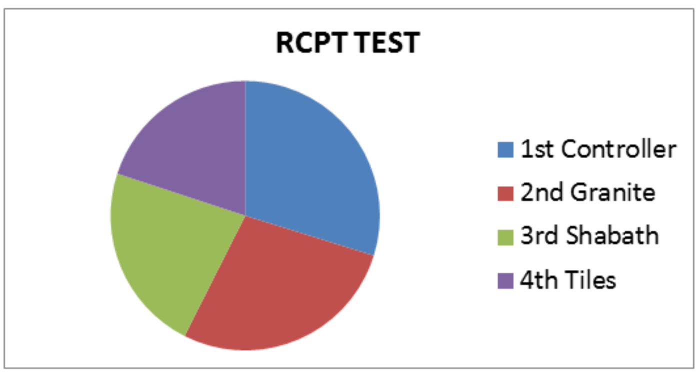

Figure: comparison of durability (RCPT) test with different waste stone aggregates

Results and discussions:

- *It can be observed from the Fig.3 the compressive strength of NSA and 75%GSA is found to be 27.9N/mm² and 29.27 N/mm².*
- *Moreover the compressive strength of SSA, GSA and TSA were decreased by 14.64%, 8.78% and 6.69% respectively than that of the NSA.*
- *Similarly the Flexure strength of NSA is found to be 10.42N/mm². The Flexure strength of TSA, SSA and GSA was decreased by 10.15%, 7.38% and 4% than that of the NSA, are depicted in fig 9. The fig 6 shows that the Split Tensile Strength of TSA, SSA and GSA were decreased by 14.52%, 8.71% and 5.39% than that of the NAC.*
- *The fig 11 also shows the Durability strength of concrete TSA, SSA and GSA were decreased by tremendously.*

- *Above 4 cases, the strength of Ceramic Tile Stone Aggregate Concrete was found to be lower than that of the other aggregates mentioned above.*

SUMMARY AND CONCLUSION:

1. *From The test result shows that the Compressive strength, Split Tensile strength, Flexure Strength and Durability of TSA were found to be lower than SSA, GSA and TSA.*
2. *The Strength of 50% & 75% GSA showed better performance than NSA and SSA Moreover the GSA gives similar strength that of the NSA.*
3. *Hence waste Granite stone can be used as a coarse aggregate in construction industry depend upon the waste granite stone availability.*
4. *Durability test also showed better performance of GSA compare with NSA.*
5. *Shabath Stone can be used as an aggregate in concrete for (unloaded structures) unimportant construction works.*
6. *Also the recycling plants should be encouraged to avoid the landfills and save our environment. "Economical and environmental pressures justify with the consideration of this alternative material source, in places where available source of new rocks are inaccessible"*
7. *From this we can efficiently utilize the solid waste material.*

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