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PARTIAL REPLACEMENT OF COARSE AND FINE AGGREGATE BY MOSAIC TILE CHIPS AND GRANITE POWDER

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Abstract - *Since last few years, construction industries has taken boom and due to this the concrete jungles had replaced the greeneries. This process continues due to increase in population also housing is the basic need of humans. But for these housing and other major constructions large amount of concrete is required and so as the requirement of coarse as well as fine aggregate arises. This leads to depletion of natural resources as quarrying sand and aggregates have adverse effect on environment. Also due to modernization people are using cladding material highly for lavish decoration of houses. Which includes excessive use of tiles, marbles and granites in new houses? Due to these reasons the reuse of constructional wastes like mosaic tiles, granite powder, marble chips came into the picture to reduce the solid waste and to reduce the scarcity of natural aggregates for making concrete. The ceramic tile waste is not only occurring from the demolition of structures but also from the manufacturing unit. Studies show that about 20-25% of material prepared in the various tile manufacturing plants are transforming into waste. This waste material should have to be reused in order to deal with the limited resource of natural aggregate and to reduce the construction wastes. This article is about finding the optimum percentage of replacement of course as well as fine aggregate and to perform various tests regarding strength of concrete.*

Keywords: Crushed ceramic mosaic tiles, Granite powder, workability, Compressive strength, Split Tensile strength.

1. INTRODUCTION

Due to the modern civilization, the solid waste from the demolition of constructions is increasing day by day. There is a huge usage of ceramic tiles in the present constructions and it is increasing in day by day . Ceramic products are part of the essential construction materials used in most buildings. Some common manufactured ceramics include wall tiles, floor tiles, sanitary ware, household ceramics and technical ceramics and faucets. They are mostly produced using natural materials that contain high content of clay minerals. However, despite the ornamental benefits of ceramics, its wastes among others cause a lot of disturbance to the environment. And also on the other side waste tile is also producing from demolished wastes from construction. Indian tiles production is 100 million ton per year in the industry, about 15%-30% waste material generated from the total production. This waste is not recycled in any form at present, however the ceramic mosaic waste is durable, hard and highly resistant to biological, chemical and physical degradation forces so, we selected these waste tiles as a replacement material to the basic natural aggregate to reuse them and to decrease the solid waste produced from demolitions of construction. Waste tiles and granite powder were collected from the surroundings.

In INDIA, the granite processing is one of the most flourishing industry. granite industries in India manufactures more than 3500 metric tons of granite powder per day. During the cutting process about 25% the original granite mass is lost in the form of dust. This mixture of slurry coming out during cutting is called stone waste. The advancement of concrete technology can reduce the use of innate resources and energy sources which in turn further lessen the burden of pollutants on the environment. The use of partial replacement of fine aggregate (sand) by granite powder, cut down some concrete production, thus brings down the requirement for land area for drawing resources and disposal of industrial waste too. Now a days, huge quantity of granite powder is coming out in natural stone processing plants having an adverse effect on the environment as well as humans.

Crushed waste mosaic tiles, crushed waste and Granite powder are used as a replacement to the coarse aggregates and fine aggregate. The waste crushed tiles were partially replaced in place of coarse aggregates by 10%, 20%, 30%, 40% and 50%. Granite powder was replaced in place of fine aggregate by 10% along with the ceramic coarse tile. M25 grade of concrete was designed and tested. The mix design for different types of mixes were prepared by replacing the coarse aggregates and fine aggregate at different percentages of crushed tiles and granite powder. Experimental investigations like workability, Compressive strength test, Split tensile strength test for different concrete mixes with different percentages of waste crushed and granite powder after 7, 14 and 28 days of curing period has done. It has been observed that the workability increases with increase in the percentage of replacement of granite powder and crushed tiles increases. The strength of concrete also increases with the ceramic coarse tile aggregate up to 30% percentage.

1.1 Benefits of Tile Aggregate Concrete:

Using the waste tile aggregate in the replacement to coarse aggregate in concrete has various benefits The major benefit or advantage is that using tile waste can reduce the cost of construction as it is freely available. Using waste tiles chips in place of course aggregate also helps in reduction of pollution from construction industry. The price of making concrete in batching plants will decrease as compared with the conventional concrete by including tile aggregate and granite powder since it is easily available at very low cost and there-by reducing the construction pollution or effective usage of construction waste.

2. METHODOLOGY

2.1 MATERIALS AND PROPERTIES:

2.1.1 Cement: A cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, and most non-specialty grout. Several types of Portland cement are available with the most common being called ordinary Portland cement (OPC) which is grey in color, but a white Portland cement is also available. In this research OPC of 53 Grade of brand name Ultra Tech Company, available in the local market was used.

2.1.2 Fine Aggregates: River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity in accordance with IS: 2386-1963.

Table -1: Properties of Fine Aggregate

S.No	Description Test	Result
1	Sand zone	Zone- III
2	Specific gravity	2.59
3	Free Moisture	1%

2.1.3 Course Aggregates: Crushed aggregates below 20mm size produced from local crushing plants were used. The aggregate exclusively passing through 20mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity in accordance with IS. The individual aggregates were mixed to induce the required combined grading. The particular specific gravity and water absorption of the mixture are given in table.

Table -2: Properties of course Aggregate

Sr.No	Description	Test Results
1	Nominal size used	20mm down
2	Specific gravity	2.9
3	Water absorption	0.15%

2.1.4 Water: Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9

2.1.5 Mosaic Tile Aggregate: Broken mosaic tiles were collected from the solid waste of ceramic manufacturing unit and from demolished building. The waste tiles were crushed into small pieces by manually and by using crusher. The required size of crushed tile aggregate was separated to use them as partial replacement to the natural coarse aggregate.

Fig -1: Mosaic tile chips

The tile waste which is lesser than 4.75mm size was neglected. The crushed tile aggregate passing through 16mm sieve and retained on 12.5mm sieve are used. Crushed tiles were partially replaced in place of coarse aggregate by the percentages of 10%, 20% and 30%, 40% and 50% individually and along with replacement of fine aggregate with granite powder.

Table -3: Properties of Mosaic tile chips

S.No	Description	Test Results
1	Specific gravity of crushed tiles	2.6
2	Water absorption of crushed tiles	0.19%

2.1.6 Granite Powder: Since granite powder is obtained from crushing of granite rocks, the chemical and mineral composition of granite is similar to that in cement and natural aggregates. It is chosen to test the behaviour of concrete along with the tile waste.

Table -4: Properties of granite Powder

Sr.No	Description	Test Results
1	Specific gravity of granite powder	2.4
2	Water absorption of granite powder	0.10%

From Industry granite powder will be collect; 4.75 mm passed materials was separated to use it as a partial replacement to the fine aggregate. Granite powder was partially replaced in place of fine aggregate by the percentages of 10% along with replacement of coarse aggregate with crushed tiles.

Methodology:

The methodology of research includes the collection of required materials from the various sources and determining the properties of all the materials gathered. Designing the concrete mix proportions for all types of replacements and Preparation of the concrete mix, Moulding and curing. The testing of concrete includes Slump cone test for determining workability of concrete in fresh state and compressive strength, split tensile test for determining the strength of concrete in hardened state.

Total 9 types of mixes are prepared along with conventional mixes. The coarse aggregates are replaced by 10%, 20%, 30%, 40% and 50% of crushed mosaic tiles and the fine aggregate is replaced by 10% granite powder individually along with the coarse aggregate. The details of mix designations are as follows:

Table -5: Details of aggregate replacement

Sr.no	Mix	Cem %	CA (%)		FA (%)	
			NCA	Tiles	Sand	GP
1	M0	100	100	0	100	0
2	M1	100	90	10	100	0
3	M2	100	80	20	100	0
4	M3	100	70	30	100	0
5	M4	100	60	40	100	0
6	M5	100	50	50	100	0
7	M6	100	90	10	90	10
8	M7	100	80	20	90	10
9	M8	100	70	30	90	10
10	M9	100	60	40	90	10

Mix Design For M25 Grade Concrete:

Final Mix Proportions:

C	FA	CA	WATER
384	646.4	1271.30	187.5
1	1.68	3.31	0.50

3. TEST RESULTS:

3.1 Slump Cone Test:

The pattern of workability obtained is True Slump. Workability Results obtained from slump cone test for various grades of concrete are shown in following.

Table -6: Test results from slump cone test for workability

S.No	Mix	% (CCA+GP)	Workability (mm)
1	M0	0+0	69
2	M1	10+0	72
3	M2	20+0	74
4	M3	30+0	77
5	M4	40+0	81
6	M5	50+0	83
7	M6	10+10	76
8	M7	20+10	82
9	M8	30+10	94
10	M9	40+10	103

3.2 Compressive strength:

A total of 30 cubes of size 150 x 150 x 150 mm were cast for 7 days, 14 days and 28 days testing. The results are tabulated below:

Table -7: Test results from compressive strength

S.No	Mix	% (CCA+GP)	CS of M25 grade in N/mm^2		
			7 days	14 days	28 days
1	M0	0+0	20.36	28.25	32.85
2	M1	10+0	23.85	31.08	36.14
3	M2	20+0	26.01	32.47	39.11
4	M3	30+0	27.77	37.15	42.71
5	M4	40+0	23.72	31.45	36.79
6	M5	50+0	22.00	28.59	33.84
7	M6	10+10	20.84	28.35	34.16
8	M7	20+10	24.35	33.24	39.11
9	M8	30+10	27.82	38.02	41.72
10	M9	40+10	21.11	27.81	33.50

3.3 Split Tensile strength:

The split tensile strength obtained by testing the cylindrical specimen for M25 grades of concrete to all the mixes designed for various replacements for 28 days only are given in as follows.

Table -8: Test results from split tensile strength

S.No	Mix	% (CCA +GP)	Split Tensile Strength M25 in N/mm^2
			28 days
1	M0	0+0	2.53
2	M1	10+0	2.58
3	M2	20+0	2.59
4	M3	30+0	2.62
5	M4	40+0	2.56
6	M5	50+0	2.49
7	M6	10+10	2.55
8	M7	20+10	2.62
9	M8	30+10	2.63
10	M9	40+10	2.59

4. DISCUSSION:

4.1 Workabilty:

From the results it is observed that the workability is increased by an amount of 4.3%, 7.24%, 11.59%, 17.39%, 20.28%, 10.14%, 18.8%, 36.23%, 49.2% for M1, M2, M3, M4, M5,M6,M7,M8,M9 mixes respectively over conventional M25 concrete grade(M0).

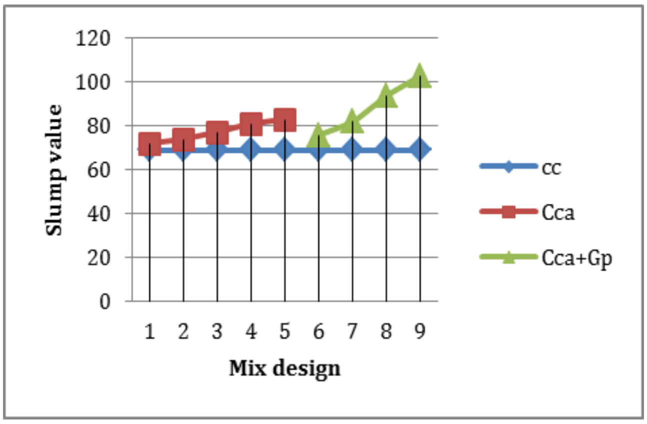

Chart -1: Comparison of workability for different mixes

4.2 Compressive Strength:

The Compressive strength of concrete varies as 17.14%, 27.74%, 36.39%, 16.5%, 8.04%, 2.36%, 19.62%, 36.64% and 3.64% for M1, M2, M3, M4, M5, M6, M7, M8, M9 compared with the conventional concrete after 7days of curing. While Compressive strength of concrete varies as 9.99%, 14.92%, 31.49%, 11.31%, 1.19%,0.3%, 17.65%, 34.54% and -1.57% for M1, M2, M3, M4, M5, M6, M7, M8, M9, compared with the conventional concrete after 14 days of curing. The CS of concrete varies as 10%, 19.04%, 30%, 11.99%,3.01%, 19.04%, 27% and 1.98% for M1, M2,M3, M4, M5, M6, M7, M8, M9 compared with the CC after 28days of curing. On comparing the strengths of all mixes, M3, M8 has the highest i.e., 30% replacement of coarse aggregate. The addition of granite powder has positive effect on strength while improving the workability.

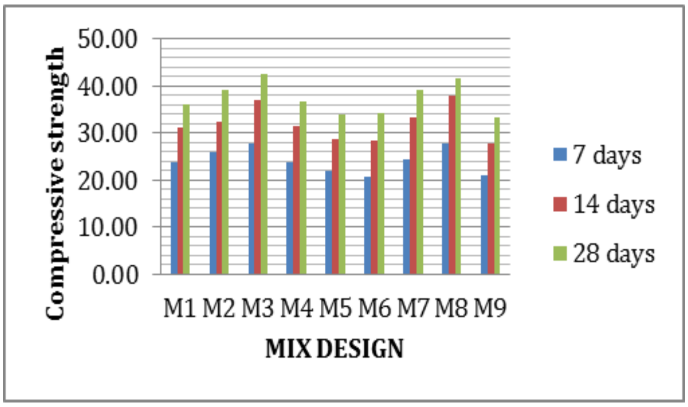

Chart -2: Comparison of Compressive strength for different mixes

5.3 Split Tensile strength:

The split tensile strength of concrete varies as 1.95%, 5%, 7%, 1.18%, -1.6%,0.78%, 3.5%, 3.9% and 2.3% for M1, M2,M3,M4,M5,M6,M7,M8,M9 compared with the conventional concrete after 28days of curing. The split tensile strength of ceramic tile aggregate is very much in a straighter path compared to the conventional grades of concrete.

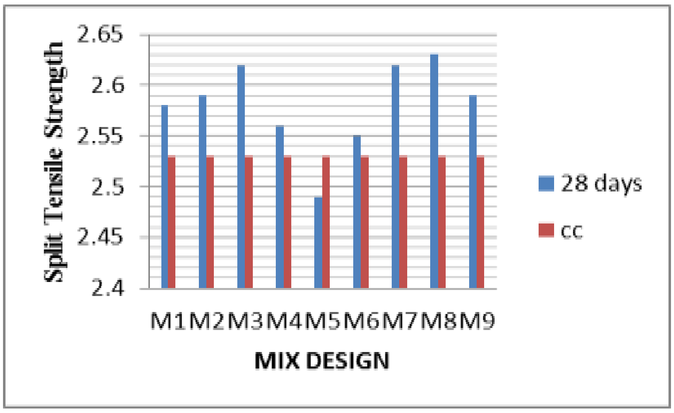

Chart -3: Comparison of split tensile strength

5. CONCLUSION

The following conclusions are made based on the experimental investigations on compressive strength, split tensile strength considering the environmental aspects also:

 The workability of concrete increases with the increase in tile aggregate replacement. The workability is further increased with the addition of granite powder which acts as admixture due to its chemical properties.

 The properties of concrete increased linearly with the increase in mosaic tiles aggregate up to 30% replacement later it is decreased linearly.

 M3 & M8 Mix of concrete produced a better concrete in terms of compressive strength, split tensile strength than the other mixes. But the mixes up to 50% of Mosaic coarse aggregate can be used.

VI.FUTURE SCOPE

There is a vast scope of research in the recycled aggregate usage in concrete especially ceramic tile wastes in the future. The possible research investigations that can be done are mentioned below:

1. The usage of marble floor tiles can be studied as it is similar to that of tile waste generation and also it is quite hard compared to the natural crushed stones using in conventional concrete.

2. The usage of granite powder in concrete as an admixture to improve the workability of concrete and the strength parameters can also be studied at various percentages.

3. A combination of different tiles (based on their usage) in different proportions in concrete and their effects on concrete properties like strength, workability etc can be determined.

4. By the use of ceramic tile aggregate in concrete, the physical properties like durability, permeability etc., can be analysed to prepare a concrete with more advantageous than conventional concrete.

5. A study on properties of concrete made with combination of recycled aggregate and tile aggregate in different proportions can be investigated to enhance the concrete properties and also to reduce the pollution or waste generation from construction industry.

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