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Impact of Glass Powder and Brick Ballast by the Partial Replacement of Fine and Coarse Aggregates in Concrete

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Abstract—

Concrete is the mixture of various materials like coarse aggregate, fine aggregate, cement & water, each of them is mixed in various proportions to achieve specific strength. The fine and coarse aggregates are the main ingredients of concrete as the filler materials. As coarse aggregates are non renewable resources, scarcity of these materials have been increased in recent years. Therefore, it is essential to search for other materials, which can be used as an alternative to fine and coarse aggregate. Now days, waste of glasses are been increasing ,and the powder form of waste glass(GP) can be used as a partial replacement for the fine aggregates(FA), which can cause increase in the strength of concrete due to the proper alkali aggregate reaction up to 10% replacement. Brick ballast (BB) can be used as coarse aggregate partially in concrete. Cement being the most important material plays an important role in the manufacturing of concrete. The high cost of conventional construction materials is a dominating factor effecting constructions cost. This is necessity research for some new kind of alternative materials in the constructions field. Waste glass in the form of fine aggregate and brick ballast as coarse aggregate can be used. The proportion of the mineral and mixtures is applied in testing cubes for compression strength. This project briefly discusses the effects of addition of glass powder & brick ballast on the properties of mortar concrete mix of M25 at 14, and 28 days for concrete mix with brick ballast as 10%, 20%, 30%, 40%, & 50% of the weight coarse aggregate. Combination of these glass powder & brick ballast will gain the strength of nominal mix. Cubes of size 150x150x150 mm are constructed to check the compressive strength. The concrete made by the mixture glass powder & brick ballast is placed in the curing tank for 14 days and 28days for curing. The concrete is tested according to Indian standard specification to identify the compressive strength. This new technology will provide new solution for the disposal of glass sheet waste as well as the damaged or half burned bricks from the kiln.

Keywords—Glass Powder, Brick ballast, Industrial by- product.

I. INTRODUCTION

Conservation of resource is always the prime need of human kind. In the starting of civilization, we have used the resources limitedly but soon after we have started over exploitation. This result causes the scarcity of resources. Later on we have known the fact that we need to conserve the resources. Thus human have decided to use resources efficiently and wisely. This phenomenon is discussed by using the principle of 3R i.e. reduce reuse and recycle. Our study primarily focuses on these "3R" concepts. The waste glass from in and around the small shops is being disposed in waste landfill. Glass is an inert material which could be recycled and used many times without changing its chemical properties. Brick waste is also increasing due to expel of half burned or improper brick from the kiln. Since the demand in the concrete manufacturing is increasing day by day, the utilization of river sand as fine aggregate and natural rock as the coarse aggregate leads to exploitation of natural resources, lowering of water table and sinking of the bridge piers and also reduce the non- renewable resources.

The most widely used fine aggregate for the preparation of concrete is the natural sand mined from the river beds. The present scenario demands identification of substitute materials for the river sand and coarse aggregate for making concrete because of the abundant scarcity it is facing. Attempts have been made in using crushed glass and brick ballast as fine and coarse aggregate as replacement for river sand and natural- coarse aggregate. In the current research, sand and natural coarse aggregate is partially replaced by glass powder and brick ballast. The sheet glass powder is obtained from crushing the waste glass, which is disposed as landfill by the glass industries. Glass is a transparent material produced by melting a mixture of materials such as silica, soda ash, $CaCO_3$ at high temperature followed by cooling where solidification occurs without crystallization. Glass is widely used in our lives through manufactured products such as sheet glass, bottles, glassware, and vacuum tubing. Glass is an ideal material for recycling.

The use of recycled glass saves lot of energy and the increasing awareness of glass recycling speeds up focus on the use of waste glass with different forms in various fields, in the same way we have used brick waste from the kiln. This will reduce the environmental waste. Then brick isbroken into various sizes. After this it is recycled into new cube for the study. Using waste glass and brick waste in the concrete construction sector is advantageous, as the production cost of concrete will go down. Most of the waste glasses and concrete waste have been dumped into landfill sites. The land filling of waste glasses and brick waste are undesirable because they are not biodegradable, which makes them environmentally less friendly. There is huge potential for using waste glass in the concrete construction sector. When waste glasses are reused in making concrete products, the production cost of concrete will go down. Crushed glass or cullet, if properly sized and processed, can exhibit characteristics similar to that of gravel or sand and sometimes asphalt, to reclaim the aggregate. Natural disasters like flood are a common disaster faced by us in now a day. Mining is the main cause of flood. We can avoid these problems by using this recycled material.

II. REVIEW OF LITERATURES

Mohammed Jasar NT, Varsha Shaji: From the experimental work carried out for M20 grade of concrete by partial replacement of fine aggregate with 10% glass powder and coarse aggregate with 10%, 20%, 30%, 40% and 50% recycled coarse aggregate. The compressive and split tensile strength increases with increase of replacement cement with recycled coarse aggregate up to 30% and coarse aggregate with 10% glass powder, beyond the limit the compressive strength decreases for both 7 and 28 days curing period. The maximum compressive strength achieved for the replacement of fine aggregate with 10% glass powder and coarse aggregate with 30% recycled coarse aggregate, which is greater than the compressive strength of conventional concrete for 7 and 28 days curing period.

R Ramasubramani1, S Divya1 and Vijay: Maximum compressive strength was achieved at 50% replacement. Compressive strength of the concrete is increased by 7.5% when 50% sand was replaced by glass powder. Tensile strength achieved its peak value when sand was replaced by glass powder at 10% replacement level. Tensile strength was increased by 6.2%. Flexural strength attained its maximum value at 10% replacement level and the increase was by 13.8%. Acid attack and alkalinity attack conducted on the concrete showed a decrease in weight and compressive strength. Acid attack showed a reduction of weight by 6.8% for conventional concrete and 7.24% for glass powder concrete.

Haramkar1Sneha Maske, Prajakta N: Results from this research confirm that the usage of glass waste as fine aggregate replacement material in concrete is effective and can use in the future. The effect of glass waste in concrete is more obvious at the later age of 28 days. The optimum percentage of glass waste that gives the maximum values of compressive strengths is 10%. This study intended to find effective ways to reuse waste glass as fine aggregate in concrete. The data presented in this paper show that there is a promising potential for the use of waste glass in concrete; further investigations may be considered regarding its long- term effect on concrete properties.

Jagriti Gupta, Nandeshwar Lata: The workability of concrete shows as slump of the concrete mix increase up to 20% replacement of control mix. For getting the proper workable concrete a super plasticizer was used up to 0.8% of Cement percentage by weight of cement. Fine waste glass bottle crushed fine material shows a pozzolanic behavior. Compressive strength in concrete was found to increase in strength with 10% replacement higher strength achieved. Use of waste glass in concrete will reduce the disposal problems of waste glass and is environment friendly thus paving way for greener concrete. Also the use of waste glass in concrete will preserve natural resources particularly river sand and thus shall make concrete construction industry sustainable

Jostin.P.jose , S.suganya: The compressive strength of concrete with glass powder is more than the conventional concrete. The increase in compressive strength is the interlocking properties of particles in the glass powder. Split tensile strength of concrete increases for glass powder. The reason for variation is the shape and texture of glass powder.

Flexural strength of concrete increase for glass powder mixed concrete. The reasons for variation are the shape and texture of the glass powder. Sand particles rounded and globular where as glass powder particles are angular, flaky and irregular in shape therefore the reasons with the fact that glass powder are finer than sand.

Panshul Jamwal1, Rohit Sharma: The optimum value of compressive strength, flexural strength, split tensile strength can be achieved by 30% replacement of brick ballast. The workability of concrete is decreased with replacement of fine aggregate. When brick ballast is used as a replacement of natural fine aggregate, there is an increase in strength. This experimental study has proved to be better way to disposal of brick ballast. The cost of ballast is almost 50% of that of natural aggregate it is a waste product obtained from different brick kilns and tile factories. Also it could be easily used as coarse and fine aggregate in all plain concrete applications

T.Subramani , S.Kumaran: Use of such waste materials not only cuts down the cost of construction, but also contributes in safe disposal of waste materials. The strength of the concrete is found out to the M15 & M25 concrete. Compressive strength of concrete is highwhen containing concrete waste 50% in concrete. The Strength of concrete containing concrete waste of 50 % was high compared with that of the conventional mix and also compared with M15 mix design concrete. From the present experimental investigation it was found that the recycled aggregates will influence much in hardened properties of concrete. As the percentage of crushed concrete coarse aggregates and crushed brick fine aggregates is increased. Coarse aggregate is replacement level of 25% & 50 % brick waste in concrete mixes was found to be the level to obtain higher value of the strength and durability at the age of 28 days.

Bidve Ganesh Shivkanth, G. N. Shete: Brick bat concrete is cheaper than conventional concrete. 3% increment in the compressive strength is found for 20% replacement of coarse aggregate by over burnt brick bat waste and the strength decreases by 3.3% when the 40% of coarse aggregate is replaced by over burnt brick bat waste, by using aggregate cement ratio (A/ C) is 4.2 and water cement ratio (W/ C) is

0.45. Current study concluded that over burnt brick bat waste can replace coarse aggregate up to 20%. The use of over burnt brick bat waste in concrete is possible to improve its compressive strength, tensile strength and flexural strength.

III. THEORITICAL INVESTIGATION

Initially, basic tests were conducted for fine aggregate, coarse aggregate and cement to check their suitability for concrete making.

A. Experimental Investigation

The Apparatus consist of moulds, mixer, trowel and tamping rod (steel bar 16 mm diameter and 60 cm long). Thorough mixing of materials is essential for the production of uniform concrete. As the mixing cannot be thorough, it is desirable to add 15% more materials. By laboratory batch mixer, first mix the Coarse aggregate, RCA, fine aggregate and copper slag until the mixture is thoroughly blended. Then, add the cement and water and mix. Finally, add the remaining water and mix until the concrete appears to be homogeneous and of the required consistency. The homogeneous concrete mix is discharged on a dry platform.

On the course of time, the moulds are cleaned and applied with thin film of oil. The fresh concrete is filled inthe mould in three layers of 5 cm depth. Each layer is compacted with tamping rod uniformly with 25 blows. The purpose of compaction is to avoid entrapped air inside the concrete moulds. After the top layer has been compacted, level top surface with a trowel. During pouring of concrete, it is better to avoid wasting of concrete for effective and economical usage. The specimens are demoulded after 24 hours from the process of moulding. If the concrete has not achieved sufficient strength to enable demoulding the specimens, then the process must be delayed for another 24 hours care should be taken not to damage the specimen during the process because, if any damage is caused, the strength of the concrete may get reduced.

TABLE I. MATERIALS FOR THE PREPARATION OF SPECIMEN

TYPE	**CEMENT (Kg)**	**GP (Kg)**	**FA (Kg)**	**CA(Kg)**	**BB (Kg)**	**WATER (*l*)**
Normal concrete	96	0	16.78	28.68	0	4.794
10% GP & 10% BB	96	1.678	15.102	25.812	2.868	4.794
10% GP & 20% BB	96	1.678	15.102	22.944	5.736	4.794
10% GP & 30% BB	96	1.678	15.102	20.076	8.604	4.794
10% GP & 40% BB	96	1.678	15.102	17.208	11.472	4.794
10% GP & 50% BB	96	1.678	15.102	14.34	14.34	4.794

FIG I. CASTED CUBE AFTER REMOLDING

B. Test Setup

Remove the specimen from water after specified curing time and wipe out excess water from the surface. Take the dimension of the specimen to the nearest 0.2 m. Clean the bearing surface of the testing machine. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast. Align the specimen centrally on the base plate of the machine. Rotate the movable portion gently by hand so that it touches the top surface of the specimen. Apply the loadgradually without shock and continuously at the rate of 140 Kg/cm²/minute till the specimen fails. Record the maximum load and note any unusual features in the type of failure.

FIG. II. CASTED CUBE AFTER REMOLDING

C. Results

The results of compressive strength test, split tensile are presented here.

TABLE II. COMPRESSIVE STRENGTH FOR 14 DAYS CURING

Combination	**Dimension (mm x mm)**	**Load(N)**	**Compressive Stength (N/mm²)**	**Average Compressive Strength (N/mm²)**
NORMAL MIX	155 X 150	280000	12.04	15.28
	149 X 150	360000	16.10	
	143 X 150	380000	17.71	
10 % GP & 10% BB	142 X 153	200000	9.2	8.11
	147 X 152	150000	6.71	
	156 X 152	200000	8.43	
10% GP & 20% BB	142 X 149	210000	9.92	8.33
	139 X 151	160000	7.62	
	135 X 159	160000	7.45	
10% GP & 30% BB	152 X 150	300000	13.15	12.09
	152 X 152	170000	7.35	
	150 X 152	360000	15.78	
10% GP & 40% BB	157 X 145	150000	6.58	8.04
	152 X 150	250000	10.96	
	150 X 152	150000	6.57	
10% GP & 50% BB	156 X 140	150000	6.86	6.67
	150 X 150	100000	4.44	
	157 X 146	200000	8.72	

TABLE III. MIX FOR SPECIMENS OF ANSYS 15.0 MODEL OF THE SPECIMEN

Combination	Dimension (mm x mm)	Load(N)	Compressive Stength (N/mm²)	Average Compressive Strength (N/mm²)
NORMAL MIX	155 X 150	500000	21.64	26.90
	149 X 150	600000	25.97	
	143 X 150	750000	33.11	
10 % GP & 10% BB	142 X 153	240000	11.03	15.33
	147 X 152	410000	17.98	
	156 X 152	380000	17.00	
10% GP & 20% BB	142 X 149	300000	13.07	17.06
	139 X 151	400000	18.77	
	135 X 159	450000	19.34	
10% GP & 30% BB	152 X 150	600000	26.67	25.28
	152 X 152	520000	23.74	
	150 X 152	500000	25.44	
10% GP & 40% BB	157 X 145	250000	11.65	12.74
	152 X 150	300000	13.24	
	150 X 152	300000	13.33	
10% GP & 50% BB	156 X 140	280000	16.02	11.31
	150 X 150	150000	6.57	
	157 X 146	250000	11.34	

TABLE IV. SPLIT TENSILE STRENGTH TEST

COMBINATION	7 DAYS (N/mm²)	14 DAYS (N/mm²)	28 DAYS (N/mm²)
NORMAL MIX	1.65	2.25	2.46
10 % GP & 10% BB	1.82	2.35	2.56
10% GP & 20% BB	1.85	2.4	2.65
20% GP & 30% BB	1.52	2.13	2.33
30% GP & 30% BB	1.35	2.09	2.2
30% GP & 40% BB	1.2	1.89	1.98

IV. NUMERICAL INVESTIGATION

V. CONCLUSION

The replacement of fine and coarse aggregate by glass powder and brick ballast respectively found was formed as remarkable method for reducing the material quantity of concrete giving sufficient strength. The pozzolanic reaction of glass powder increases the strength of concrete. The result obtained from the experiments shows that there is a great potential for utilization of best glass powder in concrete as partial replacement of cement. Partial replacement of fine aggregate in concrete by 10% of glass powder will give maximum result. The compressive strength of the concrete can be increased by using glass powder as partial replacement of fine aggregate. However, the result shows that strength of brick ballast specimens were gradually increased up to 30% replacement of brick ballast and then it gradually decreases up to 50% replacement of brick ballast. The test result showed that the concrete specimen with 30% replacement of brick ballast get highest compressive strength when compare to concrete specimen with different percentage of brick ballast. Also in split tensile strength 10% glass powder replacement and 20% brick ballast replacement give more tensile strengths compared to other percentages. Natural aggregates which are using for concrete is non- renewable resources, so we can reduce the uses of natural aggregate by the replacement of brick ballast. This modified concrete with sufficient strength will also be a best solution for the disposal problem of brick waste and glass waste materials. Also the cost of construction also can be reduced by using this modified concrete.

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