Multi-blended Concrete using Waste

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Abstract

In the world construction, one material is used above all is concrete. Concrete is far more produced all over the world than any other man made material. It is incredibly versatile, and is used in almost all major construction projects.A modern lifestyle, alongside the advancement of technology has led to an increase in the amount and type of waste being generated, leading to a waste disposal crisis. This study tackle the problems of the waste that is generated in abundance in the world such as eggshell, glass, and human hair (fiber). In order to dispose off or at least reduce the accumulation of certain kinds of waste, it has been suggested to reuse some of these waste materials to substitute a percentage of the primary materials used in the ordinary Portland cement (OPC) concrete.

In this experimental work, an attempt has been made to determine the behavior of Ordinary Portland Cement concrete of M20 grade of concrete with and without waste materials (5% & 10% ESP partially replaced with cement, 1.5% Human Hair addition by weight of cement and 10% & 20% Glass Powder partially replaced with sand) . Six specimens of each batch were casted and tested for compressive strength and split tensile strength. The cubes casted with and without 5% and 10% Egg shell Powder are showing an increase of 6.91% in C.S of concrete with 5% ESP & an increase of 19.32% in C.S of concrete with 10% ESP, at an age of 28 days. The samples with and without 1.5% Human Hair of M20 are showing an increase of 9.8% in C.S of concrete, at an age of 28days and an increase of 14% in S.T.S of concrete, at an age of 14 days. The cubes casted with and without 10% and 20% Glass Powder are showing an increase of 14.88% in C.S of concrete with 10% GP & a decrease of 32.6% in C.S of concrete with 20% GP , at an age of 28 days.

Keywords: *Concrete, partial replacement, eggshell powder, human hair, glass powder, Compressive strength, split tensile strength.*

I. INTRODUCTION

Traditionally materials like clay, sand, stone, gravels, cement, brick, block, tiles, distemper, paint, timber and steel are being used as major building components in construction sector. All these materials have been produced from the existing natural resources and will have intrinsic distinctiveness for damaging the environment due to their continuous exploitation. Nevertheless, during the process of manufacturing various building materials, especially decomposition of calcium carbonate, lime and cement manufacturing, high concentration of carbon monoxide, oxides of sulphur, oxides of nitrogen and suspended particulate matter are invariably emitted to the atmosphere. Exposure to such toxic gases escaping into the environment does lead to major contamination of air, water, soil, flora, fauna, and aquatic life and finally influences human health and their living conditions. The cost of construction materials is increasing incrementally. In India, the cost of cement during 1995 was Rs 1.25/kg and in 2005 the price increased three times. In case of bricks the price was Rs. 0.66 per brick in 1995 and the present rate is Rs. 1.9 per brick. Similarly, over a period of 10 years from the year 1995 the price of sand has increased four times.

Following a normal growth in population, the amount and type of waste materials have increased accordingly. Many of the non-decaying waste materials will remain in the environment for hundreds, perhaps thousands of years. The non-decaying waste materials cause a waste disposal crisis, thereby contributing to the environmental problems. However, the environmental impact can be reduced by making more sustainable use of this waste. This is known as the *Waste Hierarchy*. Its aim is to reduce, reuse, or recycle waste, the latter being the preferred option of waste disposal.

A. Suitability of Waste Materials in Concrete

- Increased use of concrete industry's waste products by 20%.
- Concrete with waste materials sometimes give better workability than conventional concrete.
- It helps substantially in saving power, decrease emission of CO_2– pollution free environment. If all the fly ash generated each year were used in producing concrete, the reduction of carbon dioxide released from cement production would be equivalent to eliminating 25% of the world's vehicle.
- By reducing consumption of OPC, the rate of depletion of mineral resources (National Resources) required for production of cement can be reduced.
- If supplementary cementitious materials (SCM's) are used, the problem of disposal will be reduced, thus reducing the

environmental hazards and will clear many acres of land used for disposal.

- Reduce the dead weight of a structure and reduce crane age load, allow handling, lifting flexibility with lighter weight

B. Use Of Waste in Concrete

Research efforts has been done to match society's need for safe and economic disposal of waste materials. The use of waste materials saves natural resources and dumping spaces, and helps to maintain a clean environment. The current concrete construction practice is thought unsustainable because, not only it is consuming enormous quantities of stone, sand, and drinking water, but also two billion tons a year of Portland cement, which releases green-house gases leading to global warming.

Experiments has been conducted for waste materials like- rubber tyre, e-waste, coconut shell, blast furnace slag, waste plastic, demolished concrete constituents, waste water etc. Construction waste recycle plants are now installed in various countries but they are partly solution to the waste problems.

1) Egg Shell:

Eggshell known as a smooth surface that is desirable compared rough eggshells fracture more easily. Most good quality eggshells from commercial layers contain approximately 2.2 grams of calcium in the form of calcium carbonate. About 95% of the dry eggshell is calcium carbonate weighing 5.5 grams. The average eggshell contains about 0.3% of magnesium, phosphorous, and traces of sodium, zinc,, potassium, iron, copper and manganese. There are many factor influences in quality of eggshell which is nutrient adequacy, flock health problem, environmental condition and breeding. Apart from that, the controlling rate of egg weight also contributes to a good quality of eggshell and it is not depends on the thick eggshell mean strong. Sometimes, thinner eggshell is stronger than thicker eggshell. This fact is due to shape and organization of organic and inorganic component of the shell. (Gary et al. 2004).

Egg shells are known to have good strength characteristics when mixed with concrete. Most of the eggshell waste is commonly disposed in landfills without any pre-treatment because it is traditionally useless. The use of eggshell ash in concrete production reduced the cost of raw material and contributes to the construction industry.

Eggshell also contribute to construction industry which is it can be reduce in construction budget with high strength durability of the concrete. Thus eggshells can be applicable to reduced cost of construction material and produced a new raw material for development in the construction industry.

2) Fiber:

Fiber Reinforced Concrete (FRC) was invented by French gardener Joseph Monier in 1849 and patented in 1867. The concept of using fibers as reinforcement is not new. This can be proved by the following: Fibers have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. In the early 1900s, asbestos fibers were used in concrete, and in the 1950s the concept of composite materials came into being and fiber reinforced concrete was one of the topics of interest. There was a need to find a replacement for the asbestos used in concrete and other building materials once the health risks associated with the substance were discovered. By the 1960s, steel, glass (GFRC), and synthetic fibers such as polypropylene fibers were used in concrete, and research into new fiber reinforced concretes continues today.

Hairs are used as a fiber reinforcing material in concrete to study its effects on the compressive, crushing, flexural strength and cracking control to economies concrete and to reduce environmental problems created by the decomposition of hair.

Human hair is strong in tension, hence it can be used a fiber reinforced material. Hair fiber, a non-degradable matter is available in abundance and at a very cheap cost also creating environmental problem for its decomposition. Hardened concrete tests like compressive strength and split-tensile strength were undertaken showing a remarkable increase in strength of concrete on addition of human hair as fiber reinforcement. It reinforces the mortar and prevents it from spilling.

3) Glass powder:

Normally glass does not harm the environment in any way because it does not give off pollutants, but it can harm humans as well as animals, if not dealt carefully and it is less friendly to environment because it is non-biodegradable. Thus, the development of new technologies has been required. The introduction of waste glass in cement will increase the alkali content in the cement. It also help in bricks and ceramic manufacture and it preserves raw materials, decreases energy consumption and volume of waste sent to landfill. As useful recycled materials, glasses and glass powder are mainly used in fields related to civil engineering, for example, in cement, as pozzolana (supplementary cementitious materials) , and coarse aggregate. Their recycling ratio is close to 100%, and it is also used in concrete without adverse effects in concrete durability. Therefore, it is considered ideal for recycling.

Recently, Glasses and its powder has been used as a construction material to decrease environmental problems.

II. EXPERIMENTAL PROGRAM

In present study, concrete is mainly divided into three groups. For the first group, cement is partially replaced by 5% & 10% Eggshell Powder. For the second group, Human Hair is added to concrete 1.5% by weight of cement. For the third

group, Sand is partially replaced by 10% & 20% Glass Powder. And then studied the compressive strength at 7 & 28 days and split tensile strength at 14 days.

A. *Properties of Ingredients*

The properties of concrete are significantly influenced by the basic properties of constituent materials. Therefore, the preliminary properties of Ordinary Portland cement, fine aggregates, coarse aggregates, Eggshell Powder, Human Hair, Glass powder and mixing water are evaluated according to relevant codes. Care has been taken to ensure that the same type of OPC, fine and coarse aggregates were used throughout this investigation.

1) ***Cement:*** The cement used throughout the test programme was OPC (43 grade) (Ultratech Cement) confirming to IS: 8112-1989. The routine test on cement is done as per the IS: 4031-1986[15].

2) ***Fine aggregate:*** The fine aggregate used was locally available Badarpur sand. The fine aggregate was tested for its physical requirements as per relevant IS 2386 (Part I to VII)-1963 and it confirmed to IS: 383-1970.

3) ***Coarse aggregate:*** Properties of the aggregates which influence the properties of both the fresh and the hardened concretes have to be considered when the concrete is proportioned. The coarse aggregates were locally available crushed quartzite aggregates. The coarse aggregate was tested for its physical properties as per relevant IS 2386 (Part I to VII)-1963 and it confirmed to IS: 383-1970.

4) ***Water:*** Tap water, potable without any salts or chemicals was used in the study.

5) ***Eggshell Powder:*** Locally available eggshells were collected and powdered. Chemical and physical properties were found out through internet.

6) ***Human Hair:*** Locally available Human hair were collected and trimmed for specific size. Chemical and physical properties were found out through internet.

7) ***Glass Powder:*** Waste glass available locally in New Delhi shops is been collected and made into glass powder. Chemical and physical properties were found out through internet.

III. MIX DESIGN PROCEDURE

The main object of concrete mix design is to select the optimum proportions of the various ingredients of concrete which will yield fresh concrete of desirable properties like workability and hardened concrete possessing specific characteristic compressive strength and durability.

Besides these requirements it is essential that the concrete mix is prepared as economically as possible by using the least possible amount of cement content per unit volume of concrete, with due regard to the strength and durability requirements as per IS 456-2000. Since concrete is produced by mixing several discrete materials, the numbers of variables governing the choice of mix design are necessarily large.

A mix of M20 grade of concrete was designed with "Concrete Mix Design" android application. It follows the guidelines of IS: 10262-2009[13] and IS: 456 for calculating the mix proportion.

Following data was inserted into the application:

Grade of Concrete:		M20
Water Cement Ratio:		0.45
Aggregate Size:	20mm	
Value of Slump:	50mm	
Plasticizer Used:	No	
Type of Concrete:		Plain
Aggregate Zone:	Zone 4	
Exposure Condition:		Mild
Is Concrete Pumpable:	No	
Specific Gravity For-		
Water:		1
Cement:	3.15	
Coarse Aggregate:		2.884
Fine Aggregate:	2.065	

Table 1: Designed Mix Proportion

Total Strength N/mm^2	Cement kg/m^3	F.A. kg/m^3	C.A. kg/m^3	Water Content Kg
26.6	413.33	465.29	1319.36	186

Table 2: Mix proportion of Concrete After 5% Replacement of Cement with Egg Shell Powder (ESP)

	In 1m^3	**For casting 6 Sample Cube (2.5% of 1m^3)**
Mass of Cement	392.663 Kg	9.816 Kg
Mass of ESP	20.665 Kg	0.51625 Kg
Mass of Water	186.0 Kg	4.65 Kg
Mass of F.A	465.294 Kg	11.625 Kg
Mass of C.A	1319.361 Kg	32.975 Kg

Table 3: Mix Proportion of Concrete After 10% Replacement of Cement With Egg Shell Powder (ESP)

	In 1m^3	**For casting 6 Sample Cube (2.5% of 1m^3)**
Mass of Cement	371.99 Kg	37.199 Kg
Mass of ESP	41.33 Kg	1.033 Kg
Mass of	186.0 Kg	4.65 Kg

Water		
Mass of F.A	465.294 Kg	11.625 Kg
Mass of C.A	1319.361 Kg	32.975 Kg

Table 4: Mix Proportion of Concrete After 1.5% Addition of Human Hair (H.H) By Weight of Cement

	In $1m^3$	For casting 6 Sample Cube (2.5% of $1m^3$)	For casting 6 Sample Cylinders (5% of $1m^3$)
Mass of Cement	413.33 Kg	10.33 Kg	20.66 Kg
Mass of H.H	6.199 Kg	0.153 Kg	0.306 Kg
Mass of Water	186.0 Kg	4.65 Kg	9.3 Kg
Mass of F.A	465.294 Kg	11.625 Kg	23.25 Kg
Mass of C.A	1319.361 Kg	32.975 Kg	65.95 Kg

Table 5: Mix Proportion of Concrete After 10% Replacement of Sand with Glass Powder (G.P)

	In $1m^3$	For casting 6 Sample Cube (2.5% of $1m^3$)
Mass of Cement	413.33 Kg	10.33 Kg
Mass of Water	186.0 Kg	4.65 Kg
Mass of F.A	418.76 Kg	10.469 Kg
Mass of G.P	46.53 Kg	1.163 Kg
Mass of C.A	1319.361 Kg	32.975 Kg

Table 6: Mix Proportion of Concrete After 20% Replacement of Sand with Glass Powder

	In $1m^3$	For casting 6 Sample Cube (2.5% of $1m^3$)
Mass of Cement	413.33 Kg	10.33 Kg
Mass of Water	186.0 Kg	4.65 Kg
Mass of F.A	372.235 Kg	9.306 Kg
Mass of G.P	93.058 Kg	2.337 Kg
Mass of C.A	1319.361 Kg	32.975 Kg

IV. PREPARATION OF SPECIMENS

The cube specimens of size 150 mm x150 mm x150 mm were cast as per procedure laid down in IS: 516 -1959 (Reaffirmed 2004) for each mix of concrete to determine the compressive strength. These specimens were air dried for 24 hr before they were cured for 7 and 28days for performing compressive strength test. Fig. 1 & 2 shows the mixing and casting of cubes on site.

Fig. 1. Dry-mixed Concrete

Fig 2. Mixing of Concrete

Fig 3. Casting of Cubes

A. Curing of the Specimens

The specimens were then marked for identification. And they were removed from the moulds after 24 hr from the time of adding the water to the ingredients. These specimens were then stored in water for the required period of curing.

Fig 4. Identification and Marking

Fig 5. De-moulding of Cubes

Fig 6. Curing of Cubes

B. Compressive Strength

Compressive strength of a material is defined as the value of uni-axial compressive stress reached when the material fails completely. At the test age specimens are taken out of the curing tank and kept outside for 10 minutes. Then one specimen is placed on steel platen of the machine such that the specimen is tested perpendicular to the casting position. Then the test is carried out at the loading rate of 3 KN/s.

Fig 7. Compressive Strength Testing under 100T CTM

V. RESULTS AND DISCUSSION

This paper describes the results of the tests conducted to study the compressive strength of concrete with partial replacement of its constituents (i.e. cement, sand, etc.) with waste materials like eggshell powder, human hair & glass powder. The compressive strength and split tensile strength of concrete specimens are discussed to investigate the influence of waste materials on concrete properties. The comparative results of the tested sample cubes and cylinders are shown in the graphs below.

A. Eggshell Powder-

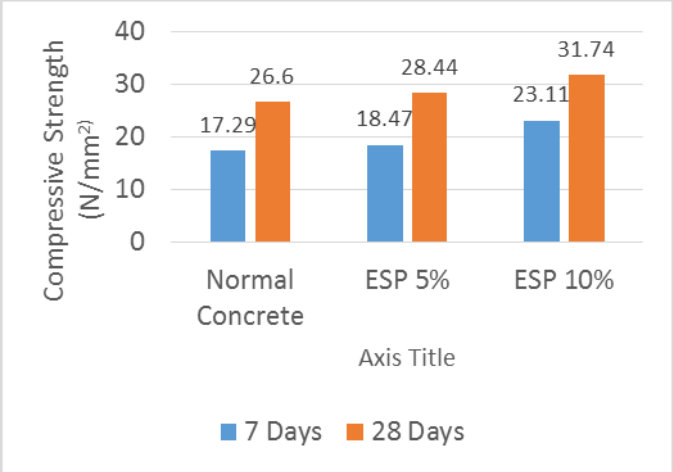

Fig 8. Comparison of Compressive Strength of Normal Concrete with Concrete Containing ESP

Table 7: % Increase in Compressive Strength of Concrete with ESP

% Increase In Strength		
	7 Days	**28 Days**
ESP 5%	6.82%	6.91%
ESP 10%	33.66%	19.32%

B. Human Hair-

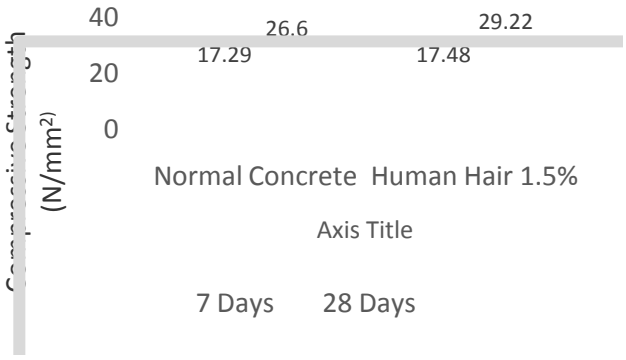

Fig 9. Comparison of Compressive Strength of Normal Concrete with Concrete Containing Human Hair

Table 8: % Increase in Compressive Strength of Concrete with Human Hair

% Increase In Strength		
	7 Days	**28 Days**
Human Hair 1.5%	1.09%	9.8%

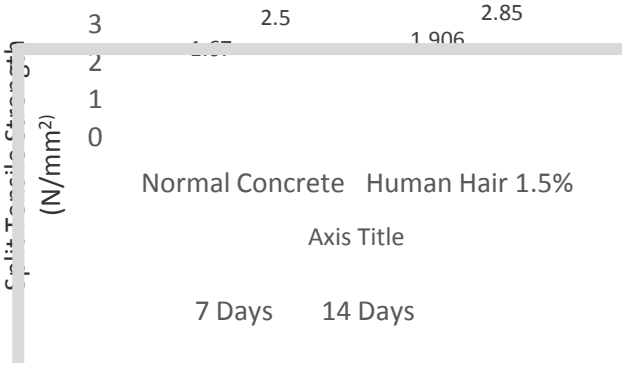

Fig 10. Comparison of Split Tensile Strength of Normal Concrete with Concrete Containing Human Hair

Table 9: % Increase in Split Tensile Strength of Concrete with Human Hair

% Increase In Strength		
	7 Days	**14 Days**
Human Hair 1.5%	14.13%	14%

C. Glass Powder

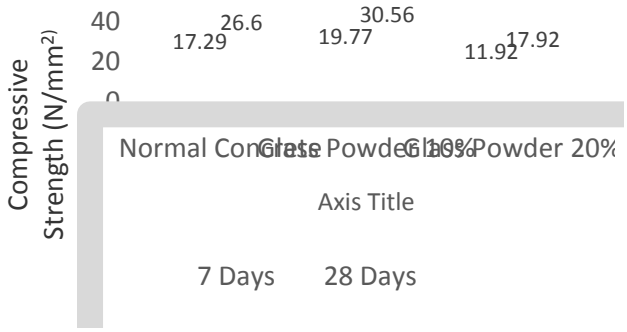

Fig 11. Comparison of Compressive Strength of Normal Concrete with Concrete Containing Glass Powder

Table 5.10: % Increase in compressive Strength of Concrete with Glass Powder

% Increase In Strength		
	7 Days	**28 Days**
Glass Powder 10%	14.34%	14.88%
Glass Powder 20%	-31.05%	-32.6%

VI. CONCLUSIONS

The tests carried out in this study were primarily designed to provide an indication of relative advantages and disadvantages of the use of a number of construction wastes, such as glass powder, eggshell powder and human hair. This would provide an overview of the reuse of construction waste materials in the construction industry. Based on the test results and on the physical observations, the following conclusions can be drawn:

1. Waste and recycling management plans should be developed for any construction project prior to the start of work in order to sustain environmental, economic, and social development principles.
2. A comparison between the cost of glass powder, human hair and eggshell powder with that of sand, fibers and cement should be considered in the project management plans, taking into consideration the availability of prime materials, and location.
3. When ESP (5% replacement of cement) was used in concrete, the strength of the concrete exhibited increased compressive strength than that of normal concrete. Therefore, it is recommended that concrete with specific amount of ESP can be used in certain civil engineering applications. This will contribute to cutting down the cost of using concrete with increased overall strength.
4. When human hair (1.5% weight of cement) was used in concrete, the strength of the concrete exhibited increased compressive and splitting-tensile strength than that of normal concrete (without using fiber

material). Therefore, it is recommended that concrete with human hair as fiber material can be used in certain civil engineering applications. This increases the overall strength of concrete.

5. The strength of concrete mixes was improved by the 10% partial replacement of sand with crushed glass powder, but the high alkali content of such aggregates may affect the long-term durability and strength, both of which need long-term investigation.

6. In addition to recycling glass by its use in concrete mixes, glass aggregates can be used aesthetically in masonry, which can give a shiny clean finishing effect on the surface of the concrete product.

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