Paper Aggregate a Leap towards Environmental Friendly Concrete

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Abstract— The research examined the use of waste paper into the development of lightweight concrete and brick. Lightweight aggregate and lightweight concrete have density less than 1120 kg/m^3 and 1850 kg/m^3 respectively. Paper aggregates were prepared by mixing of Cement, Paper Pulp and Glue. The properties of Paper Aggregates were tested through laboratory tests. Paper aggregates are in category of lightweight. Concrete and Brick samples were casted with partially and wholly replacement of conventional coarse aggregate by paper aggregate. The mechanical behavior of concrete and brick was determined after 28 days of curing period. Concrete and Brick having paper aggregates are lightweight with ample strength parameters. Chemical analysis and Environmental effects of concrete and brick having paper aggregates are recommended, along with testing of concrete slabs and beams.

Index Terms— Paper aggregate, lightweight concrete, concrete cylindrical specimen, concrete bricks, compression strength, split tensile strength.

1 Introduction

Concrete is the most commonly used building material where the composition is cement, sand, aggregate and water. If the concrete is properly designed, it is considered a durable material. Due to the lack of construction materials, it is increasing every day and many types of concrete are produced to meet the demand of the construction world [1].

Green concrete is defined as concrete that uses waste as at least one of its components or concrete whose production process does not destroy the environment. In other words, it is also called Ecological Concrete [2].

Lightweight concrete is a type of cement used in the construction industry for its advantages. The density ranges from 300 kg/m^3 to 1800 ± 50 kg/m^3 and normal concrete has a density range from 2200 kg/m^3 to 2600 kg/m^3 [3].

In addition, lightweight concrete helps to reduce the permanent load of the structure, thus helping to reduce the dimensions of the pillars and other elements of the load-bearing structure. This leads to an economic design. It also has fire resistance and thermal insulation [1].

Low-density or lightweight bricks have great constructional advantages, such as reduced structural dead load, ease of handling, reduced transport costs and reduced thermal conductivity. Light bricks can be replaced with standard bricks in most applications, unless high strength bricks are required or when a specific architectural look or finish is desired [4].

The papercrete is made of flying ash, used paper, extraction dust, cement mixed with water, and placed in a mold and dried [5]. Papercrete material has been found many years ago but undiscovered recently.

For this experimental study, paper waste has been chosen to develop the lightweight artificial aggregates and then to replace the conventional aggregates by lightweight artificial aggregates.

Pakistan generates around 30 million tonnes of solid waste per year, an increase of over 2% per year. Like other developing countries, Pakistan does not have a waste management base that causes significant environmental problems. Most urban waste is burned, thrown away and buried in empty areas that threaten the health and happiness of the general population. The Pakistani government estimates that 71,000 tonnes of solid waste will be produced every day, mainly in major metropolitan areas. Paper contamination is another influence of paper waste and is a serious problem. Paper pulp and paper pulp are the third largest industrial pollutant in the atmosphere, water and soil [6].

2 Related work

Lightweight concrete is not a completely pure form. The shape will be distorted if exposed to high temperatures for a long time. The backgrounds have little resistance and strength. Concrete is more stable than light concrete and concrete. The compressive strength limit of concrete is from 3500 to 4000 psi (pounds per square inch). The value of Papercrete is only 1200-1500 psi. As a result, it breaks down less stress [7].

The consistency and stability of the concrete mix were studied using fresh density and polymerization density of previously recorded concrete samples [8].

Instead of cement, the material used for the production of 7.5% eggshell lightweight concrete consists of ordinary Portland cement, eggshell, fine aggregate, water and bubbles. When eggshell powder has been mixed into lightweight, lightweight concrete, its compressive strength, the dissociation of the flexural strength, the Poisson strength and the compressive strength are increased. Furthermore, the microstructure of LFC was dense and the pore size of the concrete structure was lower than that of the egg shell incorporation control mix [1].

In research about the density of the actual paper, studies have shown that as the proportion of cement in the mixture increases the density of the material increases, but as the amount of

paper in the mixture increases, the density decreases [9].
The density of paper cement has decreased with the increase in the recycled paper replacement ratio. When the exchange rate of the paper was 5%, the density was 1.88g/cm^3 (1800 kg/m^3), which decreased respectively to 15% and 22% and the percentage of paper increased to 10% and at 15% [10].
The ability to compress concrete samples into paper was analyzed. The samples were analyzed after 14 days to obtain comparative data on changes in the behavior of pulp of paper during maturation. The figure shows the behavior of the pressed paper when compressed under load and the graph shows the average compressive strength of a given sample [7].

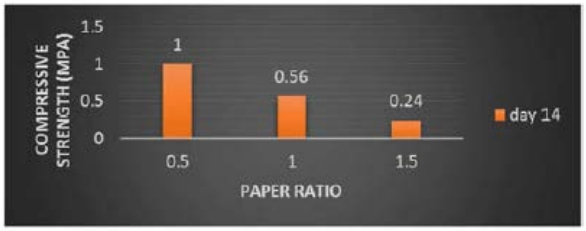

Fig. 1. Compressive Strength vs. Paper Ratio

3 MATERIALS

The materials used in this research are listed below. Experimental study conducted at Iqra National University Peshawar.

3.1 Cement

Ordinary Portland cement most commonly available in local market was used. Specific gravity of cement is 3.15.

3.2 Aggregate

Fine and Coarse aggregate collected from District Dara, Khyber Pakhtunkhwa.

3.3 Paper Aggregate

Paper aggregate is a handmade production and it is mixture of paper pulp, glue and cement. Waste papers provided by Iqra National University, Peshawar were soaked for 24 hours in water. Waste paper included old newspapers, old office papers and miscellaneous papers. Glue "Calabond WD 2" manufactured by ICI Pakistan Limited and locally available Cement were used. The aggregates when made were kept in area open sky for 72 hours to be sundried.

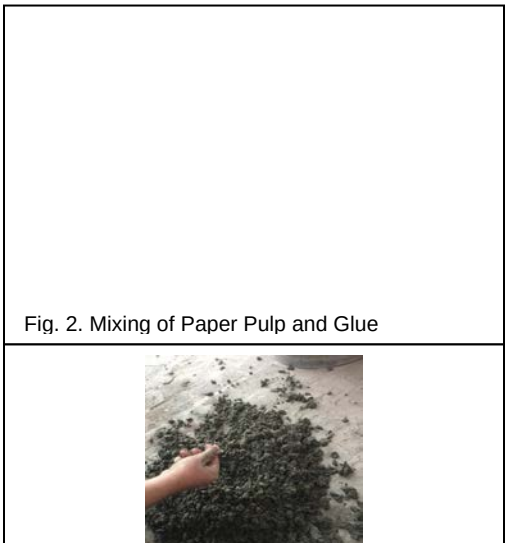

Fig. 2. Mixing of Paper Pulp and Glue

Fig. 4. Paper Aggregate

			ment
P1	1	0.4	2
P2	1.5	0.5	1
P3	1	0.5	1.5

Before the development of paper aggregates, the ratios were set. The table above shows the ratio of the samples.

TABLE 1
CONCRETE CYLINDRICAL SPECIEM

% Replacement of C.A	Compressive Strength 28 Days	Split Tensile Strength 28 Days
0 %	3	3
50 %	3	3
100 %	3	3

4 METHODOLOGY

4.1 Casting of concrete cylindrical specimen

Concrete ratio was selected as 1:1.5:2. Total 18 concrete cylindrical speciemen were casted and tested for compression and split tensile strength after 28 days of curing age the detail is given in table below.

TABLE 1
CONCRETE BRICK SPECIEMEN

% Replacement of C.A	Compressive Strength 28 Days	Samples
0 %	3	
50 %	3	
100 %	3	

3.2 Casting of concrete Brick

Total 9 concrete bricks were casted and tested for compression after completion of 28 days of curing age the detail is given in table below.

4 RESULT AND DISCUSSION

4.1 Concrete Density

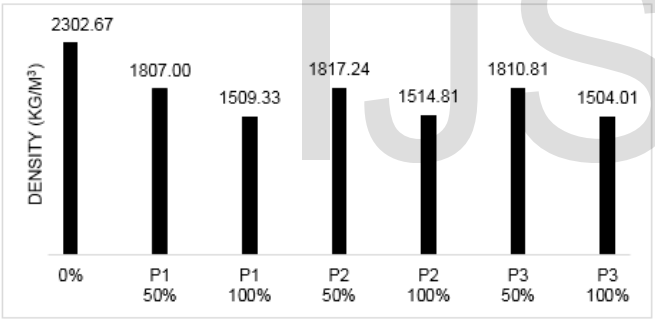

Fig. 5. Density Vs. Concrete Cylindrical Samples

Density test was conducted on concrete cylindrical samples having partial and whole replacement of conventional coarse aggregate by paper aggregate and then compared with controlled concrete for 28 days of curing age. The results showed a tendency to decrease the density with increase in the percentage paper aggregate. Controlled Concrete showed density of 2302.67 kg/m^3. Paper aggregate sample "P1" gives density of 1807.00 kg/m^3 and 1509.33 kg/m^3 at 50% and 100% replacement respectively. Paper aggregate sample "P2" gives density of 1817.24 kg/m^3 and 1514.81 kg/m3 at 50% and 100% replacement respectively. Paper aggregate sample "P3" gives density of 1810.81 kg/m^3 and 1504.01 kg/m^3 at 50% and 100% replacement respectively.
Therefore, we conclude the lowest density value of the 28-day maturation period that 100% replacement of the overall "P3" paper samples 1504.01 kg/m3.

4.2 Compressive Strength of Concrete Cylindrical

Compressive test was conducted on the concrete cylindrical samples having partial and whole replacement of conventional coarse aggregate by paper aggregate and then compared with controlled concrete for 28 days of curing age. The results showed a tendency to decrease the compressive strength with increase in the percentage of paper aggregate. Controlled Concrete shows compressive strength of 3217.36 psi. Paper aggregate sample "P1" gives compressive strength of 2494.75 psi and 1486.15 psi at 50% and 100% replacement respectively. Paper aggregate sample "P2" gives compressive strength of 2239.95 psi and 1373.51 psi at 50% and 100% replacement respectively. Paper aggregate sample "P3" gives compressive strength of 2167.66 psi and 1301.38 psi at 50% and 100% replacement respectively.
Therefore, we conclude that 50% and 100% replacement of all three samples show adequate compressive strength but the peak value of compressive strength for 28 days of curing period is on controlled concrete i.e. 3217.36 psi.

4.2 Compressive Strength of Concrete Brick

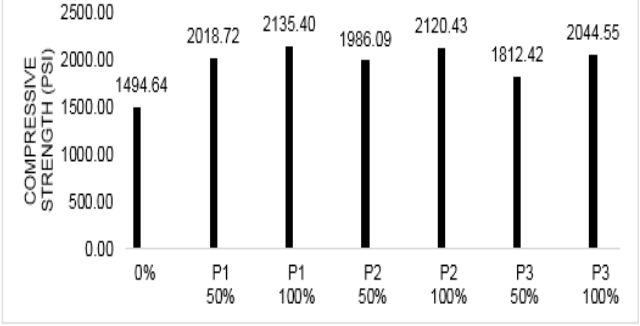

Fig. 7. Compressive Strength Vs. Concrete Brick Samples

Compressive test was conducted on the brick specimens having partial and whole replacement of conventional coarse aggregate by paper aggregate for 28 days of curing age and then compared with conventional brick. The results showed a tendency to decrease the compressive strength with increase in the percentage of paper aggregate. Conventional Brick shows compressive strength of 1494.64 psi. Paper aggregate sample "P1" gives compressive strength of 2018.72 psi and 2135.40 psi at 50% and 100% replacement respectively. Paper aggregate sample "P2" gives compressive strength of 1986.09 psi and

2120.43 psi at 50% and 100% replacement respectively. Paper aggregate sample "P3" gives compressive strength of 1812.42 psi and 2044.55 psi at 50% and 100% replacement respectively.
Therefore we conclude that 50% and 100% replacement of all three samples show more compressive strength than conventional brick. The peak value of compressive strength for 28 days of curing period is on 100% replacement of Paper aggregate sample "P1" i.e. 2135.40 psi.

4.2 Split Tensile Strength of concrete cylindrical specimen

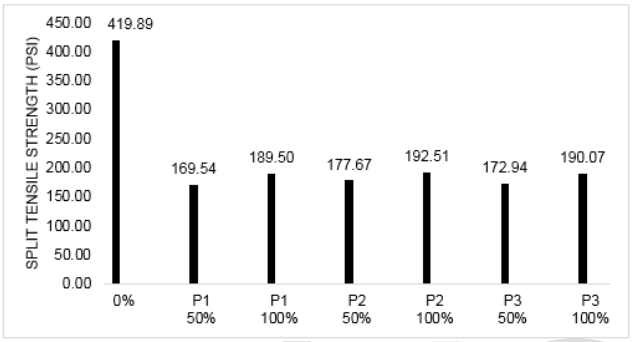

Fig. 8. Split Tensile Strength Vs. Concrete Cylindrical Samples

Split Tensile Strength test was conducted on the concrete cylindrical samples having partial and whole replacement of conventional coarse aggregate by paper aggregate and then compared with controlled concrete for 28 days of curing age. Results show the decreasing trend of split tensile strength as per increase in the percentage of paper aggregate. Controlled Concrete shows Split Tensile Strength of 419.89 psi. Paper aggregate sample "P1" gives Split Tensile Strength of 169.54 psi and 189.50 psi at 50% and 100% replacement respectively. Paper aggregate sample "P2" gives Split Tensile Strength of 177.67 psi and 192.51 psi at 50% and 100% replacement respectively. Paper aggregate sample "P3" gives Split Tensile Strength of 172.94 psi and 190.07 psi at 50% and 100% replacement respectively.
Therefore we conclude that 50% and 100% replacement of all three samples show less split tensile strength. The peak value of split tensile strength for 28 days of curing period is on controlled concrete i.e. 419.89 psi.

4 Conclusion

The use of paper in the development of aggregates should be encouraged for sustainable and ecofriendly construction.
Results have shown that the paper aggregates have the potential to be used as lightweight aggregates in concrete and brick.
It is concluded that the paper aggregates are more suitable as low strength giving lightweight aggregate when used to replace conventional coarse aggregates in the production of concrete. The results also conclude that the concrete partially and wholly replaced with paper aggregates show lesser strength but can be recommended where conventional aggregates are not easily available. While the brick partially and wholly replaced with paper aggregate show more strength than the conventional clay brick. In terms of weight, the brick with wholly replaced with paper aggregates has almost the same weight of conventional clay brick.
It can be recommended that the low density concrete and brick with partially and wholly replacement of paper aggregates indicates that these are lightweight and can be used in the form of either hollow or solid blocks for making walls of building, in high rise building.

Acknowledgment

The authors would acknowledge to Iqra National University Concrete Lab for providing sufficient environment and guidance.

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