EXPERIMENTAL STUDY ON STRENGTH AND DURABILITY PROPERTIES OF CONCRETE USING AGRO AND POULTRY WASTE

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Abstract:- **Nowadays, construction materials requirements are to be met include not only strength features but also durability resistance, resulting from the increasing pollution of the natural environment. Cost of the material also increasing day by day and the concrete produced now a day's does not exhibit its character. To reduce the cost and to increase the strength characteristic of the structure, the investigation is done on study of properties of concrete using cement replacement by egg shell powder and fine aggregate using saw dust ash. The aim of the project is to investigate the strength and durability properties of concrete. The experiment is conducted to analysis strength and durability by replacing cement by egg shell powder and fine aggregate by sawdust ash. For each ratio, specimens were prepared to find compressive, split tensile strength, flexural strength and durability of concrete at 7, 14 and 28 days are prepared for each percentage curing at the optimum replacement. The results showed that a high strength value is given for 10% replacement and it enhanced the strength of concrete making it to be the highest of any other replacement. The optimum compressive strength achieved is 33.56 N/mm^2.The durability test were conducted using $MgSO_4$ and HCl at 28 day curing. The percentage loss of weight and strength is found to be less for 5% replacement of egg shell powder and wood ash after durability tests..**

Keywords: Egg shell powder, wood ash, durability tests, poultry waste, strength tests.

1. INTRODUCTION

Concrete is a widely used construction material for various building structures due to its structural stability and strength. All the materials required in huge quantities of concrete come from the earth's crust. Thus, it depletes its resources day by day. The increasing demand for cement and concrete is met by partial cement replacement. Considerable energy and cost savings can be resulted when industrial by-products are used as a partial replacement for the energy intense Portland cement. The use of by-products is an environmental friendly method of disposal of large quantities of materials that would otherwise pollute land, water and air. Recent technological development has shown that these materials are valuable as organic and inorganic resources and can produce various useful products.

Typical concrete is a mixture of fine aggregates, coarse aggregates, cement and water. Because of its convenient use, it is not only used in building construction but also in other areas, roads, harbours, bridges and many more. The usage of concrete is very wide. It is one of the most important constituent materials. It is comparatively economical. The another need for the making of concrete is the natural sand mined from the riverbeds. However, the availability of river sand for the preparation of concrete is becoming scarce due to the excessive different methods of mining from the riverbeds, lowering of water table, sinking of the bridge piers.

To overcome the above challenges, various waste produced from any areas which includes any material that is useless during a manufacturing process such as that of factories, mills and mines etc are used in construction purpose. In recent years, special attention has been devoted to industrial sectors that are sources of pollution of the environment.. The disposal of various wastes from any source is a very important problem, which can cause risk to public health, contamination of water resources and polluting the environment. The use of sawdust ash in concrete have shown that addithion of the material in the matrix may not only lower the cost of concrete but also offer a large market for the utilization of wood ash concrete as a cost-effective alternative to current disposal methods of the waste. On the other the use of eggshell waste to replace cement in concrete can have benefits like minimizing use of cement, conserving natural lime and utilizing waste material.

2. MATERIALS AND METHODS

A. Materials

1. Ordinary Portland Cement

In the present study ,53 grade of ordinary Portland cement was used . The cement thus used was tested for various properties such as specific gravity, etc. in accordance with IS:4031-1968 and was found to be conformed with the various specifications given by IS:12269-1987.

2. Fine Aggregate (M-Sand)

The M-sand passing through 4.75mm sieve and retained on 600 μm was used as fine aggregate. Laboratory test were conducted on fine aggregate to determine the different physical properties as IS 383 (Part 3)-1970.The specific gravity was 2.7 and fineness modulus was 3.57 respectively. The fine aggregate used in the project work is 4.75 mm down grade.

3.Coarse Aggregate

The grading of natural aggregates should be as per specifications of IS 383-1970 and IS 2386-1963. In this project, 20 mm size of natural aggregate is used. The specific gravity was found to be 2.83 and the fineness modulus was 4.16 conforming to IS specifications.

4.Egg shell powder

Eggshell consists of several mutually growing layers of CaCO3. The eggshell primarily contains calcium, magnesium carbonate (lime) and protein. The quality of lime in eggshell waste is influenced greatly by the extent of exposure to sunlight, raw water and harsh weather conditions. It is the fine grained powder with suitable proportion which is sieved to the required size before use with concrete.

Fig. 1 Egg shell powder

5.Wood ash

Wood ash is a by product generated combustion of wood in hotels paper mills etc. this ash contains silica and magnesium properties. Wood ash particles are of different sizes and shapes. It also helps to reduce the dumping problem and helps in replacement of fine aggregate. To obtain the fineness for replacement with fine aggregate sieve analysis is carried.

Table 1 Properties of egg shell powder and wood ash

Properties	Egg shell powder (%)	Wood ash(%)
SiO_2	0.11	65.79
CaO	47.49	9.39
Al_2O_3	NIL	4.88
Fe_2O_3	TRACES	2.01
MgO	NIL	3.92
SO_3	0.38	0.98
Na_2O	0.14	0.06
Specific gravity	2.5	2.6
Fineness	3%	2.63%

B. EXPERIMENTAL PROCEDURE

Test on fresh concrete

Workability test

The workability is determined with the help of slump test. The slump value varies for different sample mixes. The assumed slump value is 100 mm**.**

The workability for various mixes determined with the help of slump cone are given below.

Table 2 Slump values

Mix proportions	Slump value
NM	90
5% replacement	93
10% replacement	89
15% replacement	85
20% replacement	92

Tests on hardened concrete

The specimens are casted, cured and taken for testing such as compressive strength, split tensile, flexural and durability tests. Two specimens of specimen are tested in each mix and average value is calculated.

Compressive strength test

Compression testing machine is a device used for testing the compressive strength of the specimens. The following procedure is being followed: Remove the specimen from water after specified curing time and wipe out excess water from the surface. 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 load gradually without shock and continuously till the specimen fails. Record the maximum load and note any unusual features in the type of failure.

The compressive strength of cube specimen is calculated using the following formula

Compressive strength, $F_C = P/A$ in N/mm^2

Where, P = Load at failure in N

A = Area subjected to compression in mm^2

Fig 2 Compressive testing

Table 3 Compressive strength values

Sl No	Type of Mix	Average compressive strength (N/mm^2)			
		7 days	28 days	56 days	90 days
1	Normal mix	15.34	22.00	26.44	30.89
2	5% of (ESP & WA)	17.23	21.67	32.56	33.00
3	10% of (ESP & WA)	18.37	31.78	32.66	33.56
4	15% of (ESP & WA)	11.56	16.56	21.67	22.23
5	20% of (ESP & WA)	9.41	13.56	19.00	20.34

Split Tensile Strength Test

This test is done with the help of Compression testing machine.The procedure is as follows: Take the wet specimen from water after 7 days of curing. Wipe out water from the surface of specimen. Draw diametrical lines on the two ends of the specimen to ensure that they are on the same axial place.Note the weight and dimension of the specimen. Set the compression testing machine for the required range. Place the specimen and align the specimen so that the lines marked on the ends are vertical and centered over the bottom plate.

Apply the load continuously without shock at a rate of approximately 14-21kg/cm^2/minute (Which corresponds to a total load of 9900kg/minute to 14850kg/minute) Note down the breaking load(P). Repeat the test in two specimens and the average of the value is noted as Split tensile strength of the concrete.

The split tensile strength of cylinder specimen is calculated using the following formula

Split tensile strength = $2P / \pi DL$

Where, P = Load at failure in N
L = Length of the specimen in mm
D = Diameter of the specimen in mm

Fig 3 Split tensile strength test

The splittensile strength results are given in below table. From the results obtained, it is clear that 10%replacement increase in compressive strength when compared to normal concrete.

Table 4 Split tensile strength values

Sl No	Type of Mix	Average Split Tensile Strength(N/mm^2)		
		7 days	14 days	28 days
1	Normal mix	1.835	2.085	2.295
2	5% of (ESP & WA)	1.345	1.613	2.051
3	10% of (ESP & WA)	1.94	2.192	2.405
4	15% of (ESP & WA)	1.132	1.34	1.799
5	20% of (ESP & WA)	0.283	0.94	1.515

Flexural Strength Test

The flexural tests were carried out on RCC beam specimens under standard one points loading. One concentrated loads at mid span were applied on the beams. The flexural strength depends on the dimension of the beam and manner of the supporting span that is spaced at 100 mm center to center or on either side of beam was place perpendicular to the applied force without eccentricity. Dial gauges fixed at the middle of the span of the set up.At the end of each load increment, observations and measurements were recorded for load points deflection, mid-point deflection and crack development. The load at first crack, ultimate load, type of failure etc., were carefully observed and recorded. The specimens were loaded continuously at a constant rate till failure.

The flexural strength of the specimen shall be expressed as the modulus of rupture F_b, whichshall be calculated using the following formula,

$$F_b = \frac{3pl}{2bd^2}$$

Where,

b = measured width in mm of the specimen,
d = measured depth in mm of the specimen at the point of failure
l = length in mm of the span on which the specimen was supported, and
p = maximum load in N applied to the specimen

Durability test

Durabity is one of the important characteristics of hardened concrete to find the replacement materials.In this project, durability test is carried out using acid attack and sulphate attack. The specimen is immersed in 5% of HCl and $MgSO_4$ solution to the water content added in the specimen.After 28 days, the cube is taken out and weight loss, strength loss is calculated.

C. RESULT AND DISCUSSIONS

A. Compressive strength test

The compressive strength test result of various percentage mixes specimen shows that strength of concrete is increased and then decreased when compared to controlled concrete(CC).The optimum strength is achieved at 90 days testing for both 5 and 10% replacement was 33N/mm^2 and 33.56 N/mm^2. The percentage increase was found between optimum strength values and normal values is 6.83% and 8.64%. The percentage changes between the curing stages was different for each periods.

The strength achieved at 90 days testing was found to be 33N/mm^2 , 33.56 N/mm^2, 22.23 N/mm^2, 20.34 N/mm^2 .The percentage difference in strength varies 72.99% for 7 days to 28 days, 2.76% for 28 days to 56 days and 2.756% for 56 days to 90 days. Thus it is concluded that the maximum strength is achieved slowly based on curing periods. The loss in compression strength is due to the pozzzolanic activity of the wood ash. Also the fineness of the egg shell powder contributes to the increase in compressive strength of the concrete. The percentage replacement of egg shell powder and wood ash with concrete upto 10% gave optimum strength compared to normal concrete. On excess replacement with 15% and 20% , the strength was decreased gradually.

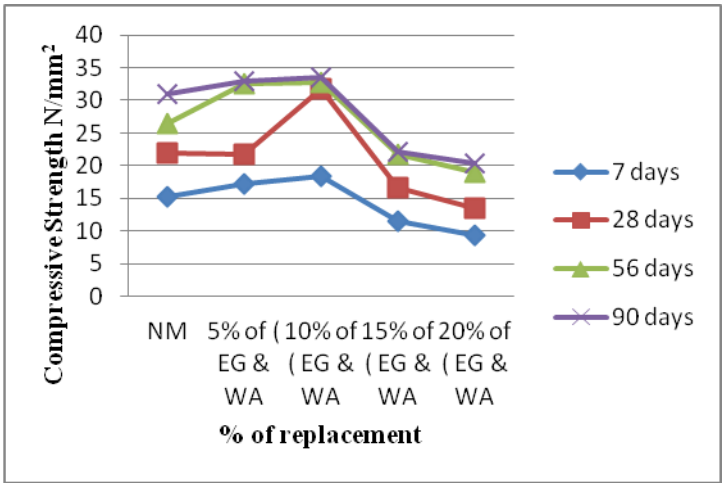

Fig. 4 Compressive strength variation

B. Split Tensile Strength test

The split strength test result of various percentage mixes specimen shows that strength of concrete is increased and then decreased when compared to controlled concrete(CC). The percentage replacement of egg shell powder and wood ash with concrete at 10% gave optimum strength compared to normal concrete. The minimum split tensile strength is found to be 0.336N/mm^2 and 0.94N/mm^2. The tensile strength at 28 days is

found to be increasing at a rate of 10.63% from 0% to 5% replacement, 4.79% increment from 0% to 10% replacement 21.61% increment for 0% to 15% replacement and 33.98% increment for 0% to 15% replacement. The better results were shown for 10% replacement which is 2.405N/mm^2.The increase in tensile strength improves the resistance against tension after ages.

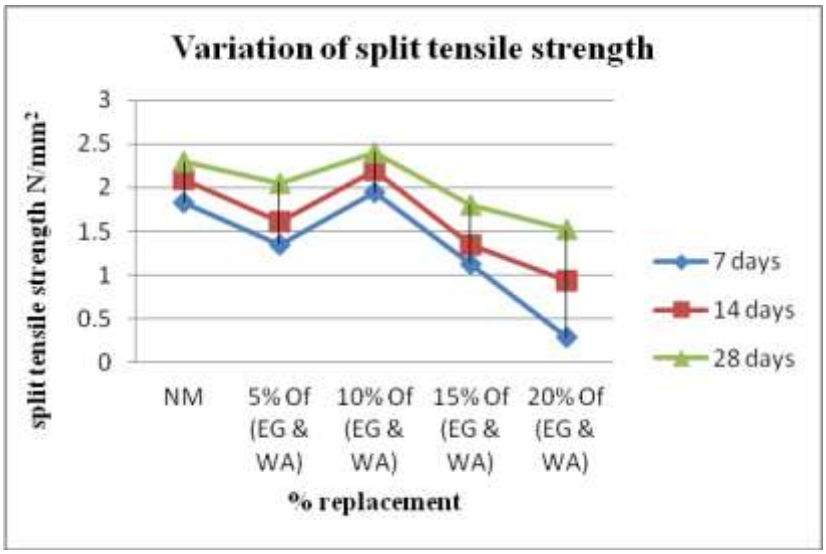

Fig.5 Split tensile strength variation

C. BEHAVIOR OF RC BEAM

Load Carrying Capacity of RC Beam

The load carrying capacity of beam is the ultimate load up to which the beam can withstand without failure. In this project work the flexural strength of RC beam is calculated for the normal mix and the 10% replacement.

Table 5 Load Carrying Capacity of the RC Beam

Type of Mix	**Initial Crack Load(kN)**	**Ultimate Load(kN)**
Normal mix	34.6	57.9
10% of (ESP &WA)	48.5	62.8

The beam's deflection until the initiation of cracks increased linearly and was proportional to load. After the initial cracking, deflection increased non-linearly until the maximum load was reached. On comparing the percentage variation of load at first crack and ultimate crack between the conventional concrete beam and 10% replacement of egg shell powder and wood ash concrete beam is found to show a increase of 4.01% and 8.46%.

Load Vs Deflection Behaviour of RC beam

The Load Vs Mid span deflection of reinforced beam is the major criteria to study the flexural behavior of beam.Load vs Deflection behaviour for conventional concrete and 10% replacement of egg shell powder and wood ash concrete is shown in table The graphical representation of load vs deflection curve is shown.

Table 6 Load Vs Deflection for Conventional concrete

LOAD (kN)	DEFLECTION (mm)
15	0.23
25.2	1.22
34.6	1.67
44.5	2.56
57.9	3.23

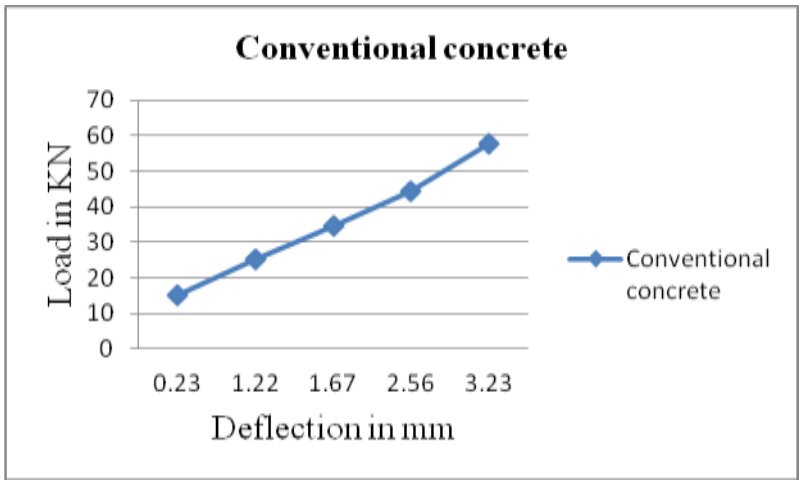

Fig. 6 LoadVs Deflection curve for conventionl concrete

Table 7 Load Vs Deflection for 10% replacement

LOAD (kN)	DEFLECTION (mm)
15	0.18
25.2	1.03
34.6	1.42

44.5	1.97
57.9	2.36
62.8	2.44

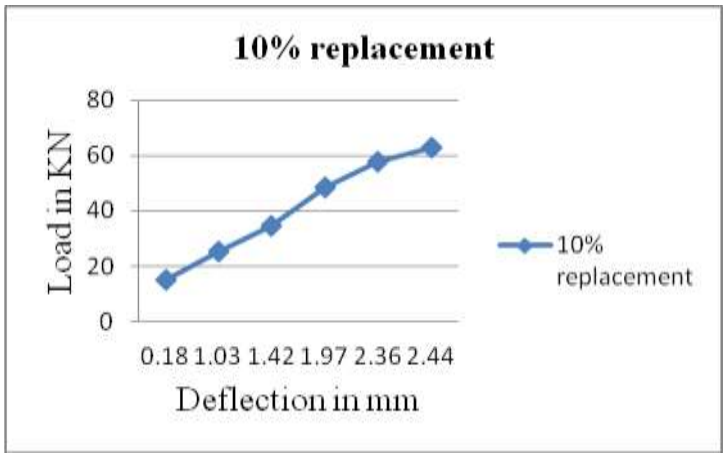

Fig.7 Load Vs Deflection curve for 10% replacement

On comparing the deflection results for 10% replacement of eggshell powder and wood ash with conventional concrete, it is clear that the beams with admixtures exhibit high load carrying capacity with minimum mid span deflection. The maximum deflection of 3.23 is observed for a load of 57.9kN for which the deflection of 10% replacement is minimum. The permissible deflection for beam of 1m span is limited to 4mm (Span/250 = 1000/250) for which the experimental value is satisfied.

D. DURABILITY TESTS

Acid resistance test

The weight and the compressive strength of the specimens were found for the age of 28 days after immersion in HCl acid. The average percentage of loss of weight and compressive strengths were calculated as shown shows the graph for the behaviour of different mixes subjected to acid curing. The graph shows a clear results regarding the weight loss percentage of comparison of the concrete mixes cured under HCl for 28 days. The acid attack leads to the degradation of the concrete and thus results in weight loss and corresponding compressive strength of the specimens. It is to be noted that the impact of the acid is more on the calcium rich components. A maximum weight loss of 0.95% is obtained on 20% replacement mix in which CaO is the major component.. Also, about half of the strength is being reduced at the end of 28 days when subjecting the specimens to acid attack.

Table 8 Acid Resistance test Results

Mix	**Weight before acid attack (kg)**	**Weight after acid attack (kg))**	**% loss in weight**	**28 days Compressive strength (N/mm^2)**	**% loss in strength**

Normal mix	8.43	8.39	0.47	17.5	25.71
5% of (ESP & WA)	8.41	8.35	0.71	16.8	28.98
10% of (ESP & WA)	8.42	8.37	0.59	21.8	45.78
15% of (ESP & WA)	8.41	8.34	0.83	18.5	10.49
20% of (ESP & WA)	8.38	8.3	0.95	15.0	9.6

Sulphate attack test

The sulphate attack was evaluated by measuring the weight losses of the specimens at 28 days of Na_2SO_4 curing. The results for sulphate attack are shown.The loss of weight was observed in 5% replacement was to be lower in concrete specimen with other percentage replacement concrete mixes. A maximum weight loss of 0.95% was obtained for 20% replacement of egg shell powder and wood ash. A largest percentage of 29.71% compression strength gets lost in the sulphate attack test which should be under consideration.

Table 9 Sulphate Attack Tests on cubes

Mix	**Weight before sulphate attack (kg)**	**Weight after sulphate attack (kg)**	**% loss in weight**	**28 days Compressive strength (N/mm^2)**	**% loss in strength**
Normal mix	8.41	8.34	0.83	22.7	3.08
5% of (ESP & WA)	8.42	8.38	0.47	21.4	1.23
10% of (ESP & WA)	8.43	8.38	0.59	24.5	29.71
15% of (ESP & WA)	8.41	8.35	0.71	19.4	14.64
20% of (ESP & WA)	8.4	8.32	0.95	15.8	14.18

D. CONCLUSION

The concrete with the addition of 10% replacement of egg shell powder and wood ash greatly influence the strength and durability characteristics under curing conditions. The test result shows that the weight of concrete is gradually increased and then decreased while adding egg shell powder and wood ash. The percentage replacement of 10% partial replacement of cement and fine aggregate increases the compressive strength of concrete by 8.64% as compared to conventional concrete which is found to be 33.56 N/mm^2 at 90 day curing. The split tensile strength concrete decreased by about increase in addition of eggshell powder and wood ash. The better results were shown for 10% replacement which is 2.405 N/mm^2. The flexural tests conducted on reinforced beams concluded that the optimum strength achieved performs well in bearing load and resisting deflection.Considering the durability properties, the acid attack and sulphate attack tests concluded that there is a little percentage of loss in the weight when subjected to acids and sulphates in which the less calcium content mixes has better resistant to the attacks.The compressive strength of concrete specimens after subjected to acids and sulphates conclude thatthere is considerable decrease to the reaction between the chlorides and sulphates with the egg shell powder and wood ash.

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