PARTIAL REPLACEMENT OF FINE AGGREGATES WITH WASTE GLASS POWDER AND CEMENT WITH WASTE PAPER SLUDGE ASH IN CEMENT CONCRETE

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ABSTRACT - *In this research work, there is partial replacement of cement and fine aggregates with waste paper sludge ash and waste glass powder respectively. Cement was replaced partially up to 15% at regular interval of 5% and fine aggregates were also replaced partially up to 35% at regular interval of 10%. Concrete of M 20 design was used throughout the work. The cylinder specimen of size 300m length and 150mm diameter was used for split tensile strength test, beam of 150 x 150 x 750mm beam was used for flexural test and cube specimen of 150 x 150 x 150mm was used for compressive strength test for 7, 14, and 28 days. Cube specimen was also tested for water absorption after 28 days.*

Key words: - Waste Glass, Waste Paper Sludge Ash, Compressive Strength, Water Absorption etc.

INTRODUCTION

Natural resources are left very limited in quantity and continuous use of natural resources in concrete industry give rise to various problems. If natural resources are used at this speed then time is close when we have to stop using concrete as a construction material and have to search for alternatives. If we have to stop this cause then we must use natural resources in better way and also by shifting to waste material as an alternative to natural resources. This shifting not only lessens the fear of shortage of natural resources for concrete industry but also reduce the cost of production. Waste materials not only affect our environment but also cause disposal problems. Most of the waste materials are of no use and some of them are non biodegradable and occupy land area in present world when there is no space for people to live. If such waste materials are used in concrete industry as ingredients, it will be greatly beneficial for concrete industry as well as for our environment.

Concrete is a mixture of cement, sand and aggregate. In today's world, concrete is being used everywhere and also with a very high speed. India is a developing nation and use of concrete is already very high but is going to increase with time. Big shopping malls, houses, roads, bridges are constructed everyday and all these requires concrete for building. When aggregates are dry mixed with cement and water then it forms a slurry which can be poured in desired place or in container to get desired shape and size structure. There are famous building structures made of concrete like Bruj Khalifa which are very tall and strong and some big structures like Dams are also build with reinforced concrete.

There is a lot of waste product all around in world and in India, 0.7% of total waste from urban area consists of glass. Waste glass can be crushed into required size to use it as a replacement of fine aggregate in concrete. Waste glass after crushing can also be used as material for filtration. Fine aggregate used in concrete are taken from river and it leads to exploitation of river bed and natural resources. It also lower the water table and also cause erosion which is major cause of flood now a days. If fine aggregates are replaced by waste glass powder after sieve analysis then it will help in utilization of waste material and also help in preventing natural resources from deterioration. Taking aggregates from river has now become a major reason for water table lowering which further cause sinking of bridges which are made on rivers. Replacing the fine aggregates with waste glass decreases the content of fine aggregates and also help the river from getting eroded. Waste glass quantity is increasing day be day from last few years. Waste glass is non biodegradable and most of the waste glass is dumped in land and other left on the surface of land. If waste glasses are used in making concrete, the cost of production of concrete goes down. Waste glass can be crushed in Los Angles Abrasion machine and then sieved from 1.18mm sieve. After sieve analysis, waste glass powder can be used as a replacement of fine aggregates. Waste paper sludge, a byproduct of paper comes from paper recycling industry is another waste product which can be recycled only few times. If cannot be recycled number of times because it can cause paper to lose its strength and paper of high quality cannot be made. Paper which are broken or paper which becomes weak after recycling are separated out and becomes waste sludge. Around 300 kg of sludge is produces for every ton of recycled paper. Huge amount of sludge which is produced from recycling are thrown on land or dumped in landfills which affect our environment. Use of waste paper sludge up to a certain percentage in concrete as a replacement of cement can help use in utilization of waste on land and also help us in using less cement. Cement manufacturing process also affected our environment at huge. Cement

manufacturing generate high pollution which is hazardous for our environment. Replacement of cement with waste paper sludge can lessen the waste material and also help us to make economical concrete because it will lessen the production cost of concrete.

RESEARCH SIGNIFICANCE

Utilization of hazardous waste of environment in concrete. The prospective of this research is to check the potential of partial replacement of fine aggregates and cement with waste glass powder and waste paper sludge respectively. It is expected that resulting concrete would increase infrastructural durability and provide us Green concrete.

MATERIAL

The material used are as follows:

Cement: The cement used in this research is Ambuja Ordinary Portland cement (43 grade).

Aggregates: The Fine aggregates used in this research are taken from river with max size of4.75mm. Coarse aggregates used are of machine crushed stone passing through 20mm IS sieve and retained on 4.75mm IS sieve.

Waste Glass Powder: Window waste glass was used and it was collected from Singh Glass House, Bathindi, Jammu, J&K, and then crushed in Los Angeles abrasion apparatus and then sieved through 1.18mm IS sieve.

Waste Paper Sludge Ash: Waste paper sludge was obtained from Sunrise Tissue, Jammu, J&K, India. It was then sun dried and incinerated so as to convert it into ash and sieved through 90 micron IS sieve.

Table 1: - Chemical composition of Waste Glass

Oxides	% Content
SiO_2	70.4
Al_2O_2	1.9
Fe_2O_3	1.2
MgO	10.3
Na_2O	14.0
K_2O	0.4

Table 2: - Chemical composition of Waste paper Sludge Ash

Element	% Content
O	15.83
Ca	14.94
Si	60.57
Al	2.06
Mg	3.59
S	1.07
K	0.16
Fe	0.92

METHODOLOGY

The effect of waste glass and waste paper sludge on the strength of concrete for M20 grade can be studied by varying the percentage of waste glass in concrete by replacing it with fine aggregate and waste paper sludge in concrete by replacing it with cement. Waste glass powder content is varied by 0%, 5%, 15%, 25%, and 35% of weight of fine aggregate and waste paper sludge by 0%, 5%, 10%, 15%, of weight of cement. Compressive strength and tensile strength of concrete is determined by performing various tests in lab related to them. Cubes of size 150mmX150mmX150mm are casted to check the compressive strength, beam of 150 x 150 x 750mm and 300mm length and 150mm diameter cylinders are casted to

check the tensile strength of concrete. All the specimens were cured for the period of 7, 14 and 28 days before crushing and thus compression test, flexural test and split tensile test is performed.

Fig 1. Cube moulds with Concrete

Fig 2. Curing of Cubes

TESTING AND RESULTS

Slump Test

Slump test was carried out in three stages. Firstly, with the replacement of fine aggregates by waste glass powder and it was noted that the slump was maximum for 35% of replacement of fine aggregates as waste glass powder does not absorb more water than fine aggregate.

Table 3:- Slump Value by replacing Fine Aggregates with Waste Glass Powder.

Waste glass %	Slump value
0	24
5	28
15	33
25	38
35	45

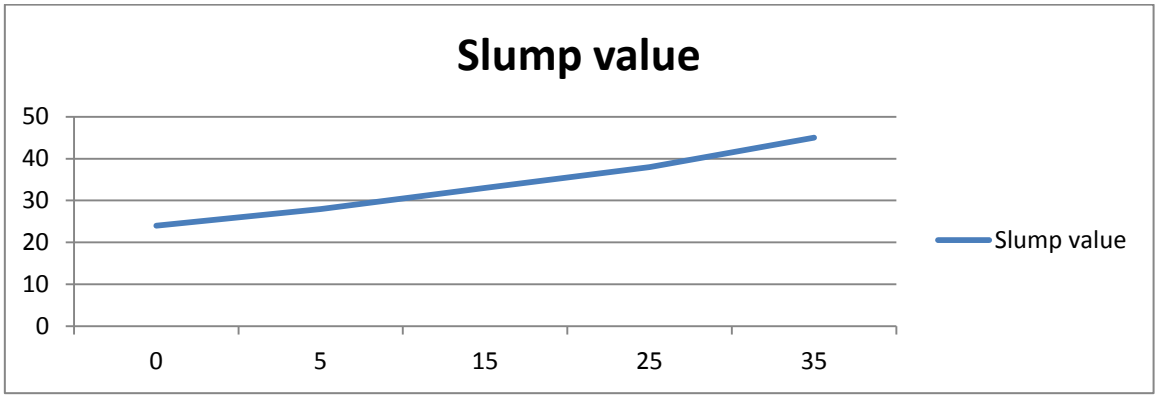

Fig 3:- Variation of Slump value after replacement of fine aggregates with Waste Glass

Secondly, cement was replaced by waste paper sludge ash and then slump test was carried out and it was noted that only 5% of replacement is allowed as this waste material absorb more water than cement.

Table 4:- Slump Value by replacing Cement with Waste Paper Sludge Ash.

Waste Paper Sludge Ash %	Slump value
0	24
5	22
10	19
15	16

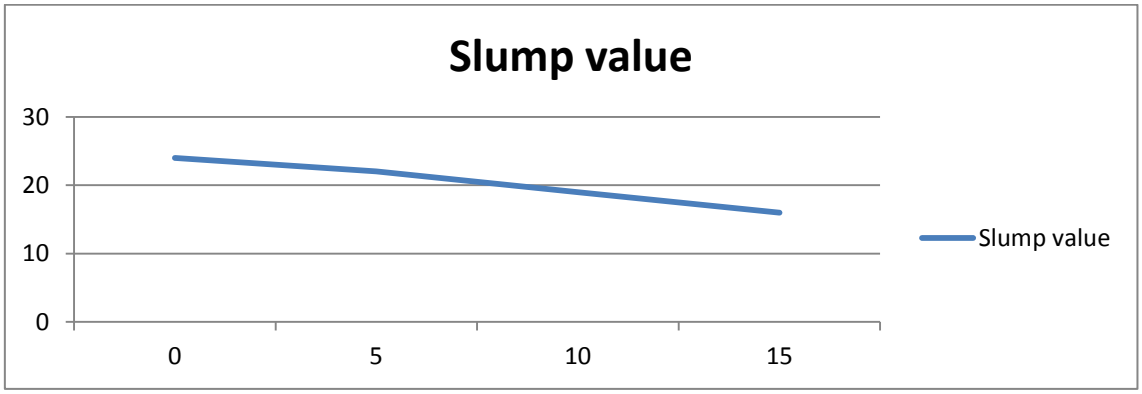

Fig4:- Variation of Slump Value after replacement of Cement with Waste Paper Sludge Ash

Lastly, combination of waste paper sludge ash and waste glass powder is used in place of cement and fine aggregate respectively. Test was performed and it was noted that only 5% of waste paper sludge ash is allowed with a combination of 35% of waste glass powder.

Table 5**:-** Slump Value by combination of Waste paper Sludge Ash and Waste Glass Powder.

Waste Glass %	Waste Paper Sludge Ash %	Slump Value
0	0	24
5	5	26
15	5	28
25	5	32
35	5	36

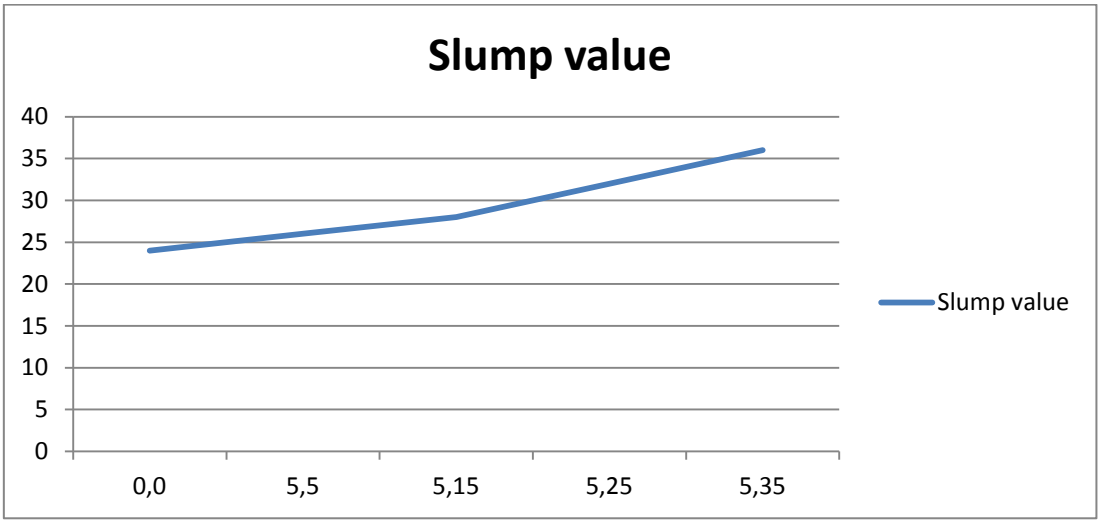

Fig 5: - Variation of Slump Value after replacement of fine aggregates with Waste Glass in combination with the replacement of Cement with Waste Paper Sludge Ash.

Compressive Test

For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm were cast for M25 grade of concrete. The moulds were filled with 0%, 5%, 15%, 25%, and 35% of waste glass and 0%, 5%, 10% and 15% of waste paper sludge.. Vibration was given to the moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank wherein they were allowed to cure for 7, 14 and 28 days. After curing, these cubes were tested on compression testing machine and the failure load was noted. The compressive strength was calculated as follows.

Compressive strength = Failure load / cross sectional area

Table 6**:-** Compressive strength test of specimen by replacement of cement with waste paper sludge ash.

Sludge ash %	**Compressive Strength of Specimen in N/mm²**		
	7 Days	**14 Days**	**28 Days**
0	21.04	25.31	27.11
5	24.18	28.24	33.19
10	20.91	22.77	26.31
15	18.87	21.13	25.16

Table 7:- Compressive strength test of specimen by replacement of fine aggregates with waste glass powder.

Waste Glass %	**Compressive Strength of Specimen in N/mm²**		
	7 Days	**14 Days**	**28 Days**
0	21.04	25.31	27.11
5	23.62	28.17	30.76
15	24.37	30.52	32.63
25	26.01	31.34	34.01
35	22.11	27.27	29.14

Table 8:- Compressive strength test of specimen by replacement of fine aggregates with waste glass powder and cement by waste paper sludge ash in combination.

Waste Glass %	Waste Sludge %	Compressive Strength of Specimen in N/mm²		
		7 Days	14 Days	28 Days
0	**0**	21.04	25.31	27.11
5	**5**	22.35	27.91	32.71
15	**5**	25.27	29.47	34.26
25	**5**	27.12	32.65	36.87
35	**5**	24.65	27.25	33.14

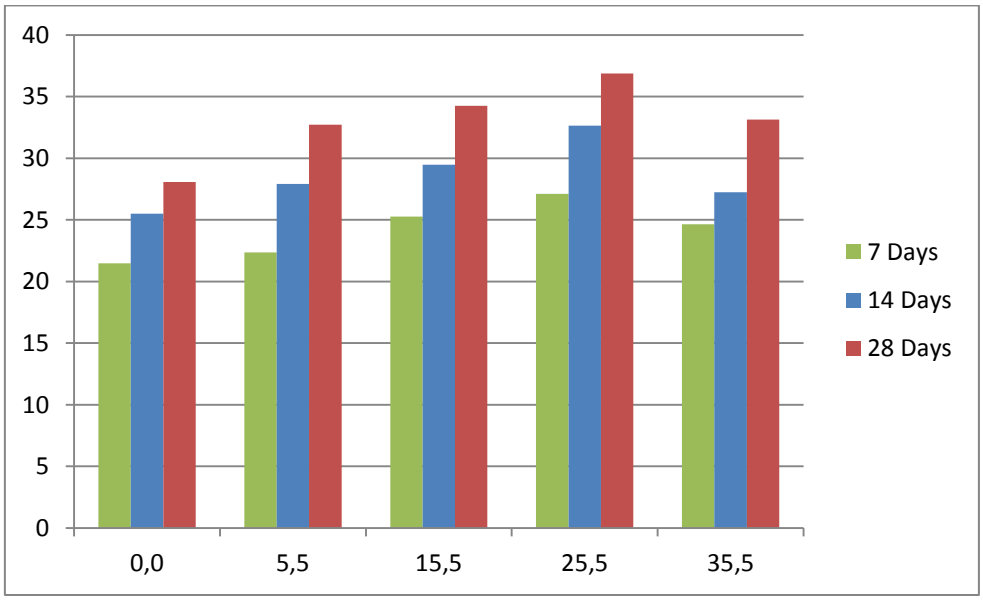

Figure 6:- Compressive Strength Variation by replacement of waste paper sludge ash and waste glass powder with cement and fine aggregates respectively. The percentage of replacement is mentioned in Table 8.

Split Tensile Strength Test

This test method is used for the determination of splitting tensile strength of cylindrical concrete specimen of 150mm diameter and 300mm length. The moulds were filled with 0%, 5%, 15%, 25%, and 35% of waste glass and 0%, 5%, 10% and 15% of waste paper sludge.. Vibration was given to the moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank wherein they were allowed to cure for 7, 14 and 28 days. After curing, these cubes were tested on split tensile strength.

Table 9:- Tensile strength test of specimen by replacement of cement with waste paper sludge ash.

Sludge ash %	Split Tensile Strength of Specimen in N/mm²		
	7 Days	14 Days	28 Days
0	2.09	2.29	2.59
5	2.30	2.49	2.72
10	2.23	2.32	2.57
15	2.11	2.20	2.39

Table 10:- Split Tensile Strength test of specimen by replacement of fine aggregates with waste glass powder.

Waste Glass %	Split tensile Strength of Specimen in N/mm²		
	7 Days	14 Days	28 Days
0	2.09	2.29	2.59
5	2.06	2.25	2.56
15	2.04	2.17	2.40
25	1.94	2.03	2.27
35	1.77	1.84	2.03

Table 11:- Split Tensile Strength test of specimen by replacement of fine aggregates with waste glass powder and cement by waste paper sludge ash in combination

Waste Glass %	Waste Sludge %	Split Tensile Strength of Specimen in N/mm²		
		7 Days	14 Days	28 Days
0	0	2.09	2.29	2.59
5	5	2.04	2.21	2.47
15	5	1.99	2.16	2.39
25	5	1.87	2.01	2.31
35	5	1.93	2.19	2.34

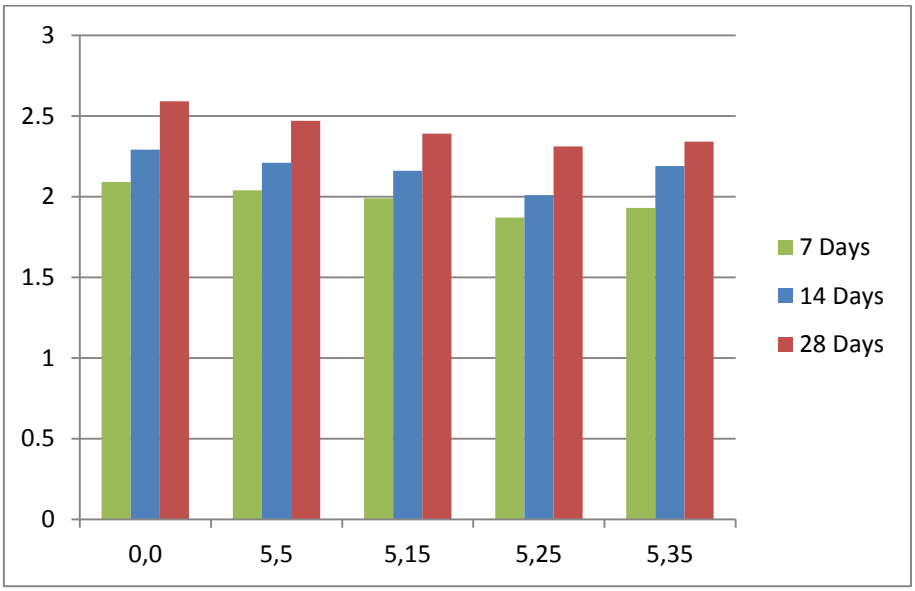

Figure 7:- Split Tensile Strength Variation by replacement of waste paper sludge ash and waste glass powder with cement and fine aggregates respectively. The percentage of replacement is mentioned in Table 11.

Flexural Test

This test method is used for the determination of flexural strength of beam specimen of 150 x 150 x 750mm. The moulds were filled with 0%, 5%, 15%, 25%, and 35% of waste glass and 0%, 5%, 10% and 15% of waste paper sludge ash. Vibration was given to the moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank wherein they were allowed to cure for 7, 14 and 28 days. After curing, these beams were tested for flexural strength.

Table 12:- Flexural Strength by replacement of Cement

Sludge ash %	Flexural Strength of Specimen in N/mm²		
	7 Days	14 Days	28 Days
0	2.93	3.29	4.01
5	3.83	4.39	5.52
10	3.23	4.03	4.37
15	3.07	3.64	3.89

Table 13:- Flexural Strength by replacement of Fine Aggregates.

Waste Glass %	Flexural Strength of Specimen in N/mm²		
	7 Days	14 Days	28 Days
0	2.93	3.29	4.01
5	3.10	3.66	4.20
15	3.51	3.97	4.74
25	3.74	4.11	4.81
35	3.61	4.06	4.57

Table 14:- Flexural Strength by replacement of Fine Aggregates and Cement.

Waste Glass %	Waste Sludge %	Flexural Strength of Specimen in N/mm²		
		7 Days	14 Days	28 Days
0	0	2.93	3.29	4.01
5	5	3.09	3.48	4.19
15	5	3.28	3.62	4.37
25	5	3.56	4.14	4.84
35	5	3.30	3.97	4.46

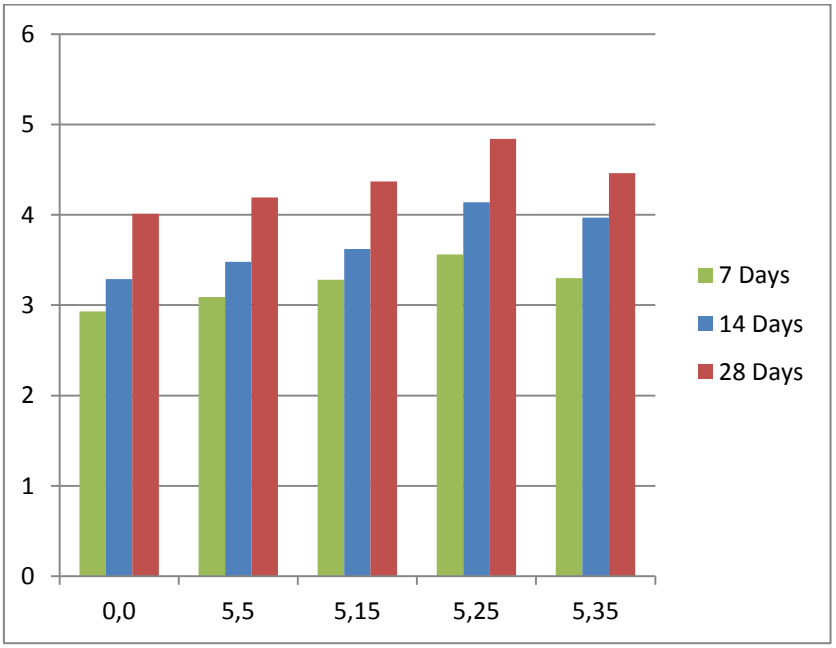

Figure 8:-Flexural Strength by replacement of Cement and Fine Aggregates.

Water Absorption Test

Cube of 150mm was made from fresh concrete without any replacement and then the dry weight of cube specimen was noted after removing it from mould and weight of cube specimen was again noted after curing it for 28 days.

Replacement of fine aggregate with Waste Glass Powder.

Cube specimen was made by replacement of fine aggregates with Waste Glass powder at 5%, 15%, 25% and 35%. The dry weight of cube specimen was measured after removing it from mould and weight of cube specimen was again noted after curing it for 28 days.

Table 15: - Shows variation in weight after adding Waste Glass.

Waste Glass %	Dry weight before curing (g)	Wet weight after curing for 28 days (g)	Water absorbed (g)
0	8427	8511	84
5	8398	8473	75
15	8301	8352	51
25	8221	8263	42
35	8137	8174	37

Replacement of Cement with Waste Paper Sludge Ash

Cube specimen was made by replacement of cement with Waste Paper Sludge Ash at 5%, 10% and 15%. The dry weight of cube specimen was measured after removing the cube from mould and weight of cube specimen was again measured after curing it for 28 days.

Table 16: - Shows variation in weight after adding Waste Paper Sludge Ash.

Waste Paper Sludge Ash %	Dry weight before curing (g)	Wet weight after curing for 28 days (g)	Water absorbed (g)
0	8427	8511	84
5	8387	8483	96
10	8261	8365	104
15	8155	8271	116

Replacement of fine aggregate and cement with waste glass powder and waste paper sludge ash respectively

Cube specimen was made by replacing fine aggregate at 5%, 15%, 25% and 35% in combination with the replacement of cement with Waste paper Sludge ash at 5%. The dry weight of cube was noted after removing it from mould and weight of cube was noted after curing it for 28 days.

Table 17: - Shows variation in weight after adding Waste Glass and Waste Paper Sludge Ash in combination

Waste paper sludge ash %	Waste Glass %	Dry weight before curing (g)	Wet weight after curing for 28 days (g)	Water absorbed (g)
0	0	8427	8511	84
5	5	8371	8450	79
5	15	8265	8347	82
5	25	8197	8299	102
5	35	8017	8085	68

CONCLUSIONS

On the basis of test and their results, following readings are noted:-

1. There is 20% increase in compressive strength by replacing 25% of Fine Aggregates with Waste Glass Powder after 7, 14 and 28 days.
2. 5% replacement of Cement with Waste Paper Sludge Ash can increase 13% of Compressive Strength after 7 and 14 days, and 19% increase in strength after 28 days.
3. 5% replacement of Cement with Waste Paper Sludge Ash shows 10% increase in Split Tensile Strength after 7 and 14 days and 5% increase in split tensile strength after 28 days.
4. Replacement of 5% of Cement and 25% of fine aggregates with Waste paper Sludge Ash and Waste Glass Powder respectively in combination shows 22.5% increase in compressive strength after 7 and 14 days, and 26.5% increase after 28 days.
5. Replacement of 5% of Cement and 25% of fine aggregates with Waste paper Sludge Ash and Waste Glass Powder respectively shows approx 20% increase in Flexural strength after 7, 14 and 28 days.
6. Workability increases with increase in Waste Glass Powder due to less absorption of water by Glass.
7. Workability decreases with increase in Waste Paper Sludge Ash because cement absorb less water than Waste Paper Sludge Ash.
8. Use of waste material like glass and paper sludge will reduce environment waste and also less the disposal problem of these non-biodegradable waste.
9. Use of waste glass and paper sludge also help in maintaining our natural resources like river sand and maintain balance in our environment.
10. Use of waste glass and waste paper in appropriate percentage in concrete results in improvement in strength of concrete.

REFERENCES

Tabish Tariq et. all 2015, perform experiment on replacement of fine aggregate with waste glass powder and cement with waste paper sludge ash. Fine aggregate were replaced up to 40% by weight using waste glass powder and cement was replaced up to 20% by weight using waste paper sludge for 7 days, 28 days and 60 days. Experiment showed replacement of 20% of fine aggregate with waste glass powder and 5% replacement of cement with waste paper sludge for specimen increases strength of concrete.

M.Adaway & Y. Wang 2015**,** in their research paper determine the level of glass replacement resulting in optimal compressive strength. Three concrete samples were tested at 7 and 28 days, for glass replacement proportions of 15%, 20%, 25%, 30% and 40% compressive strength was found to increase upto a level of 30%.

Sadoon Mushrif Abdallah, perform experimental work to study slump, unit weight, compressive test, split tensile test, flexural strength etc under curing age 7, 14 and 28 days. Four concrete mixes with 0%, 5%, 15%, and 20% replacement by weight of sand with waste glass were prepared. The compressive, tensile and flexural strength and modulus of elasticity of specimen with 20% waste glass content were 5.28%, 18.38%, 8.92% and 9.75% respectively, which is higher than the controlled mix at 28 days.

Ishan Srivastava, et. all 2017, perform experimental work to study compression test, water absorption test, slump test, light weight test to check the strength of concrete after replacement of fine aggregate by 10%, 20%, 30% and 40% replacement level and found that replacement of 20% of waste glass with the fine aggregate increases the strength of concrete and after 20%, strength of concrete start of decreasing.

M.Iqbal Malik, et. all 2013, perform experimental work on replacement of fine aggregate with waste glass powder by 10%, 20%, 30% and 40% by weight for M-25 mix. The specimen is tested for compaction test, tensile test, water absorption and density at 28 days and found that 30% of replacement of fine aggregate with waste glass increases the strength.

S.P Gautam et. all 2012, perform test on replacement of fine aggregate by glass waste under curing age of 7 and 28 days. Six concrete mixes with 0%, 10%, 20%, 30%, 40% and 50% by weight of fine aggregate with waste glass were made to study compressive test and found that replacement up to 20% increases the strength.

Cherian Varkey et. all 2016, perform test on replacement of cement by waste paper sludge by 2.5%, 5% and 7.5% for M-25 mix and tested for its compressive test, split tensile test, and flexural strength under curing age of 28 days and found that 5% of replacement of cement with waste paper sludge increases the strength.