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Original Article

Utilisation of Waste Plastic Bottles for Manufacturing of Blocks

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Abstract: *Plastic is light weight and resistant material capable of being fabrication in various ways. Nowadays, large number of plastic bottles are wasted and disposed every day. To construct building the plastic bottles are useful. Waste plastic bottles provides thermal comfort while being sustainable. Waste plastic bottles are non- biodegradable and its disposal has always been a problem therefore utilizing the waste plastic bottles for manufacturing of concrete block, we are using the plastic bottles in the form of crushed mixed in the concrete material in three different grades (M15, M20, M25). Normal concrete cubes are made up of all the conventional concrete materials such as cement, sand, water, coarse aggregate and fine aggregate. Plastic is economical and lightweight material and hence used as binding material in the concrete cubes. Concrete blocks are prepared with normal concrete materials and concrete materials with waste plastic bottles. Compressive strength of normal concrete block and concrete block with plastic bottle are tested at 7 days, 14 days and 28 days. It is found that compressive strength is more for concrete blocks with plastic bottles than concrete blocks with normal materials.*

Keywords: *Concrete Block, Plastic Bottle, Compressive Strength.*

I. INTRODUCTION

Normal concrete block is made up of materials such as cement, sand, coarse aggregate and fine aggregate. Concrete is heterogeneous materials and used for the construction of the most of the elements of the civil engineering structures. Concrete cubes are the platforms to check the compressive strength of the concrete. Compressive strength of the concrete has greater impact on the design of various RCC elements. Hence, it is necessary to improve the compressive strength of the concrete. Concrete with normal materials such cement, coarse aggregate, fine aggregate and water has greater impact on the compressive strength and gives good compressive strength values. There is greater impact of various recycled materials such plastic bags on the compressive strength of the concrete. Recycled materials with good plastic properties has greater impact on the compressive strength of the concrete. Hence, in this study, plastic bag is used as the one of the material along with conventional concrete materials and compressive strength of the concrete is measured at 7 days, 14 days and 28 days respectively. It is found that there is considerable increase in the compressive strength of concrete with inclusion of plastic materials. It is also statistically proved that there is significant increase in the compressive strength of concrete with plastic bag as waste materials with respect to concrete block with normal materials. General regression modelling is also done to check influence of plastic material on the compressive strength of concrete. Regression model is calibrated with good R-square value and it is found that there is increase in the compressive strength of concrete with inclusion of plastic bags.

II. LITERATURE REVIEW

Saje et al. 2009 [1] examined the compressive strength of high strength concrete containing silicafume over a long period of time, from the start of concrete hardening up until the age of concrete of one year (SF). Piro et al. 2021 [2] developed comprehensive multiscale techniques to estimate comprehensive strength of concrete. Several methods, including the artificial neural network model (ANN), M5P tree model, nonlinear regression model (NLR), multilinear regression model (MLR), and linear regression model, were put forth to predict the compressive strength of conventional concrete enhanced with carbon nanotubes (LR). Hamada et al. 2022 [3] studied influence of different curing methods on the comprehensive strength of concrete.

The current article examines studies that examined the effects of compressive strength for various curing methods, including microwave curing, autoclave curing, carbon curing, steam curing, electric curing, ambient and air curing, and water curing. All curing techniques produced compressive strength results that were adequate. Behfarnia et al. 2017 [4] studied the creation and comparison of two data-driven models, namely the Adaptive Neuro-based Fuzzy Inference System

(ANFIS) model and the Artificial Neural Network (ANN) model, for the estimation of 28-day compressive strength of concrete for 160 various mix designs. Thomas et al. 2015 [5] has carried out comprehensive application of waste tire rubber in cement concrete.

The research that has been done on the properties of rubberized concrete while it is fresh and when it has hardened is summarised in this paper. Studies indicate that the use of used tyre rubber as a partial aggregate replacement in cement concrete has a bright future. Ahmed et al. 2021 [6] has undergone systematic review of recycled fibres in the concrete composites. The impact of recycled plastic fibres (RPFs), recycled carpet fibres (RCFs), and recycled steel fibres (RSFs) on the fresh, mechanical, and ductility properties of concrete was thoroughly reviewed in this research.

Behfarnia et al. 2017 [7] has undergone compressive study on the concrete compressive strength estimation using artificial neural network and adaptive neuro-fuzzy interface system. The benefits of adding strength-enhancing ingredients, such as rice husk ash and silica fume, to geo-polymer concrete and OPC-based concrete are described in this review along with the essential comparisons from numerous research projects conducted globally. Hoover et al. 2013 [8] studied comprehensive concrete fracture tests along with description and results. The kinetics of the biomass fly ash and calcium hydroxide mixture as well as the strength, microscopic research, and durability (mitigation of Alkali Silica Reaction (ASR) expansion) of biomass fly ash concrete are all thoroughly examined in this publication.

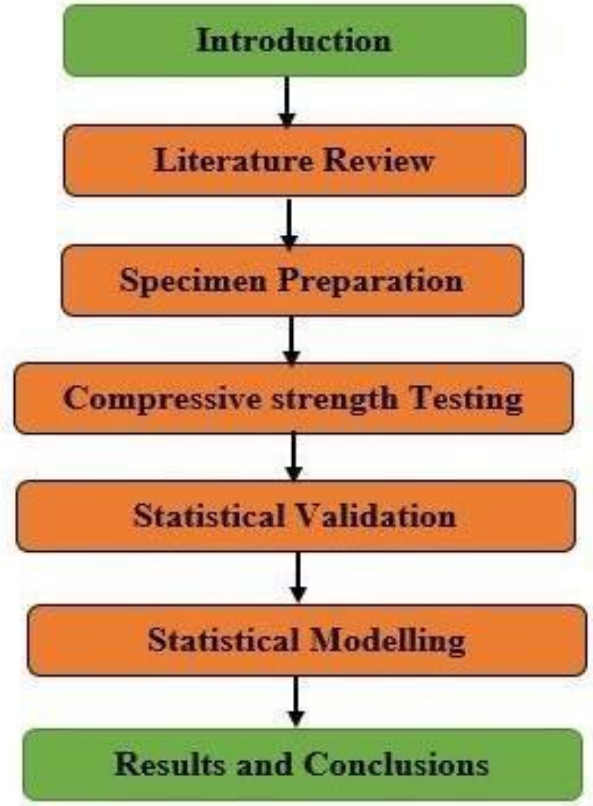

Figure 1: Detailed Methodology

III. METHODOLOGY

The first step of the methodology is the Introduction. Introduction involves the basic components of the compressive strength of normal concrete and concrete with plastic bags. Mix design of the concrete is prepared by optimum proportion of coarse aggregates, fine aggregates, cement and water to cement ratio. Mix design of concrete uses certain IS code for the appropriate proportion of coarse aggregate, fine aggregate, cement and water. Cement is replaced by percentage of plastic bag waste in the concrete. Various specimens of the concrete are prepared for normal concrete mix and concrete with plastic bags as waste material. Compressive strength of the concrete mix is tested by using Uniform Testing Machine (UTM). Plastic bag material is added to the mix with increment of 5 %, 7.5 %, 10%, 12.5 % and 15 % by weight of cement replacement. There are 10 samples of each mix conditions are tested for compressive strength. One way ANNOVA test is performed to check there is significant difference between compressive strength of various samples of concrete. Statistical regression modelling is developed for the compressive strength of concrete with influencing variables as percentage of plastic waste.

Finally results and conclusions are drawn.

A. Specimen Preparation

Specimen preparation section involves the preparation of various samples of the concrete mix with normal materials and concrete mix with plastic bag. Mix design of the concrete is prepared as per IS 10262.

Steps Required in the Mix-Design of the Concrete:

- Determination of Target strength of concrete.
- Selection of Water/Cement ratio.
- Selection of water content
- Selection of Cement Content
- Estimation of Coarse aggregate preparation
- Estimation of the mix ingredients
- Correction due to absorbing/ moist aggregate
- Concrete trail mixes.

Plastic waste material is added in the concrete mix with replacement of cement. Cement is replaced with 5%, 7.5%, 10 %, 12.5 % and 15 % of plastic bags. There are total of 10 samples of each mix are prepared in order to test the compressive strength of the concrete.

B. Testing of Specimen

Compressive strength of concrete is concrete is tested by using Uniform Testing Machine (UTM). Test cubes of various mixes are prepared with 150mm * 150 mm * 150 mm cubes sizes. Following stepwise procedure is used to calculate the compressive strength of concrete.

- Clean the mounds properly and apply oil inside the cube frame
- Fill the concrete in the moulds in layers approximately 50mm thick
- Compact each layer with not less than 35 strokes per layer using a tamping rod (steel bar 16mm diameterand 600 mm long,)
- Level the top surface and smoothen it with a trowel
- The concrete cubes are removed from the moulds between 16 to 72 hours, usually this done after 24 hours. Remove the specimen from water after specified curing time and wipe out excess water from thesurface. Take the dimension of the specimen to the nearest 0.2mm and then 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 at the rate of 140 kg/cm2/min. till the specimenfails
- Record the maximum load and note it

There are various samples prepared with variation of cement content and plastic bag as waste material. There areeach of 10 samples prepared with 5 %, 7.5 %, 10 %, 12.5 % and 15 % plastic waste material. There are total 60 samples are prepared and tested. 10 samples with normal concrete mix, 10 samples with 5 % of plastic waste, 10samples with 7.5 % of plastic waste, 10 samples with 10 % of plastic waste, 10 samples with 12.5 % of plastic waste, 10 samples with 15 % of plastic waste.

IV. RESULTS OF TESTS

Results of the tests are divided into various sub-sections. There are total 60 samples of the test specimens are prepared. All the 60 samples of the specimens are tested to check the compressive strength of concrete. Compressive strength of the concrete are tested under Uniform Testing Machine (UTM) under constant loading rate. All the test results are analysed and average and standard deviation is calculated for each combination of the specimen mixes. One analysis of the samples is done then one way ANNOVA is calculated to check there is significant difference between series of various samples. Finally, statistical regression is applied to study the effect of plastic bag on compressive strength of the concrete.

A. Compressive Strength

Compressive strength of the concrete is tested for total 60 samples. All the samples are prepared with design mixesas per IS 10262. All the samples are tested under Uniform Testing Machine (UTM). All the samples are tested for the compressive strength of the concrete. Table 1 shows the compressive strength of concrete for various mixes.

Table 1: Compressive Strength of Concrete for Various Mixes

Sample	Normal Mix	Normal Mix +5% plastic waste	Normal Mix +7.5% plastic waste	NormalMix + 10% plasticwaste	Normal Mix + 12.5 % plastic waste	Normal Mix + 15 % plastic waste
1	19.5	23.6	25.6	27.6	29.4	32.1
2	21.3	24.5	26.4	28.2	29.8	33.4
3	20.4	25.5	24.5	28.4	28.5	34.5
4	18.9	22.8	25.2	27.8	29.7	31.5
5	20.4	23.4	25.7	28.4	29.4	34.2
6	21.3	23.8	25.4	27.9	30.1	33.2
7	20.4	24.1	25.7	28.6	28.4	32.4
8	19.5	23.7	25.4	28.5	27.6	32.7
9	19.4	24.1	25.8	27.8	29.4	32.9
10	18.9	24.3	24.9	27.9	30.1	33.1

Average value of compressive strength is calculated along with standard deviation is shown in the bracket. Table2 shows the average value of compressive strength with standard deviation in the bracket.

Table 2: Average Compressive Strength with Standard Deviation in the Bracket

	Normal Mix	Normal Mix +5% plastic waste	Normal Mix +7.5% plastic waste	Normal Mix +10% plastic waste	Normal Mix + 12.5 % plastic waste	Normal Mix +15% plastic waste
Concrete Samples	20 (0.89)	23.98(0.722)	25.46 (0.521)	29.24 (0.351)	30.24 (0.818)	33 (0.907)

B. Statistical Validation

Statistical validation of various samples are carried out. One way ANNOVA test is carried out to check whether there is significant difference between sets of samples or not. Table1 shows the one way ANNOVA test. It is found that all the samples of the mix are statistically different form each other. F value for given combination is 3.47. F-Value for 95 % confidence interval is 2.08. F (Obtained) > F (Calculated), hence it is proved that there issignificant difference in the compressive strength value of different samples.

C. Statistical Modelling

It is very necessary to study the effect of plastic waste on the compressive strength of the concrete. In order to study this effect, statistical regression modelling is carried out with percentage of plastic waste as independentvariable and compressive strength as dependant variable. Table 3 shows the regression statistics.

Table 3: Regression Statistics

Regression Statistics	
Multiple R	0.993046
R Square	0.9861403
Adjusted R Square	0.9826754
Standard Error	0.622971
Observation	6

Table 4 shows coefficient and standard error for the tests. It is found that there is increase of compressive strength by 0.87 times with unit percentage increase in the plastic waste of the concrete.

Table 4: Coefficient and Standard Error for the Tests.

	Coefficient	Standard Error	t Stat	P-Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	19.73429	0.499488	39.5090	2.45E-06	18.34748	21.12109	18.34748	21.12109
X Variable 1	0.870286	0.051587	16.87029	7.24E-05	0.727058	1.013514	0.727058	1.013514

IV. CONCLUSION

The study focuses on the compressive strength of the concrete. It is very necessary to have the good compressivestrength of the concrete in all the elements of the RCC structure. Following important conclusions are made for the given study.

- Compressive strength of concrete is influenced by the proportion of Coarse aggregate, Fine aggregate,cement and water to cement ratio in the concrete mix.
- Compressive strength of the concrete increases with increase in the percentage of plastic waste.
- One way ANNOVA test is applied satisfactorily and it is proved that there is significant difference in thecompressive strength of concrete for various mixes.
- Regression modelling is calibrated with good R-squared value, it is found that compressive strength of concrete increases 0.87 times with unit increase in the percentage of the plastic waste.

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