

Experimental and Analytical Study on Strength Properties and the Influence of Addition of Industrial Waste

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ABSTRACT

In this research work, extensive experimental and analytical study on strength properties and the influence of addition of industrial by products like waste glass powder, rice husk powder, Sugarcane bags ash, polypropylene and plastic wastes as cement and fine aggregate replacement materials in concrete production was carried out and the results are reported.

The research work was carried out in five Phases under the following five topics.

Properties of Concrete with glass powder as fine aggregate replacement:

The feasibility of using waste glass as fine aggregate replacement in concrete was investigated, which is an interesting possibility for economy on waste disposal sites and conservation of natural resources. Glass, being non-biodegradable material, is not suitable for addition to landfill, and as such recycling opportunities need to be investigated. To deal with these problems, this study has been conducted through basic experimental research in order to investigate the feasibility of using crushed waste glass powder as fine aggregate replacement in concrete. An experimental work was performed to study the slump , unit weight, compressive strength, splitting tensile strength, flexural strength, modulus of elasticity, ultrasonic pulse velocity, dry density and chloride ion penetration test at different curing ages of 7, 14 and 28 days. Five concrete mixes with 0%, 5%, 15% and 20% replacement by weight of sand with waste glass were prepared. In this research, an experimental investigation was carried out to study the complete stress-strain behaviour, mechanical strength and durability properties of concrete with partial replacement of natural river sand by glass powder.

Estimation of Efficiency factor and Activity Index for Rice Husk Ash, Waste Glass Powder, and Sugar cane Bagasse Ash as cement replacement in concrete:

Various types of Supplementary Cementitious Materials (SCMs) like Rice Husk Ash (RHA), Waste Glass Powder (GP), and Sugarcane Bagasse Ash (SBA) are investigated experimentally and analytically, for a potential use in concrete. The relative performances of these SCMs are compared with that of the portland cement using the concept of the efficiency factor (or k value). Extensive experimental works have been carried out to study the influence of these three SCMs in strength properties of concrete and to find their optimum quantity of replacements for cement in order to attain the target concrete strength.

Prediction of Compressive strength of Concrete with Rice Husk Ash (RHA) as partial replacement for cement using Artificial Neural Network (ANN) model: In this section, the method of prediction of compressive strength of concrete with Rice Husk Ash(RHA) as cement replacement material using Artificial Neural Network (ANN) models is presented. The experimental results of the present work and that of various authors of published research works have been used in the development of these models. In the present work the concrete cube specimens designed with various % of (5%, 10%, 15% and 20%) Rice Husk Ash (RHA) as replacement for cement were tested for compressive strength at various ages(3days, 7days, 28 days and 56 days). The compressive strength results obtained in the present work and the data published by various authors were used in developing the prediction models using ANN. The compressive strength of concrete with Rice husk ash was modeled as a function of seven variables such as cement content(C), sand content(S), coarse aggregate(CA), rice husk ash (RHA), water(W), super plasticizer content(SP) and the age of concrete (Age) testing.

Strength properties of concrete with plastic wastes as fine aggregate replacements: Recycling of plastic wastes helps in reducing waste disposal problems and helps for the sustainable development of the country. Besides that, reuse of plastic waste in construction industry results in the environmental and economic benefits in the production of concrete. Concrete with various % (0 to 55%) of waste plastic aggregates were tested for their workability and strength properties.

Key Words: Strength properties of concrete, Sugar cane Bagasse Ash, glass powder, rice husk powder, polypropylene and plastic wastes.

INTRODUCTION

In concrete productions, cement is used as a basic material worldwide. Production process of Portland cement largely contributes for global warming due to release of CO₂ which is one of the green house gases in to the environment. One ton of CO₂ and other green house gases are produced during the production of one ton of cement clinker (Shekhawat *et al.* 2014). Therefore various research works on the properties of alternate cementing materials known as Supplementary Cementitious Materials (SCMs) and pozzolanas are underway.

A huge mass of industrial by products and solid wastes like flyash, silica fume, waste glass powder, rice husk ash and sugarcane bagasse ash have become as a challenge for their disposal problem and for environmental concern. These SCMs and solid wastes possess pozzolanic properties and can be used in cement system through detailed research.

A vast research have been already done on some industrial wastes such as fly ash, silica fume, Blast Furnace Slag (BFS) for their use as the cement replacement material.

In the present research work, the author has focused on the study on pozzolanas like waste glass powder, rice husk ash and sugarcane bagasse and on solid wastes like plastic and polypropylene wastes for their addition in concrete productions.

PROPERTIES OF MATERIALS USED

Glass Powder

Glass is an amorphous material with high silica content, it can be produced with variety of particle size of less than 700 μm , 425 μm , 150 μm and with 75 μm and therefore can be considered as a pozzolanic material (Vijayakumar *et al.* 2013). Glass powder with silica content more than 72% and particle size 600 μm gives increased strength and enhanced durability in the concrete (Bajad *et al.* 2011).

OBJECTIVES OF THE RESEARCH

The current research was focused on the following five objectives:

1. To carry out experimental investigation on the workability properties of fresh concrete, mechanical and durability properties of the concrete with

strength concrete with different glass powder replacement percentages of 0%, 10%, 20%, 30%, 40% and 50% on five different grades of concrete M20, M30, M40, M50 and M60.

2. To carryout extensive experimental and analytical investigation on various types of Supplementary Cementitious Materials (SCMs) like Rice Husk Ash (RHA), Waste Glass Powder (GP), and Sugarcane Bagasse Ash (SBA) are investigated experimentally and analytically, for a potential use in concrete. To investigate the relative performance of these SCMs compared with that of the portland cement using the concept of the efficiency factor (or k value) and to study the influence of these three SCMs in strength properties of concrete and to find their optimum quantity of replacements for cement in order to attain the target concrete strength.
3. To develop a model for the prediction of compressive strength of concrete with Rice Husk Ash(RHA) as cement replacement material using Artificial Neural Network (ANN) models using various types of networks.
4. To investigate the performance of beam with polypropylene rope reinforcements through experiments.
5. To perform experimental investigation on the influence of addition of plastic waste on the mechanical strength such as compressive strength, tensile strength and flexural strength of concrete.

Result:-

AN EXPERIMENTAL STUDY ON POLYPROPYLENE ROPE REINFORCED PRE STRESSED CONCRETE BEAMS

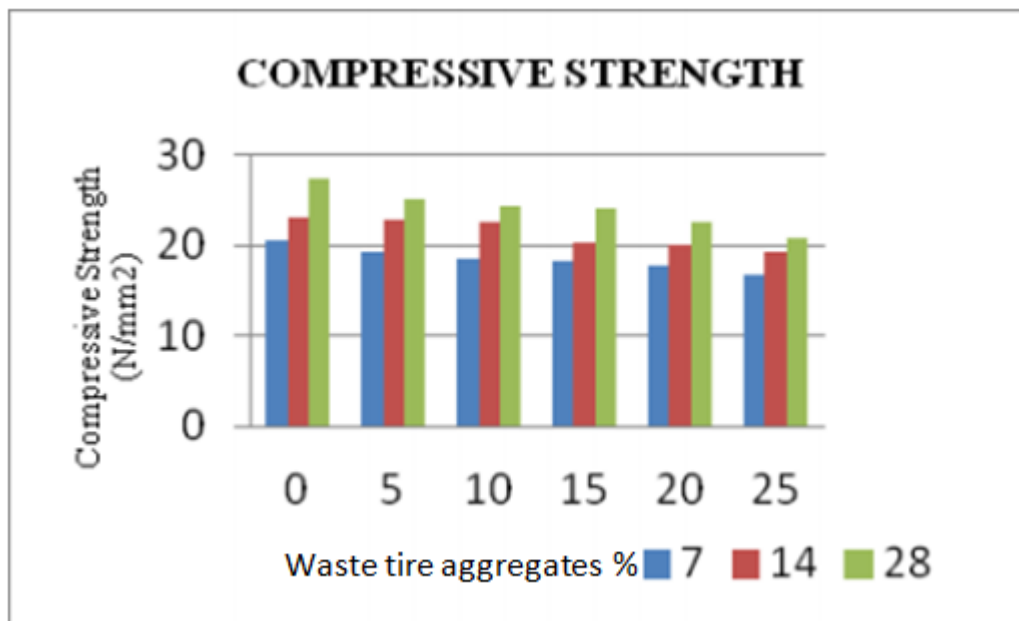


Figure 1 Compressive strength of concrete with waste tire aggregates

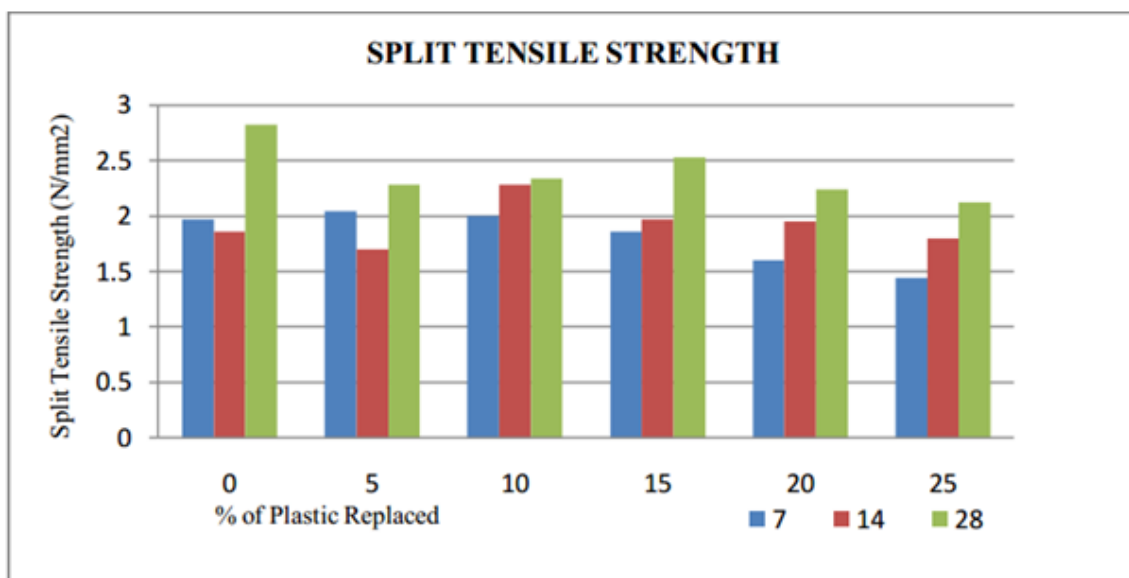


Figure 2 Split tensile strength of concrete

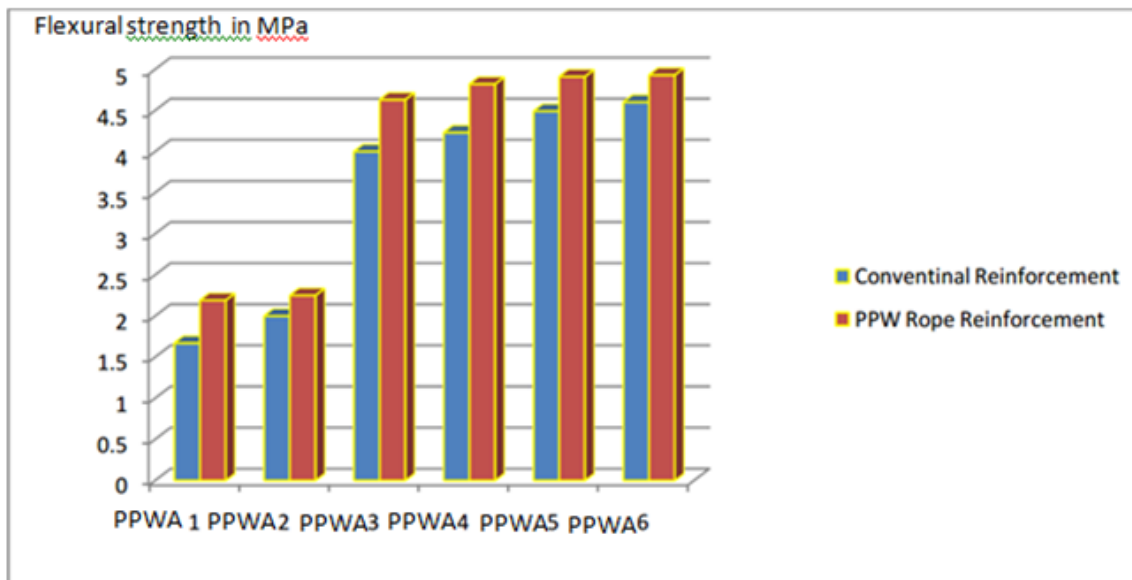


Figure 3 Flexural Strength of Concrete

STRENGTH PROPERTIES OF CONCRETE WITH PLASTIC WASTES AS FINE AGGREGATE REPLACEMENTS

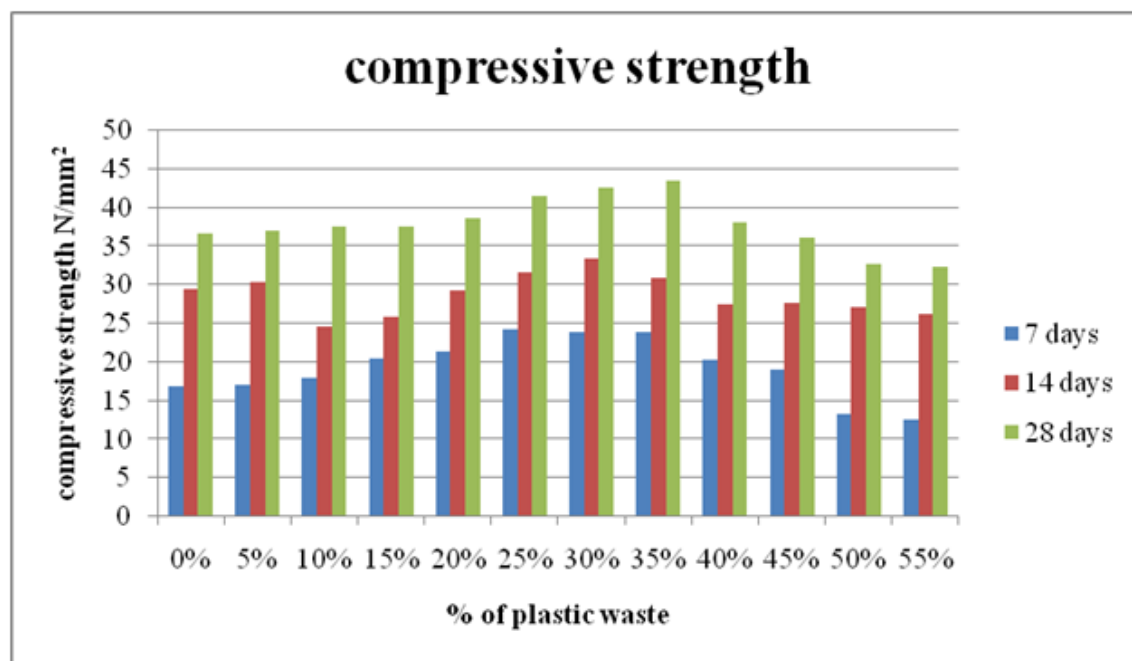


Figure 4 Bar chart for Compressive strength of concrete with plastic waste aggregates

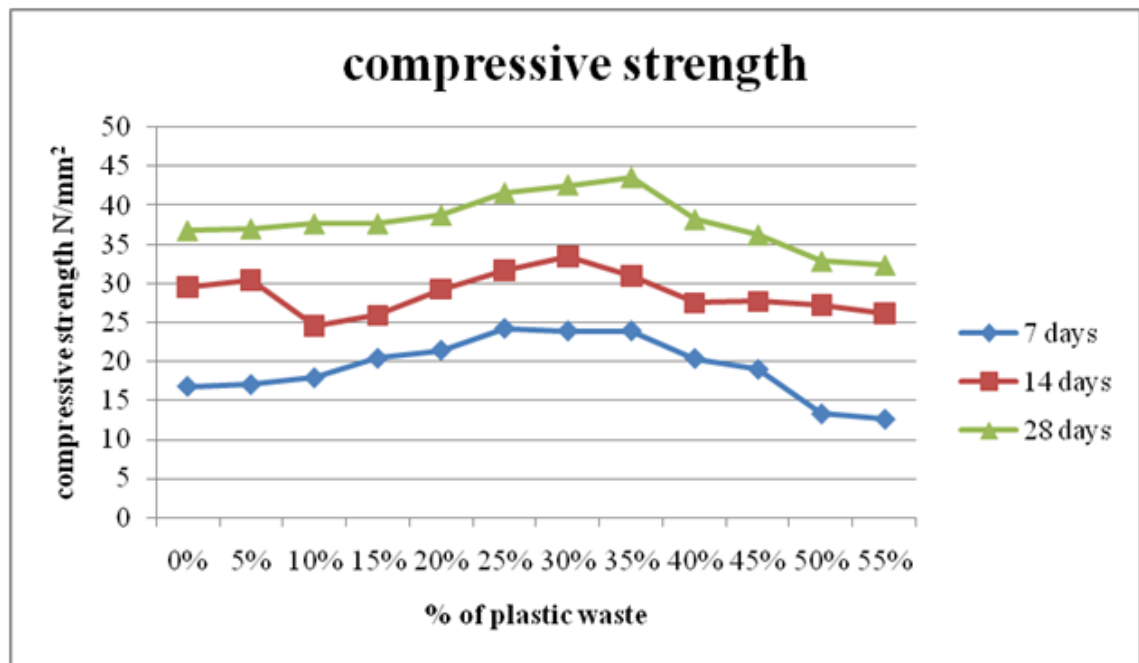


Figure 5 Compressive strength of concrete with plastic waste aggregates at various ages

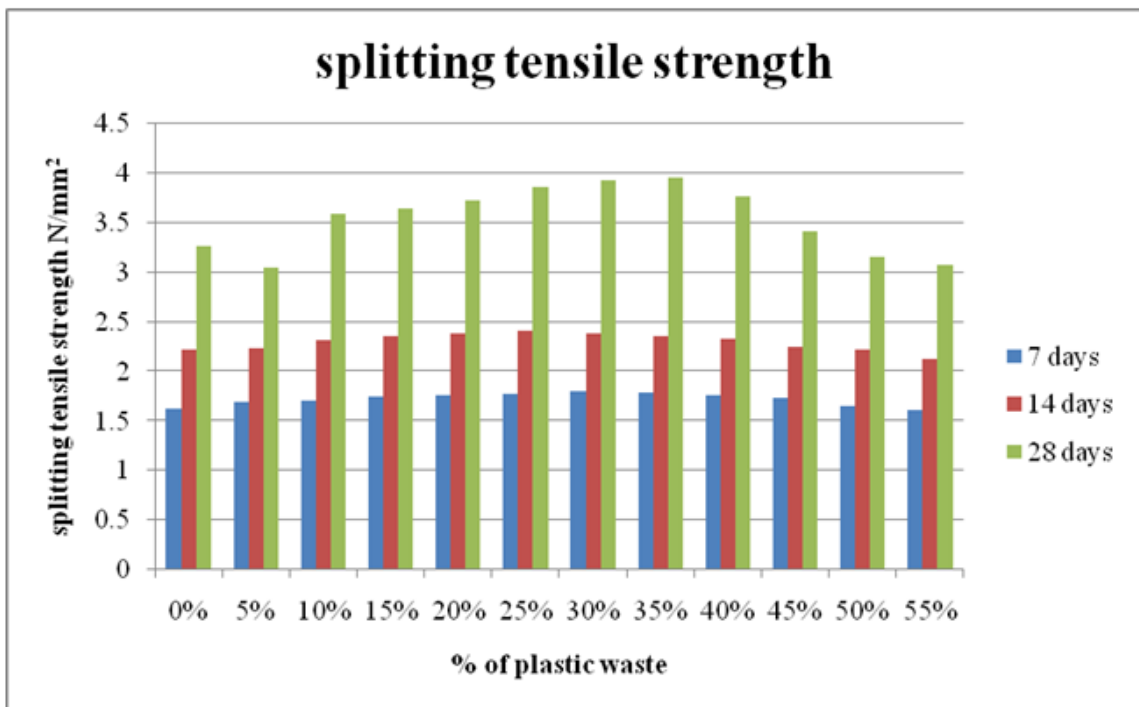


Figure 6 Bar chart for Split tensile strength of concrete with plastic waste aggregates

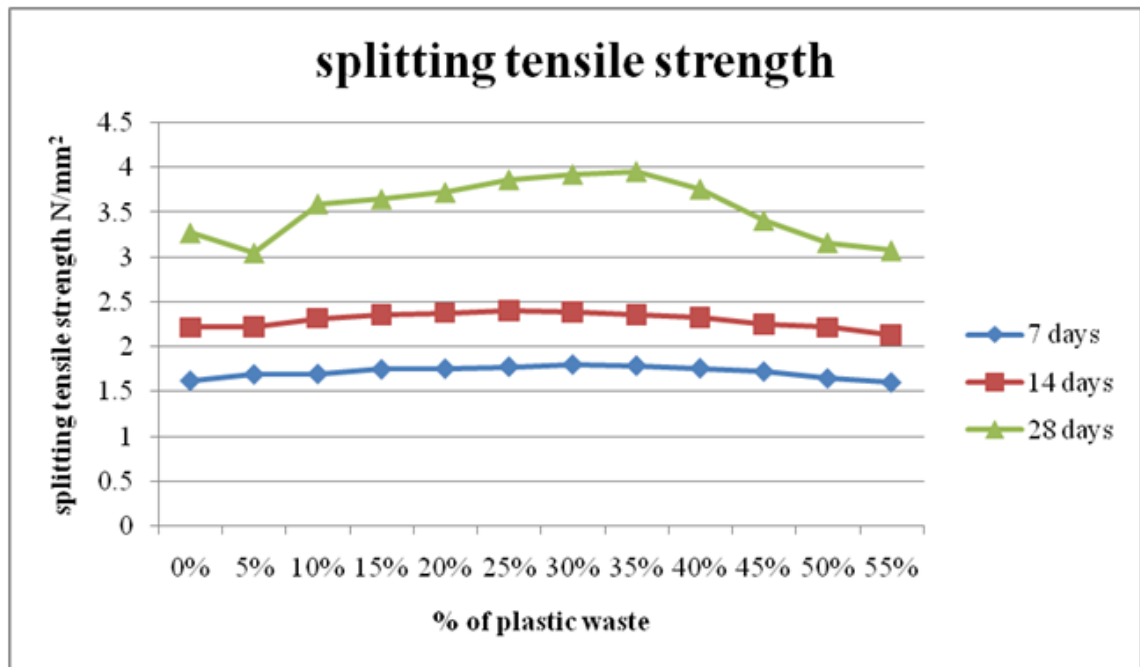


Figure 7 Split tensile strength of concrete with plastic waste aggregates at various ages

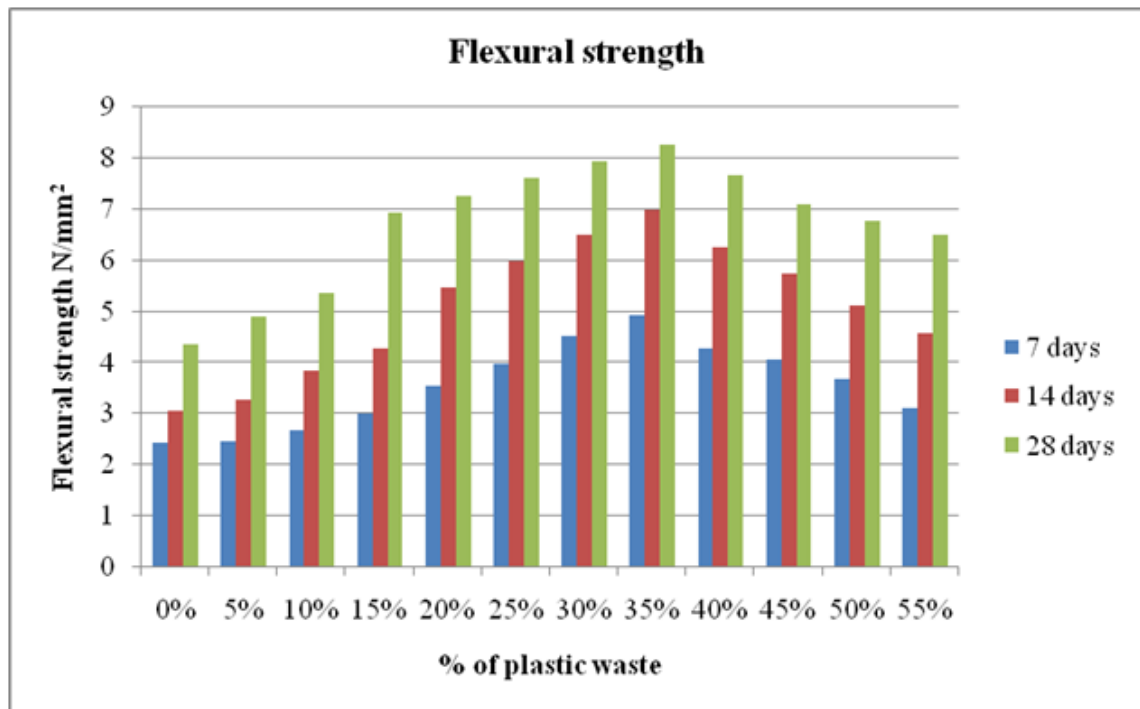


Figure 8 Bar chart for Flexural strength of concrete with plastic waste aggregates

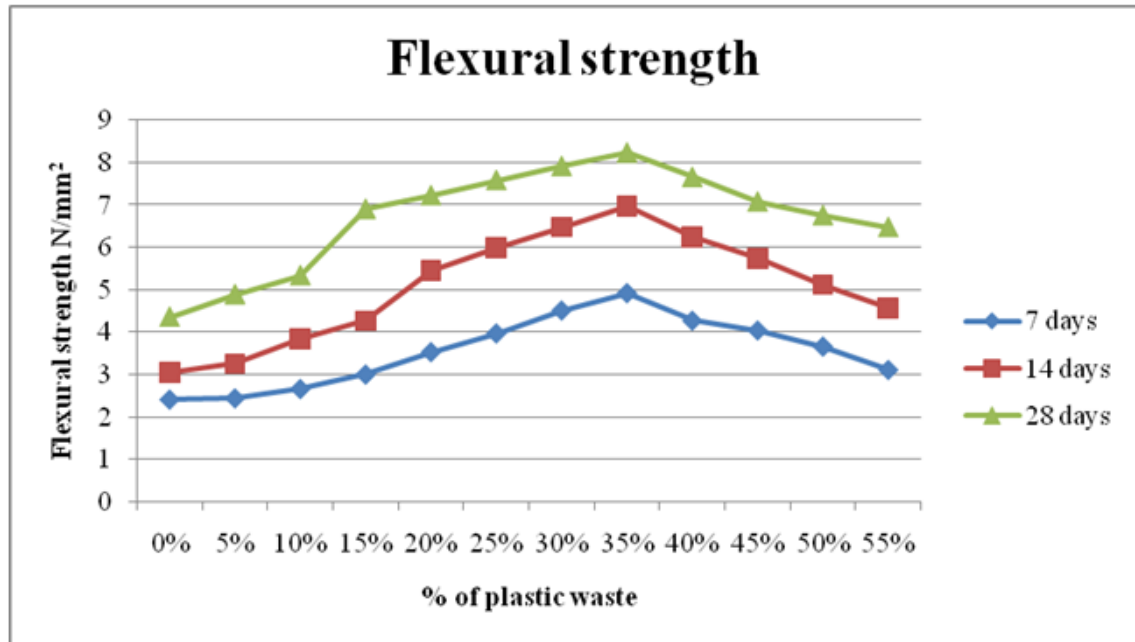


Figure 9 Flexural strength of concrete with plastic waste aggregates at various ages

Conclusion-

The following conclusions were arrived after conducting the experimental and analytical investigations at different phases of this research study:

- The mix design for concrete with five various grades (M20, M30, M40, M50, M60) was done. Extensive experimental study on strength and durability properties of these five grades of concrete with different % of (0%, 10%, 20%, 30%, 40% and 50%) waste glass powder for cement replacement was carried out. The stress strain behavior of all the above concrete mixes was investigated and reported in this section. Based on this study the following conclusions are drawn :
- According to the test results, it is observed that the slump value of fresh concrete increase gradually with % of glass powder upto 40% replacements.
- The increase in compressive strength, flexural strength and split tensile strength gradually increase upto 30% addition of waste glass powder and for 40% and 50% replacements the strength values are comparable

with that of the control mix.

- The density and modulus of elasticity of concrete also gradually increases from 0% to 50% addition of glass powder in the concrete.
- The RCPT test results show that the chloride penetration rate is highly reduced with addition of glass powder and permeability properties of concrete is enhanced upto 50% replacement levels.
- Therefore 50% of glass powder can be used as the replacement material for fine aggregates without much compromise on the strength and durability properties and to achieve economic and environmental benefits.
- In the second phase of this research work, the experimental and analytical study was carried out and the following conclusions are arrived :
- It is observed that the concept of efficiency factor can be applied to find the relative performance of various SCMs (Rice husk Ash, waste Glass powder and Sugarcane bagasse powder) with reference to ordinary Portland cement . From the current research works, the efficiency factors for various SCMs (RHA,GP and SBA) are calculated and reported in Table 3. These values are valid for a certain amount of SCM in concrete (upto 20%) and they are different depending on the various ages of concrete specimens.
- It is observed that when SCMs substitute aggregates, strengths of the SCM (RHA,GP and SBA) concrete found to be higher than that of the control specimens. However ,when SCMs (RHA,GP and SBA) replace cement, the strength is reduced at first and , at later ages, this gap is gradually reduced and the SCM concrete reaches higher strength than that of the control concrete mix due to higher active silica content in comparison with the cement.
- By introducing the efficiency factor concept, the Sugarcane bagasse ash of this work can substitute, equivalently, for Portland cement ($k=1$). The

Rice husk ash exhibit lower efficiency factors ($k= 0.35\text{--}0.6$) and waste glass powder have little higher value of efficiency factors ($k= 0.3\text{--}0.95$) at later ages.

In the third phase of this research work, Artificial Neural network technique was used for the prediction of compressive strength of concrete with rice husk as replacements for cement. For the ANN model development, a multiplayer feed forward neural network with back propagation algorithm was used. One input layer with 7 neurons, one hidden layer with 10 neurons and one output layer with one neuron was used in the model. The ANN model was trained with input and output data from various references (340 data) and also from the present experimental works. The ANN model developed was validated with the measured compressive strength values obtained by the author. The ANN model developed was validated by comparison of the measured compressive strength values with the values obtained using the developed ANN model.

At the fourth phase of this research, it is concluded that, provision of polypropylene reinforcements in concrete increases the flexural strength and by proper design, the conventional steel reinforcements can be partially replaced with polypropylene rope in RC beams for cost effective concrete productions.

At the fifth phase, plastic aggregates obtained as end product of a polymer recycle industry in the form of gains called as plastic aggregates are used as fine aggregate replacements. According to the experimental results, the addition of plastic aggregate as fine aggregate replacements results in increase in compressive strength, split tensile strength and flexural strength upto 40% replacements for sand and hence they can be used in concrete productions for sustainable developments.

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