

## REPLACEMENT OF TRADITIONAL COARSE AGGREGATE

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### ABSTRACT

Plastic waste disposal has become one of the most important issues in today's world because of its non-biodegradable nature. Using plastic in construction practice has become popular in recent years. In this study plastic is used in concrete as replacement of coarse aggregate, both crushed stone and brick chips, and compared their various fresh and hard properties to find out its applicability in structural concrete. Both crushed stone and brick chips are partially replaced with polypropylene (10% and 20% by volume) and the results are compared with concrete without any polypropylene. After conducting extensive tests, it can be concluded that polypropylene can be used as a partial replacement (10% by volume) of coarse aggregate for construction practice.

Keywords: Polypropylene, Compressive Strength, Workability, Tensile Strength.

### INTRODUCTION

In 2013, around 299 million tons of plastics were produced which was about 4% more than the production in 2012. In America alone around 31750 thousand tons of plastic waste was introduced in the municipal solid waste in 2012. During the year 2010 – 2011, some 750 thousand tons of recycled plastic waste was produced in Bangladesh (Islam, M.J et.al, 2015). Non-biodegradable behavior is the main problem with plastic materials which leads to congestion and pollution of the environment. Polypropylene (PP) is a cheap and plentiful thermoplastic used in a wide variety of applications including food packaging, textiles, laboratory equipment, automotive components, and polymer banknotes. Because of its wide application it is also turned out in significant amount as solid waste material. In 2012, 34.20% of PP was found in the total plastic products as durable goods in the municipal solid waste in the USA. So surely it has made people's lives much easier but it also has a difficult disposal system, negative environmental impact and other consequences. Some research works were previously conducted where plastic wastes were used as a replacement for aggregate in concrete. Based on the literature review, it is evident that PP performs better as a replacement of aggregate in concrete compare to other form of plastics. In the present study fresh and dry properties of concrete with PP used as partial replacement of coarse aggregate has been investigated. Tests have been carried out to compare the compressive and tensile strengths, slump test and unit weight of 10% and 20% PP replaced concrete with the conventional concrete (0% replacement).

### METHODOLOGY

Using plastic in construction practice is a modern idea. In order to achieve the desired outcome, a lot of experiments have been performed. The ideas were to find out the workability, compressive as well as tensile strength of the sample concrete cylinder and also to inspect the uniqueness of the material.

### Materials:

For the research work, three different types of coarse aggregates have been used, Stone chips, Brick chips and recycled Polypropylene (PP). The grading of the coarse aggregate were done according to ASTM C33. For fine aggregates, Local sand has been collected and used. Burnt clay brick were purchased from the local market and then crushed into desired sizes. Crushed stones were purchased from local market according to desired shapes. Shredded polypropylene (PP) was used as coarse aggregate in this research

work.. PP aggregate were prepared through a process . At first, scrap plastic had been collected and washed, and then it had been melted and cooled into certain shape. Those cooled plastic bars can be shredded into specific sizes.

Unit weight, fineness modulus ,specific gravity and absorption capacity of coarse and fine aggregates used are summarized in the table provided following. Materials properties have been found out doing specific tests in the laboratory according to the ASTM standards.

**Table-1:** Properties of aggregate

Description	Crushed Stone	Brick Chips	Sand	Polypropylene (PP)
Maximum size	19 mm	19 mm	-	19mm
Bulk specific gravity	2.61	6.54	2.25	0.85
Apparent specific gravity	2.58	2.43	2.43	-
Water absorption	1.05%	14.3%	3.40%	0.80%
Fineness modulus	7.29	6.54	2.60	7.29

**Mix design:**

Mix design for the concrete specimens is proposed for both types of aggregates(Stone Chips and Brick Chips).For both cases,two different water cement ratios were chosen along with three different types of replacements. The water cement ratios were .45 and .55.

Both Stone chips and Bricks chips are replaced by PP(Polypropylene) and thus mix design for 1 m<sup>3</sup>concrete has been proposed. Three different replacement ratios by volume were chosen and thus three different cases were proposed for both type of aggregates. The proposed cases were a) with no PP,b)With 10% PP by volume and c) With 20% by volume .

Following tables shows the mix design for the concrete specimens. WC45P0 = water-cement ratio 0.45 and 0% PP replacement, WC55P0 = water-cement ratio 0.55 and 0% PP replacement, WC45P10= water-cement ratio 0.45 and 10% PP replacement, WC55P10= water-cement ratio 0.55 and 10% PP replacement, WC45P20= water-cement ratio 0.45 and 20% PP replacement, WC55P20= water-cement ratio 0.55 and 20% PP replacement. BWC45P0 = water-cement ratio 0.45 and 0% PP replacement, BWC55P0 = water-cement ratio 0.55 and 0% PP replacement, BWC45P10= water-cement ratio 0.45 and 10% PP replacement, BWC55P10= water-cement ratio 0.55 and 10% PP replacement, BWC45P20= water-cement ratio 0.45 and 20% PP replacement, BWC55P20= water-cement ratio 0.55 and 20% PP replacement..

**Table 2:** Mix Design for 1 m<sup>3</sup> concrete(Stone chips replaced with PP)

Designation	Cement (kg)	Water (kg)	Sand (kg)	Crushed Stone (kg)	PP (kg)
<b>Water/Cement ratio = 0.45</b>					
WC45P0	340	153	539	1251	-
WC45P10	340	153	539	1126	40.5
WC45P20	340	153	539	1001	81.0
WC45P30	340	153	539	876	121.5
<b>Water/Cement ratio = 0.55</b>					
WC55P0	340	187	514	1192	-
WC55P10	340	187	514	1073	38.6
WC55P20	340	187	514	954	77.2
WC55P30	340	187	514	834	115.8

**Table 3:** Mix Design for 1 m<sup>3</sup> concrete(Brick Chips replaced with PP)

Designation	Cement (kg)	Water (kg)	Sand (kg)	Brick Chips (kg)	PP (kg)
<b>Water/Cement ratio = 0.45</b>					
BWC45P0	340	153	539	1251	-
BWC45P10	340	153	539	1126	40.5
BWC45P20	340	153	539	1001	81.0
BWC45P30	340	153	539	876	121.5
<b>Water/Cement ratio = 0.55</b>					
BWC55P0	340	187	514	1192	-
BWC55P10	340	187	514	1073	38.6
BWC55P20	340	187	514	954	77.2
BWC55P30	340	187	514	834	115.8

## RESULTS

For determining the applicability of polypropylene in concrete following test were performed and their results are shown in the graphs for better perceptive.

### *Effects on Slump values:*

Slump test is done to find out the workability of the concrete .The workability depends on various factors like size and shape of the aggregates, water-cement ratios etc. As previously stated, two conventional aggregates,Stone chips and brick chips were partially replaced by Polypropylene, workability seems to increase for both cases with the increment of replacements. Following graphs shows the comparison among various replacements made with Polypropylene.

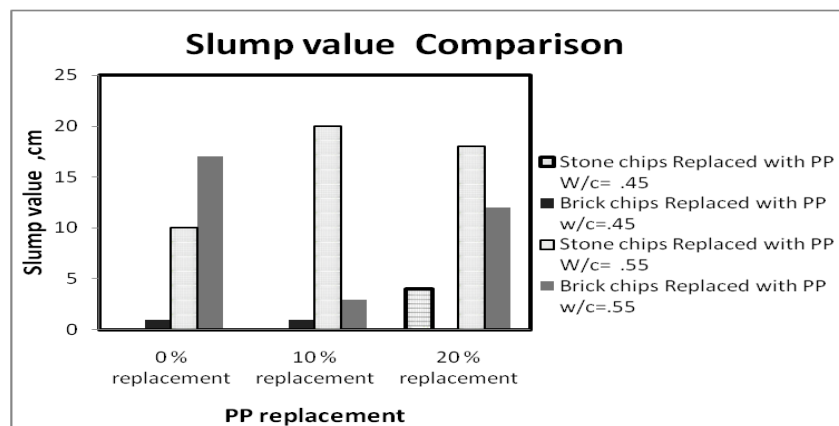


Fig 1:Slump values of Conventional Concrete with PP replaced Concrete with Stone chips and Brick Chips

### *Effects on Compressive strengths:*

Compressive strength of the sample cylinders were measured for both type of replacements.Compressive strength tests were done after 7 days and 28 days of casting.

For Stone chips replaced with PP,increments in strengths were 14% and 69% for 10% replacements and for both water cement ratio respectively than conventional concrete. Similarly for brick chips,anincrements in strengths were observed 9% and 4% for 10 % replacements and for both water cement ratio respectively than conventional concrete .This increase in strength may be caused due the rough and edgy surface texture of the PP aggregates. However, with further increase in PP content in concrete (20% replacements) decrease in strength trend was observed for Stone chips and Brick chips replaced concrete.Following figures shows the comparison of compressive strength of 7 days and 28 days of all types of replacements for both Stone chips and Brick chips.

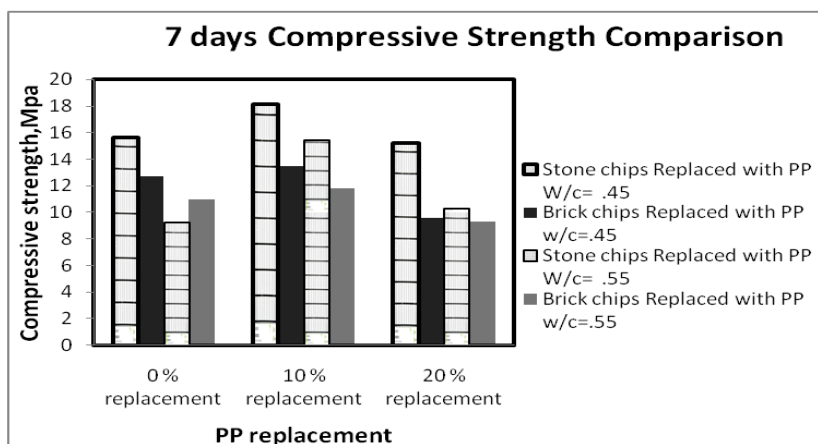


Fig 2:Compressive Strength (28 days) of PP replaced Concrete with Stone chips and Brick Chips

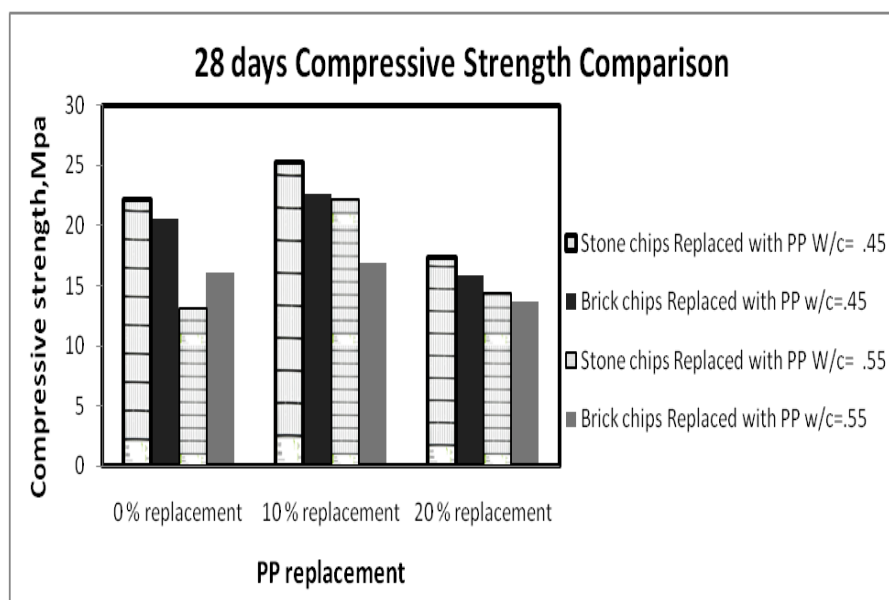
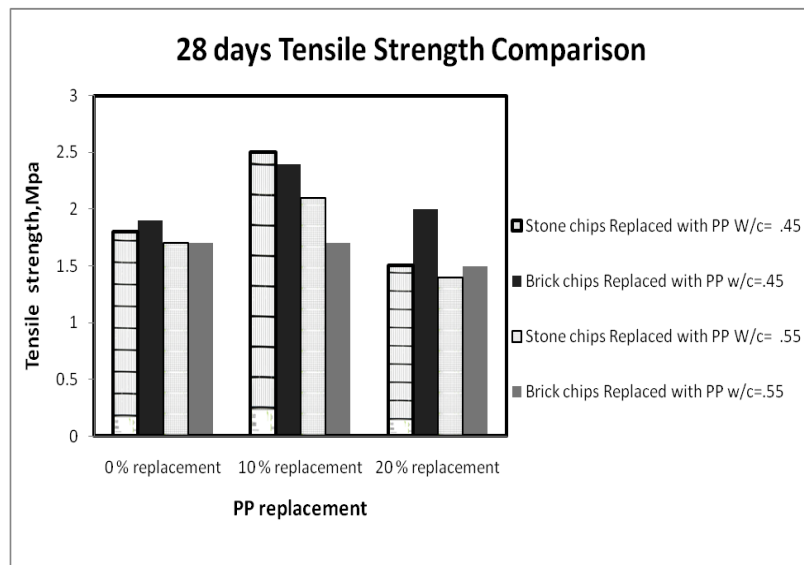


Fig 3:Compressive Strength (7 days) of PP replaced Concrete with Stone chips and Brick Chips

**Effects on Tensile Strength:**

For both of aggregates (Stone chips and Brick chips) replaced with Polypropylene, showed increment in tensile strength with certain increase of Polypropylene. In 10% replacements of Stone chips with PP ,for both water cement ratios, tensile strength increased certain amount than regular concrete .For further replacement(20% by volume) ,strength seemed to be decreased for both water cement ratios.Similarly for Brick chips replaced concrete ,also shows the similar trend.

Following graphs shows the values of tensile strength of both types of aggregates with two different water cement ratios.



**Fig 4:** Tensile Strength (28 days) of PP replaced Concrete with Stone chips and Brick Chips

#### DISCUSSIONS:

After investigating the above data appropriately, following conclusion can be provided ;

1. Compare to the concrete with no PP, 10 % PP replaced concrete in case of stone chips showed a significant increase in both compressive and tensile strengths However, with 20% replacement showed opposite trend.
2. For the brick chips replacements, 10% PP replaced concrete showed better results than other concrete in the case of compressive as well as tensile strengths.
3. For both cases, density of the concrete reduced significantly for PP replaced concrete.
4. But overall, polypropylene replacement with crushed stone chips showed better results than brick chips replaced concrete. This type of concrete may be used for structural purpose having low density as well as high strength.

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