Experimental Investigation and Comparative Study on Waste Plastic Modified Concrete and Conventional Concrete

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***Abstract*— Plastic are and chemical produced polymer and polythene based material which pollutant all kind of our environment such as air, land, water. Therefore we are in needed to utilized are treated this plastic to save our environmental. First we design the conventional concrete mix without plastic and all the property of the aggregate & concrete is analyzed.**

1. **30% replacement of the Sand material with this crumbled waste plastic in the mix and properties this modified concrete has been analyzed.**
2. **50% replacement of the 10mm material with this crumbled waste plastic in the mix and properties this modified concrete has been analyzed.**
3. **According to the result basic material are proportionated in the mix to achieve best result cost compute statement also prepare to the fine this material is cost effective are not.**

Hence we come up with innovative idea to utilized this waste plastic in concrete we utilized this waste plastic to enhance the concrete property such as strength workability etc. This electronic document is a "live" template and already defines the components of your paper [title, text, heads, etc.] in its style sheet.

Keywords—Plastic, concrete, compressive strength, enviromental polution, plastic waste management,

I. OBJECTIVE OF THE PROJECT:

Plastic in different forms is found to be almost 5% in municipal solid waste, which is toxic in nature. It is a common sight in both urban and rural areas to find empty plastic bags and other type of plastic packing material littering the roads as well as drains. Due to its biodegradability it creates stagnation of water and associated hygiene problems. In order to contain this problem experiments have been carried out whether this waste plastic can be reused productively in the construction industry. The experimentation at several institutes indicated that the waste plastic, when added to aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the cement concrete is found to give higher strength, higher resistance to water and better performance over a period of time. Therefore, it is proposed that we may use waste plastic in the concrete construction.

1. To evaluate the properties of aggregate (course & fine aggregate) , cement & concrete.
2. To evaluate the properties of waste plastic formulations by testing various physical & engineering properties.
3. To conduct the Mix design as per IS 10262-1987. For both conventional concrete and modified mix.
4. To cast the concrete cubes & cylinder for testing and comparative study.
5. To evaluate the performance of concrete mixes with and without the addition of plastic.

II. SYMBOLS & TERMINOLOGY

- PMC 1- Plastic Modified Concrete design 1 (Sand Replacement)
- PMC 2- Plastic Modified Concrete design 1 (10mm Replacement)
- V = absolute volume of fresh concrete,
- W = mass of water (Kg) per m3 of concrete,
- C = mass of cement (Kg) per m3 of concrete,
- Sc = specific gravity of cement
- ρ= ratio of fine aggregate to total aggregate by absolute volume,
- fa, ca = total masses of fine aggregate and coarse aggregate (Kg) per m3 of concrete respectively,
- Sfa, Sca = specific gravities of saturated surface dry fine aggregate and coarse aggregate respectively.

III. INTRODUCTION

Generation of plastic waste is one of the fastest growing areas. Every year more than 500 billion plastic bags are used (nearly one million bag per minute). Hundreds of thousands of sea turtles, whales and other marine mammals die every year from eating discarded plastic bag for mistaken food. On land many animals suffer from similar fate to marine life. Collection, hauling ad disposal of plastic bag waste creates an additional environmental impact. In a landfill or in environment, Plastic bags take up to 1000 year to degrade. The need for an integrated waste management approach to be considered involving efficient use of plastic materials, recycling and disposal mechanisms. The amounts of plastics consumed annually in the growing tends of Indian scenario was discussed. The possibilities of a comprehensive investigation of the technical economic and ecological aspects of recycling was addressed by the project.

In our project two kinds of plastic waste which is crumbled from the waste plastic is utilized for the replacement of concrete aggregates such as 10mm & fine aggregate. All the test for materials are conducted as per IS SP-23 Code provision.

IV. PLASTIC AND PLASTIC WASTE:

A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are mouldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural.

Figure 1 : Plastic Waste

A. *Compostion*

Most plastics contain organic polymers. The vast majority of these polymers are based on chains of carbon atoms alone or with oxygen, sulfur, or nitrogen as well. The backbone is that part of the chain on the main "path" linking a large number of repeat units together. To customize the properties of a plastic, different molecular groups "hang" from the backbone (usually they are "hung" as part of the monomers before the monomers are linked together to form the polymer chain). The structure of these "side chains" influence the properties of the polymer. This fine tuning of the properties of the polymer by repeating unit's molecular structure has allowed plastics to become an indispensable part of the twenty-first century world.

B. *Thermoplastics And Thermosetting Polymers*

There are two types of plastics: thermoplastics and thermosetting polymers. Thermoplastics are the plastics that do not undergo chemical change in their composition when heated and can be moulded again and again. Examples include polyethylene, polypropylene, polystyrene and polyvinyl chloride. Common thermoplastics range from 20,000 to 500,000 amu, while thermosets are assumed to have infinite molecular weight. These chains are made up of many repeating molecular units, known as repeat units, derived from monomers; each polymer chain will have several thousand repeating units. Thermosets can melt and take shape once; after they have solidified, they stay solid. In the thermosetting process, a chemical reaction occurs that is irreversible. The vulcanization of rubber is a thermosetting process. Before heating with sulphur, the polyisoprene is a tacky, slightly runny material, but after vulcanization the product is rigid and non-tacky.

C. *Biodegradability*

Biodegradable plastics break down (degrade) upon exposure to sunlight (e.g., ultra-violet radiation), water or dampness, bacteria, enzymes, wind abrasion, and in some instances, rodent, pest, or insect attack are also included as forms of biodegradation or environmental degradation. Some modes of degradation require that the plastic be exposed at the surface, whereas other modes will only be effective if certain conditions exist in landfill or composting systems. Starch powder has been mixed with plastic as a filler to allow it to degrade more easily, but it still does not lead to complete breakdown of the plastic. Some researchers have actually genetically engineered bacteria that synthesize a completely biodegradable plastic, but this material, such as Biopol, is expensive at present. Companies have made biodegradable additives to enhance the biodegradation of plastics.

D. *Enviromentel Hazards Due To Waste Plastics:*

Plastic pollution involves the accumulation of plastic products in the environment that adversely affects wildlife, wildlife habitat, or humans. Many types and forms of plastic pollution exist. Plastic pollution can adversely affect lands, waterways and oceans. Plastic reduction efforts have occurred in some areas in attempts to reduce plastic consumption and promote recycling. The prominence of plastic pollution is correlated with plastics being inexpensive and durable, which lends to high levels of plastics used by humans.

Plastic pollution occurs in many forms, including but not limited to littering, marine debris (man-made waste that has been released in a lake, sea, ocean, or waterway), plastic particle water pollution, plastic netting and friendly Folates. A large percentage of plastic produced each year is used to make single-use, disposable packaging items or products which will get permanently thrown out within one year. Often, consumers of the various types of plastics mainly use them for one purpose and then discard or recycle them. As Per the United States Environmental Protection Agency, in 2011 plastics constituted over 12% of municipal solid waste. In the 1960s, plastics constituted less than 1% of municipal solid waste.

V. EFFECTS ON THE ENVIRONMENT

A. Land

Chlorinated plastic can release harmful chemicals into the surrounding soil, which can then seep into groundwater or other surrounding water sources. This can cause serious harm to the species that drink this water. Landfill areas are constantly piled high with many different types of plastics. In these landfills, there are many microorganisms which speed up the biodegradation of plastics. Regarding biodegradable plastics, as they are broken down, methane is released, which is a very powerful green-house gas that contributes significantly to global warming. Some landfills are taking initiative by installing devices to capture the methane and use it for energy, but most have not incorporated such technology. Release of methane does not only occur in landfills, biodegradable plastics also degrade if left on the ground, in which case degradation takes longer to occur.

B. Ocean

Nurdles are plastic pellets (a type of micro-plastic) that are shipped in this form, often in cargo ships, to be used for the creation of plastic products. A significant amount of nurdles are spilled into oceans, and it has been estimated that globally, around 10% of beach litter is nurdles. Plastics in oceans typically degrade within a year, but not entirely, and in the process toxic chemicals such as biphenyl A and polystyrene can leach into waters from some plastics. Polystyrene pieces and nurdles are the most common types of plastic pollution in oceans, and combined with plastic bags and food containers make up the majority of oceanic debris. In 2012, it was estimated that there was approximately 165 million tons of plastic pollution in the world's oceans.

C. Effects On Animals

Plastic pollution has the potential to poison animals, which can then adversely affect human food supplies. Plastic pollution has been described as being highly detrimental to large marine mammals, described in the book Introduction to Marine Biology as posing the "single greatest threat" to them. Some marine species, such as sea turtles, have been found to contain large proportions of plastics in their stomach. When this occurs, the animal typically starves, because the plastic blocks the animal's digestive tract. Marine mammals sometimes become entangled in plastic products such as nets, which can harm or kill them. Over 260 species, including invertebrates, have been reported to have either ingested plastic or become entangled in the plastic. When a species gets entangled, its movement is seriously reduced, therefore making it very difficult to find food. Being entangled usually results in death or severe lacerations and ulcers. It has been estimated that over 400,000 marine mammals perish annually due to plastic pollution in oceans. In 2004, it was estimated that seagulls in the North Sea had an average of thirty pieces of plastic in their stomachs.

D. Effects On Humans

Plastics contain many different types of chemicals, depending on the type of plastic. The addition of chemicals is the main reason why these plastics have become so multipurpose, however this has problems associated with it. Some of the chemicals used in plastic production have the potential to be absorbed by human beings through skin absorption. A lot is unknown on how severely humans are physically affected by these chemicals. Some of the chemicals used in plastic production can cause dermatitis upon contact with human skin. In many plastics, these toxic chemicals are only used in trace amounts, but significant testing is often required to ensure that the toxic elements are contained within the plastic by inert material or polymer.

VI. REUSE OF WASTE PLASTIC IN CONCRETE WORKS

For the concrete, stone aggregate with specific characteristics is used and the aggregate is chosen on the basis of its strength, porosity and moisture absorption capacity. The aggregate which is was partially replaced with waste plastic material may elevate the properties such as Aggregate Impact Value, abrasion value etc. In those manner waste plastic has been utilized in the concrete works to increase the quality of concrete and decrease the cost of roads by utilizing this kind of waste material which shall reduce numerous environmental problems.

VII. LABORATORY INVESTIGATION

Following lab investigation on the materials have been done on aggregates and concrete mix and results are tabulated below

- Specific gravity
- Water Absorption (%)
- Impact value
- Sieve analysis
- Consistency of cement
- Fineness of cement (Dry Sieving)
- Initial & final Setting time of Cement
- Compressive strength of concrete

Table 1 : Plastic Properties

Description	Plastic Properties
Specific gravity	1.01
Absorption (%)	<0.2
Color	White & Dark
Shape	Angular
Crushing Value	<2%
Impact value	<2%

Table 2 : Aggregate Properties

Description	Course aggregate Properties
Specific gravity	2.661 g/cc
Absorption (%)	0.855 %
Color	Blue
Shape	Angular
Sieve analysis	Passed
Impact value	22.5%

Table 3 : Cement Properties

Description	Cement Properties
Fineness of cement	6.5%
Consistency of cement	31.5
Compressive strength	54.5 N/mm^2

VIII. CONCRETE MIX DESIGN

As per IS: 10262-1982-recommended guidelines for concrete mix design

A. Design Stipulations

Characteristic strength required in the field at 28-days	**20**	**N/MM^2**
Maximum size of aggregate	20	Mm
Degree of workability (table 6 is:10262-1982)	0.8	Compacting factor
Degree of quality control	Good	
Type of exposure	Normal	

B. Test Data For Materials

Cement: Ordinary **Portland** cement grade 43 — Chettinad

Specific gravity of cement — 3.15

Specific gravity of coarse aggregates

- Coarse aggregates 20 mm — 2.642
- Coarse aggregates 10 mm — 2.680
- Combined Specific gravity of Coarse aggregates — 2.661
- fine aggregate — 2.652

Water absorption

- Coarse aggregates 20 mm — 0.78%
- Coarse aggregate 10 mm — 0.93%
- fine aggregate — 1.2%

Free (surface) moisture

- Coarse aggregate 20mm — 0%
- Coarse aggregates 10 mm — 0%
- Fine aggregate (Zone III) — 0%

C. Target Mean Strength Of Concrete

$$F_{ck} = F_{ck} + t \times s$$

t=	1.65	
s=	3.5	
(Table 1 & 2 IS 10262) 20 + 3.5 x 1.65 =	25.8	N/mm^2
Adopted Target mean strength of concrete:	26	N/mm^2

D. Selection Of Water-Cement Ratio

From Fig No.1 of (IS:10262-1982) — **0.5**

Adopted Water-Cement Ratio: 0.5

Selection of Water and Sand content

From table 4, IS:10262-1988 for 20mm nominal maximum size aggregate and sand conforming to grading zone II, water content per cubic meter of concrete is equal to 186 kg and sand content as percentage of total aggregate by absolute volume is equal to 35 percent.

Adopted water content	186	Liter
Adopted Sand content	40%	

E. *Determination Of Cement Content*

Water-Cement ratio:	0.5	
Water:	186	
W/C= 0.5 (W=186) from formula Cement	372	
Adopted cement content:	372	Kg/m^3

F. *Aggregate Quantities Required For The Mix Per Cubic Meter Of Concrete:*

Calculation of Aggregate content (As per Cl. 3.5 of IS: 10262-1982)

$$V = \left(W + \frac{C}{S_c} + \frac{1}{\rho}\frac{f_a}{S_{fa}} x \frac{1}{1000} \right)$$

$$V = \left(W + \frac{C}{S_c} + \frac{1}{(1-\rho)}\frac{c_a}{S_{ca}} x \frac{1}{1000} \right)$$

Where:

V = absolute volume of fresh concrete, which is equal to gross volume (m3) minus the volume of entrapped air,

W = mass of water (Kg) per m3 of concrete,

C = mass of cement (Kg) per m3 of concrete,

Sc = specific gravity of cement

ρ= ratio of fine aggregate to total aggregate by absolute volume,

fa, ca = total masses of fine aggregate and coarse aggregate (Kg) per m3 of concrete respectively,

Sfa, Sca = specific gravities of saturated surface dry fine aggregate and coarse aggregate respectively.

Mass of water (Kg) per m3 of concrete	(*W*)	180Kg
Water Cement ratio	*W/C*	0.50
Mass of cement (Kg) per m3 of concrete	(*C*)	372 Kg
Specific gravity of cement	(*Sc*)	3.15
Specific gravity (SSD) of fine aggregate	(*Sfa*)	2.6
Specific gravity (SSD) of coarse aggregate	(*Sca*)	2.7
Entrapped air content (For table-3 of IS: 10262-1982)		2.0 %
Ratio of fine aggregate to total aggregate by absolute volume	(ρ)	40 %

∴ Quantity of fine aggregate (Sand) per m3 of concrete (*fa*):

$$0.98 = 186 + \frac{372}{3.15} + \frac{1}{40\%}\frac{f_a}{2.6} x \frac{1}{1000}`$$

fa **= 708 Kg.**

∴ Quantity of coarse aggregate per m3 of concrete *ca*:

$$0.98 = 186 + \frac{372}{3.15} + \frac{1}{(1-40\%)}\frac{c_a}{2.7} x \frac{1}{1000}$$

C***a*** **= 1070 Kg.**

In coarse aggregate Fraction I (20mm) = 50%

Fraction II (10mm) = 50%

∴ Quantity of 20mm per m3 of concrete = 50% of 1070 Kg.

= 534 Kg.

Quantity of 10mm per m3 of concrete = 50% of 1199 Kg.

= 534 Kg.

Table 4 : Mix Design propositions

Ingredients	Conventional concrete Mix Design per cubic Meter	Mix Ratio	Conventional concrete Mix Design per 9 cube	Plastic Modified concrete Mix Design per 9 Cube: Design No.1 PMC 1 By Sand Replacement	Plastic Modified concrete Mix Design per 9 Cube: Design No.2 PMC 2 By 10mm Replacement
	Kg.		Kg.	Kg.	Kg.
Cement	372	1.00	3.35	3.35	3.35
Water	203	0.50	1.83	1.83	1.83
Sand	708	1.90	6.38	4.44	6.38
20 mm	534	1.44	4.82	4.82	4.82
10mm	535	1.44	4.81	4.81	2.4
Waste Plastic Replacement				1.94 (Small)	2.4 (Big)

IX. DISCUSSION ON EXPERIMENTAL RESULTS

Table 5 : Cube Test Results

Test	Conventional Concrete	Plastic Modified Concrete PMC 1 (by Sand Replacement)	Plastic Modified Concrete PMC 2 (by 10mm Replacement)
7 Days	14 N/mm^2	13 N/mm^2	14 N/mm^2
14 days	17 N/mm^2	15.5 N/mm^2	16.5 N/mm^2
28 Days	22 N/mm^2	20.5 N/mm^2	24 N/mm^2

1. As Per the IS code provision both modified plastic concrete (PMC 1 & PMC 2) compliance the standard requirements
2. Plastic modified concrete (PMC 1) with sand replacement compliance the M20 grade specification but cube strength is lower than the conventional concrete.
3. Plastic modified concrete (PMC 2) with 10 mm replacement attain higher strength than the sand replaced concrete.
4. This concrete are having better water resistant than conventional concrete mix. Therefore we suggest this concrete shall be used in higher seepage area footing and plain cement concrete works (PCC) to avoid water seepage.

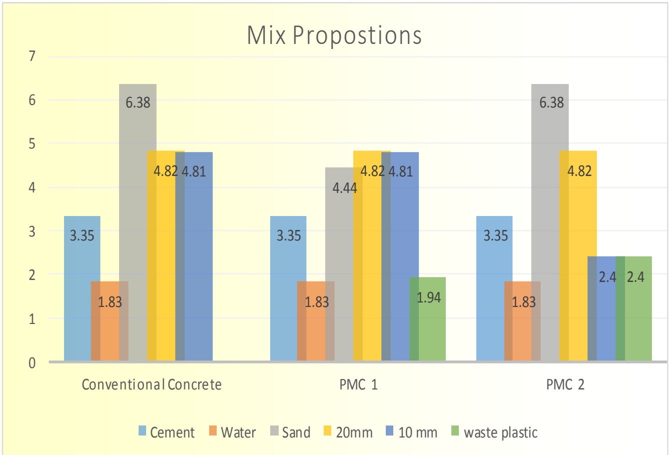
X. COST COMPARATIVE STATEMENT

Table 6 : Cost Statement

Ingredients	Conventional Concrete	PMC 1	PMC 2
	Cost in INR of materials as per mix design		
Cement	296	296	296
20 mm	627	627	627
10 mm	430	430	215
Sand	621	396.5	621
Plastic		150	190
Total	Rs.1678 Per cubic Meter	Rs.1603.5 Per cubic Meter	Rs.1653 Per cubic Meter

1. In accordance cost comparative statement it is conclude as the following results
2. Use of plastic waste is cost effective comparing to the conventional concrete mix
3. 1 Cubic meter of conventional concrete production cost is Rs.1678 /-
4. But 1 Cubic meter of plastic modified concrete (PMC 1) production cost is Rs.1603.5 /- which is Rs.74.5 lesser cost than conventional mix
5. Even-though 1 Cubic meter of plastic modified concrete (PMC 2) production cost is Rs.1653/- which is Rs.25 lesser cost than conventional mix

XI. GRAPHS



XII. CONCLUSION

This study intended to find the effective ways to reutilize the hard plastic waste particles as concrete aggregate. Based on the Experimental result following points are summarized with regard to effect of plastic on the properties of concrete. Analysis of the strength characteristics of concrete containing recycled waste plastic and gave the above results.

1. It is identified that waste can be disposed by using them as construction materials.
2. Since the waste is not suitable to replace fine aggregate it is used to replace the coarse aggregate.
3. The compressive strength and split tensile strength of concrete containing plastic aggregate is retained more or less in comparison with controlled concrete specimens.
4. Has been concluded 50% of waste plastic aggregate can be incorporated as coarse aggregate and replacement in concrete without any long term detrimental effects and with acceptable strength development properties.
5. Thus it is conclude that the use plastic can be possible to increase the tensile strength of concrete.
6. From the above discussion it is identified that the use of plastic can be possible to improve the properties of concrete which can act as a one of the plastic disposal method.

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XIII. REFERNCE

1. IS 456 - Plain And Reinforced Concrete - Code Of Practice
2. IS 10262- As per IS: 10262-1982-recommended guidelines for concrete mix design
3. IS 516 – Methods Of Tests For Strength Of Concrete
4. IS SP 23 – Handbook On Concrete Mixes
5. R.Lakshmi, S. Nagan, "Utilization of waste E plastic particles in cementitious mixtures" Journal of Structural Engineering,Vol.38, No. 1, April – May 2011,
6. P.Muthupriya, K. Subramanian, B.G. Vishuram, "Experimental investigation on high performance reinforced concrete column with silica fume and fly ash as admixtures" Journal of Structural Engineering,Vol.38, No. 1, April – May 2011,
7. Ahamed Shayan, Aimin Xu, "Value added utilization of waste glass in concrete", Cement and Concrete Research vol 34 (2004) pp 8189.
8. SecungBum Park, Bong Chun Lee, "Studies on expansion properties in mortar containing waste glass & fibering. Cement and Concrete Research, vol 34 (2004) pp 11451152.
9. C.H.Chen, R.Hwang, "Waste Eglass particles used in cementious mixtures" Cement and Concrete Research, vol 36 (2006) pp 449456.
10. P.M.Subramanian, "Plastic recycling and waste Management in the US" Resources, Conservation and Recycling vol (28) pp 253263.
11. Caijun shi, "Corrosion of glasses and expansion mechanism of concrete certaining waste glasses as aggregates, Journal of Materials in Civil Engineering ASCE, October 2009, pp 529534.
12. Hai yong kang, "Electronic waste recycling: A review of U.S. infrastructure and technology options, Resources, Conservation and Recycling vol 45 (2005) pp 368400.