Feasibility of Waste Metallised Polythene Used as Concrete Constituent

A. Bhogayata, K. D. Shah, B. A. Vyas, N. K. Arora

Abstract – Utilising fibres in concrete was introduced in early 1900s. Since then large variety of fibres are experimented and being practiced effectively around the world. The prime concern was the improvisation of concrete properties. With time, the scenario gets diverted towards utilisation of wastes and by products from industry and municipal wastes especially the plastic wastes were in concern. The most stable form of plastic wastes made them non biodegradable and somewhat difficult to recycle. In last ten years, large range of various wastes are added to concrete as dual solution towards mitigation of waste management problems and reducing natural material use as concrete constituent. This paper presents the experimental investigation of feasibility of polyethylene post consumer waste used for food packaging along with fly ash as another by product of thermal power stations. The ample numbers of samples were prepared in M10 concrete mix with two different water/ cement ratio. Plastic waste was converted in fibre form and added from 0% to 1.5% of volume along with variation of fly ash from 0% to 30% of volume. Different curing conditions were used to note the effect of chemical attack and corresponding change in the compressive strength of the concrete mix.

Keywords: metallised polyethylene, land filling, compressive strength, acid curing, sulphate curing, water/cement ratio.

I. INTRODUCTION

Since the ancient times, various fibres are utilised to overcome this limitations. For a durable concrete, along with high compressive strength it must be impermeable and strong enough towards environmental effects and chemical attacks. Use of fibres shows satisfactory laboratory results to improve the durability aspects of concrete. Many types of fibre are available commercially today, to be added in concrete. Fortunately fibres of different types namely steel, glass, and plastic are successfully being used. This has enhanced the concrete performance at variety of levels. Indirectly it has helped in material saving also. The present Indian concrete industry alone, is consuming about 370 million m^3 of concrete every year and it is expected, that it shall reach about 580 million m^3 by 2022[1][10].The re-formation of natural sources is beyond the proportion of mankind. Hence the increased demand of concrete has raised a serious question on the quickly vanishing valuable natural sources. A new term evolved called Green concrete – it is a concrete prepared by using the waste products of different industries with the conventional materials. Wide variety of such wastes are already being added and tested for various observations and their effects on different aspects of concrete properties. Interestingly, researchers were moved towards the use of waste materials as fibres in the conventional concrete to check the possibility to combine three issues at a time like concrete properties improvement, waste management and mitigation of use of natural resources at small scale.

One of the fastest growing industries is a plastic industry. Around the world almost one trillion bags per year are being used and it is just one example of a product of plastic. The plastic is one of the recent engineering materials which have appeared in the market all over the world. There has been a steep rise in the production of plastics from a mere 30 million KN in 1955; it has touched 1000 million KN at present. Plastics are normally stable and not biodegradable. So, their disposal is a problem. Research works are going on in making use of plastics wastes effectively as additives in plain and reinforced concrete mixes for variety of purposes. Different forms and types of wastes are utilised to check the feasibility of them in concrete. This study attempts to give a contribution to the effective use of waste plastics in concrete in order to prevent the ecological and environmental strains caused by them, also to limit the high amount of environmental degradation.

II. RESEARCH WORK EXTRACTS

Immense efforts are made towards checking the feasibility of use of plastic waste in different form along with the fibre form. Physical and mechanical behaviour was checked for waste PET bottle fibres used in controlled concrete by Luiz A. Pereira de Oliveira and João P. Castro-Gomes [5]. They noticed that the PET fibre incorporation (1:1:6) increases the bending strength about 100% at 7 days, 30% at 28 days and the order of 50% at 63 days. The volume of PET fibre of 1.5% is the optimum volume for the best performance of the mortar. F. Mahdi and et all [3], noticed the energy saving aspect of use of PET bottle resins in mortar and concrete. They also noticed the improvement of tensile strength of the mortar and concrete when PET resins were added. F. Pacheco-Torgal et and all [4], tested the durability aspects of concrete added with rubber waste and PET bottles fibre in different aspect ratio and form of rubber wastes. They observed that such materials can be used for non load bearing structures. They have suggested further investigations to maximise such energy effective utilisation of wastes in concrete mix. C. Meyer [2] has presented an overview of different variety of wastes from different industries like fly ash, silica flume, recycled aggregates, granulated blast furnace slag, tire wastes, post consumer glass products, and recycled plastic wastes, experimented towards the sustainable building material as an alternative towards the conventional and energy consuming conventional material.

Manuscript Received June 2012.

A. Bhogayata: Assistant Professor & Head, Department of Civil Engineering, Marwadi Engineering College, Rajkot-360005,
K. D. Shah: Post graduate student, Applied Mechanics department, L.D.College of engineering, Ahmedabad-380015,
B. A.vyas: Assistant Professor, Applied Mechanics department, L.D.College of engineering, Ahmedabad-380015,
Dr. N. K. Arora: Associate Professor, Applied Mechanics department, L.D.College of engineering, Ahmedabad-380015,

This paper discusses the similar efforts towards utilisation of post consumer plastic waste used in packaged food and snacks in India. It is observed that even after a well organised waste management in various cities such plastic bags remains unhandled and becomes problem for the environmental cleanliness.

III. MATERIALS

The experiment was done with the basic and conventional concrete making materials like OPC 53 grade, fine and coarse aggregate of maximum size as 20mm and tap water. The metalized polythene waste bags were shredded to the macro flakes form. The bags were not given any treatment except the normal water wash cleaning and day light drying. The properties of polythene bags were as given in table no.1

Table 1: Properties of polythene film used

Properties	Values
Thickness	60µ
Density	1.4 gm/cc
Type	Polythene film (single metallised)
Category	Metallised food packing grade

Fig.1: Shredded fibres of polythene bags

Cement: Ordinary Portland cement of 53 grades available in local market is used in the investigation. The specific gravity was 2.96 and fineness was $3200cm^2/gm$.

Coarse aggregate: Crushed angular granite metal of 20 mm and 10 mm size from a local source was used as coarse aggregate. The specific gravity of 2.71 and fineness modulus 7.13 was used.

Fine aggregate: River sand was used as fine aggregate. The specific gravity of 2.60 and fineness modulus 3.25 was used in the investigations.

Fly ash: class F fly ash was used. The chemical details are as given below in table no. 2

Content	value
Silica	52.8%
Alumina	22.3
Lime	Trace
Iron	9.2
Sulphur	0.7
Magnesium	0.2
Available alkalis	0.5
Specific gravity	2.25

Table: 2 Contents of F class fly ash used

IV. TESTING METHODS

All materials except the fibres were tested for their basic properties and towards quality control of the experiment. Standards were followed including general and specific notes in ASTM and the IS codes. For mix preparation and curing purposes, the general laboratory methods were used with utmost care.

V. MIXING AND CASTING

Mixing being an important aspect of any successful experiment and to avail the desired results, utmost care was taken in the mixing and casting process. All materials were mixed with the standard practice of mixing them in a mixer and the plastic fibres were added to the mix. Specimens were prepared by following the standard methods of mould preparation. Total 48 cubes of the size of 150X150X150 mm were prepared for the compressive strength tests.

VI. TESTS

Total 64 cubes were prepared including controlled concrete and concrete mixed with polyethylene fibres in different proportions from 0%, 0.5%, and 1% to 1.5% of the volume of concrete. The fly ash was added in proportion of 0%, 10%, 20% and 30% by volume. The samples were tested at full curing periods and the average values were taken in to the consideration. The curing of cubes was done with three different mediums namely normal water, acid and sulphate solution. The compressive strength was compared with the controlled normal concrete specimens.

VII. RESULTS AND DISCUSSIONS

All the cube samples were tested for compressive strength. Following are the results obtained,

- The controlled concrete with normal curing showed result as $26.65N/mm^2$, compressive strength. The minimum value was $9.24\ N/mm^2$.
- The maximum value of compressive strength sample cured in acid was $25.42\ N/mm^2$, that was nearer to the controlled sample. The lowest strength recorded was $8.53\ N/mm^2$, containing 1.5% fibres and 20% fly ash.
- The maximum compressive strength was 34.31 N/mm^2 with 0% plastic and 10% added fly ash when cured in sulphate solution. The minimum value was 10.67% with 1.5% plastic and 30% of fly ash.
- Addition of fibres affected the compressive strength as reduction but not less than the controlled sample.
- Addition of fly ash raised the strength loss due to addition of fibres.
- Three different water cement ratio showed varying results as the lowest w/c ratio of 0.45 showed the maximum compressive strength of $45.33\ N/mm^2$.

VIII. CONCLUSIONS

Based on the experimental data received after a wide range of samples with different proportions of fibres and fly ash, following conclusions are made,

- The plastic bags could be used preferably in shredded form to avoid difficulty in workability.
- Plastic fibres along with fly ash showed good combination as far as strength gain is concerned.
- The most suitable water to cement ratio was found as 0.45. However the tests were performed with three different curing medium like water, acid and sulphate, the best results were noticed with w/c ratio as 0.45.
- It could be noticed that the addition of fibres with the combination of fly ash showed relatively good chemical resistant without any significant loss in the strength.
- The authors are experimenting different types of post consumer plastic wastes in different form and proportions to check the feasibility of usage of such wastes in concrete to have an alternate solution towards the solid wastes.
- To increase the durability aspects of non structural concrete the concept of using fibres could be a very good environmental friendly option as far as the waste disposal of non biodegradable plastics are concerned.
- The area bears a good potential for further research for more insight in to the suitability of the waste usage in concrete.

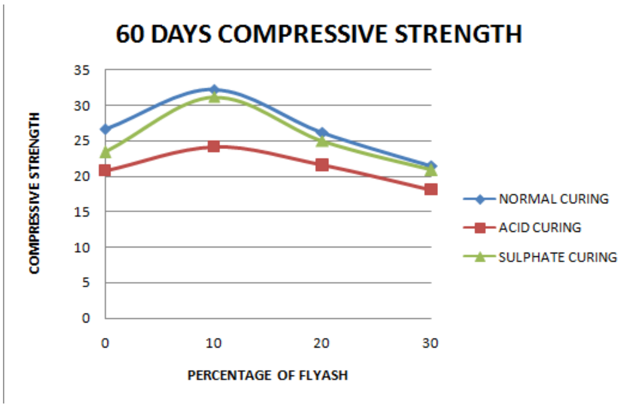

Fig.2: 0% plastic samples compressive strength

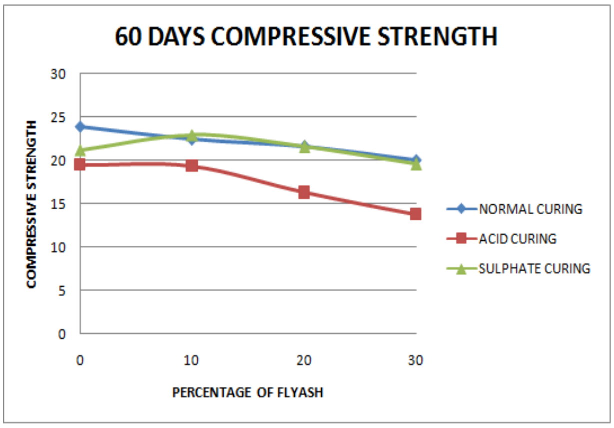

Fig.3: 0.5% plastic samples compressive strength

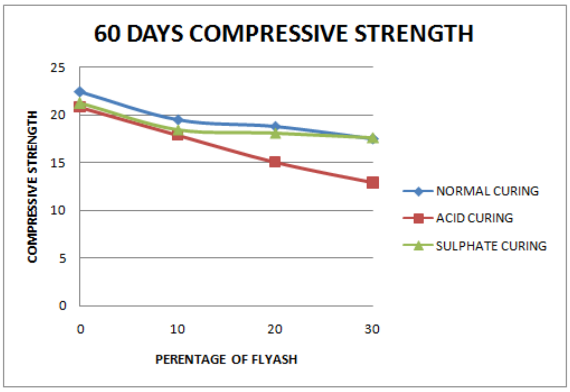

Fig.4: 1.0% plastic samples compressive strength

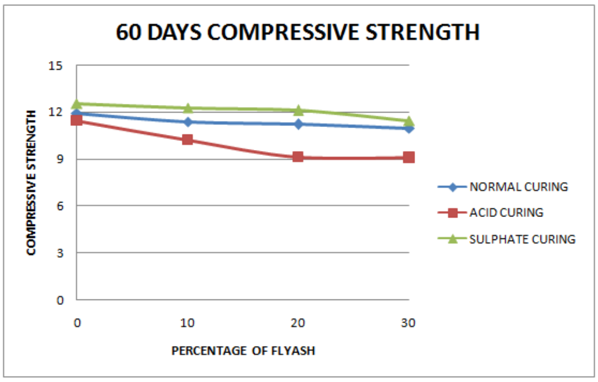

Fig.5: 1.5% plastic samples compressive strength

NORMAL CURING			ACID CURING			SULPHATE CURING		
cube	strength	av	cube	strength	av	cube	strength	av
CUBE-1	24.18	26.665	CUBE-1	20.44	20.74	CUBE-1	24	23.41
CUBE-2	29.16		CUBE-2	20.97		CUBE-2	25.42	
CUBE-3	29.68		CUBE-3	20.8		CUBE-3	20.8	
CUBE-4	23.64							
CUBE-1	32.89	32.2225	CUBE-1	23.11	24.18	CUBE-1	30.4	31.17
CUBE-2	32.53		CUBE-2	24		CUBE-2	34.31	
CUBE-3	34.67		CUBE-3	25.42		CUBE-3	28.8	
CUBE-4	28.8							
CUBE-1	25.5	26.1925	CUBE-1	20.98	21.57	CUBE-1	33.07	24.95
CUBE-2	25.77		CUBE-2	20.27		CUBE-2	23.11	
CUBE-3	23.64		CUBE-3	23.46		CUBE-3	18.67	
CUBE-4	29.86							
CUBE-1	23.47	21.46	CUBE-1	19.91	18.13	CUBE-1	21.15	20.85
CUBE-2	21.15		CUBE-2	17.78		CUBE-2	22.93	
CUBE-3	21.69		CUBE-3	16.71		CUBE-3	18.49	
CUBE-4	19.55							
CUBE-1	24.71	23.9125	CUBE-1	19.38	19.49	CUBE-1	19.91	21.21
CUBE-2	23.29		CUBE-2	19.2		CUBE-2	20.62	
CUBE-3	24.89		CUBE-3	19.91		CUBE-3	23.11	
CUBE-4	22.76							
CUBE-1	23.64	22.405	CUBE-1	20.44	19.37	CUBE-1	24.53	22.93
CUBE-2	21.86		CUBE-2	21.33		CUBE-2	23.28	
CUBE-3	22.44		CUBE-3	16.35		CUBE-3	20.98	
CUBE-4	21.68							
CUBE-1	20.8	21.55	CUBE-1	13.33	16.24	CUBE-1	20.09	21.57
CUBE-2	20.44		CUBE-2	16.89		CUBE-2	21.33	
CUBE-3	23.64		CUBE-3	18.49		CUBE-3	23.29	
CUBE-4	21.33							
CUBE-1	20.62	20.04	CUBE-1	12.8	13.74	CUBE-1	20.8	19.61
CUBE-2	20.44		CUBE-2	14.13		CUBE-2	19.02	
CUBE-3	19.37		CUBE-3	14.31		CUBE-3	18.87	
CUBE-4	19.73							
CUBE-1	22.93	22.44	CUBE-1	19.02	20.80	CUBE-1	17.78	19.08
CUBE-2	22.22		CUBE-2	20.8		CUBE-2	19.02	
CUBE-3	21.33		CUBE-3	22.58		CUBE-3	20.44	
CUBE-4	23.29							
CUBE-1	20.98	19.51	CUBE-1	16.71	17.89	CUBE-1	17.07	18.49
CUBE-2	20.27		CUBE-2	17.95		CUBE-2	20.8	
CUBE-3	18.84		CUBE-3	19.02		CUBE-3	17.6	
CUBE-4	17.95							
CUBE-1	20.27	18.84	CUBE-1	13.69	15.05	CUBE-1	17.24	18.13
CUBE-2	19.02		CUBE-2	16.18		CUBE-2	16.35	
CUBE-3	18.84		CUBE-3	15.29		CUBE-3	20.8	
CUBE-4	17.24							
CUBE-1	16.53	16.8	CUBE-1	10.84	12.86	CUBE-1	18.49	18.64
CUBE-2	18.13		CUBE-2	12.62		CUBE-2	19.73	
CUBE-3	16.71		CUBE-3	15.11		CUBE-3	17.78	
CUBE-4	18.82							
CUBE-1	11.1	12.13	CUBE-1	12.09	11.44	CUBE-1	14.22	12.41
CUBE-2	11.38		CUBE-2	12.44		CUBE-2	10.67	
CUBE-3	12.62		CUBE-3	9.78		CUBE-3	12.8	
CUBE-4	12.62							
CUBE-1	12.44	11.37	CUBE-1	10.13	10.19	CUBE-1	12.26	12.28
CUBE-2	12.1		CUBE-2	11.55		CUBE-2	12.62	
CUBE-3	11.73		CUBE-3	8.89		CUBE-3	11.96	
CUBE-4	9.24							
CUBE-1	12.44	11.2	CUBE-1	10.31	9.12	CUBE-1	12.09	12.09
CUBE-2	10.84		CUBE-2	8.53		CUBE-2	12.62	
CUBE-3	10.13		CUBE-3	8.53		CUBE-3	11.55	
CUBE-4	11.38							

Table: 3 Results of compressive strength (all cases)

REFERENCES

1. Ankur Bhogayata and Narendra K. Arora, "Green concrete from the post consumer plastic wastes: Indian scenario", *ICTSET proceedings*, ISBN: 978-81-906377-9-4, pages: 437-440, April, 2011.
2. C. Meyer,"The greening of the concrete industry",Cement & Concrete Composites 31 (2009) 601–605
3. F. Mahdi a, H. Abbas b, A.A. Khan c "Strength characteristics of polymer mortar and concrete using different compositions of resins derived from post-consumer PET bottles", Construction and Building Materials 24 (2010) 25–36.
4. F. Pacheco-Torgal a,⇑, Yining Ding b, Said Jalali a "Properties and durability of concrete containing polymeric wastes (tyre rubber and polyethylene terephthalate bottles): An overview", Construction and Building Materials 30 (2012) 714–724.
5. Luiz A. Pereira de Oliveira , João P. Castro-Gomes "Physical and mechanical behaviour of recycled PET fibre reinforced mortar", Construction and Building Materials 25 (2011) 1712–1717.
6. M.Sivaraja, S. Kandasamy and A. Thirumurugan, "Mechanical strength of fibrous concrete with waste rural materials", Journal of engineering and applied science, vol. 69, April, page: 308 – 312, 2010.
7. M. Sivaraja and Kandasamy, "Reinforced concrete beams with rural composites under cyclic loading", Journal of engineering and applied science 2 (11), page: 1620 -1626, 2007.
8. Marzouk OY, Dheilly RM, Queneudec M. "Valorisation of Post Consumer Waste Plastic in Cementitious Concrete Composites", PubMed, U.S.National Library of Medicine, National Institute of Health, vol. 27 (2), Issue-12, 310- May, 2006.
9. Priya Narayan, "Analysing Plastic Waste in India- Case Study of PET bottles and poly bags", Lund University, Sweden, September, 2001.
10. Prvinkumar and S.K. Kaushik, "Some trends in the use of concrete: Indian Scenario", *The Indian concrete Journal*, December, page: 1503 –1508, 2003.
11. T.R.Naik, S.S. Singh, C.O.Huber, and B.S.Brodersen, "Use of Post Consumer Plastics in Cement Based Composites", Cement and Concrete Research, Science Direct, Vol. 26, Issue 10, October, page: 1489 – 1492, 1996.
12. Zainab Z. Ismail, Enas A. Al – Hashmi, " Use of Waste Plastic in Concrete Mixture as Aggregate Replacement", Waste Management, Science Direct, Vol. 28, Issue 11, November, page: 2041 – 2047, 2008.