# Feasibility of Metalized Polymer Plastic Waste used as Concrete Ingredient

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*Abstract*— Utilizing 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 utilization 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 three 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. And Check the permeability of concrete by using oxygen permeability test and water sorptivity test.

***Key words:*** Metalized Polymer Plastic, Oxygen Permeability Test, Sorptivity Test, Water/Cement Ratio, Fly Ash

## 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. 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 polymer waste bags were shredded to the macro pallets 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.

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

Table 1: Properties of Metalize Polymer Plastic

Fig. 1: Shredded Metalize Polymer Plastic

1) 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 /gm.

2) 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

3) 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.

4) 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

| Vol. | Cement | Water | F.A | Kapachi | Grit | w/c |
|---|---|---|---|---|---|---|
| 1 $m^3$ | 319.3 kg | 191.58 kg | 735.3 kg | 679.6 kg | 453.0 kg | 0.65 |

Table 3: Mix Design of M10 Grade

## 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.

### *A. Oxygen Permeability Test*

Oxygen permeability test is used to measure the oxygen permeability of concrete. The durability of structures made of reinforced concrete is conditioned by the mechanism of movement of aggressive fluids within the micro-structure of the concrete. In this respect, the concrete acts as a protection barrier for the steel reinforcing bars against potentially damaging matter such as $O_2$, $CO_2$ and $H_2O$. Oxygen is normally selected for permeability testing given its chemical inertia within the porous structure of concrete. This method cannot be used on samples saturated in water as well as samples with fissures that are samples with evident defects such as honeycombing, cracks etc. The test result is the mean specific coefficient of oxygen permeability. The concrete cylinder disk (diameter 150mm x height 50 mm) was taken. During the oxygen permeability test on concrete disk it was observed that the amount of oxygen gas required for testing concrete disk is not constant. The number of concrete disk tested in one small size oxygen cylinder may not be fixed. It depends on time duration of testing, proper connection of rubber tube between oxygen cylinder valve and oxygen permeability test apparatus, namely oxygen gas pressure of cylinder, control gas pressure from control valve at oxygen cylinder, increase and control of oxygen gas pressure with increase as well as control valve at oxygen permeability test apparatus and skill as well as experience of oxygen permeability apparatus operator.

### *B. Water Sorptivity Test*

Water sorptivity test was used to measure the capillary water absorption of concrete. Some materials with extremely coarse pore structure experience little capillary suction and may show significant deviation from linearity after prolonged wetting. Capillary suction can be measured in dry concrete. Sorption does not take place in saturated materials, and in totally dry materials substantial absorption of water by the gel will distort the results. The sorptivity will depend on the initial water content and its uniformity throughout the specimen under test. Furthermore, as water absorption and capillary suction depends on porosity, any non- uniformity in the latter could lead to different sorptivity in samples obtained from what is supposed to be the same material. It is, therefore, essential that materials under test be consistent and homogeneous. Water sorptivity test is performed on same disc which was used for oxygen permeability test. Oxygen permeability and water sorptivity of concrete disc was measured in the same direction. During the water sorptivity test on concrete disc it was observed that the water absorption at 300 seconds was higher than at 1800 seconds in a cast disc. In sorptivity test on concrete disc the second observation made was when metallized polymer plastic increases from 0.6% to 1.6%, the water absorption increases.

 

## V. MIXING & 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 specimens of the size of 150 mm dia. & 50 mm height were prepared for the oxygen permeability & water soraptivity test.

## VI. TESTS

Total 48 specimens were prepared including normal concrete and concrete mixed with metalize polymer fibres in different proportions from 0%, 0.5%, and 1% to 1.5% ofthe volume of concrete. The fly ash was added in proportion of 0%, 10%, 20% and 30% by volume. The samples were tested at full dry curing periods and the values were taken in to the consideration.

## VII. RESULTS & DISCUSSIONS

All the disk samples were tested for oxygen permeability & water sorptivity test. Following are the results obtained,

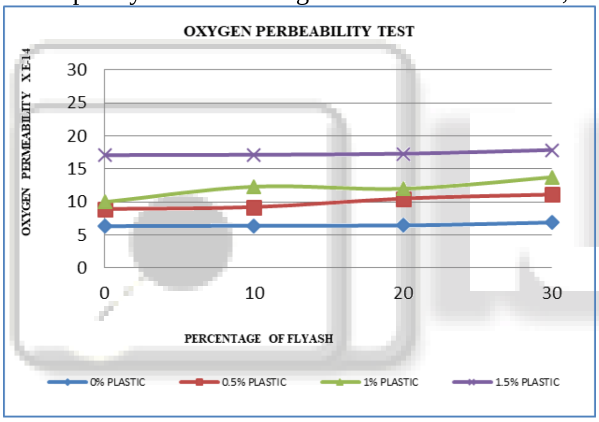


Fig. 2: Mix 1 (W/C = 0.65)

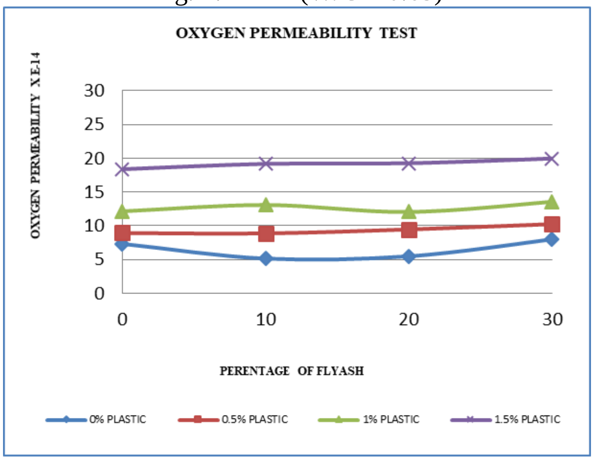


Fig. 3: Mix 2 (W/C = 0.55)

– Fly ash 0% to 30%

Oxygen permeability increases in the range of 2% to 34% as compare to plain concrete.

– Metallized polymer Plastic 0% to 1.5%

Oxygen permeability increases in the range of 25% to 62% as compare to plain concrete.

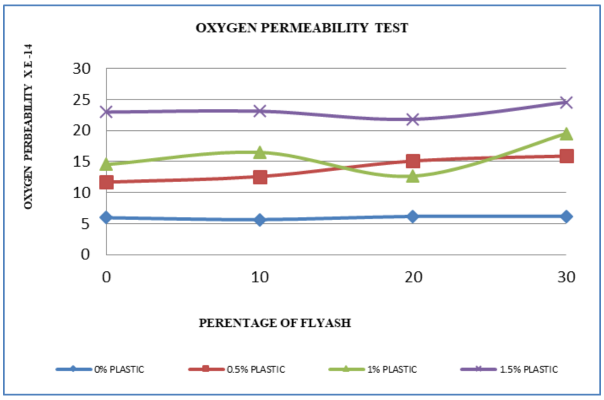


Fig. 4: Mix 3 (W/C = 0.45)

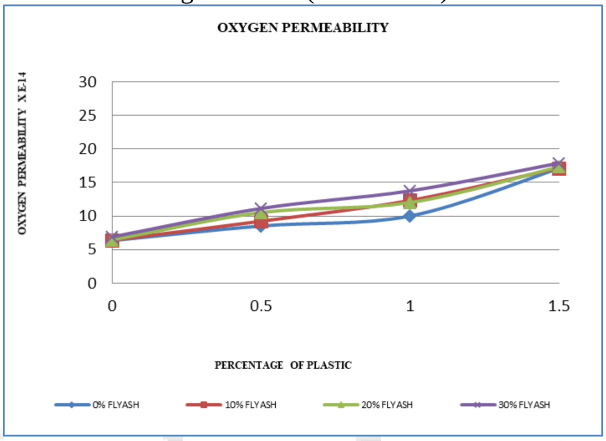


Fig. 5: Mix 1 (W/C = 0.65)

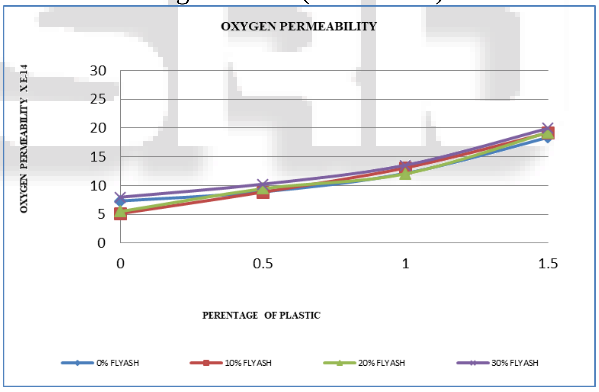


Fig. 6: Mix 2 (W/C = 0.55)

– Combination of fly ash and metallized polymer plastic

Oxygen permeability increases in the range of 24% to 60% as compare to plain concrete.

– W/C ratio

Decreases from 0.65 to 0.45, oxygen permeability of cast disk decreases to 1.10 to 5.00 times.

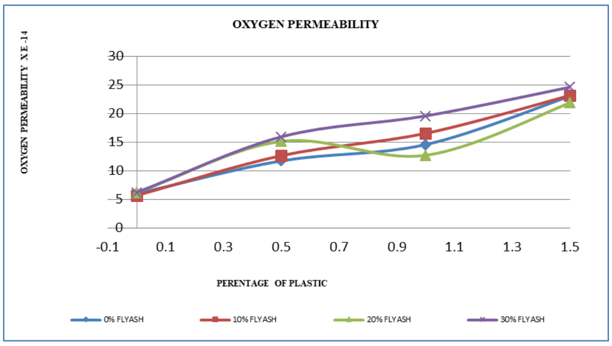


Fig. 7: Mix 3 (W/C = 0.45)

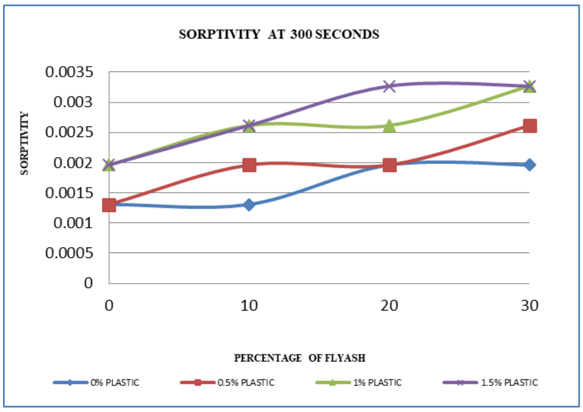


Fig. 8: Mix 1 (W/C = 0.65)

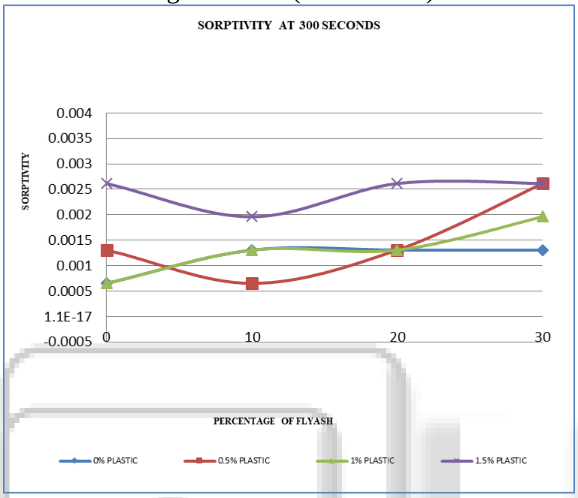


Fig. 9: Mix 2 (W/C = 0.55)

– Fly ash 0% to 30%

Sorptivity of concrete increases in the range of 6% to 38% as compare to plain concrete.

– Metallized polymer Plastic 0% to 1.5%

Sorptivity of concrete increases in the range of 23% to 68% as compare to plain concrete.

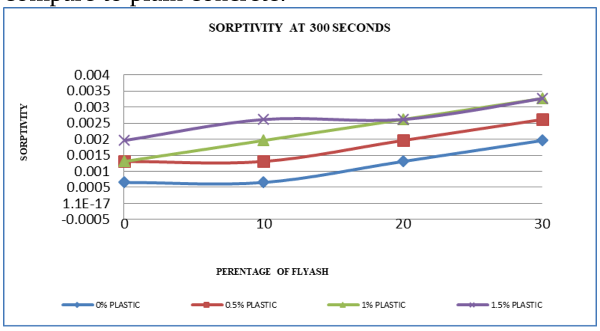


Fig. 10: Mix 3 (W/C = 0.45)

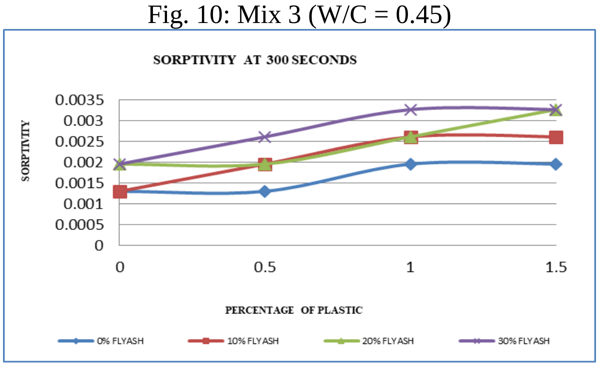


Fig. 11: Mix 1 (W/C = 0.65)

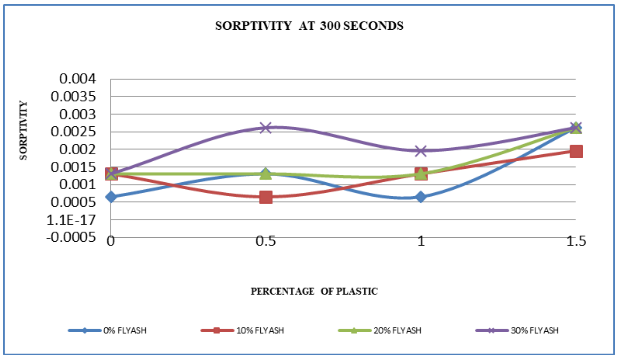


Fig. 12: Mix 1 (W/C = 0.55)

– Combination of fly ash and metallized polymer plastic

Sorptivity of concrete increases in the range of 20% to 50% as compare to plain concrete.

– W/C Ratio

Decreases from 0.65 to 0.45, sorptivity of concrete decreases in range of 3% to 25%.

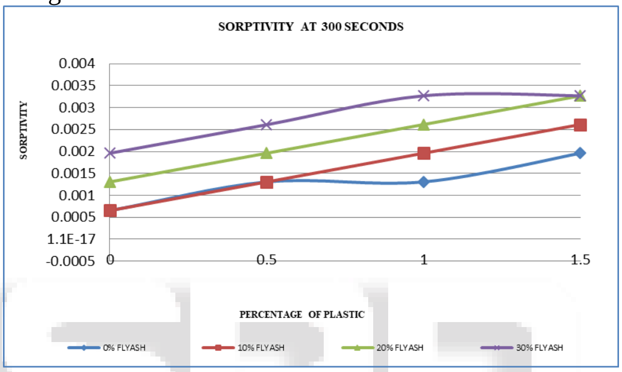


Fig. 13: Mix 1 (W/C = 0.45)

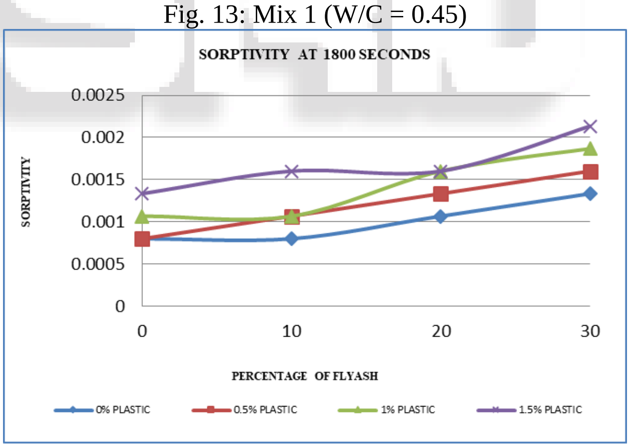


Fig. 14: Mix 1 (W/C = 0.65)

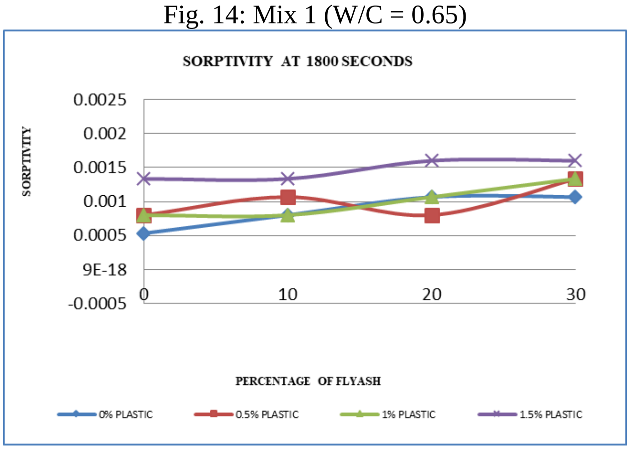


Fig. 15: Mix 1 (W/C = 0.55)

 

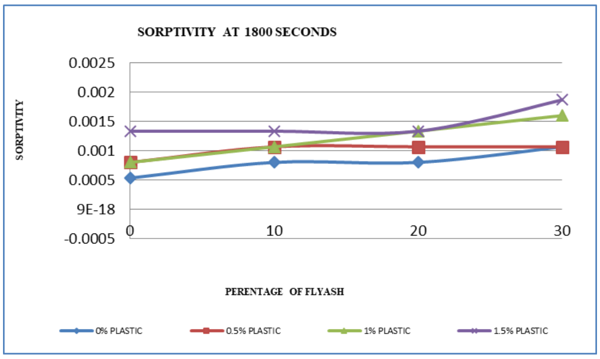


Fig. 16: Mix 1 (W/C = 0.45)

– Fly Ash 0% to 30%

Sorptivity of concrete increases in range of 20% to 38% as compare to plain concrete.

– Metallized Polymer Plastic 0% to 1.5%

Sorptivity of concrete in the range of 31% to 61% as compare to plain concrete.

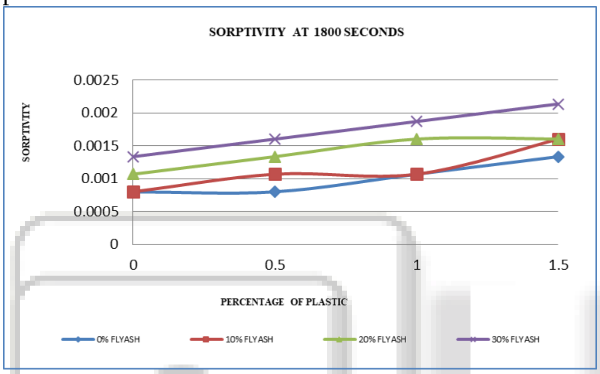


Fig. 17: Mix 1 (W/C = 0.65)

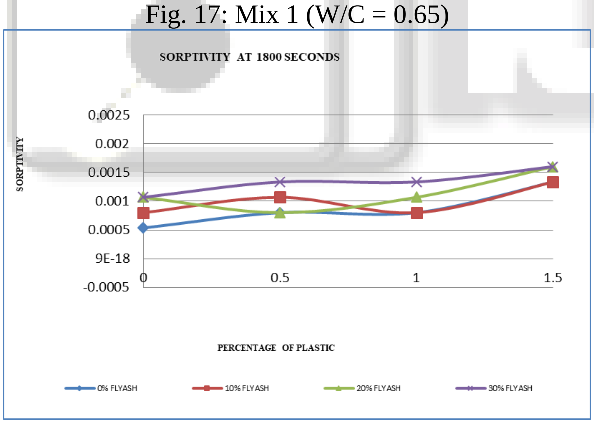


Fig. 18: Mix 2 (W/C = 0.55)

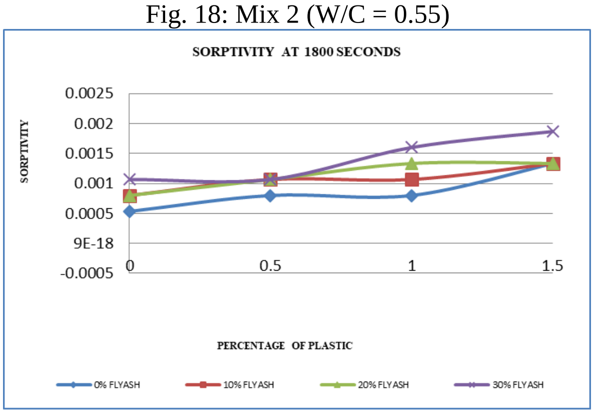


Fig. 19: Mix 3 (W/C = 0.45)

– Combination of fly ash and metallized polymer plastic

Sorptivity of concrete increases in range of 30% to 65% as compare to plain concrete.

– W/C Ratio

Decreases from 0.65 to 0.45, sorptivity of concrete decreases in the range of 18% to 53%.

## 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,

1) The oxygen permeability of plain concrete disk was observed to be 1.75 to 5.30 times higher than metallized polymer plastic plus fly ash concrete. Hence the concrete mix with 0% percent metallized polymer plastic plus 0% fly ash was observed to have minimum permeability.
2) When the sorptivity of concrete disk was checked, at 300 seconds for addition of fly ash from 0% to 30% plus metallized polymer plastic from 0% to 1.5%, water sorptivity increased in the range of 20 % to 55% compared to plain concrete. But when the sorptivity of concrete disk was checked at 1800 seconds it increased in the range of 30% to 65% percent for addition of fly ash from 0% to 30% plus metallized polymer plastic from 0% to 1.5%.

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