International Journal of Research
Available at https://edupediapublications.org/journals

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

Polymeric Waste Material In Concrete For Road Pavements

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ABSTRACT

There is a growing awareness in India about extensive damage being caused to the environment due to accumulation of POLEMERIC WASTE MATERIALs from industrial plants, power houses, colliery pits and demolition sites and it has become one of the major environmental, economical and social issues. POLEMERIC WASTE MATERIAL is the material unused, unwanted and rejected as worthless into the environment in our society as whole. POLEMERIC WASTE MATERIALs coming out of industry nowadays is posing a great environmental problem in disposing them into the air, water and on the land. But, with proper utilization of these materials in construction industry as well as in making road pavements will greatly help the society to have a better and pleasant environment. Substitution of POLEMERIC WASTE MATERIALs will conserve dwindling resources, and will avoid the environmental and ecological damages caused by quarrying and exploitation of the raw materials for making cement. These POLEMERIC WASTE MATERIALs can partly be used, or processed, to produce materials suitable as aggregates or fillers in concrete. Use of waste products is not only a partial solution to environmental and ecological problems and it significantly improves the microstructure, and consequently the properties of concrete. The output of these POLEMERIC WASTE MATERIALs in India are more than double the production of cement and other construction material used in all the civil engineering activities. So, use of POLEMERIC WASTE MATERIALs not only to make the cement concrete (generally used in all the construction activities) less expensive, but to provide a blend of tailored properties of POLEMERIC WASTE MATERIALs and Portland cements suitable for specified purpose. This paper outlines regarding the optimum utilization of POLEMERIC WASTE MATERIALs in some construction activities as a green concept, which ultimately reduces the environmental pollution.

INTRODUCTION

A material that contains one or more organic polymers of large molecular weight, solid in its finished state and at some state while manufacturing or processing into finished articles, can be shaped by its flow, is called as 'Plastic'. Plastics are durable and degrade very slowly; the chemical bonds that make plastic so durable make it equally resistant to natural processes of degradation. Plastics can be divided in to two major categories: thermoses and thermoplastics. A thermo set solidifies or "sets" irreversibly when heated. They are useful for their durability and strength, and are therefore used primarily in automobiles and construction applications. These plastics are polyethylene, polypropylene, polyamide, polyoxymethylene, polytetrafluorethylene, and polyethyleneterephthalate. A thermoplastic softens when exposed to heat and returns to original condition at room temperature. Thermoplastics can easily be shaped and moulded into products such as milk jugs, floor coverings, credit cards, and carpet fibers. These plastic types are known as phenolic, melamine, unsaturated polyester, epoxy resin, silicone, and polyurethane. According to recent studies, plastics can stay unchanged for as long as 4500 years on earth with increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily by each household. 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. The experimentation at several institutes indicated that the waste plastic, when added to hot aggregate will form a fine coat of plastic over the aggregate and such aggregate, when mixed with the binder is found to give higher strength, higher resistance to water and

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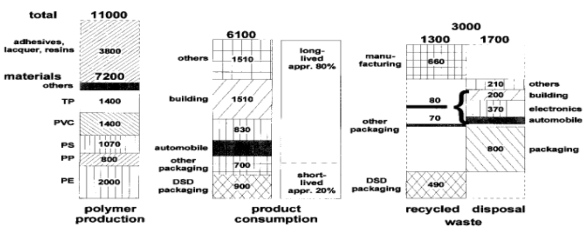
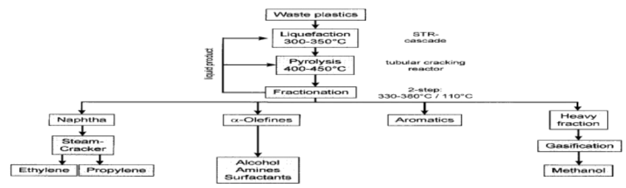
better performance over a period of time. Waste plastic such as carry bags, disposable cups and laminated pouches like chips, pan masala, aluminum foil and packaging material used for biscuits, chocolates, milk and grocery items can be used for surfacing roads.Use of plastic along with the bitumen in construction of roads not only increases its life and smoothness but also makes it economically sound and environment friendly. Plastic waste is used as modifier of bitumen to improve some of bitumen properties Roads that are constructed using plastic waste are known as Plastic Roads and are found to perform better compared to those constructed with conventional bitumen. Further it has been found that such roads were not subjected to stripping when come in contact with water. Use of higher percentage of plastic waste reduces the need of bitumen by 10%. It also increases the strength and performance of the road.



Acrylic polymers, poly methyl methacrylates (PMMA) and their copolymers, are not bulk polymers. Because of their high quality and optical properties, they are applied mainly in fields where high transparency and colorfast properties are required. Examples are light coverings and automobile rear lights. In 1993, the world production totalled 1 million tons, divided in roughly one third on Europe, Japan and the USA Acrylic polymers are fabricated mainly as long lived consumer goods. One-way articles of PMMA are used at most for hygienic reasons, e.g., in the health care application. Acrylic polymers will not be used as packaging materials or appear in domestic wastes.

Polymer Hydrogenation

The polymer hydrogenation process is derived from coal refining processes and the processing of heavy crude oil residues. The process of the coal/oil plant in Bottrop (KAB) (Fig. 3), developed by Veba-Oel AG, is mainly based on the Veba Combi-Cracking process' (VCC) [30]. After visbreak-ing in a depolymerization reactor at temperatures of about 420 C (with the polymer alone or in a mixture with heavy crude oil components), the real hydrocracking follows in a bubble-column-type reactor. Molecular hydrogen is used for this hydrogenation at approx. 200 bar and 480 C. Less agressive conditions can be applied when polymers are used exclusively as feed stocks. Hydro-bitumen and a syncrude as products can be further converted to chemical raw mater.



ADVANTAGES OF HIGH STRENGTH CONCRETE: High strength concrete resists loads that cannot be resisted by normal-strength concrete. Not only does high strength concrete allow for more applications, it also increases the strength per unit cost, per unit weight, and per unit volume as well. These concrete mixes typically have an increased modulus of elasticity, which increases stability and reduces deflections. Along with the inherent advantages of high-strength concrete, several less clearly defined disadvantages can materialize. Most of these disadvantages are due to a lack of adequate research under field conditions, although many of the issues are currently being alleviated though the use of improved admixtures. First, increased quality control is needed in order to maintain the special properties desired. High-strength concrete must meet high-performance standards consistently in order for it to be effective. Second, careful materials selection is necessary. High quality materials must be used. These materials may cost more than materials of lower quality. Third, allowable stress design discourages the use of high-strength concrete. One solution is to use load factor and resistance design when using high-strength concrete.

LITERATURE REVIEW

e-ISSN: 2348-6848
p-ISSN: 2348-795X
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The literature review shows that a lot of work has been carried out on the mechanical and durability properties of concrete in the presence of polymeric POLEMERIC WASTE MATERIALs as a replacement of cement. The literature survey reveals that very little work has been carried out on the high strength concrete by using a polymeric waste.

R.F.Feldman and Huang cheng yi (1985) has done the Polymeric POLEMERIC WASTE MATERIALs accelerates hydration reactions with Portland cement by providing nucleation sites for $Ca(OH)_2$ within minutes after reaction commences, and also by reacting with Ca^{++} ions. Reduced Ca^{++} ion affects the nature of hydration products. The degree of hydration of pastes and mortars of polymeric POLEMERIC WASTE MATERIALs blends differs, possibly due to the presence of sand in the mortar, which acts as a sink for well crystallized $Ca(OH)_2$ and lowers the permeability of the paste phase of the mortar.

G.Appa Rao (2000) has done the rate of strength developed between 3 to 7 days was the highest. At w/b ratio (water + cement + polymeric waste) 0.35, 0.4, 0.45 the optimum polymeric POLEMERIC WASTE MATERIALs content for achieving highest compressive strength range between 17.5% and 22.5%. The strength development after 28 days has been very moderate at w/b ratio 0.35, 0.4 and relatively relatively better at 0.45. It is very good and consistent at w/b ratio 0.50 at any age with all polymeric POLEMERIC WASTE MATERIALs contents. The ratio of compressive strengths at 3 and 7 days to strength 28 days and at and 3,7,28 days to that of 90 days have been observed to be higher at w/b ratio 0.35 than those with other w/b ratios.

B.W.Langan et al (2002) has studied the Effect of polymeric POLEMERIC WASTE MATERIALs varies depending on the water-cement ratio (w/c). Polymeric POLEMERIC WASTE MATERIALs accelerates cement hydration at high water-cement ratio (w/c). Polymeric POLEMERIC WASTE MATERIALs retards cement hydration at low water-cement ratio (w/c). Low w/c ratio prolongs the dormant period, followed by enhanced hydration of the cement.

H. Temiz (2002) has studied the significant amount of SiO_2 in the chemical composition of high calcium fly ash and polymeric waste. During the chemical reaction period of Portland cement, this polymer reacted with free $Ca(OH)_2$ and formed amorphous C-S-H gel. The amount of $Ca(OH)_2$, which is harmful for concrete, decreased.

Th. M. Salem (2002) has studied the conduct grams of all the OPC–SF blends show two conductivity peaks, the first peak is attributed to the initial hydrolysis of the OPC constituents, while the second transient maximum is explained by the ettringite–mono sulfate transformation. The second conductivity peak is shifted towards a shorter time of hydration with increasing SF content of the OPC–SF blends; similar effect was also observed with increasing hydration temperature. For mixes made with a W/S ratio of 0.60, the thixo tropic character is unchanged in both the second and third cycles for mixes made with lower SF contents, while mixes having higher SF contents showed mainly a mixed behavior. The increase of the molar Ca(OH)2/SF ratio in the mixes is almost accompanied by a marked narrowing in the hysteresis loops of the flow curves indicating an increase in the antithixo tropic character. The Ca(OH)2-rich mixes (IIa and IIb) possess an excess free Ca(OH)2 that increase the stability of the formed hydrates, mainly as Ca(OH)2-rich calcium polymers.

POLYMERIC POLEMERIC WASTE MATERIALS: This chapter summarizes the literature available on the various research work carried out on the properties of polymeric POLEMERIC WASTE MATERIALs hydration reactions and its futuristic applications in construction industry. This review also encompasses the advantages of using polymeric POLEMERIC WASTE MATERIALs for initiating cement hydration reactions with the formation of ettringite – primarily responsible for early setting of the cementitious system. The following section summarizes the various experimental studies carried out in hydration of cement, pozzolanic reaction of polymeric POLEMERIC WASTE MATERIALs with cement hydration.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
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Plastic waste: The rapid Urbanization and Industrialization in India has resulted in large deposition of Plastic waste. Plastic waste, consisting of carry bags, cups etc. can be used as a coating over aggregate and this coated stone can be used for road construction as cement and asphalt concrete. This is a eco-friendly process. By using plastic waste as modifier, the quantity of cement and sand by their weight can be reduced, thereby decreasing the overall cost of construction.

Fly ash: Fly Ash is a mineral by-product of coal combustion in thermal power plants. It is generally finer than cement and consists of mostly of spherical glassy compounds of complex composition. It is a POLEMERIC WASTE MATERIAL and dumped on the land adjoining thermal power plants and townships. Although fly ash is commonly used as a mineral admixture in Portland cement for rigid pavements, it has had a very limited use in flexible pavement. Although fly ash inclusion in concrete results in slower strength development initially, the ultimate strength is higher than that of the plain concrete. Aspects which add to the advantages in use of fly ash in the construction of roads like durability

Rubber Waste: Discarded vehicle tires constitute an important part of POLEMERIC WASTE MATERIAL, which had historically been disposed of into landfills. The production of waste by the tire industry has been a growing problem, indicating the need for its reuse in the construction field. Rubber can be added to asphalt, which increases its durability and improve pavement quality and safety conditions by absorbing the rubber elastic properties. Rubber can also be used for concrete pavements for light traffic.

Recycled aggregates: Recycled aggregates are the aggregates obtained from construction and demolition waste (CDW), from residential, commercial, industrial structures or from pavements. These aggregates can be re-used in all the construction activities with some % of volume of construction, in order to have the same mechanical properties of hardened concrete, without disposing these POLEMERIC WASTE MATERIALs in to the environment

PREPARATION OF DESIGN MIX

Plain Bituminous Mix:: Bitumen is a black, oily, viscous material that is a naturally-occurring organic byproduct of decomposed organic materials. Also known as asphalt or tar, bitumen was mixed with other materials throughout prehistory and throughout the world for use as a sealant, adhesive, building mortar, incense, and decorative application on pots, buildings, or human skin. The material was also useful in waterproofing canoes and other water transport.

SELECTION OF MIX CONSTITUENTS

Binder and aggregates are the two main constituents of bituminous mix. This section discusses some of the issues involved in selection of binder and aggregates.

Generally binders are selected based on some simple tests and other site-specific requirements. These tests could be different depending of the type of binder viz. penetration grade, cutback, emulsion, modified binder etc. For most of these tests, the test conditions are pre-fixed in the specifications. Temperature is an important parameter which affects the modulus as well as the aging of binder. Superpave specifications [Superpave 1997, 2001] suggest that these acceptability tests are to be carried out at the prevalent field temperatures

Aggregate: Number of tests is recommended in the specifications to judge the properties of the aggregates, e.g. strength, hardness, toughness, durability, angularity, shape factors, clay content, adhesion to binder etc. Angularity ensures adequate shear strength due to aggregate interlocking, and limiting flakiness ensures that aggregates will not break during compaction and handling.

Various Mix Design Approaches:: There is no unified approach towards bituminous mix design, rather there are a number of approaches, and each has some merits are demerits. Table-1 summarizes

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[RILEM 17 1998] some of the important bituminous mix design approaches are as follows

MIXING PROCEDURE AT HOT MIX PLANT

Step I: Plastics waste like bags, bottles made out of PE and PP cut into a size between 2.36 mm and 4.75mm using shredding machine. Care should be taken that PVC waste should be eliminated before it proceeds into next process.

Step II: The aggregate mix is heated to 1650C and then it is transferred to mixing chamber. Similarly the bitumen is to be heated up to a maximum of 1600C. This is done so as to obtain a good binding and to prevent weak bonding. During this process monitoring the temperature is very important.

Step III: At the mixing chamber, the shredded plastics waste is added over the hot aggregate. It gets coated uniformly over the aggregate within 30 to 45 seconds. It gives an oily coated look to the aggregate.

Step IV: The plastics waste coated aggregate is mixed with hot bitumen. Then this final resulted mix is used for laying roads. The road laying temperature is between 110oC 120OC. The roller used should be of is 8-ton capacity.

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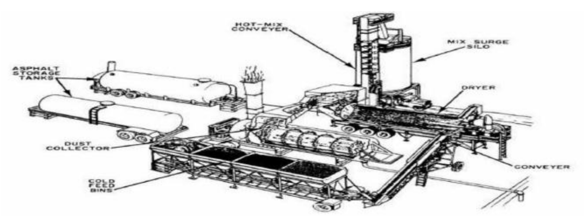

MATERIALS AND METHODOLOGY: This chapter deals with the various materials used and their properties used for producing self compacting concrete. The various physical properties of the materials used are given in tabulation. Further the various detailed description of the experimental methodologies conducted for assessing the strength and durability properties are provided.

MATERIAL: Polymeric POLEMERIC WASTE MATERIALs from Coimbatore, Tamil Nadu, India. Cement was used as a binding material. Palar river sand passing through 4.75mm, 2.36mm sieve; with a specific gravity of 2.69 was used as fine aggregate; aggregate of passing through 12mm and 10mm sieve were used as coarse aggregate in this study. Super plasticizer is used for the workability of the concrete

EXPERIMENTAL INVESTIGATION

Aim of this study to find the consistency and setting properties of cement with partial replacement of polymeric waste, hardened concrete test like mechanical properties of mortar cube and concrete with partial replacement of cement with polymeric waste.

Consistency Test: Consistency test is a characteristic test to determine the workability of the neat cement paste. Primarily it can be used to asses the transformation of the solid phase into plastic mobility of the particle. This is determined as per IS 4031.

Initial & Final Setting Time: Initial setting time test is used to measure the onset of hydration and further strength gain over time. This is a standard test method to determine the setting property of cement and polymeric POLEMERIC WASTE MATERIALs in present study and tested as per IS 4301.

HARDENED CONCRETE TESTS: Concrete has hardened it can be subjected to a wide range of tests to prove its ability to perform as planned or to discover its characteristics if its history is unknown.

General: The behavior of hardened concrete can be characterized in terms of its short-term and long-term properties. Short-term properties include strength in compression and modulus of elasticity. The long-term properties include creep, shrinkage, behavior under fatigue, and durability characteristics such as porosity, permeability, freeze-thaw resistance, and abrasion resistance.

EXPERIMENTAL RESULTS AND ANALYSIS

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p-ISSN: 2348-795X
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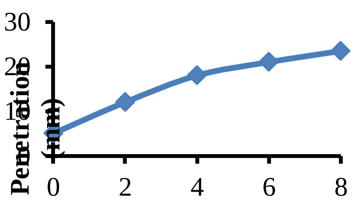
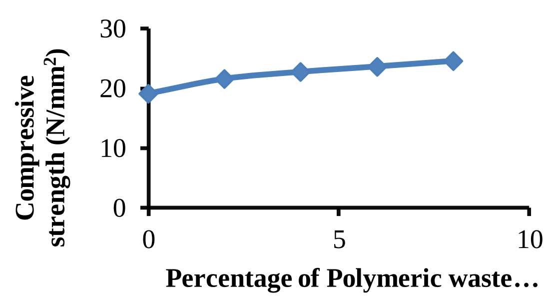
CONSISTENCY: Consistency dictates the working limit of the paste when mixed with water and hence provides a plastic behavior. The amount of water required for hydration is lesser than the water required for making a flow able paste. The present study deals with the new kind of composite wherein the minimum water content required for its hydration is not known; hence the water required to make a consistent paste is determined and taken as water content for further tests. This provides enough water available for hydration as well as for good workability and the test have been carried out as prescribed by IS 4031- part 4.

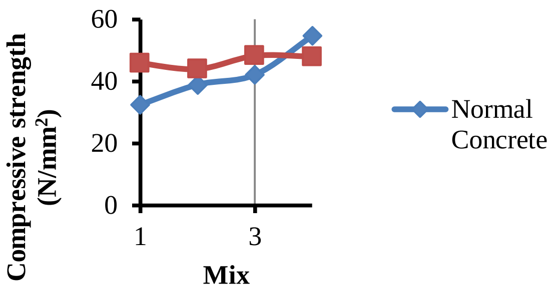
INITIAL SETTING TIME : Solidification of the cement paste is known as setting. The time interval between addition of water and beginning of solidification (loss of consistency) is known as initial setting time. Initial setting time for the OPC generally varies between 30-45 minutes. Initial setting time test is an important one as it indicates the formation of hydration products. The initial setting time test is done through for different percentage of polymeric POLEMERIC WASTE MATERIALs like 2%, 4%, 6% and 8% with the cement (OPC) paste. The water-cement ratio 0.3 is constant for the all percentage of polymeric POLEMERIC WASTE MATERIALs with cement paste. The depth of penetration of the needle for initial setting time. When paste stiffens sufficiently for needle to a point 5±1 mm from the bottom, initial set is said to have taken place. When polymeric POLEMERIC WASTE MATERIALs percentage is increased the setting time is decreased. The cement becomes harsh and hard when polymeric POLEMERIC WASTE MATERIALs is increased. So the plunger is not penetrating into paste.

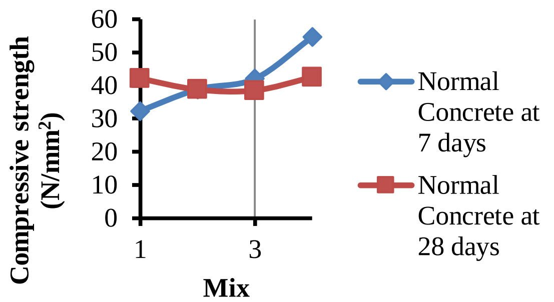


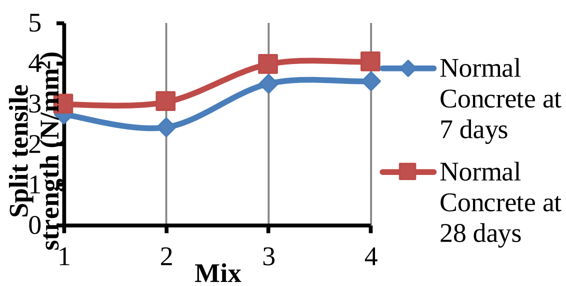
FINAL SETTING TIME ; Final setting time is the time taken for the initiation of hardening process. In general it is known that the final setting time for OPC is approximately 10 hours. The final setting time test is done through for different percentage of polymeric POLEMERIC WASTE MATERIALs like 2%, 4%, 6% and 8% with the cement (OPC) paste. The water-cement ratio 0.3 is constant for the all percentage of polymeric POLEMERIC WASTE MATERIALs with cement paste. Final set is said to have take place when the needle, gently lowered to the surface of the paste, makes an impression on it but the circular cutting edge fails to do so. When polymeric POLEMERIC WASTE MATERIALs percentage is increased the setting time is decreased. The cement becomes harsh and hard when polymeric POLEMERIC WASTE MATERIALs is increased. So the plunger is not penetrating into paste.

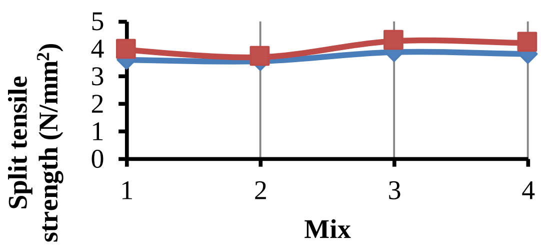
COMPRESSIVE STRENGTH OF CEMENT MORTAR CUBE : The testing for the cement strength (OPC) for that the compressive strength of cement mortar cubes should be known. The experiment is carryout according to the IS: 4031-1988 (Part 6). The test is done for the different percentage of polymeric POLEMERIC WASTE MATERIALs like 2%, 4%, 6% and 8%. The test is carryout for each percentage of polymeric POLEMERIC WASTE MATERIALs with constant 30% of water-cement ratio. The compressive strength of the mortar cubes are tested after standard curing days like 7 days and 28 days. The results are shown in the Table . The polymeric POLEMERIC WASTE MATERIALs percentage is increased the strength is also increased.











SUGGESTION FOR FURTHER STUDIES

1. A detailed study may be taken to arrive a suitable mix design for polymeric POLEMERIC WASTE MATERIALs concrete with replacement levels to assess the hardened properties.
2. A study on various water-cement ratio with various percentage of polymeric waste.
3. The effects of polymeric POLEMERIC WASTE MATERIALs in reinforced cement concrete and flexural members to asses the failure mode, bond characteristics of rebar, crack spacing and ultimate strength.
4. Other concrete properties such as drying shrinkage, pore size distribution, heat of hydration, transition zone characteristics of polymeric POLEMERIC WASTE MATERIALs concrete mixtures need a detailed study.
5. Study on long time durability properties of cement polymeric POLEMERIC WASTE MATERIALs concrete mixture is important and to be carried out.

CONCLUSION

GENERAL

In general based on the observations, results of the experiments and discussions, the behavior of the concrete in partial replacement of cement with polymeric POLEMERIC WASTE MATERIALs (8%) achieves more strength compare to the normal mix. Further conclusions are summarized below.

CONCLUSION

1. The increase in polymeric POLEMERIC WASTE MATERIALs additions makes the consistent strength gain in the composite specimens.
2. When the percentage of polymeric POLEMERIC WASTE MATERIALs is increased the initial and final setting time is decreased because of the presence of calcium polymer in cement and polymeric dioxide in the polymeric POLEMERIC WASTE MATERIALs makes the early setting.
3. From the test results carried out in consistency, initial and final setting time the maximum polymeric POLEMERIC WASTE MATERIALs content was observed to be 8%. This maximum polymeric POLEMERIC WASTE MATERIALs content is taken for further study on concrete properties.
4. The mix proportions are arrived by absolute proportioning and the particle size was varied for the fine and coarse aggregate of the various concrete mixtures.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

5. From the test results on compressive strength and split tensile strength, the maximum strength was observed for the mix-3 in 7 and 28 days of curing. Because of particle size is fine in the mix-3 compared with other concrete mixtures.

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