Effective Utilization of PET Bottles in Self-Compacting Concrete

U.Balamurugan
Department of Civil Engineering
Erode Sengunthar Engineering College
Perundurai, Tamil Nadu

V.Goutham
Department of Civil Engineering
Erode Sengunthar Engineering College
Perundurai, Erode

Abstract**—*****This paper seeks to optimize the benefits of using post consumed waste PET bottles in the fiber form in concrete. Now a days, we are facing environment protection problems. Many things which are invented for our luxurious life are responsible for polluting environment due to improper waste management technique. One of them is a plastic which has to be disposed or recycled properly to maintain the beauty of our nature. To address this issue, the fibers from used plastics were added in various percentages in the M30 grade concrete. The post consumed waste mineral water plastic bottles are shredded into fibers of specific size and shape. Several design concrete mixes with different percentages (0.5% , 1.0% and 1.5%) of waste plastic fibers having aspect ratio varies from 50 to 60, are cast in desire shape and size as per the requirement of the tests. Specimens were cured for 7 days and 14 days. The compression, split tension and flexural tests were carried out. The results are compared with conventional concrete without fibers. The improvement in mechanical properties of concrete was observed. The significant improvements in strengths were observed with inclusion of plastic fibers in concrete. The optimum strength was observed at 1% of fiber content for all type of strengths. The behavior of this fiber reinforced concrete depends on sizes of fibers is resulted in this paper.*

Keywords**—*****PET fibers; Self Compacting Concrete; Flyash;Super plasticizer*

I. Introduction

Concrete is the most widely used construction material. Because of its specialty of being cast in any shape it has replaced stone and brick masonry. It has major disadvantages such as low tensile strength and low strength to weight ratio, and it is liable to cracking. Micro cracks are present in concrete and because of its poor tensile strength the cracks propagate with the application of load leading to brittle fracture of concrete. Polymer recycling has received a great deal of attention in this recent year. Presently, small percentage of polymer wastes in Malaysia has been undergoing the recycling process. This recycling process has typically been through reprocessing of the waste material into other polymeric items, or energy recovery from complete combustion. Development of concrete with non-conventional aggregate such as polymer waste (especially Polystyrene),ceramic waste or any wastes were used to get comparable properties of the conventional concrete and economical aspect.

Fibers in the cement based matrix acts as crack arrester, which restricts the growth of flaws in the matrix preventing these from enlarging under load into cracks, which eventually cause failure. The addiction of discrete reinforcing fibers into the concrete mix has been shown to improve the mechanical properties of concrete. However, there are various factors influencing the behavior of the fiber-reinforced concrete and consequently also the degree of improvement. The properties of concrete can be changed by adding some special natural or artificial ingredients. The concrete has many advantageous properties such as good compressive strength, durability, impermeability, specific gravity and fire resistance. However the concrete has some bitter properties, like- weak in tension, brittleness, less resistance to cracking, lower impact strength, heavy weight, etc. Some remedial measures can be taken to minimize these bitter properties of concrete. Some of the bitter properties of concrete are due to micro cracks at mortar aggregate interface. To overcome this, the fibers can be added as one of the ingredients of concrete. The fibers inclusion in cement 2 base matrix acts as unwanted micro crack arrester. The prevention of prorogation of cracks under load can result in improvement in static and dynamic properties of cement based matrix . Waste is one of the challenge to dispose and manage. It has major environmental, economical and social issues. Industrial activities are associated with significant amount of non-biodegradable solid waste. It is common to serve the mineral water in plastic bottles (polyethylene teraphthelne (PET) bottles) in every country. It has non-biodegradable properties. The polyethylene teraphthelne (PET) bottles are recycled and are used in industry for different purposes. Maintaining the Integrity of the Specifications

II. MATERIALS USED

INTRODUCTION

For making FRCC, it is essential to select proper ingredients, evaluation of their properties and know how about the interaction of different materials for optimum usage. The ingredients used for concrete for the project were the same as that used for conventional cement concrete, coarse and fine aggregate, and water except mineral admixtures and chemical admixtures which is generally not used in conventional concrete.

CEMENT Selection of type of cement mainly depends on the specific requirements of concrete .It determined the strength and properties of fresh and hardened concrete. Variation in chemical composition and physical properties of cement affects the concrete compressive strength more than variation in any other single material.

FINE AGGREGATE Among various characteristics, the most important for SCC is its grading. Fine aggregate used for SCC should be properly graded to give the minimum voids ratio and shall be free from deleterious materials like clay, silt content and chloride contaminations. River sand is normally preferred over crushed sand SCC contains high quantity of cement and fine particles and fine particles in the form of micro silica and hence use of coarser sand is preferable. Properties such as voids ratio, gradation, specific surface and 10 bulk density have to be assessed to design a dense SCC mix optimum cement and reduced mixing water.

COARSE AGGREGATE The crushed stone aggregates were collected from the local query. The maximum size of aggregates were 12.5mm(MSA) and tested. The physical properties of coarse aggregate are Specific gravity2.77, Water absorption 1.23%, Bulk density 1694.8 Kg/m 3 , Fineness modulus 5.96.

WATER Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. The strength of cement concrete comes mainly from the binding action of the hydrates cement gel. The requirements of water should be reduced to that required for chemical reaction of un hydrated cement as the excess water would end up only formation of undesirable voids, the hardened cement paste in concrete.

CHEMICAL ADMIXTURES 3.6.1 Super Plasticizer To impart additional workability a super plasticizer Conplast SP 337 was used. It is concrete plasticizer with less than 0.05 % chloride content and conforms to IS: 9103- 1999. The super plasticizer was added 2 % by weight of cement to all mixes. Super plasticizer is a low cost water reducer which can be used to get one or a combination of benefits. 3.6.2 Advantages • Increased workability • Easier placing compaction and finishing • Increased strength and durability • Higher cohesion – reduces risk of segregation and bleeding • Lower water requirement for given workability.

Viscosity modified agent It is added 0.5% of weight of cement to all concrete mixes to control the flow of concrete while casting. The VMA is incorporated to enhance the yield value and viscosity of fluid mixture. The VMA used in this investigation was Glenium stream-2 which is a product of BASF construction chemicals

PET FIBERS Plastic Fibers, The post consumed PET mineral water bottles of single brand were collected from local restaurants. The fibers were cut after removing the neck and bottom of the bottle. The length of fibers was kept 25mm to 30mm and the breadth was 2 mm and 3 mm. The aspect ratio (AR) of waste plastic fibers were ranges from 50 to 60. The plastic fibers used were having specific gravity 1.34, water absorption 0.00 %. The different fractions of fibers were used in this experimentation.

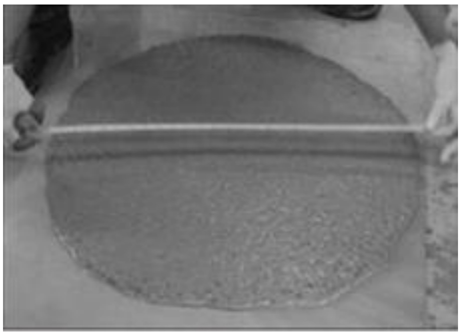
PET Fibres

III. MIX DESIGN FOR SCC

GENERAL The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. REQUIRMENTS FOR CONCRETE MIX DESIGN The requirements which form the basis of selection and proportioning of mix ingredients are: a) The minimum compressive strength required from structural consideration b) The adequate workability necessary for full compaction with the compacting equipment available. TYPES OF MIXES Nominal Mixes In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength. 4.3.2 Standard Mixes The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum 16 compressive strength has been included in many specifications. These mixes are termed standard mixes. IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm2 . The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively. 4.3.3 Designed Mixes In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically. However, the designed mix does not serve as a guide since this does not guarantee the correct mix proportions for the prescribed performance 4.4 FACTORS AFFECTING THE CHOICE OF MIX PROPORTIONS The various factors affecting the mix design are: 4.4.1 Compressive Strength It is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix. The other factor affecting the strength of concrete at a given age and cured at a prescribed temperature is the degree of compaction. According to Abraham's law the strength of fully compacted concrete is inversely proportional to the water-cement ratio. 4.4.2 Workability The degree of workability required depends on three factors. These are the size of the section to be concreted, the amount of reinforcement, and the method of compaction to 17 be used. For the narrow and complicated section with numerous corners or inaccessible parts, the concrete must have a high workability so that full compaction can be achieved with a reasonable amount of effort. This also applies to the embedded steel sections. The desired workability depends on the compacting equipment available at the site. 4.4.3 Durability The durability of concrete is its resistance to the aggressive environmental conditions. High strength concrete is generally more durable than low strength concrete. In the situations when the high strength is not necessary but the conditions of exposure are such that high durability is vital, the durability requirement will determine the watercement ratio to be used. 4.4.4 Maximum Nominal Size of Aggregate In general, larger the maximum size of aggregate, smaller is the cement requirement for a particular water-cement ratio, because the workability of concrete increases with increase in maximum size of the aggregate. However, the compressive strength tends to increase with the decrease in size of aggregate. IS 456:2000 and IS 1343:1980 recommend that the nominal size of the aggregate should be as large as possible. Guideline for Mix Composition, • Coarse aggregate < 50% • Water/powder ratio = 0.8 to 1.0 • Total powder content = 400-600 kg/m3 • Sand content = < 40% of the mortar (by volume) • Sand = < 50% of paste volume • Sand = > 50% by weight of total aggregate • Free water < 200 liter • Paste > 40% of the volume of the mix.

IV. RESULTS AND DISCUSSIONS

TESTS ON FRESH CONCRETE The fresh properties of self-compacting, self-curing concrete are determined using workability tests such as slump flow test, V-Funnel test and L-Box test. 5.1.1 Slump flow Test This test is used to determine the workability of concrete. It is a most commonly used test and gives good assessment of filling ability. It can be used at site. The test also indicates the resistance to segregation. The apparatus is a cone of 10cm top diameter, 20cm bottom diameter and 30cm height. It has two handles for lifting purposes. Initially, the cone is cleaned and oil is applied on the inner surface. Slump test is found to be the simple test and is widely used. About 6 litre of concrete is needed for this test. Place the base plate on level ground. Keep the slump cone centrally on the base plate. Fill the cone with the scoop. Do not tamp. Simply strike off the concrete level with the trowel. Remove the surplus concrete lying on base place. Raise the cone vertically and allow the concrete to flow freely. Measure the final dia of the concrete in 2 perpendicular directions and calculate the average of two diameters. This is the slump flow in mm. Note that there is no water or cement paste or mortar without CA is seen at the edge of the spread concrete. The slump flow test is shown in fig 5.1.



SLUMP FLOW TEST

L-Box Test This test is based on a Japanese design for under water concrete, has been described by Peterson. The test assesses the flow of the concrete and also the extent to which it is subjected to blocking by reinforcement. The apparatus consist of rectangular section box in the shape of an 'L', with a vertical and horizontal section, separated by a movable gate, in front of which vertical length of reinforcement bar are fitted. About 14 liters of concrete is required for this test. Ensure that sliding gate can open freely and then close it. Moisten the inside surface, remove all surplus water. Fill the vertical section of the apparatus of the concrete. Leave it standing for 1 minute. Lift the sliding gate and allow the concrete to flow out into the horizontal section. Simultaneously start the stopwatch and record the time taken for the concrete to reach 200 and 400 mm marks. When the concrete stops flowing, the height H1 and H2 are measured. Calculate, H1/H2, the blocking ratio. The whole test has to be performed within 5 minutes. The LBox test is shown in fig 5.2

V-Funnel Test This test was developed in Japan. The equipment consists of a V-shaped funnel. The V-funnel is used to determine the filling ability (flow ability) of the concrete with a maximum size of aggregate 20 mm size. About 12 litre of concrete is needed for the test. Set the V-funnel on firm ground. Moisten inside of the funnel. Keep the trap door open to remove any surplus water. Close the trap door and place a bucket underneath. Fill the apparatus completely with concrete. No compaction or tamping is done. Strike off the concrete level. Open within 10 seconds the trap door and record the time taken for the concrete to flow down. Record the same for emptying. This can be judged when the light is seen when viewed from top. The whole test is to be performed within 5 minutes.

FUNNEL TEST

TEST ON HARDENED CONCRETE 5.2.1 Compression strength Test The compression test is carried out on specimens cubical in shape. The cube specimen of the size 15 cm x 15 cm x 15 cm, since the largest nominal size of a aggregate does not exceed 12.5 mm. The cube is kept in the compression testing machine and adjusted until the top steel bearing platen touches the surfaces of cube. The load is applied until the ultimate crack appears on the specimen fails and crushing load is observed. Compressive strength = ultimate load/ contact area of the cube (N/mm2) 5.2.2 Split Tensile Strength Test The cylinder specimen is of size 150 mm x 300 mm, if the largest nominal size of the aggregate does not exceed 12.5 mm. The test is carried out by placing a cylindrical specimen horizontally between the loading surface of a compression testing machine and the load is applied generator, an element on the vertical diameter of the cylinder is subjected to, Split tensile strength = 2P/ πLD (N/mm2) Where, P is the compressive load on the cylinder L is the length of cylinder D is the diameter. The advantages of this method is that the same type of specimen and the testing machine as are used for the compression test can be employed for this test. That is why this test is gaining popularity. The splitting test is simple to perform and gives more uniform result than other tension tests. Strength determined in the splitting test believed to be closer to the true tensile strength gives about 5 to 12% higher than the direct tensile strength. 24 5.2.3 Flexural Strength Test The systems of loading used in finding out the flexural tension are central point loading and third point loading. Here we have used central point loading. In this type the maximum fibre stresses will come below the point of loading where the bending moment is maximum. The flexural strength is calculated using the formula, Fb = (P x l) / (b x d2) in N/mm2 Where, P- Load l- Length of the prism d- Depth of the prism b- Breadth of the prism

COMPRESSION TEST

SPLIT TENSILE TEST

V. Conclusions

Thus in this fast moving world every technology needs to be updated with innovations. The students contribute a minor part to these innovations. In this project PET fibers in self-compacting concrete. These fibers impart strength to the concrete and impart crack control at the initial stage. The Self Compacting concrete on the other hand needs good workability. When poured in the complex reinforcements, it should have passing and filling ability. Hence the addition of fibres should not affect the workability property. The results of the project satisfies the fresh concrete test like Slump Flow and also satisfies the strength requirements. The compressive strength of the Fibre Reinforced Self Compacting Concrete is higher that of the conventional concrete for M30 grade. There is around 10% increase in the strength. Finally the compressive strength for various fractions of fibers were determined and compared with conventional concrete. There were 7 days and 14 days curing for each type of concrete mix. Then optimum addition of fiber is obtained from the graph which plot between addition of fiber and compressive strength. 1% fiber is the optimum fiber content for compressive strength and flexural strength in this project. In similar manner, the optimum result for split tensile strength is determined as 1.5% fiber. From this experimental investigation, the composites would appear to be low-cost materials which would help to resolve some solid waste problems and preventing environment pollution.

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