Study on Mechanical Properties of Polymer-Modified Interlocking Paver Block using crumb rubber and silica fume

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Abstract- The concrete structures do not have much capability to withstand impact loads for a longer period. The sudden impact loads acting on concrete structures affect the structural integrity, which lowers the member's stiffness capacity and reduces the structure's service life. The service life of concrete structures directly depends on the stress level, stress range, and intensity of loading. In India, problems due to impact loading are frequently encountered in structure like airport pavements, Highways, railways, bridges, road pavements and high-speed wind turbines. The addition of tyre waste crumb rubber (TWCR) to polymer-modified concrete improves the ductility and toughness performance of the concrete. In this experimental study, tyre waste crumb rubber is used as an alternative sustainable material that partially replaces the fine aggregate in the concrete mixture. Also, for additional support against the strength, a fixed percentage of silica fume is to be used. Tyre waste is one of the predominant wastes that is produced on earth day by day. The National Green Tribunal says that 2,75,000 tyres were discarded daily in India. Disposing of tyre waste causes health, economic, and environmental risks through air, water, and soil pollution. Hence, the problem may be reduced by using it as an alternate material in concrete.

***Keywords*-Crumb rubber, silica fume, Paver block, fine aggregate, sustainable**

I.INTRODUCTION

Disposal of waste tyre rubber has become a major environmental issue in all parts of the world, representing a serious threat to ecology. One possible solution for using scrap tyre rubber is to incorporate it into concrete to replace some of the natural aggregate. An estimated 1000 million tyres reach the end of their useful lives every year and 5000 millions more are expected to be discarded in a regular basis by the year 2030. A small part is recycled and millions of tyres are just stockpiled, landfilled or buried. The volume of polymeric wastes like tyre rubber and polyethene terephthalate bottles (PET) is increasing at a fast rate. This paper reviews the tests performed to determine the compressive strength and flexural tensile strength, water absorption, and water penetration of using rubber tyre waste concrete samples. Scanning Electron Microscopy (SEM) images were also presented in this paper. It was observed that the compressive strength, flexural tensile strength and depth of water penetration of the rubberized concrete were less than that of the control mix, while the abrasion resistance and water absorption (up to 10% substitution) exhibited better results than that of the control mix concrete. This paper also reviews the performance of concrete mixtures incorporating 5%, 7.5% and 10% of discarded tyre rubber as

aggregate and cement replacements. Numerous projects have been conducted on the replacement of aggregates by crumb rubber but scarce data are found on cementitious filler addition. Hence to examine characteristics of tyre crumb-containing concrete, two sets of concrete specimens were made. In the first set, different percentages by weight of chipped rubber were replaced for coarse aggregates and in the second set scrap-tyre powder was replaced for cement. Selected standard durability and mechanical test were performed and the results were analysed.

II. MATERIAL CHARACTERIZATION:

A. MATERIAL

There are various reasons where new material can be favored. Typical examples include materials which are less expensive, lighter, stronger or more durable when compared with common materials. Various industrial by-products as environmentally friendly wastes were shown to be promising to achieve such concretes. Meanwhile, due to the rapid industrial developments and modernized lifestyle, the tire wastes became a serious environmental concern. Inclusion of these tire wastes into the concretes was demonstrated to be beneficial to design the rubber-modified sustainable concretes. The below mentioned materials plays a major role in our system.

- OPC CEMENT
- FINE AGGREGATE
- COARSE AGGREGATE
- WATER
- CRUMB RUBBER
- SILICA FUME
- EPOXY POLYMER

B. MATERIAL CHARACTERIZATION:

1) OPC CEMENT:

Portland cement as it has similarity in colour and quality found in Portland stone, which is a white grey limestone in island of Portland, Dorset. Argillaceous or silicates of alumina in the form of clays and shales. Calcareous or calcium carbonate, in the form of limestone, chalk and marl which is a mixture of clay and calcium carbonate. The ingredients are mixed in the proportion of about two parts of calcareous materials to one part of argillaceous materials and then crushed and ground in ball mills in a dry state or mixed in wet state.

DENSITY kg/m3	830-1650
FINENESS	8%
SPECIFIC SURFACE AREA	330 kg/m2
CONSTITUENTS	SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3
INITIAL & FINAL SETTING TIME min	65 & 275

2) FINE AGGREGATE :

Fine aggregates are essentially natural sand particles won from the land through through mining process . Fine aggregates consist of natural sand or any crushed stone particles that are ¼” or smaller. This product is often referred to as 1/4”’ minus as it refers to the size, or grading, of this particular aggregate.

3) COARSE AGGREGATE :

Coarse aggregates are any particles greater than 0.19 inch, but generally range between 3/8 and 1.5 inches in diameter. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remain.

4) WATER :

Water, a substance composed of the chemical element's hydrogen and oxygen and existing in gaseous, liquid, and solid states. It is one of the most plentiful and essential of compounds.

5) CRUMB RUBBER :

Rubber waste is a major waste material produced in earth. The tyre waste are placed in dumbs as land filling, so the land gets highly polluted. By making tyre as crumb rubber and used as alternative material helps to prevent dubbing.

DENSITY	570-730 3kg/m
SPECIFIC GRAVITY	1.15
BULK DENSITY	2.31-2.36

Fig.1 Crumb Rubber

6) SILICA FUME:

Silica fume, a by-product of the ferrosilicon industry, is a highly pozzolanic material used to enhance concrete's mechanical and durability properties. It may be added directly to concrete as an individual ingredient or in a blend of Portland cement and silica fume.

Fig.2 Silica Fume

7) EPOXY POLYMER:

Epoxy is an adhesive used for bonding in concrete. Epoxy resins are used with concrete in the form of coatings, repair materials, grouts, bonding agents, paints, adhesives, epoxy mortars, sealers, penetrating sealers, wearing surfaces, and as admixtures to cement concrete to make epoxy polymer-modified concrete.

III. MATERIALS AND METHODS:

A. CEMENT OF CONSISTENCY:

The standard consistency of any cement is achieved when cement permits the Vicat plunger to penetrate to a point 33 to 35 mm from the bottom of the Vicat molds. Of all, take about 585 gm of cement into a tray and is mixed with a known percentage of water by weight of cement.

B. SOUNDNESS:

Soundness of cement may be determined by two methods, namely Le-Chatelier method and autoclave method. In the soundness test a specimen of hardened cement paste is boiled for a fixed time so that any tendency to expand is speeded up and can be detected. Soundness means the ability to resist volume expansion.

C. INITIAL SETTING AND FINAL SETTINGTIME:

INITIALSETTING:

Initial setting time of cement is defined as the time elapsed between the moments when water is added to the cement to the time when the cement paste starts losing its plasticity.

FINAL SETTING:

Final setting time of cement can be defined as the time elapsed between the moments when water is added to the cement to the time when the cement paste has Completely lost its plasticity.

D. SPECFIC GRAVITY TEST FOR CEMENT:

We know that specific gravity of cement or the Density of cement ranges between 3.1- 3.16g/cc. By this, cement is 3.16 times heavier than water of the same volume.

E. FINENESS MODULUS FOR AGGREGATE:

The Fineness Modulus is an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves and dividing the sum by 100. In general, however, a smaller value indicates a finer aggregate.

F. SPECFIC GRAVITY TEST FOR AGGREGATE:

The specific gravity of fine aggregate (sand) is considered to be around 2.65 to 2.67. Sand particles composed of quartz have a specific gravity between 2.65 to 2.67. While inorganic clays generally range from 2.70 to 2.8.

The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average of about 2.68. Water absorption shall not be more than 0.6 per unit by weight.

I.CRUSHING STRENGTH FOR AGGREGATE:

The strength of coarse aggregates is assessed by the aggregates crushing test. The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied compressive load.

J. IMPACT STRENGTH FOR AGGREGATE:

The aggregate impact test value measures resistance to sudden impact or shock, which may vary from resistance to gradually applied compressive load.

K. WATER PH:

pH is a measure of how acidic/basic water is. The range goes from 0 to 14, with 7 being neutral. A pH of less than 7 indicates acidity, whereas a pH

greater than 7 indicates a base.

L. *TESTING OF MECHANICAL PROPERTIES*

All the blocks are tested for compressive strength, split tensile strength and flexural strength

Fig.3 Compressive strength test

IV.RESULTS AND DISCUSSION

The interlocking paver block is made up of the following components: they are cement,fine aggregate,coarse aggregate,water,crumb rubber,silica fume and epoxy polymer.The size of the crumb rubber is based on the dimension (1/4 inch) or mesh (holes per inch: 10,20). Crumb rubber has been used to partially replace fine aggregate in concrete. Silica fume is used in this concrete to increase the compressive strength of the concrete as the crumb rubber reduces the compressive strength of the concrete.The epoxy polymer that is used acts as an adhesive and is used for bonding in concrte as the tyre waste crumb rubber is inert.

The material testing that is conducted on the interlocking paver block are

1. Compressive strength
2. Split tensile test
3. Flexural strength

The compressive strength of the concrete mould of size 150cm x 150cm x 150cm.The test procedure

follows to IS4031 part VI-1988.from the journal in building and building materials,the compressive strength after the curing of 28 Days is about 42.8MPa than the controlmix which is of 33.8MPa.

The split tensile strength of ṭhe concrete mould which of the size Día = 150mm radius = 0.075mm Height = 300mm cylinder. The test procedure follows to IS4031 part VI-1988.The cube specimen was tested ina CTM after a curing period of 7 and 28 days and an average of the values gives the compressive strength of the given previous concrete sample.

The flexural strength of the concrete mould which is of the size 100x100x500 Prism. The test procedure follows to IS4031 part VI-1988. . The prism specimen was tested in a Flexural testing after a curing period of 7 and 28 days and an average of the values gives the Flexural Strength of the given pervious concrete sample.

V.CONCLUSION

The tyres store water for a long period because of its particular shape and impermeable nature providing a breeding habitat for mosquitoes and various pests. Tyre burning, which was the easiest and cheapest method of disposal, causes serious fire hazards. Once ignited, it is very difficult to extinguish as the 75% free space can store lot of free oxygen. Tyre landfilling is responsible for a serious ecological threat. Mainly waste tyres disposal areas contribute to the reduction of biodiversity also the tyres hold toxic and soluble components. Disposal of waste tyre rubber has become a major environmental issue in all parts of the world representing a very serious threat; one of the possible solutions for the use of scrap tyre rubber is to incorporate it into concrete, to replace some of the natural aggregate. An estimated 1000 million tyres reach the end of their useful lives every year. A small part is recycled and millions of tyres are just stockpiled, landfilled or buried. The volume of polymeric wastes like tyre rubber, the recycling of waste tyre rubber in construction and road materials has emerged as a potential innovative solution to the growing waste rubber tyre dilemma. However, to determine the feasibility of any recycling method, it is crucial to assess the potential environmental implications of the proposed method. The environmental conditions waste tyre rubber products are exposed to are often not accurately simulated in leachate. Crumb rubber is recycled rubber produced from automotive and truck scrap tires. During the recycling process, steel and tire cord (fluff) are removed, leaving tire rubber with a granular consistency. Continued processing with a granulator or cracker mill, possibly with the aid of cryogenics or by mechanical means, reduces the size of the particles further. Epoxy is an adhesive used for bonding in concrete. Epoxy resins are used with concrete in the form of coatings, repair materials, grouts, bonding agents, paints, adhesives, epoxy mortars, sealers, penetrating sealers, wearing surfaces, and as admixtures to cement concrete to make epoxy polymer-modified concrete. Crumb rubber has been used to partially replace fine aggregate in concrete. This was a comprehensive study in which additives such as silica fume, crumb rubber, and tire-derived aggregates were added to concrete and properties such as the compressive strength, flexure strength, workability, and splitting tensile strength were examined. The concrete strength decreases significantly when crumb rubbers were used to replace the fine mineral aggregates. The crumb rubber is a material which was recycled from waste tyres in all over the world, replacing it as a substitute for fine aggregate for a minimum percentage without affecting the strength of the concrete will help the environment and dumping the tyre waste into the land affecting the soil and ground

water. The tests for 35 crumb rubber, silica fume, epoxy polymer and opc cement results are shown above then the CM ratio is 1:1.5:3 and grade M20 the casting for M0 sample is in progress and soon M1 sample will be casted.

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