AN EXPERIMENTAL INVESTIGATION ON CONCRETE BY PARTIAL REPALCEMENT OF CEMENT BY SILICA FUMEAND FINE AGGREGATE BY RUBBER TYRE POWDER

[1]Mrs.P.Dennis flora
Assistant Professor,
Department of Civil Engineering
Sri Bharathi Engineering College for Women
Pudukkottai – 622303, India
[1]flora.dennis7@gmail.com

[2]S. Pushpaveni
Department of Civil Engineering
Sri Bharathi Engineering College for Women
Pudukkottai – 622303, India
[2]Pushpaveni200125@gmail.com

***Abstract* - Concrete is a major building material which is used in construction throughout the world .It is extremely versatile and is used in all type of structure due to rapid growth in construction activity. The consumption of concrete is increased. Thus it is becoming inevitable to use alternative material for aggregates in concrete., In which to increase the market demand of cement, on other hand rising prices, to overcome such problems, we use industrial by product / waste like silica fumeand rubber tyre as the partial replacement of fine aggregate and cement it should be used to promoted for better performance as well as for environmental sustainability, which also increase strength than the conventional concrete.**

Keywords: Silica fume, Rubber tyre powder, Compressive strength.

INTRODUCTION

GENERAL

Waste materials resulting from various physical and chemical processes are the most important challenge in the industrial and developing countries. Extensive investigations on wastage recycling are being implemented to minimize the environmental damages. One of the non-recyclable materials enters the environment is automotive used tires. Large quantities of scrap tires are generated each year globally. This is dangerous not only due to potential environmental threat, but also from fire hazards. Over the years, disposal of tires has become one of the serious problems in environments. Land filling is becoming unacceptable because of the rapid depletion of available sites for waste disposal. Investigations show that used tires are composed of materials, which do not decompose under environmental conditions and cause serious contaminations. Burning is a choice for their decomposition; however, the gases exhausted from the tire burning results in harmful pollutions. In order to prevent the environmental problem from growing, recyclingtire is an innovative idea or way in this case. Recycling tire is the processes of recycling vehicles tires that are no longer suitable for use on vehicles due to wear or irreparable damage. Based on examinations, another way is using the tires in concrete. This results in the improvement of such mechanical and as energy adsorption, ductility, and resistance to cracking. However, this may cause a decrease in compressive strength of the concrete.

The cracker mill process tears apart or reduces the size of tire rubber by passing the material between rotating corrugated steel drums. By process an irregularly shaped torn particles having large surface area are produced and this particles are commonly known as rubber tyre. Mixing of rubber tyre particles with Portland cement concrete does not involve high temperature mixing hence final bond between the cement strength of the matrix. Portland cement concrete with addition of c rubber tyre powder becomes a heterogeneous mixture due to different specific gravities of the ingredients. The past research shows that rubber Portland cement concrete causes the reduction in strength, it improves certain durability aspects such as freeze thaw resistance, sound absorption, and damping properties and reduces water absorption.

Silicon metal and alloys are produced in electric furnaces .The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being land filled. In recent years, using silica fume in concrete in order to increase its strength has attracted much attention. Filling capability and pozzolanic property of silica fume results in filling the capillary gel pores with thismaterial and its compounds with calcium hydroxide. This phenomenon increases theconcrete strength significantly. The reaction of silica fume in concrete depends on the amount of this material. One of the main features of silica fume, which improves the properties of fresh and hardened concrete, is its fine particles. Most of the silica fume particles are in the range of 0.01- 0.3 micrometre and their mean particle size ranges between 0.1- 0.2 micrometre. It is apparent that silica grains, which are 100 times smaller than the cement particles, fill the free spaces between the cement and increase the concrete strength. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Placing, finishing, and curing silica-fume concrete require special attention.

RUBBER TYRE

Rubber tyre is a term usually applied to recycled rubber from automotive and truck scrap tires. During the recycling process steel and fluff is removed leaving tire rubber with a granular consistency. Continued processing with a granulator and/or cracker mill, possibly with the aid of cryogenics or mechanical means, reduces the size of the particles further. The particles are sized and classified based on various criteria includingcolour (black only or black and white). The granulate is sized by passing through a screen, the size based on a dimension (1/4") or mesh (holes per inch: 10, 20, etc.).Mesh refers to material that has been sized by passing through a screen with a given number of holes per inch. For example, 10 mesh crumb rubber has passed through a screen with 10 holes per inch resulting in rubber granulate that is slightly less than 1/10 of an inch. The exact size will depend on the size of wire used in thescreen.

Rubber tyre powder

SILICA FUMES

Silica fumes also known as micro silica is a fine-grain, thin, and very high surface area silica. It is sometimes confused with fumed silica (alsoknown as pyrogenic silica) and colloidal silica. These materials have different derivations, technical characteristics and application. Silica fumes is a by-product silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fumes is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolana. Concrete containing silica fumes can have high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified is simply added during concrete production. Placing, finishing, and curing silica-fumes concrete require special attention on the part of the concrete contractor. A silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (sio2). The individual particles are extremely small, approximately 1/1000th the size of an average cement particle. Because of its fine particles, large surface area, and the high sio2 content, silica fumes is a very reactive pozzolana when used in concrete. Silica fume for use in concrete is available in wet and dry forms. It is usually added during concrete production at a concrete plant as shown in the photo.

Fig.2 Silica fume

SILICA FUMES WORK IN CONCRETE

In cementitious compounds, silica fumes works on two levels, the first one described here is a chemical reaction called the pozzolanic reaction. The hydration (Mixing with water) of Portland cement produces many compounds including calcium silica hydrates (CSH) and calcium hydroxide (CH). The CSH gel is known to be the source of strength in concrete. When silica fumes is added to fresh concrete it chemically reacts with the CH to produces additional CSH. The benefit of this reaction is twofold, increased compressive strength and chemical resistance. The bond between the concrete paste and the coarseaggregate, in the crucial interfacial zone is greatly increased, resulting in compressive strengths that can exceed 15000 psi. The additional CSH produced by silica fume is more resistant to attack from aggressive chemicals then the weaker CH. The second function silica fume performs in cementitious compound is a physical one. Because silica fumes is 100 to 150 times than a cement particle it can fill the voids created by free water in the matrix. This function, called particle, packing, refines the microstructure of concrete, creating a much denser pore structure. Impermeability is dramatically increased, because silica fume reduces the number and size of capillaries that would normally enable contaminants to infiltrate the concrete. Thus silica fumes modified concrete is not only stronger, it lasts longer, because it‘s more resistant to aggressive environments. As filler and pozzolana silica fume‘s dual action in cementitious compounds are evident throughout the entire hydration process.

SCOPE

Now a day due to the rapid industrial growth, waste material management is a challenging field. It possesses lot of environmental impact. Due to the rapid growth in construction field, construction material scarcities will arise. So we need to find some alternate material for construction. Crumb rubber is a waste material from the scrap tyre. By using this as fine aggregate we can prevent the natural aggregate depletion. This avoids so much of environmental problems.

OBJECTIVES

The main object of investigation is to study the strength behaviours of crumb rubber concrete with economical basis. Partially replacement of cement by using silica fumes up to 15%. Partiallyreplacement of sand by using crumb rubber up to 5%. To investigate the use of crumb rubber in conventional concrete. Find The Compressive Strength of concrete cubes with 5% to15% replacement of fine aggregate by crumb rubber with silica fume. Find The Split Tensile strength of concrete cylinder. Find The Flexural strength of concrete beam. Comparisons of all the above results with ordinary concrete.

REVIEW OF LITERATURE

A. Khan., S. Danish., S. Arif., S. Ramzan., M. Mushtaq (2013)

This paper, through experimental study and literary sources investigates the utilization of rubber waste in developing Green Concrete (GC). The natural aggregate (sand) of Conventional Concrete (CC) is replaced as 10%, 20% and 30% with coarse and fine rubber aggregate. The samples were tested in laboratory after a specific time on various aspects including compression strength and results were compared with each other and also with Conventional Concrete Mix (CCM). The paper concludes that structural and non-structural rubberized concrete can be developed by using specific quantity of rubber waste in placement of fine and coarse aggregates in conventional concrete. The key objective of this research is to find out an efficient solution for utilizing rubber waste for better environment and also to provide initiative for concerned government organization for framing effective legislation for the use of rubberized concrete in building and construction industries. It reveals from compressive strength's tests of rubberized concrete (RC) that it can be produced for various use in building and construction Industries. RC will not only save the natural ingredients of concrete resulting environmental sustainability but recycling of rubber waste will also contribute towards better environment. The replacement of 10 % of fine aggregate (sand) of Conventional Concrete (CC) with Fine Crumb Rubber (FCR) is useful for producing Structural Concrete. Therefore use of CCR concrete should be encouraged for use so that maximum consumption of waste rubber could be achieved.

K. C. Panda, P. S. Parhi and T. Jena (2012)

In this study an attempt has been made to identify the various properties necessary for the design of concrete mix with the coarse tyre rubber chips as aggregate in a systematic manner. In the present experimental investigation, the M20 grade concrete has been chosen as the reference concrete specimen. Scrap tyre rubber chips, has been used as coarse aggregate with the replacement of conventional coarse aggregate. Slump value is decreased as the percentage of replacement of scrap tyre rubber increased. So decrease in workability. The compressive strength is decreased as the percentage of replacement increased, but rubber concrete developed slightly higher compressive strength than those of without rubber concrete. The split tensile strength is increased with decreased percentage of scrap tyre rubber. Decrease in compressive strength, split tensile strength and flexural strength of the specimen. Lackof proper bonding between rubber and cement paste matrix.

G.SenthilKumaran, NurdinMushule, M.Lakshmipathy (2008)

This study reviews the feasibility of using waste tires in the form of chips and fibers with different sizes in concrete to improve the strength as well as protecting the environment. Also it reviews the potential application in the field by exploiting its unique characteristics and properties. In this study, we outline the use of rubberized concrete in structural and non-structural members and show how it is suitable for the concrete, its uses, barriers and benefits and way to future study. A research is underway using the grade of cement 53, to improve the strength, fine sand and coarse aggregate of a combination of 10mm and 20mm. The waste tyre rubber shall be used in the form of chips and fibers by partially replacing the coarse aggregate by 0, 5, 10, 20 and 25%.Recycling technology for concrete has significantly developed in the recent years, making the material sufficiently recyclable. It is evident that from the above discussion, the reduction of compressive and tensile strength can be increased by adding some super plasticizers and industrial wastes as partial replacement of cement will definitely increase the strength of waste tyre rubber modified concrete. Many studies reveal that there will be increase in strength enhancements as well as environmental advantages. The future NGC using waste tyre rubber could provide one of the environmental friendly and economically viable products. Though problems remain regarding the cost of production and awareness among the society the wastes can be converted into a valuable product But further research is needed to increase performance against fire.

El-Gammal, A., A. K. Abdel-Gawad, Y. El-Sherbini, and A. Shalaby (2010)

In this paper the density and compressive strength of concrete utilizing waster tire rubber hasbeen investigated. Recycled waste tire rubber has been used in this study to replace the fine and coarse aggregate by weight using different percentages. The results of this paper shows that although, there was a significant reduction in the compressive strength of concrete utilizing waste tire rubber than normal concrete, concrete utilizing waste tire rubber demonstrated a ductile, plastic failure rather than brittle failure. A total of 4 main mixtures were cast. One control mixture and three concrete mixtures. The control mixture was designed to have a water cement ratio of 0.35 with cement content of 350 kg/m^3. To develop the rubberized concrete mixtures, tire rubber was used to replace the aggregate by weight. In the first rubberized concrete mixture, the chipped rubber totally replaced the coarse aggregate in the mixture. While, in the other two concrete mixtures, the tire rubber replaced the fine aggregate by 100% and 50% of fine aggregate weight. Concrete casted using chipped rubber as a full replacement to coarse aggregate shows a significant reduction in the concrete strength compared to the control specimen. However, significant ductility was observed before failure of the specimens. Concrete casted using chipped rubber as a full replacement to coarse aggregate shows a significant reduction in the density of concrete compared to the control specimens. Concrete casted using crumb rubber as a full replacement to sand shows a significant reduction in the concrete strength compared to the control specimen. However, significant ductility was observed before failure of the specimens. Concrete casted using crumb rubber as a full replacement to sand shows a significant increase in the concrete strength compared to the concrete casted using chipped rubber as a replacement to coarse aggregate. There was no significant increase in the concrete compressive strength and the concrete density when different percentage of crumb rubber, as a replacement to sand, was used in the concrete mix. It is recommended to test concrete with different percentage of crumb rubber ranging between (10% up to 25%) to study its effect on the concrete strength.. It is recommended to use concrete in the production of curbs, roads,concrete blocks, and non-bearing concrete wall.

T. SenthilVadivel& R. Thenmozhi (2012)

In this Study, our present study aims to investigate the optimal use of waste tyre rubber crumbs as fine aggregate in concrete composite. A total of 90 cubes, cylinders and beam specimens were cast with the replacement of fine aggregate by shredded rubber crumbs with the proportion of 2, 4, 6, 8, and 10% by weight and compared with 18 conventional specimens. Fresh and hardened properties of concrete such as workability, compressive strength, tensile strength and flexural strength were identified and finally it is recommended that 6% replacement of waste tyre rubber aggregate with fine aggregate will gives optimal and safest replacement in concrete composites. Compressive strength decreases when the percentage of replacement of shredded fine rubber crumbs increases. Split tensile strength decreases at the maximum of 25% when rubber crumbs replaces up to 10% in fine aggregate. Flexural strength of concrete increases when rubber crumbs increases up to 6%. It is identified that the grade of concrete plays the major role in the ductility performance of rubber replaced Concrete. Slump test results show no change in workability in all the percentage of replacement of rubber crumbs. Hence no effect in consistency during rubber replaced concrete. 6% replacement of waste tyre rubber proves exceptionally well in compression, tensile and flexural strength and follow the curvature of the conventional specimens all the tests in both the grades. Hence it is recommended that 6% replacement of waste tyre rubber aggregate with fine aggregate will gives optimal and safest replacement in concrete composites. Further it is suggested to use this concrete composite for lintel beams, floor slabs, and ribs where load carrying capacity not governing the design.

2. METHODOLOG YMATERIAL USED

Various materials used for the experimental study are the following:

CEMENT

Cement is a material that has cohesive and adhesive properties in the presence of water. Such cement is called hydraulic cements. These consist primarily of silicates and aluminates of lime obtained from limestone and clay. There are different types of cement; out of that I have used one type.

ORDINARY PORTLAND CEMENT

Ordinary Portland cement (OPC) is the basic Portland cement and is best suited for use in general concrete construction. It is of three types, 33 grades, 43grade, 53 grade. One of the important benefits is the faster rate of development of strength. Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel, and crushed stone to make concrete. The cement and water form a paste that binds the other materials together as the concrete hardens. The basic composition of cement is provided in table. In the present work 43 grade cement was used for testing.

FINE AGGREGATE

Locally available free of debris and nearly riverbed sand is used as fine aggregate. Among various characteristics, the most important one is its grading coarse sand may be preferred as finesand increases the water demand of concrete and very fine sand may not be essential in as it usually has larger content of thin particles in the form of cement. The sand particles should also pack to give minimum void ratio, higher voids content leads to requirement of more mixing water.

3. 4 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 hydration of cement get the requirement of water should be reduced to that required chemical reaction of un hydrated cement as the excess water would end up in only formation undesirable voids or capillaries in the hardened cement paste in concrete. It is important to have the compatibly between the given cement and the chemical material admixtures along with the water used for mixing.

It is generally stated in the concrete codes and also in the literature that the water fit for drinking is fit for making concrete. This may not be true always. For example some water containing a small amount of sugar would be suitable for drinking, but they are good for cement concrete, as the sugar would adversely affect the hydration process. The limits of the content of water have to be determined from the following considerati on. High content of cement is susceptible to a rapid loss of workability on Account of higher amount of heat of hydration generated. Therefore attention is required to see that the initial hydration rate of cement should not be significantly affected. The saltin water would not interface with the development of strength of later ages. Apart from the strength consideration, the durability characteristics such as porosity, degree of resistance to diffusion of CO_2, $CaSO_4$, moisture, air oxygen, etc. should also be investigated after specified curing period.

MIX DESIGN DEFINITION

Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportion with the object of certain minimum strength and durability as economically as possible.

DESIGN OF M25 GRADE CONCRETE

Design parameters

Characteristic strength: 25 N/mm²Compaction factor: 0.85

Degree of quality control: GoodType of exposure:Moderate

Data on material

Cement used: Grade 53 conforming to

IS: 12269-1987

Specific gravity of cement: 3.15Sand: Conforming to zone II

Specific gravity of fine aggregate: 2.62 Bulk density of fine aggregate: 1.698 Fineness of modulus: 2.71

Specific gravity of coarse aggregate: 2.72 Bulk density of coarse aggregate: 1.82 Fineness of modulus: 2.59

Bureau of Indian Standards method (a). Target mean strength for specified characteristic cube strength is

Fck = fck +ts

= 25+1.65x 4

= 31.6 N/mm²

(b).Selection of water cement ratio required for the target mean strength of 31.6/mm² is maximum freeW/C ratio is 0.5 from IS 456-2000

(c). Selection of water and cement content

20mm maximum size aggregate sand containing to grading zone II. Water content per cubic meter of concrete 186 kg and sand content as percentage of total aggregate by absolute volume 35% Correction for decrease in water cement ratio: Total aggregate by absolute volume is 35-3 = 32%(d).

Determination of cement content

W/C ratio = 0.45

Water = 160

lit

Cement = 160/ 0.45 =355.5Kg/m^3

(e). Determination of course and fine aggregate.

The amount of entrapped air is 2% rubber tyrepowder is 5%

Absolute volume of concrete, V = 1- (0.02+ 0.10)

= 0.93

Determination of fine aggregate:

V = {W+ C/Se + (1/P x fa/Sfa)} x 1/1000

0.93 = {160+ 355.5/3.15 + (1/.32 x fa/2.62)} x 1/1000

FA = 684 kg/m^3 (Similarly for coarse aggregate)V = {W+ C/Se + [1/ (1-P) x (Ca/Sca)]} x 1/1000

0.93 = {160+ 355.5/3.15 + (1/0.68 x Ca/2.67)} x 1/1000

Course aggregate, CA = 1030 Kg/m^3

The mix proportion per cubic meter

Water = 160 lit

Cement= 355.5 Kg

Fine aggregate= 684 kg /m^3

Course aggregate= 1030 Kg/m^3

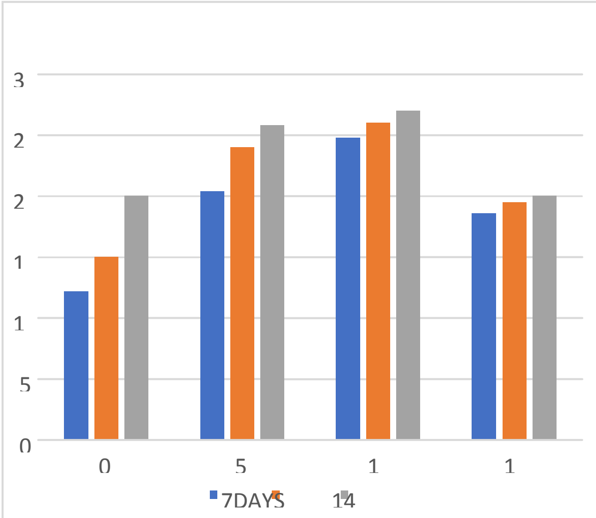
COMPRESSIVE TEST OF CONCRETE CUBE

Compression test of the concrete specimen is most widely used to measure its compressive strength .Two types of concrete cube specimen are used to for this test.Cube size of 150mm x 150mm x 150mm in diameter is used.Cubes for compression test are caste in a steel or cast-iron mould of prescribed dimensions.BS1881: Part 108:1983 approximately 50mm.Compaction of each layer is achieved by not less than 35 strokes for 150mm cubes or 25 strokes for 100mm cubes.A standard tampingbar of a 25mm square of steel section is used for this purpose. Compaction by vibrating or tamping rod may also be used.

After finishing the cube it should be stored at a temperature of 15 degree celcius to 25degree celcius ,when the cubes are to be tested at or more than 7 days. When thetest days are less than 7 days,the temperature to be maintained is 18 degree celcius to 22 degree celcius.Also, relative humidity of 90 percent is to be maintained always.The cube is demoulded just before testing at 24 hours.For greater ages at test,demoulding takes place between 16 to 28 hours after adding water in a concretemix and the specimens are stored in a curing tank until the required age of 7,14 and28 days.

The load applied at constant rate of stress within the range of 0.2 to 0.4 Mpa/sec. practically,the compression testing system ratherdevelops a complex system of stresses due to end restrains by steel plates. The strength if concrete is also decreases with the size of the specimen till its lateraldimension is 450mm,all larger specimens or members give approximately the same strength.This is evident from the fact that the probability of occurrence of weak spots is greater when the volume of the concrete is larger for a given stress level to whichitis subjected.

Experimental Setup for Testing of Cube Specimens



CONCLUSIONS

The 7- day and 28- day compressive strength of the specimens increased by addition of silica fumeto concrete containing crumb rubber. This happens because of filling capability of silica fume fine particles as well as good adhesion between the rubber and the cement paste.

Based on the above test results concluded thefollowing:

Compressive strength decreases when the percentage of replacement of shredded fine silica fume increases.

Split tensile strength decreases at the maximum of 15% when rubber crumbs replaces up to 5% in fine aggregate.

Flexural strength of concrete increases when rubber crumbs increases up to 5% and silica fumeupto 10%.

It is identified that the grade of concrete plays the major role in the performance of rubber replaced concrete

CRSF 3 (10) % replacement of waste tyre rubber proves exceptionally well in compression, tensile and flexural strength and follow the curvature of the conventional specimens all the tests in M20 grades.

Hence it is recommended that Crumb rubber (CR) 5% replacement of fine aggregate, Silica fume (SF) 10% replacement of cement will gives optimal and safest replacement in concrete composites.

REFERENCES

1. Amudhavalli, N. K. & Mathew, J. (2012). Effect of silica fume on strength and durability parameters of concrete. International Journal of Engineering Sciences& Emerging Technologies. Perumal, K., Sundararajan , R. (2004). Effect of partial replacement of cement with silicafume on the strength and durability characteristics of High performance concrete.
2. 29th Conference on our world in concrete & structures: 25 – 26 August 2004, Singapore. Kumar, R. , Dhaka, J. (2016). Review paper on partial replacement of cement with silica fume and its effect on concrete properties. International Journal for Technological Research in Engineering.
3. N, Eldin, A. B, Senouci,. "Rubber-tire particles as concrete aggregate". Journal of materials in civil engineering.
4. IS: 456:2000, "Plain and Reinforced Concrete", Code of Practice, Bureau of Indian Standards, New Delhi, 2000.
5. IS: 2386 (Part v) -1963, Methods of test for aggregates for concrete, Bureau of Indian standards, New Delhi, India.
6. IS 10262: 1982 Recommended Guidelines for Concrete Mix Design