A Literature Review on Partial Replacement of Copper Slag and Steel Fiber in Concrete

[1]Kushappa M Kabade, [2] Suprit Y Naik, [3]Sarfaraj

[1]Assistant Professor, [2]Student, [3]Student
[1]Civil Engineering Department,
[1,2,3]Secab Institute of Engineering and Technology, Vijayapur, Karnataka, India

***Abstract*: Concrete is one of the world's most common and vastly used construction materials. Because of the rapid growth in technology and population in India, there is a huge demand for construction material mostly for natural sand, the excessive consumption of sand causes ecological and economical imbalance. Hence, it is necessary to have alternative materials for concrete to fulfill the role of sand to achieve desired strength. Copper slag is a by-product obtained during smelting and refining of copper, many researchers have already found its potential to use copper slag as natural sand substitute. Copper slag has similar particle size characteristics seemingly to that of sand. Fine-grained powder of copper slag is used as a supplementary cementing material in concrete and in cement clinker production. Copper slag as a partial replacement of sand can help increase the compressive strength, and it is also known that concrete is weak in tension. Weak tensile strength in combination with brittle behavior of concrete results in sudden tensile failure without warning. To overcome these effects large modifications are being carried out in construction industries, i.e. usage of by-products or residues such as steel fibers, the closely spaced fibers improved toughness, tensile and flexural strength of concrete and assisted to control cracking. Hence, in this study an attempt is made to review different research papers related to improvement of compressive strength by replacing natural sand with copper slag and also related to improvement of tensile strength of concrete by adding steel fibers and literature review has been done.**

***Keywords*: Copper slag, Steel Fiber, Compressive strength, Tensile strength.**

I. INTRODUCTION

Concrete is one of the world's most common and vastly used construction materials. Because of the rapid growth in technology and population in India, Aggregates are considered one of the main constituents of concrete since they occupy more than 70% of the concrete matrix. In so many countries there is scarcity of natural aggregates that are used for construction whereas in other countries the usage of aggregates has been increased, due to the increase in the demand by the construction industry. In order to decrease dependence on natural aggregates as the primary source of aggregates in concrete, industrial manufactured aggregates from wastes gives an alternative for the construction industry. Hence, utilization of aggregates from manufacturing plants and industrial wastes can be alternative to the natural aggregates. The usage of industrial waste or secondary materials has encouraged the production of cement concrete in construction. Different by-products and waste materials are being produced by various industries. Dumping and disposal of waste materials effects environment and causes health problems. Therefore, recycling and reuse of waste materials is a great potential factor in concrete industry. For many years, industrial by products such as fly ash, silica fume, copper slag and metal slag were considered as waste materials. Concrete prepared with these kinds of materials showed improvement in workability and durability compared to conventional concrete and has been used in the construction of power plants, chemical plants, mega structures and under-water structures. Copper slag is copper manufacturing industrial by-product material. In India 8 lakh tons of copper slag is generated every year and in world-wide generation of annually about 24.6 million tonnes of slag. Though copper slag is basically used in abrasive tool manufacturing and in the sand blasting industries, but the leftovers are disposed without any proper use, recycling or reclamation. Copper slag has numerous favorable mechanical properties that can be used as partial replacement for fine aggregate, properties such as good abrasion resistance, good stability and sustainability. So the core objectives of this study is to determine the outcome of using copper slag as replacement of natural aggregates when used in optimum content to enlighten its strength and sustainability.

Steel fiber reinforced concrete (SFRC) can be defined as a composite material made with Portland cement, aggregate, and incorporating steel fibers. Concrete is a brittle material, with a low split-tensile strength. If the fibers are sufficiently strong, sufficiently bonded to material, and permit the SFRC to carry significant stresses over a relatively large strain capacity in the post-cracking stage. The actual contribution of the steel fibers is to increase the toughness of the concrete under different type of loading. However, because of the basic material properties of fiber concrete, the presence of fibers in the body of the concrete can be expected to improve tensile strength, cracking, deflection and other serviceability conditions of concrete.

The strength and durability of concrete can be altered by making suitable changes in its ingredients and mixing ratio and by adding some chemical additives. However, concrete has some vulnerability as listed below:

1) Low tensile strength
2) Low post cracking capacity
3) Brittleness and low ductility
4) Limited fatigue life
5) Incapable of accommodating large deformations
6) Low impact strength

The presence of micro cracks due to air entrapped in the mortar-aggregate mixture is responsible for the weakness of conventional concrete. The weakness can be eliminated by addition of steel fibers in the concrete mixture. The steel fibers help to transfer loads at the internal micro cracks. Such a concrete is called steel fiber-reinforced concrete (SFRC).

II. LITERATURE REVIEW

2.1. Alaa M. Rashad: In this research paper author has been studied that in the last 15 years, it has become clear that the availability of good quality natural sand is decreasing. The shortage of the resources of natural sand paved way for using byproducts as fine aggregate. Reuse of by-products as a partial or full replacement of fine aggregate in construction not only reduces the demand for mining of natural raw materials, but also saves landfill and dump yard space. It can also be used as binder material (after suitable grinding). In this research work, author shares overview of the previous studies carried out on the use of GBFS and CS as a partial or complete replacement of natural fine aggregate in conventional mortars and concretes of Portland cement (PC). Tests were conducted on concrete cubes for two different time period cured (7, 28 days) specimen (CC) to observe difference in compressive and tensile strength (Fig 1) and flow rate with respect to time (Fig 2). From this study authors has been conclude that indeed the compressive strength increases compared to conventional concrete up to 60% replacement of CS after that the strength decreases due to lack of cohesiveness; the tensile strength also increases at a certain level. And it has been also concluded that flow of concrete reduces with time as the copper slag content increases the flow increases comparatively.

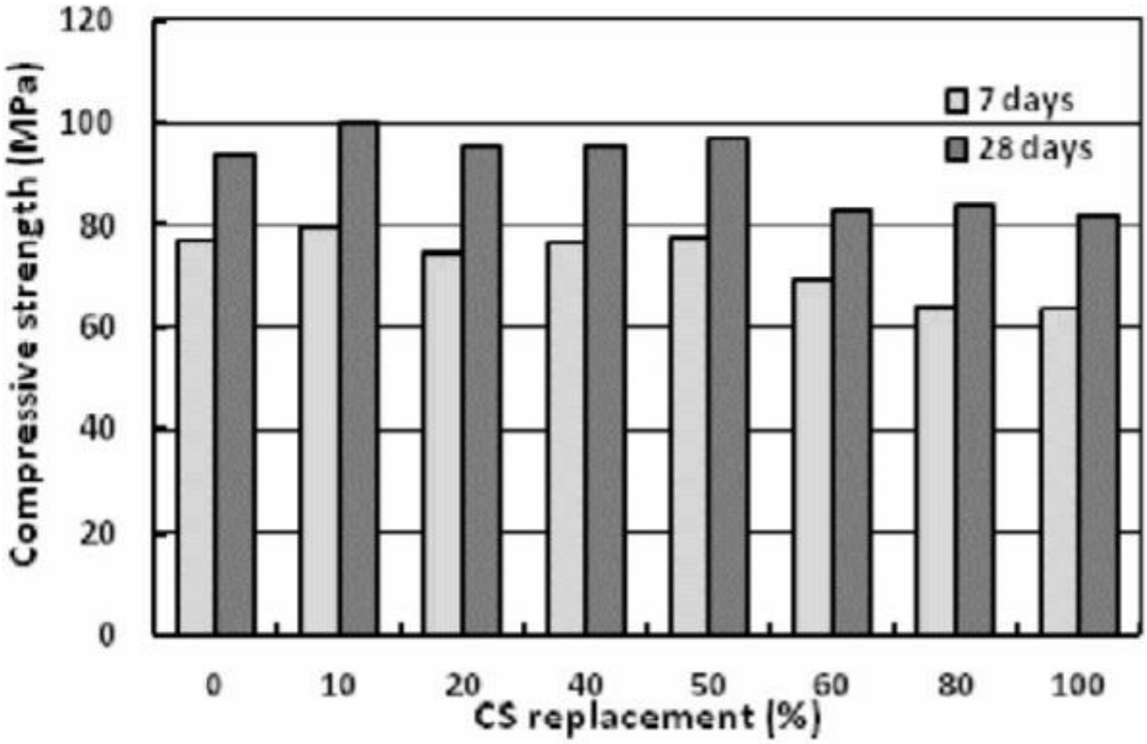


Figure 1: Compressive strength v/s CS replacement (%)

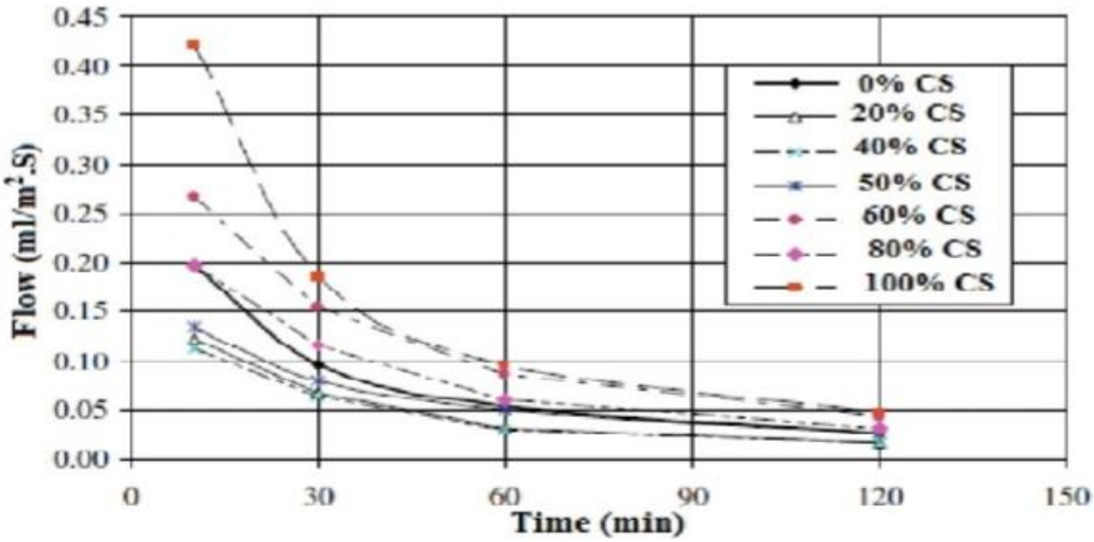


Figure 2: Flow v/s Time

2.2. Binod Kumar: In this research paper the author has been reported on a laboratory study carried out to investigate the feasibility of using copper slag, a by-product of copper manufacturing, as a partial replacement of sand/fine aggregate in the making of pavement quality concrete (PQC) and dry lean concrete (DLC) mixes. A control mix for PQC was prepared with 400 kg/m3 of ordinary Portland cement and water–cement ratio of 0.40. Workability, bleeding of green concrete, flexural strength, compressive strength, drying shrinkage and abrasion resistance were measured for all the concrete mixtures at 7 and 28 days. Authors designed DLC mixtures with 150 kg/m3 of OPC and different mix ratios of stone dust with 20%, 40%, 60% and 80% copper slag as fine aggregate. DLC mixes were prepared with different water contents to find out the optimum water content go get maximum density, and compressive strength at 7 and 28 days for each blend of stone dust and copper slag. The test results showed that the compressive strength of PQC for 7 and 28 days was not affected by addition of any content of copper slag in the concrete mixture (Fig 3). Small gradual increase in flexural strength at 28 days was observed with an increase in copper slag content (Fig 4). Dry shrinkage of PQC decreased with the increase in slag and the decrease in stone dust content. Abrasion resistance of concrete mixes containing slag was observed to be less as compared with that of conventional concrete. Compressive strength decreased with the increase in copper slag content over 40%. Keeping in view the strength and other important requirement of PQC such as cohesiveness, segregation, finishing, texturing, shrinkage and abrasion resistance, the authors has concluded that a mixture of stone dust with copper slag content up to 40% could be used as partial replacement for fine aggregate for PQC as well as DLC.

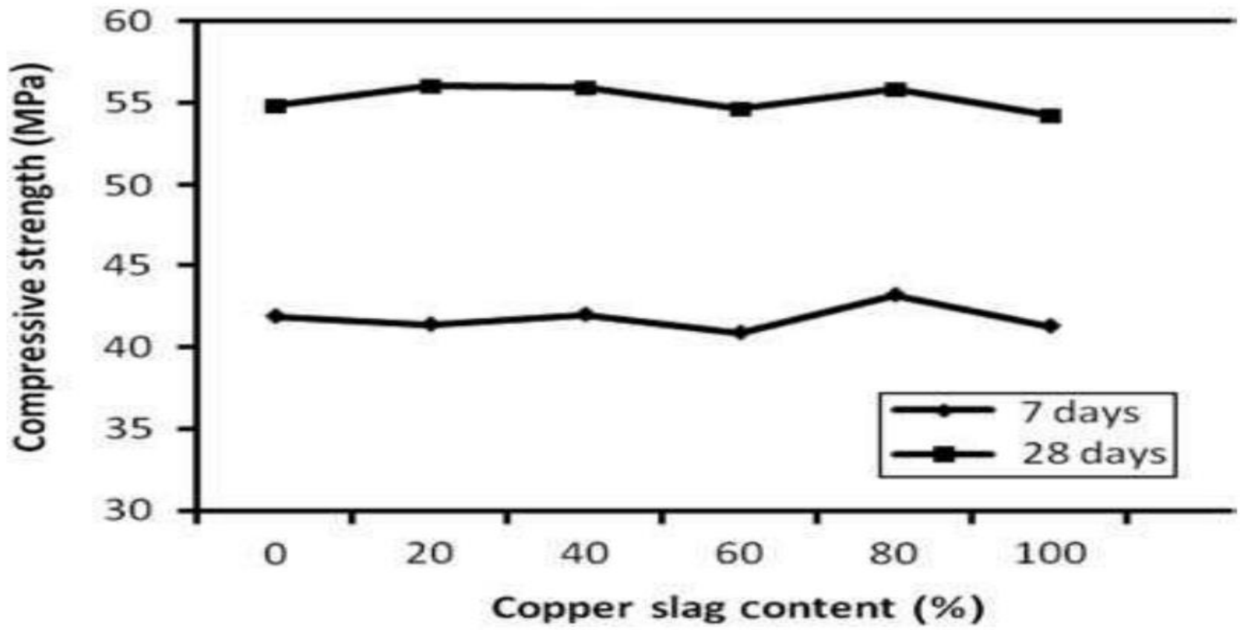


Figure 3: Compressive strength v/s CS content (%)

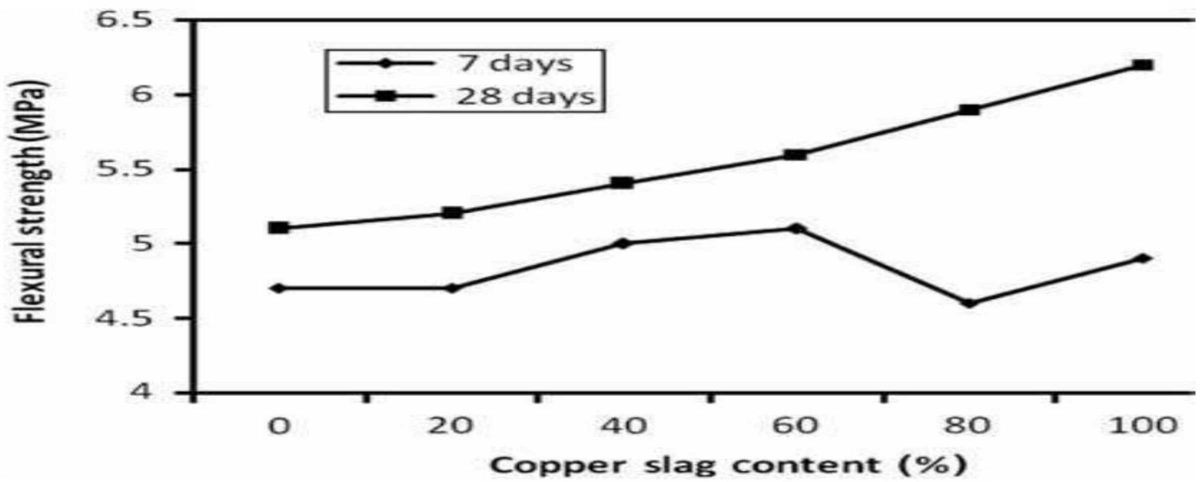
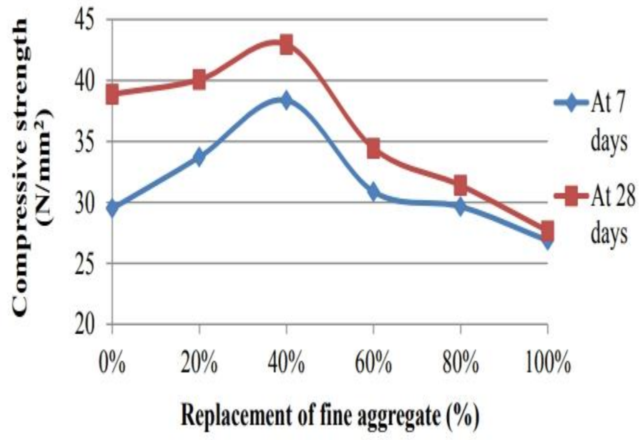


Figure 4: Flexural strength v/s CS content (%)

[2.3]. Tamil Selvi P, Lakshmi Narayani P and Ramya G: In this research paper author has been studied the effect of concrete using copper slag as fine aggregate replacement. In this research work, M40 grade concrete was selected and IS method was used for mix design. The properties of material for fine aggregate, cement, coarse aggregate and copper slag were studied and analyzed for mix design. Different kinds of strength of concrete like flexural, compressive and split tensile strength were studied and tests such as ultrasonic pulse velocity measurement and rebound hammer test were studied for various replacements of fine aggregate using copper slag that are 0%, 20%, 40%, 60%, 80% and 100%. Hence the authors have concluded that the maximum compressive strength of concrete attained at 40% replacement of fine aggregate at 7 and 28 days (Fig 5). The split tensile strength (Fig 6) and the flexural strength (Fig 7) were also obtained higher strength at 40% replacement level at 28 days. At 40% fine aggregate replacement the rebound hammer test showed higher compressive strength, this is due to uniformity of the concrete. For 40% CS replacement for fine aggregate the pulse wave velocity is higher, it is understood that it is free from pores the density of the mix is high.



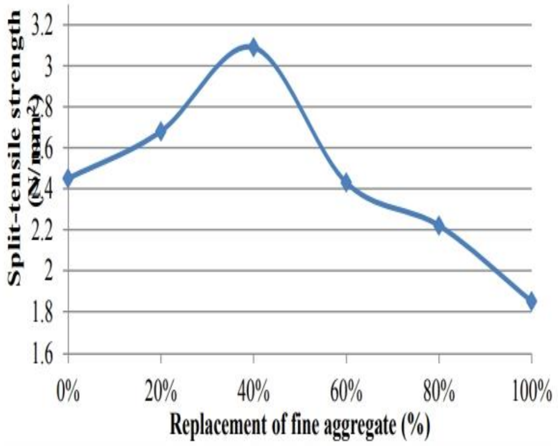


Fig 5: Compressive strength v/s Replacement of Fine aggregate (%) **Fig 6:Split-Tensile strength v/s Replacement of Fine aggregate (%)**

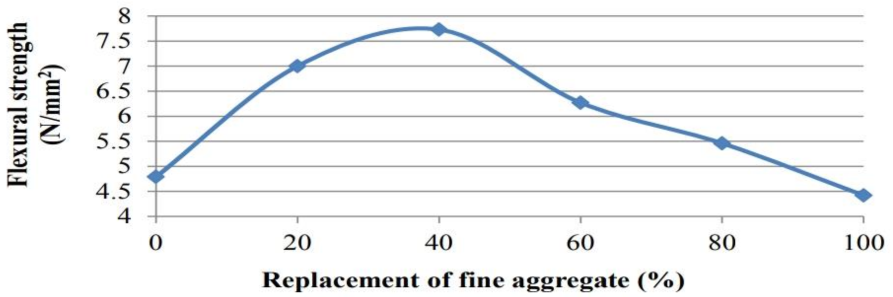


Figure 7: Flexural strength v/s Replacement of Fine aggregate (%).

[2.4]. K. S. Al Jabri: In this paper the author presented results from an experimental investigation carried out to study the potential use of copper slag as fine aggregate on the different strengths of both normal and high strength concrete. Concrete blocks were prepared using varied proportions of copper slag mix ratio. 10-100% was the range of percentage of copper slag added by weight in concrete. For each concrete mixture, 6 - 150mmx150mmx150mm cubes, 3 - 300mmx150mm dia. cylinders and 3 - 100mmx100mmx500mm prisms were cast. Compressive, tensile, flexural strengths and density were determined at 28-day of curing. Compressive strength of cube was also determined after 7 days of curing. Results showed that there is general increase in the workability and density of both normal and high strength concretes as copper slag content increases. The authors have concluded that the compressive strength of concrete is generally improved, compared with the control mix, with the increase of copper slag up to a certain copper slag content beyond which the strength generally reduces (Fig 8). Segregation and bleeding due to the significant increase of workability was seen in concrete mixes because of high copper slag percentage.

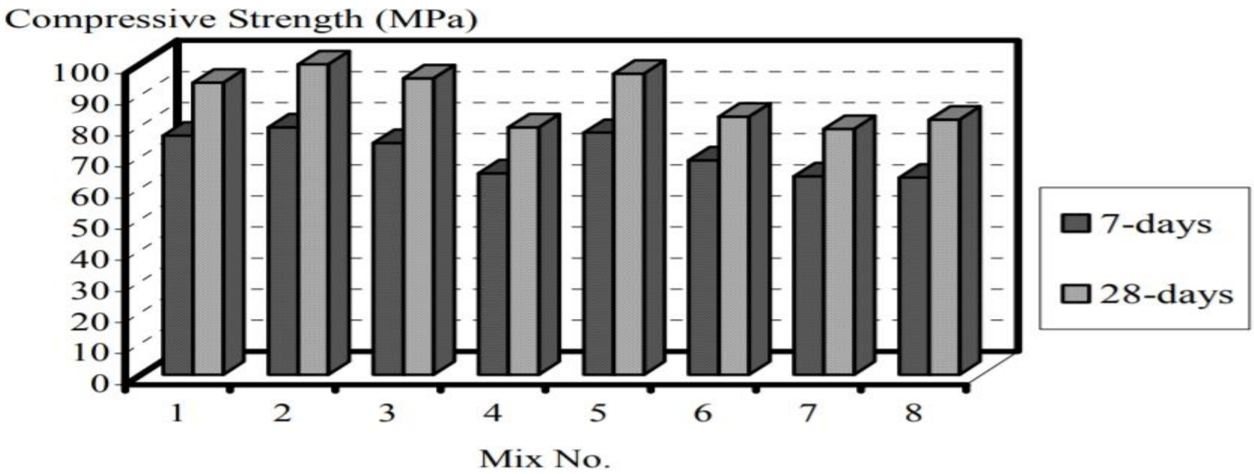


Figure 8: Compressive strength v/s Mix No.

[2.5]. Binaya Patnaik, Seshadri Sekhar.T and Srinivasa Rao: In this research paper authors has been studied that concrete is one of the most utilized materials by the construction industry which is made of heterogeneous materials like Cement, sand and aggregate. Due to rapid urbanization there is growth in demand for natural sand which in turn has made it even more expensive. This makes the researchers to go look out for alternate materials which could be used as partial or full replacement of sand which contains chemical composition of Silica (SiO2). After broad research, researchers found that materials like Copper Slag, Stone dust, Carbonate Sand, Coal Fly Ash etc. which consists silica composition could be used as a partial or full replacement of sand. This experimental investigation by authors is carried out forM20 grade of concrete mixes with partial replacement of Fine Aggregate (Sand) with Copper Slag. Compressive Strength at the curing periods of 7, 28 and 90 days for various mix ratios of Copper Slag and Sand content were carried out. Sand was replaced w/ Copper Slag by 0%, 10%, 20%, 30%, 40% and 50% (Fig 9). Authors have been concluded that at 40% Copper Slag replacement maximum compressive strength is achieved and beyond that strength deteriorate.

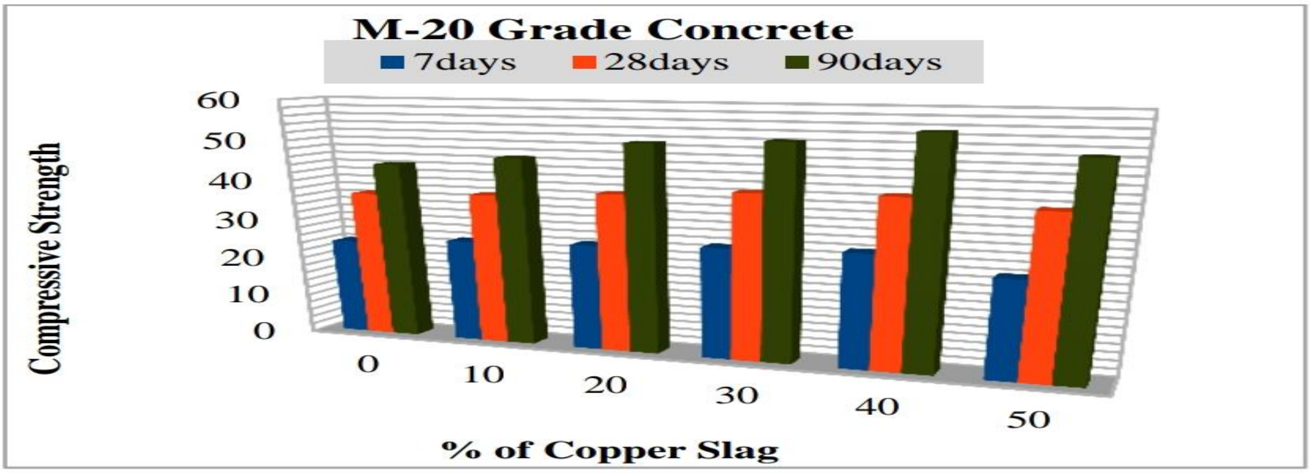


Figure 9: Compressive strength v/s % of Copper Slag

[2.6]. Khalifa S. Al-Jabri , Makoto Hisada , Salem K. Al-Oraimi, Abdullah H. Al-Saidy: In this research paper author has been studied an experimental program to investigate the effect of using copper slag as a replacement of sand on the properties of high performance concrete (HPC). Eight concrete mixtures were prepared with different proportions of copper slag ranging from 0% (for the control mix) to 100% (Fig 10). Concrete mixes were investigated for compressive strength, tensile strength, flexural strength, density, workability and durability. Results indicate that the increase of copper slag content increased HPC density by nearly 5%, and also with increase in copper slag percentage workability increased rapidly. At 50% of copper slag as sand replacement showed comparatively higher strength than that of the conventional mix. However, more than 50% of copper slag caused reduction in the strength due to an increase of the free water content in the mix. The lowest compressive strength value of approximately 80 MPa, which is almost 16% lower than the strength of the control mix were given by concrete mixes with 80% and 100% copper slag replacement (Fig 11). Results also indicated that as copper slag quantity increases up to 40% replacement the surface water absorption decreased; further more than that level of replacement, the absorption rate increases rapidly. Therefore, for conclusion authors has recommended that 40 wt% of copper slag can use as replacement of sand in order to obtain HPC with good strength and durability properties.

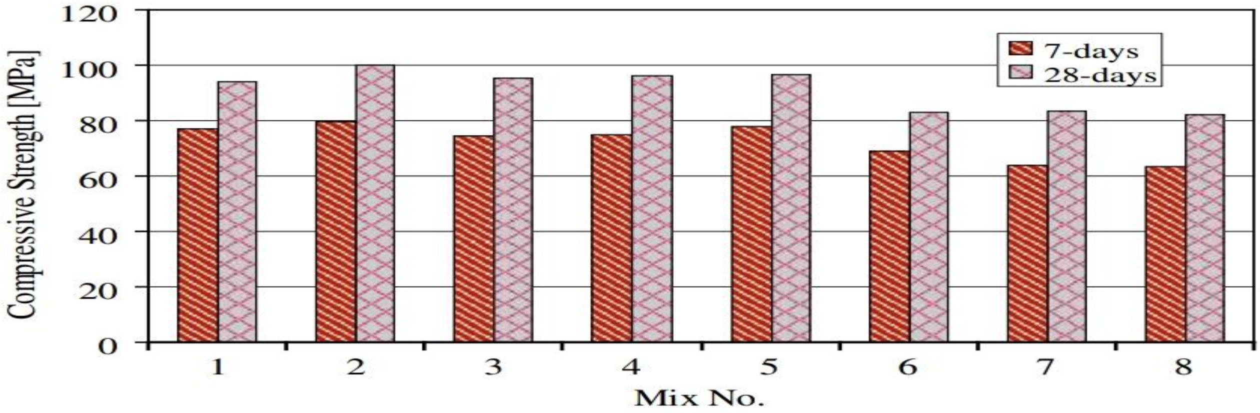


Figure 10: Compressive strength v/s Mix No.

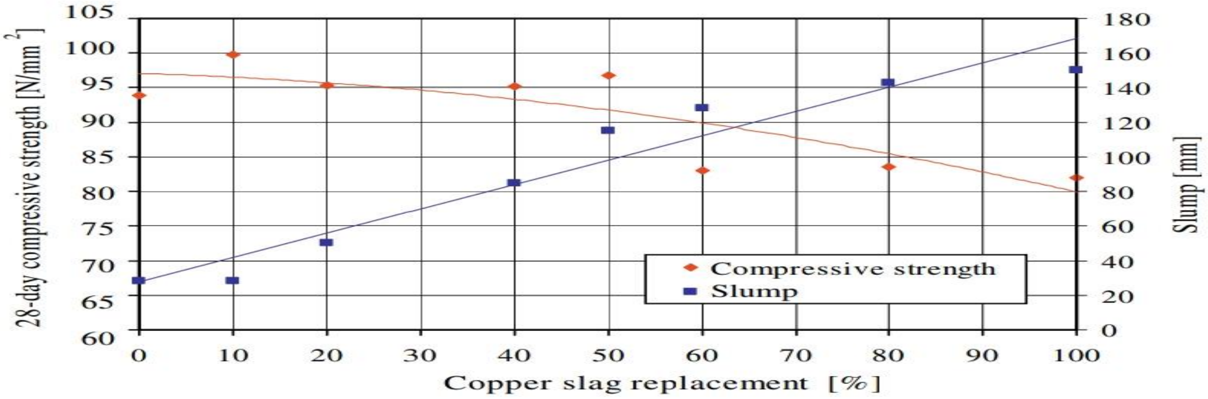


Figure 11: Compressive strength v/s CS replacement (%)

[2.7]. M. Pavan Kumar, Y.Mahesh: In this research paper author has been studied the replacement of natural resources in the manufacture of cement and sand is the present issue in the present construction scenario. Ground Granulated Blast furnace Slag (GGBS) and Copper slag are industrial by-product materials produced from the process of manufacturing copper and iron. In this study by authors an attempt has been made to minimize the cost of sand and cement with M25 concrete mixture by studying the mechanical strength behavior of this concrete mix by partially replacing with advanced mineral admixtures such as GGBS and Copper slag in concrete mixture. Authors conducted experimental study to evaluate the strength characteristics of hardened concrete and workability, properties of concrete have been studied by partially replacing sand with Copper Slag and cement with GGBS. The cement was replaced by GGBS in the range of 0-20% by weight of M25 mix cement. Sand was replaced by Copper slag in the range of 0-40% by weight of M25 mix cement. Concrete mixtures were made, tested and compared in terms of compressive strength (Fig 12), flexural and split tensile strength (Fig 13) with the conventional concrete mixture. After test results, authors have been concluded that indeed the maximum strength achieved at 30&15% of copper slag and GGBS (in %) replaced with sand and cement respectively.

Table 1: CS & GGBS replacement

% of copper slag & GGBS replacement	7 days	14 days	28 days
0	19.06	25.6	31.36
10 & 5	20.10	26.4	32.53
20 & 10	21.30	27.3	33.41
30 & 15	22.41	28.1	34.33
40 & 20	19.80	26.06	32.02

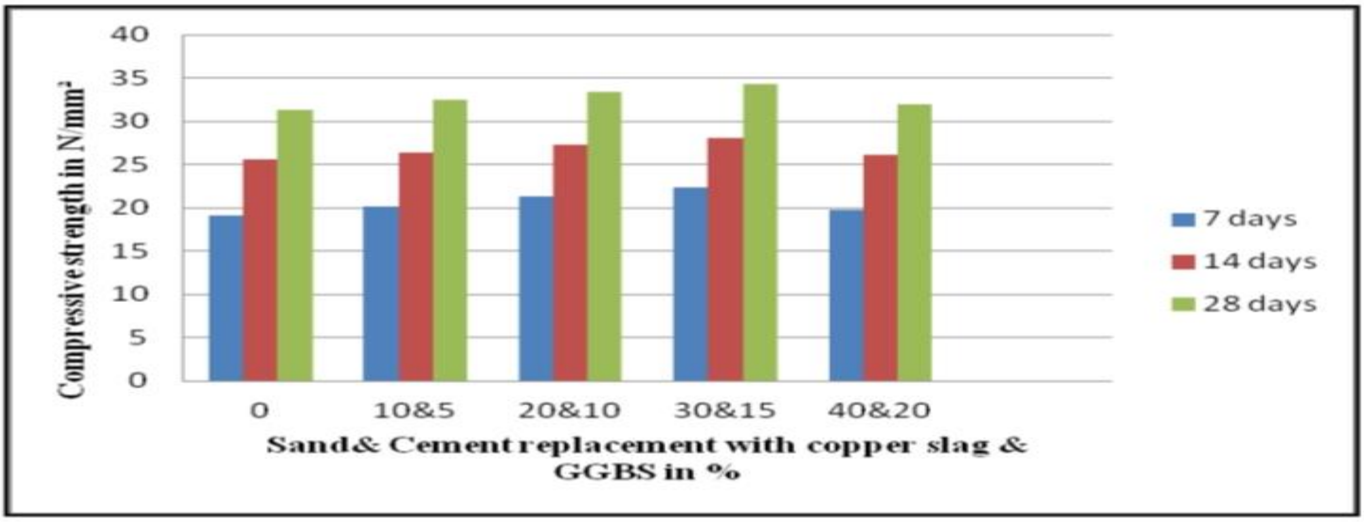


Figure 12: Compressive strength v/s GGBS and CS replacement (%)

Table 2: CS & GGBS replacement

% of copper slag & GGBS replacement	7 days	14 days	28 days
0	2.18	2.56	3.51
10 & 5	2.30	2.68	3.56
20 & 10	2.41	2.74	3.67
30 & 15	2.48	2.82	3.72
40 & 20	2.25	2.58	3.53

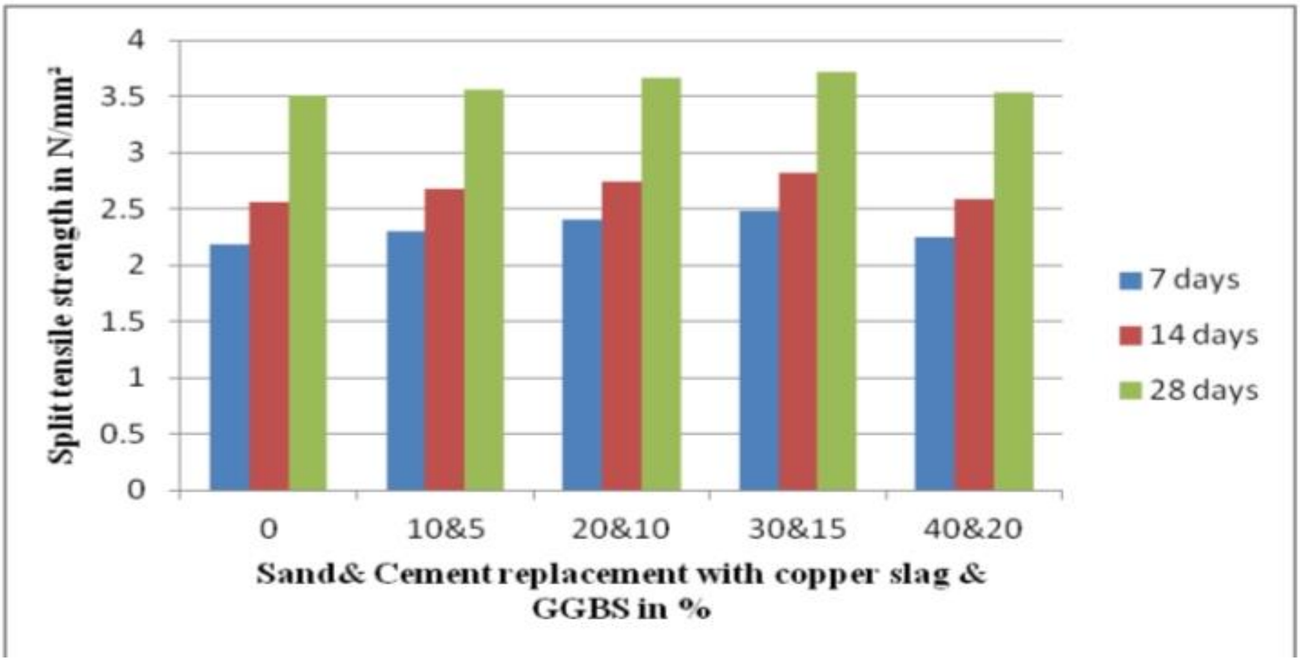


Figure 13: Split-Tensile strength v/s GGBS and CS replacement (%)

[2.8]. Jayapal Naganur, Chethan B.: In this research paper author has been studied utilization of industrial waste or secondary materials has encouraged in construction industry for the production of concrete because it can help reducing the usage of natural resources like sand. Copper slag is an industrial waste which can be used in construction Industry. In this paper author presents the results of an experimental study on the strength properties and characteristics of concrete using copper slag as partial replacement of fine aggregate (sand). For this experimental work, grade of concrete used was M20 and tests were conducted. Numerous concrete mixtures were prepared with different mix ratio of copper slag. Concrete mixtures were evaluated for workability, compressive strength (Fig 14), splitting tensile strength (Fig 15), corrosion, acid resistivity and micro structural analysis. The authors have concluded that workability increased significantly as copper slag percentage increase compared with the control mixture. A substitution of up to 40 to 50% copper slag as a fine aggregate yielded comparable strength to that of the control mixture. However addition of copper slag more than 50% resulted in strength reduction compared to conventional concrete.

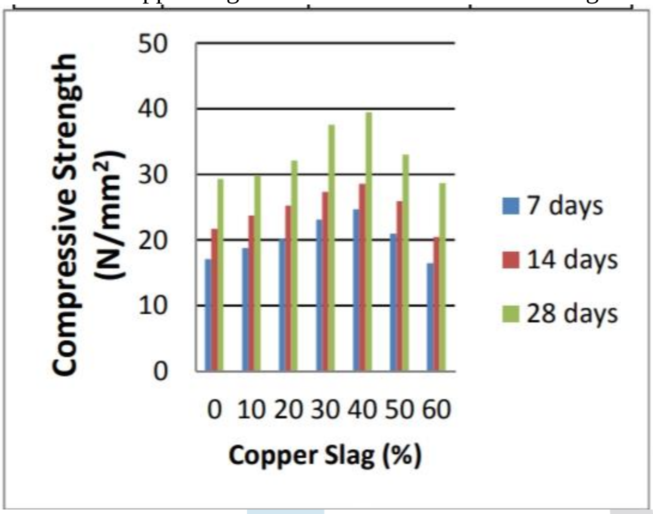


Figure 14: Compressive strength v/s CS (%)

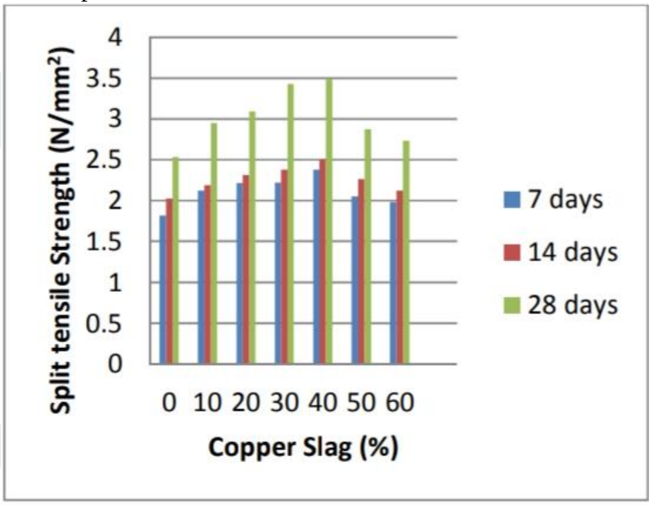
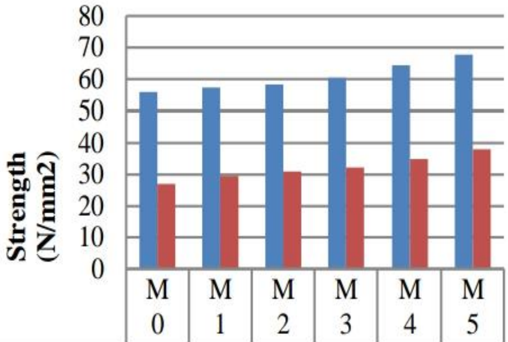


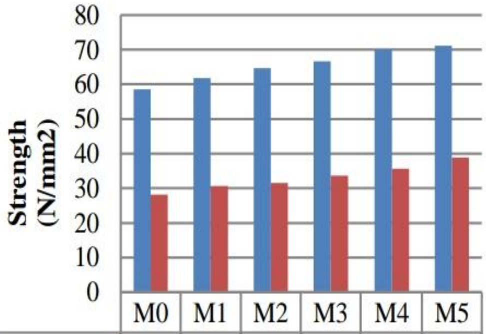
Figure 15: Split-Tensile strength v/s CS (%)

[2.9]. K.Mahendran, N.Arunachelam: In this research paper author has been studied about Geopolymer concrete being an innovative, environment friendly, sustainable and green technology in the field construction industry. The utilization of industrial by -products in the production of alkaline based concrete from the source materials like fly ash, calcined kaoline, metakaolin, Ground Granulated Blast Furnace Slag (GGBS) and filler material such as, Manufactured sand (M-Sand), quarry dust which will reduce the cost and impact to the environment. The authors have carried out investigation on Geopolymer Concrete with copper slag industrial by-products as a replacement of fine aggregates was studied. The properties of six different proportions with control mix concrete and others were 10 %, 20 %, 30 %, 40 % and 50 % sand were replaced with copper slag are compared and discussed. The authors have conclude that the mix with Copper slag shows maximum compressive strength (Fig 16) (Fig 17) and split tensile strength (Fig 18) (Fig 19) of 71.2 N/mm2 and 4.95 N/mm2 respectively which was cured at 60 ˚C, while the mixes cured at ambient temperature attains a maximum compressive strength and split tensile strength of 38.90 N/mm2 and 3.87 N/mm2 respectively.



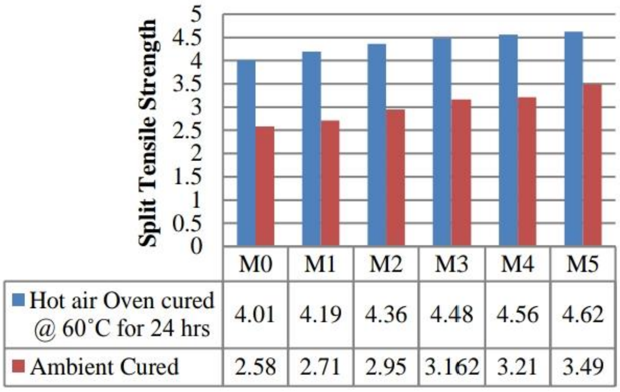
	M 0	M 1	M 2	M 3	M 4	M 5
Hot air Oven cured @ 60˚C for 24 hrs	55.8	57.3	58.3	60.4	64.4	67.8
Ambient Cured	27.01	29.56	31.03	32.21	34.91	38.02

Figure 16: 7th & 28th day Compressive strength of Geopolymer concrete



	M0	M1	M2	M3	M4	M5
Hot air Oven cured @ 60˚C for 24 hrs	58.6	61.8	64.7	66.7	70.1	71.2
Ambient Cured	28.24	30.67	31.57	33.71	35.62	38.90

Figure 17: 7th & 28th day Compressive strength of Copper slag concrete



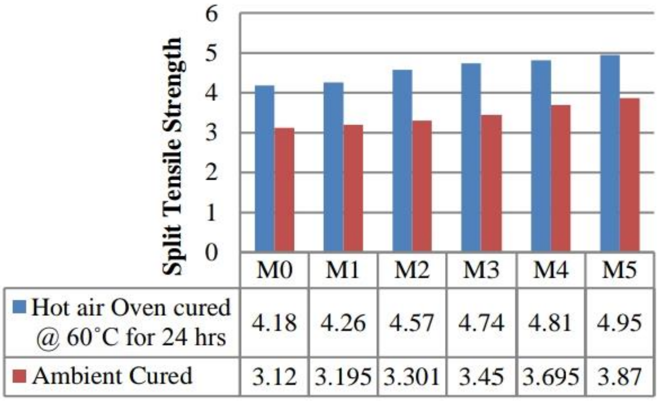
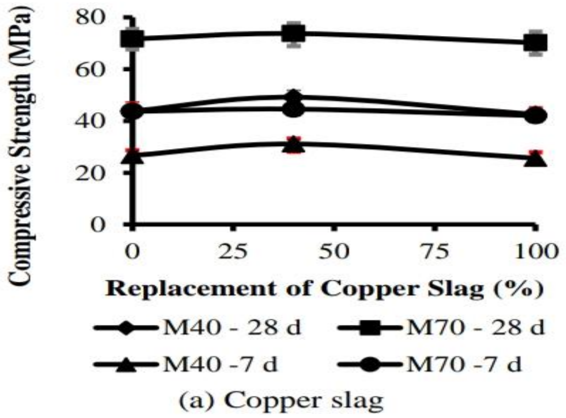


Figure 18: 7th & 28th day Split-Tensile strength of Geopolymer concrete   Figure 19: 7th & 28th day Split-Tensile strength of Copper slag concrete

[2.10]. Job Thomas, Nassif N. Thaickavila and Mathews P. Abraham: In this research paper author has been studied ever-increasing cost of natural sand and the environmental impacts of extracting manufactured sand (quarry sand) calls for exploring the potential to use alternative materials like industrial waste as fine aggregates in concrete. Ferrous slag and Copper slag are industrial by products obtained from the smelting process of iron and copper respectively. A large quantity of copper slag and ferrous slag is generated by industries which are then dumped as waste in landfills and pits and this intern effects the environment. Ferrous slag and Copper slag have similar kind of physical and chemical properties as natural sand and also shows pozzolanic behavior. The compressive strength test (Fig 20) and split tensile strength (Fig 21) test results indicate that the strength properties are not affected by 40% or 100% replacement of quarry sand with iron slag or copper slag. However, 40% replacement of quarry sand with iron slag or copper slag in concrete is recommended by authors considering the durability aspects of concrete.



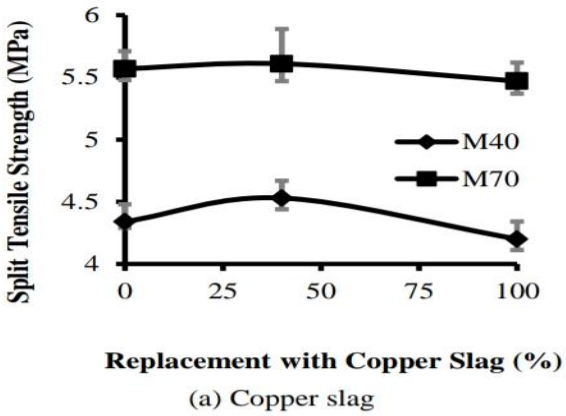


Figure 20: Compressive strength v/s CS replacement (%)   Figure 21: Split-Tensile strength v/s CS replacement (%)

[2.11]. Zine Kiran Sambhaji, Prof. Pankaj B. Autade: In this research work the authors made an extensive study using copper slag has been carried out to investigate strength, workability and durability. Copper slag is an industrial by-product material which is considered as waste is produced from the process of manufacturing of copper or smelting of copper. Copper slag partial or full replacement with sand in M25 grade concrete. In this paper the authors studied the effect of using copper slag as a fine aggregate on properties of cement mortars & concrete mixtures were prepared with varied proportions of copper slag ranging from 0to100%; (0CS+100S)%, (10CS+90S)%, (20CS+80S)%,(30CS+70S)%, (40CS+60S)%, (50CS+50S)%, (60CS+40S)%, (70CS+30S)%, (80CS+20S)%, (90CS+10S)%, (100+0S)%. Form the test result authors have concluded that the 50% CS+50% S gives optimum proportional of CS that can be used as a replacement substitute material for fine aggregate in concrete. We can use any proportion of CS replacement as per our requirement for creating concrete; because authors have concluded that the all results of replacement of CS indicate that the overall strength increased (Fig 22) is more than the control mix. However the strength peaks between 30-50% of CS replacements.

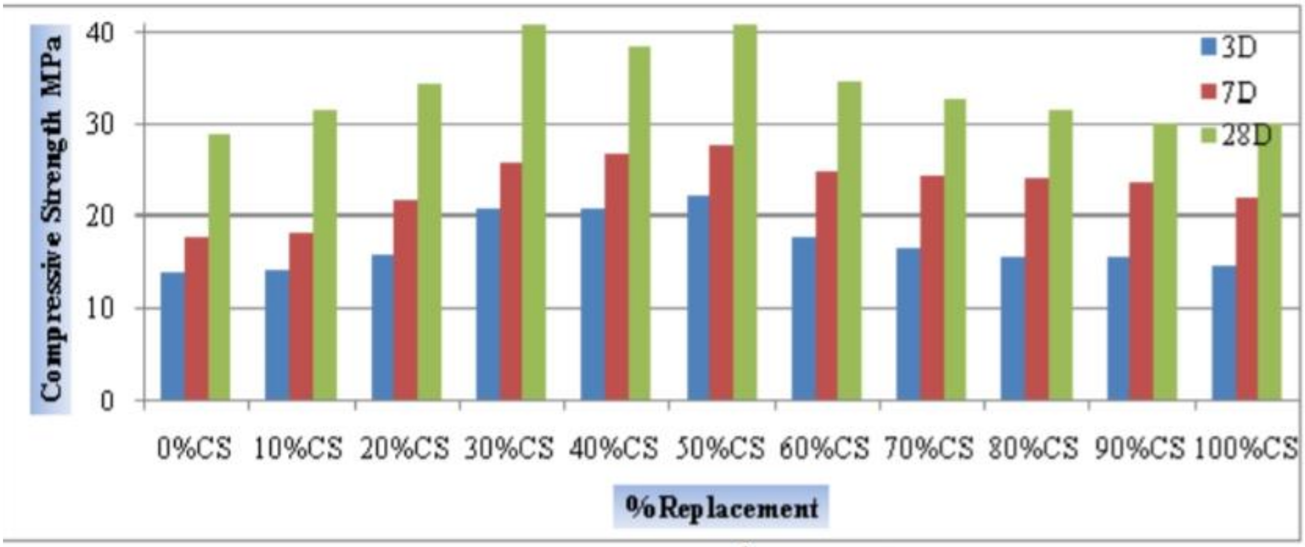


Figure 22: Compressive strength v/s CS replacement(%)

[2.12]. Bhosale Mahesh Bhimarao, Sathe Akash Shrikant, Dr.Santosh K Patil: In this research paper authors made an extensive study using copper slag has been carried out to investigate strength, workability and durability. Copper slag is an industrial byproduct material also considered as waste produced from the process of smelting of copper. In this paper authors studied the effect of using copper slag as a partial or full replacement with fine aggregate on properties of cement mortars & concrete mixtures were prepared with varied proportions of copper slag ranging 20-70%; (20CS+80S)%, (30CS+70S)%, (40CS+60S)%, (50CS+50S)%, (60CS+40S)%,(70CS+30S)%.The cubes were prepared & de-molded after 24 hours and properly cured. Form the test results authors have concluded that the 50%CS+50%S gives optimum proportional of CS that can be used as a replacement material for fine aggregate in concrete mixture (Fig 23). We can use any proportion of CS replacement as per our requirement for creating concrete mixture, because authors have concluded that the all result of replacement of CS is more than control mix.

Table 3: CS replacement with Compressive strength (Mpa)

Sr.No.	Percentage Replacement	Compressive Strength (Mpa)
01.	20%	28.65
02.	30%	33.50
03.	40%	31.40
04.	50%	38.75
05.	60%	28.75
06.	70%	26.85

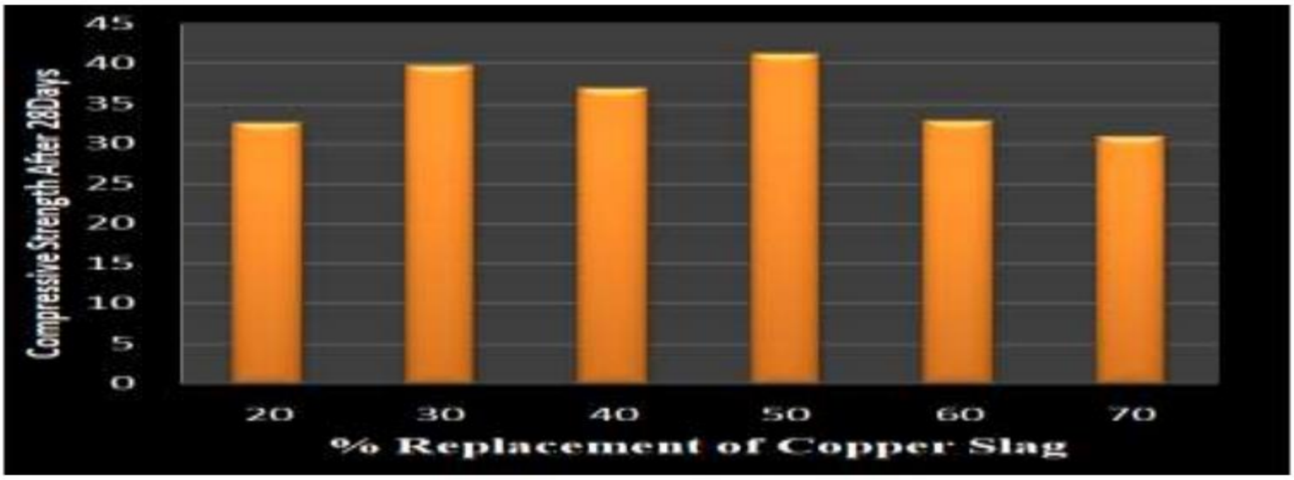


Figure 23: Compressive strength v/s CS replacement(%)

[2.13]. V.Karthik, Dr.G.Baskar: In this research work authors has been studied utilization of industrial waste materials has encouraged in construction field for the making of concrete because it contributes to reducing the consumption of natural resources.

SCC can accelerate the placement and reduce the labor needs for compaction and finishing. Copper slag is an industrial byproduct material also considered as waste produced from the process of smelting of copper. The objective of authors was to study the strength properties of self-compacted copper slag concrete. For this purpose M30 grade concrete was used and test were conducted for various proportion of sand replaced by copper slag at 0%, 20%, 40%, 60%, 80%, 100% and admixture used here is silica fume. Authors have concluded that at 60% CS replacement maximum compressive strength (Fig 24) and tensile strength (Fig 25) is obtained.

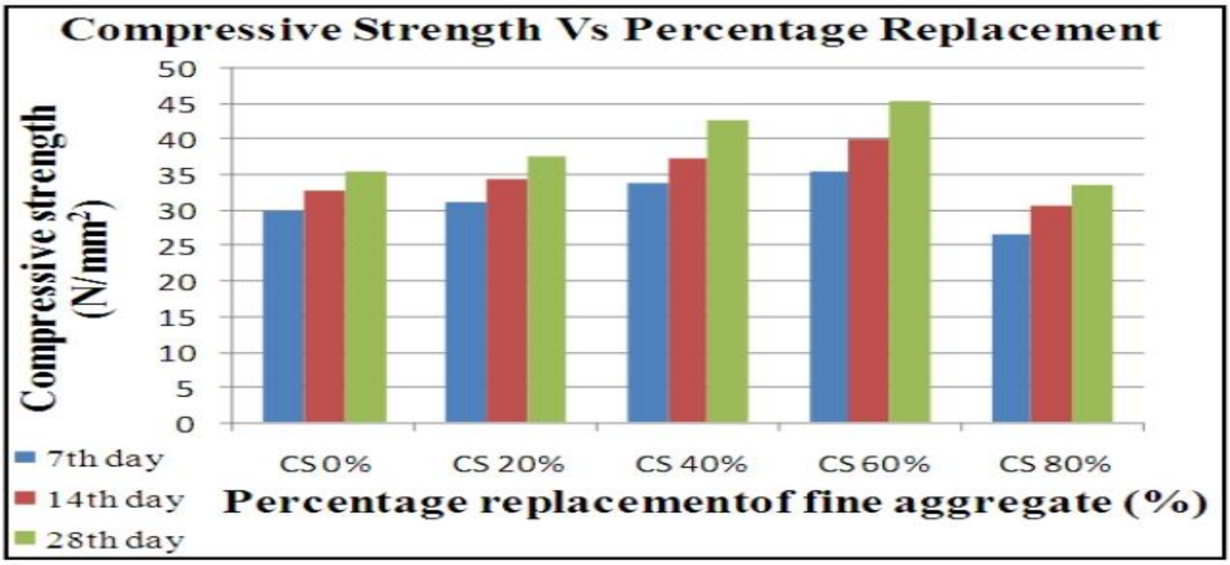


Figure 24: Compressive strength v/s fine aggregate replacement(%)

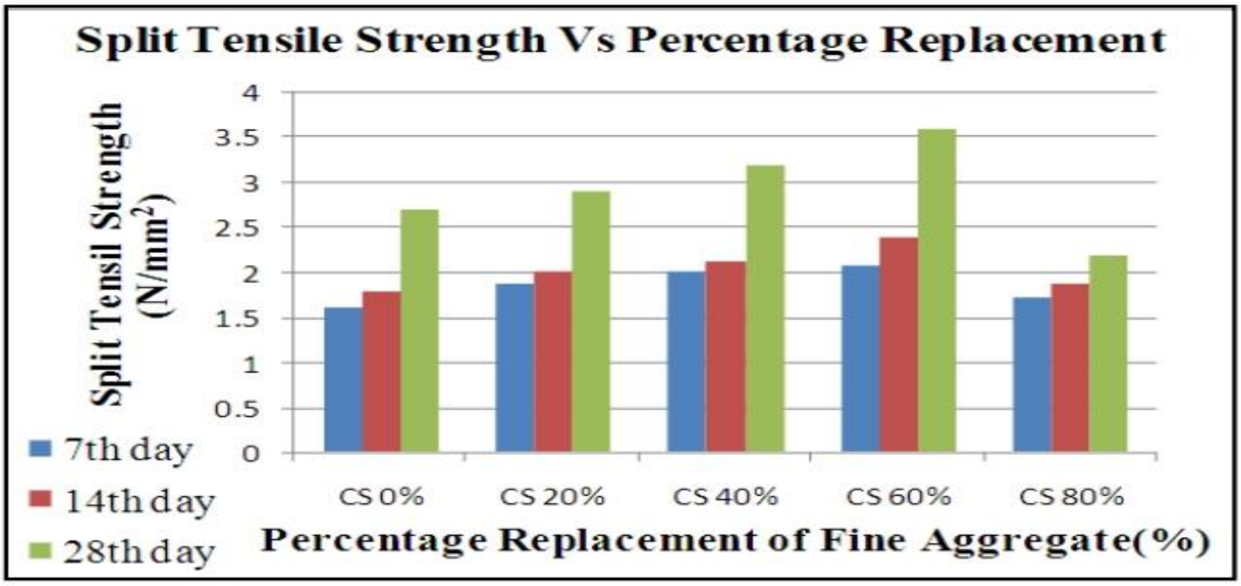


Figure 25: Split-Tensile strength v/s fine aggregate replacement(%)

[2.14]. R.V. Balendran, F.P. Zhou, A. Nadeem, A.Y.T. Leung: In this research paper author has been studied the results of a series of experiments conducted to investigate the effectiveness of fiber inclusion in the improvement of mechanical or strength performance of concrete with regard to kind of concrete and specimen size. The compressive strength of the concrete mixes varied between 90 and 115 MPa and the fiber content was 1% by volume. Three-point bending test on notched beams and Splitting tests on prisms were carried out on specimens of varying sizes to examine the size effect on toughness, splitting strength and flexural strength. The authors indicate that the low volume of fiber has little effect on compressive strength but improve remarkably splitting tensile strength, flexural strength and toughness. The increase in splitting tensile strength (Fig 26), flexural strength and toughness index for lightweight concrete seems much higher than that of normal aggregate concrete. The effect of size on prism splitting tensile strength is not as impactful beyond a critical size. There are effects on toughness index and flexural strength due to size. As the specimen size increases, splitting and flexural strengths appear to decrease, and fracture behavior tends to be more brittle. Authors have concluded that steel fibers do increase strength for a certain limit depending upon size and shape of the concrete.

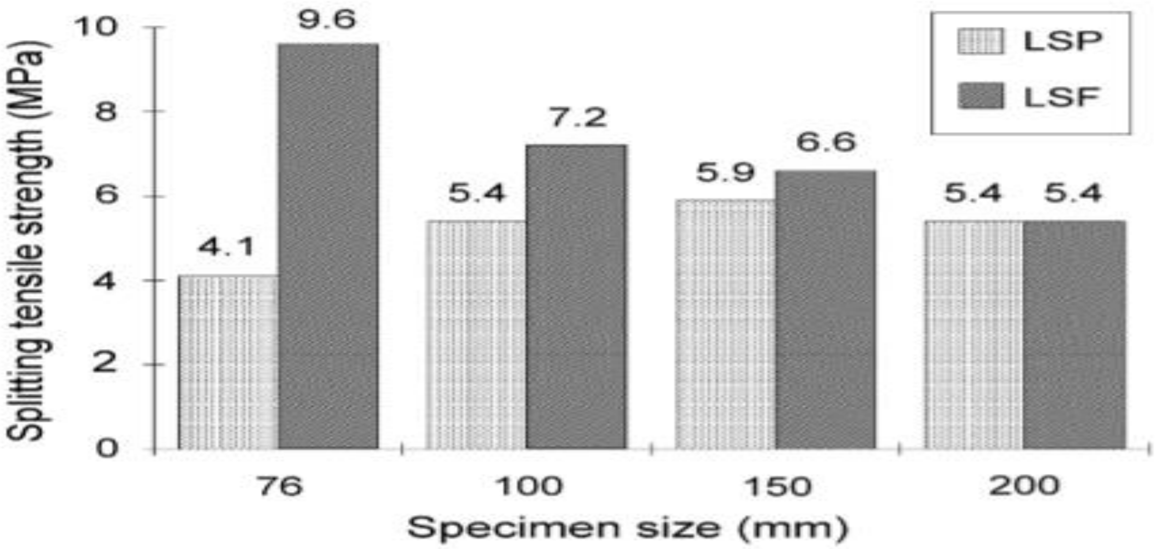


Figure 26: Split-Tensile strength v/s Specimen size (mm)

[2.15]. A.M. Shende, A.M. Pande, M. Gulfam Pathan: In this research paper author has made investigation for concrete graded M-40 having mix proportion 1:1.43:3.04 with water cement ratio 0.35 to study the flexural strength, Split tensile strength, compressive strength of 0-3% volume fraction of hook tain of steel fiber reinforced concrete (SFRC) containing fibers. A relationship between aspect ratio vs. Compressive strength (Fig 27), aspect ratio vs. flexural strength, aspect ratio vs. Split tensile strength (Fig 28) represented graphically. Authors have concluded that result data clearly shows percentage increase in 28 days Compressive strength, Flexural strength and Split Tensile strength for M-40 Grade of Concrete.

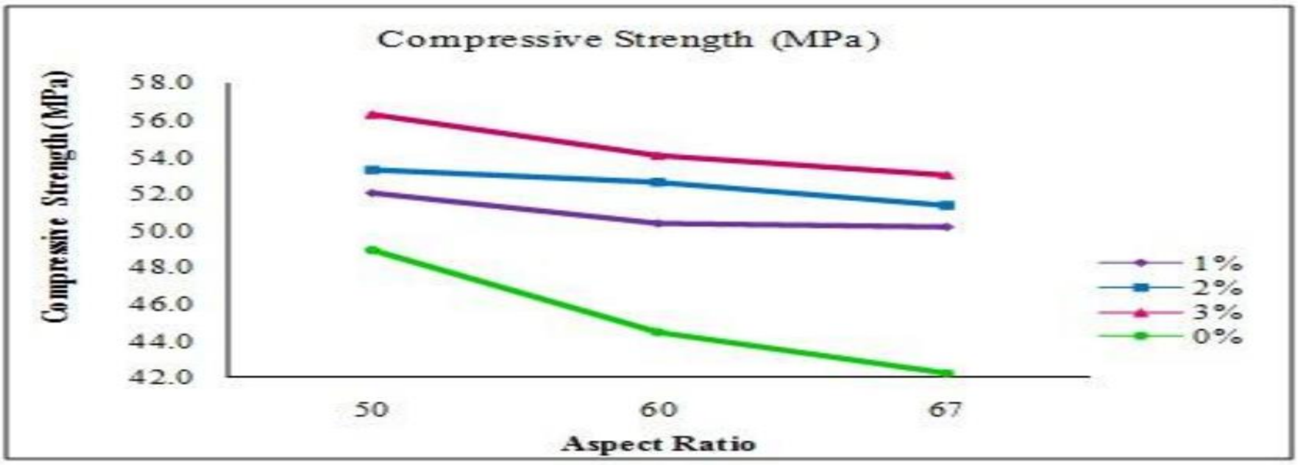


Figure 27: Compressive strength v/s Aspect Ratio

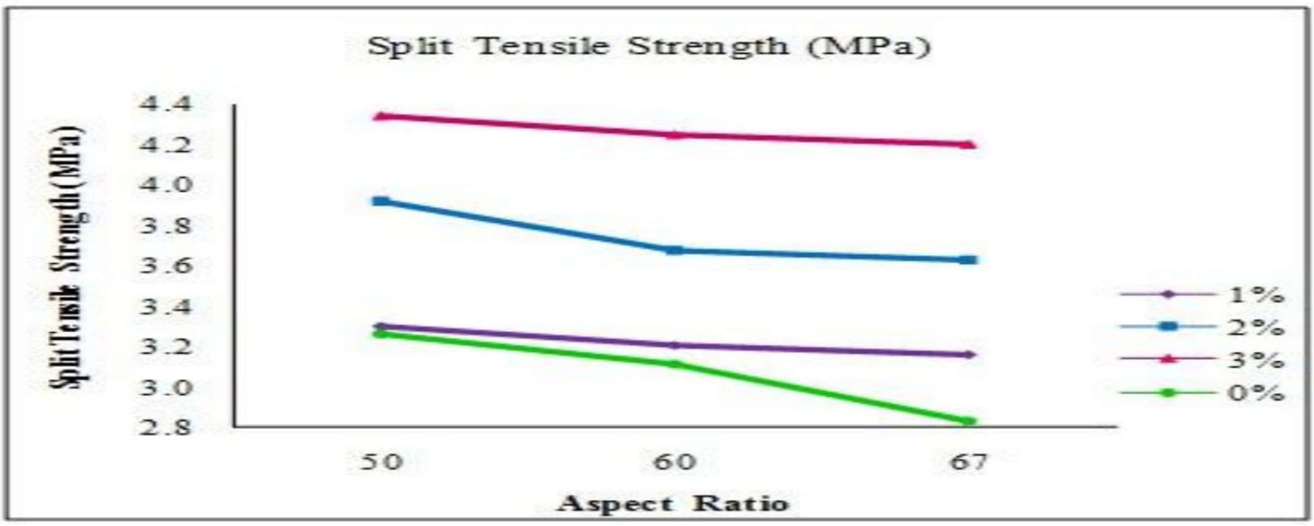


Figure 28: Split-Tensile strength v/s Aspect Ratio

[2.16]. Nguyen Van CHANH: In this research paper author has been studied about the mechanic properties, technologies, and applications of SFRC are discussed. It is now well known that important property of steel fiber reinforced concrete (SFRC) is its resistance to cracking and crack continuation. As a result of this ability to arrest cracks, fiber composites possess increased extensibility and tensile strength (Fig 29), both at first crack and at ultimate, particular under flexural loading; and the fibers are able to hold the blocks together even after radical cracking. The authors have concluded to impart to the fiber composite pronounced post – cracking ductility which is unheard of in ordinary concrete. The concrete's characteristic change from a brittle to a ductile type of material behavior would increase the energy absorption drastically as the ability of fiber composite to resist repeatedly applied load, shock or impact load changes drastically.

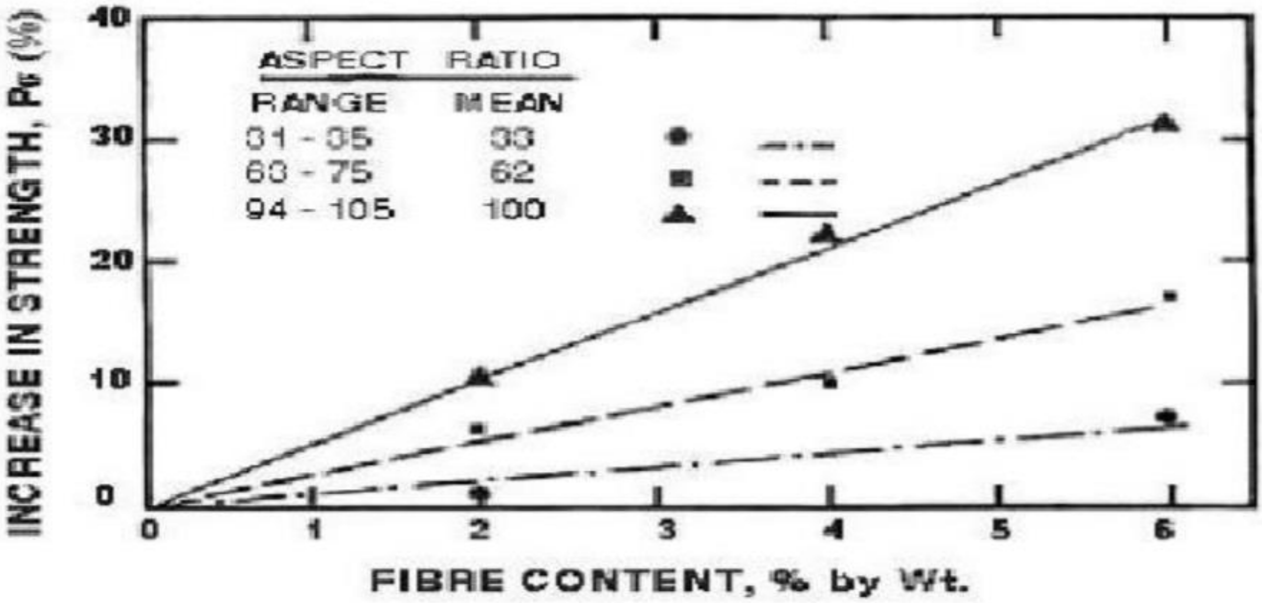


Figure 29: Increase in strength v/s Fiber content

[2.17]. Bensaid Boulekbache, Mostefa Hamrat, Mohamed Chemrouk, Sofiane Amziane: In this research paper author has been examining the influence of the yield stress and compressive strength on the behavior of fiber-reinforced concrete (FRC) versus direct shear. The parameters studied are the steel fiber contents, the aspect ratio of fibers and the concrete strength. Prismatic specimens of dimensions 10*10*35 cm made of concrete of various yield stress reinforced with steel fibers hooked at the ends with three fiber volume fractions (i.e. 0%, 0.5% and 1%) and two aspects ratio (65 and 80) were tested to direct shear. Three types of concretes with various compressive strength and yield stress were tested a self-compacting concrete (SCC), a high strength concrete (HSC) and an ordinary concrete (OC). Authors concluded that the shear strength and ductility are affected and have been improved very significantly by the fiber contents, fiber aspect ratio and concrete strength. As the compressive strength (Fig 30) and the volume fraction of fibers increase, the shear strength increases. However, yield stress of concrete has an important influence on the orientation and distribution of the fibers in the matrix. Due to Concrete with good workability the ductility was much greater for ordinary and self-compacting concretes. When the fibers are perpendicular to the shear plane it has significantly improved the ductility in direct shear as it depends on the fiber orientation. On the contrary, for concrete with poor workability, an inadequate distribution and orientation of fibers occurred, leading to a weak contribution of the fibers to the direct shear behavior.

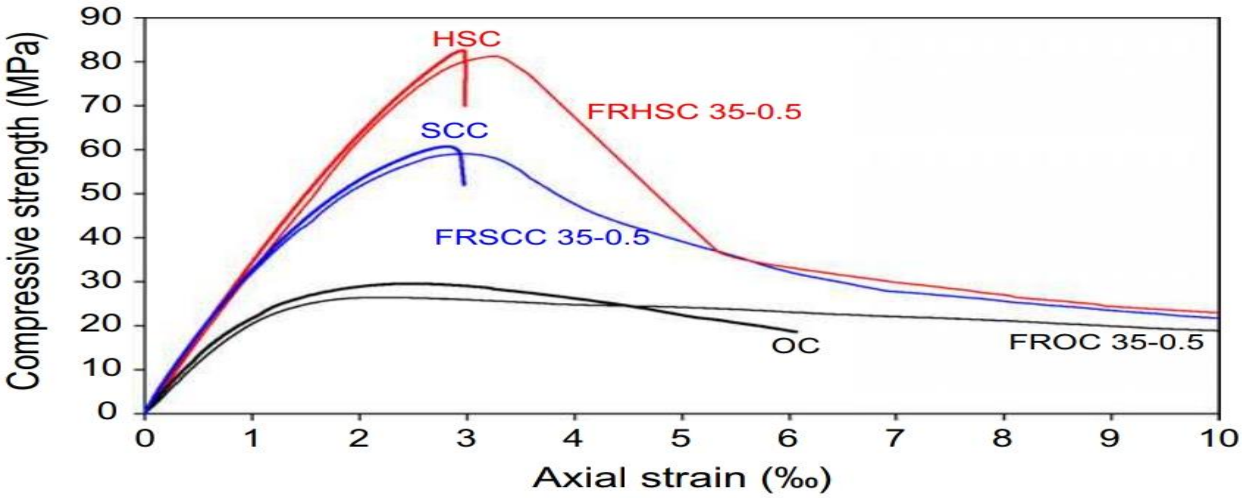


Figure 30: Compressive strength v/s Axial strain(%)

[2.18]. Hamid Pesaran Behbahani: In this research paper author has been studied that in many situations it is prudent to combine fiber reinforcement with conventional steel reinforcement to improve performance. Identifying the advanced properties of the steel fiber reinforced concrete, further studies on steel fiber reinforced concrete (SFRC) has been started since the last three decades. The authors present an overview of the mechanical properties of Steel Fiber Reinforced Concrete (SFRC), its advantages, and its applications. Authors have concluded that SFRC are indeed more effective than conventional concrete for greater compressive stress (Fig 31) and increase in overall strength (Fig 32).

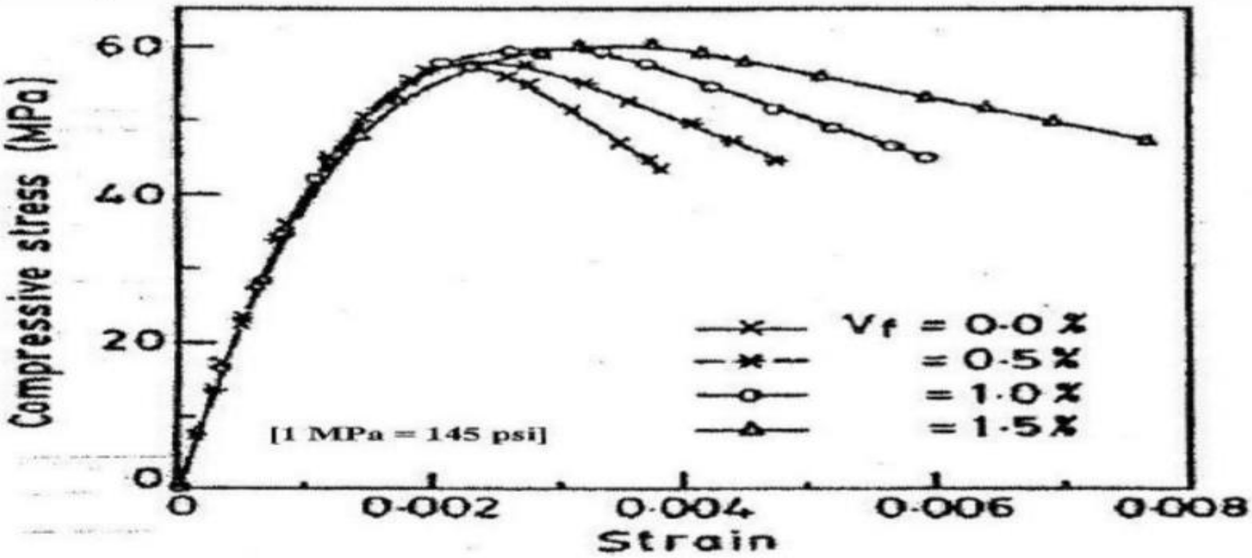


Figure 31: Compressive stress v/s Strain

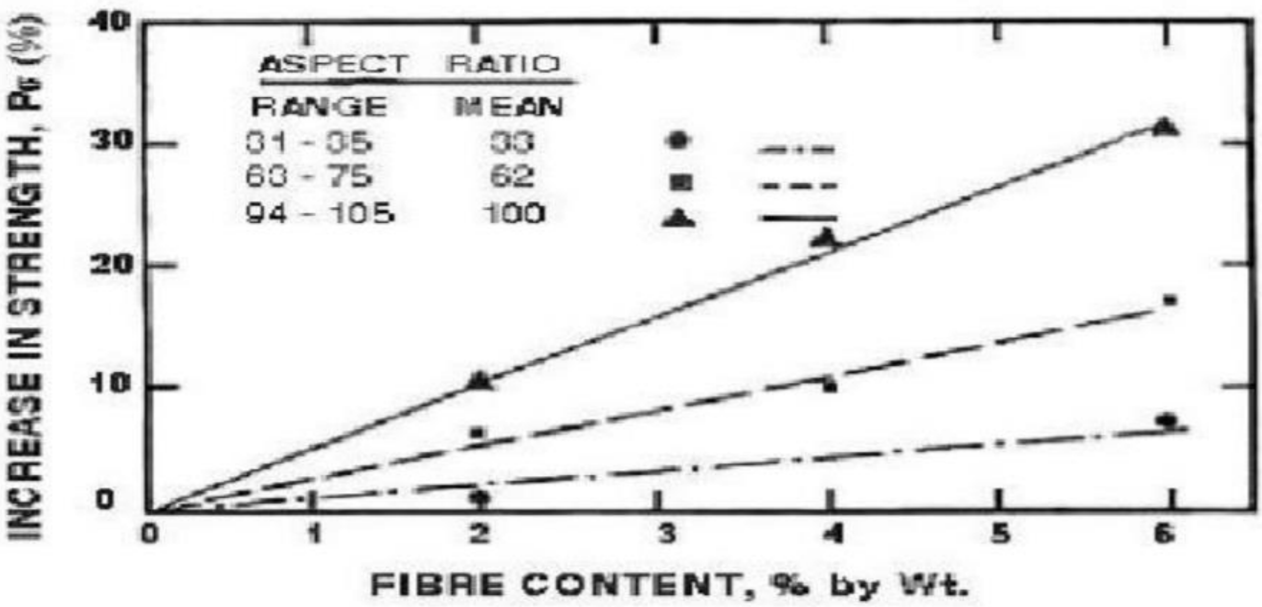


Figure 32: Increase in strength v/s Fiber content(%)

[2.19]. Shende.A.M , Pande.A.M: In this research paper author has been made an investigation conducted to study the tensile strength of steel fiber reinforced concrete (SFRC) containing fibers of 0%, 1%, 2% and 3% volume fraction of Hook taint steel fibers of 50, 60 and 67 aspect ratio are presented. Cylinder specimens of size 150 mm diameters and 300 mm length were tested under compression testing machine as per I.S. 5161959. A result data obtained has been analyzed and compared with control beam (0% fibers). A relationship aspect ratio vs. Tensile strength (Fig 33) represented graphically and governing equation of graphs and prepared Mathematical model for Tensile strength can be used to predict Tensile strength of SFRC by using appropriate values of aspect ratio (A) and percentage of fibers (Vf). Authors have concluded that at 3% aspect ratio (50) maximum tensile strength is obtained.

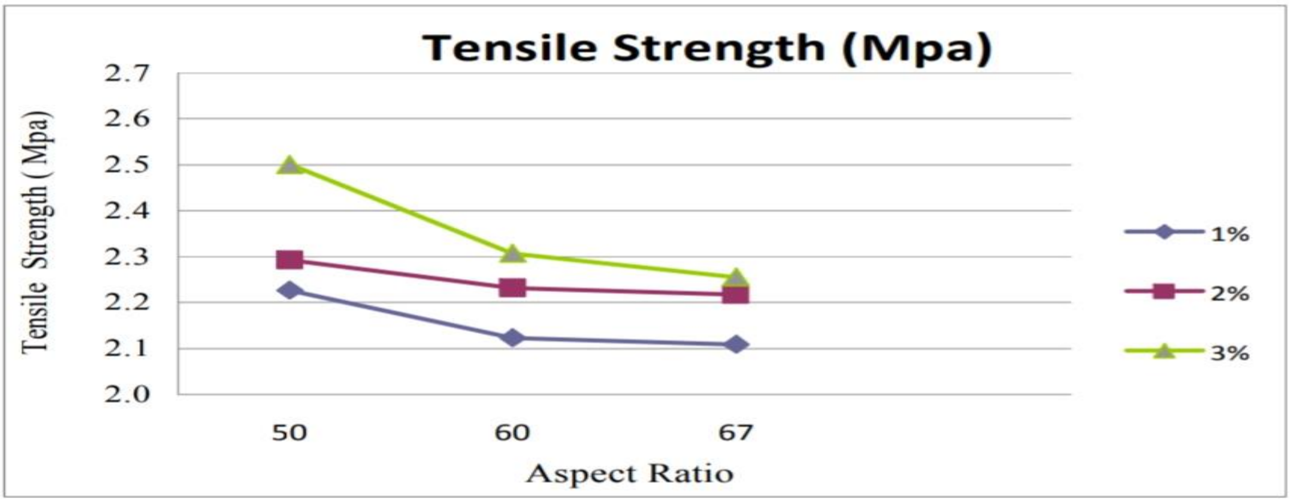


Figure 33: Split-Tensile strength v/s Aspect Ratio

[2.20]. Jianming Gao, Wei Suqa & Keiji Morino: In this research paper authors has been studied basic information on the mechanical properties of steel fiber-reinforced, high-strength, lightweight concrete with compressive up to 85.4 MPa and flexural strengths 11.8 MPa. The influence of steel fiber on Poisson's ratio and modulus of elasticity of concrete are investigated and toughness flexural fracture is computed. Authors have concluded that the effect of fiber volume fraction (v) and aspect ratio on flexural strength and fracture toughness is extremely prominent, compressive strength is only slightly improved, and tensile (Fig 34) & compressive strength ratio is obviously enhanced. Authors observed that the flexural deflection corresponded to ultimate load increased with the increase of V and I due to fiber arresting cracking, the shape of the descending branch of load-deflection tend towards gently.

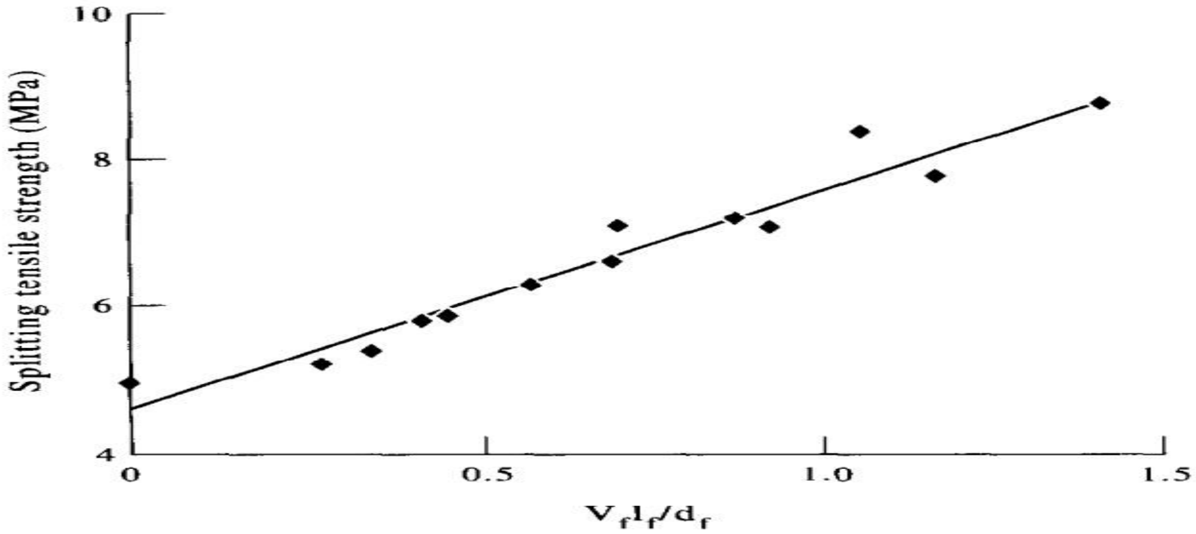


Figure 34: Split-Tensile strength v/s Effect of Vf lf/dr

[2.21]. Waqas Arshad Tanoli, Amjad Naseer, Fazli Wahab: In this research paper author has been studied the tensile reinforcement compensates for the lack of tensile ability, increased brittleness and decreased strain capacity. With the progression in nearly all the fields of science, it is the need of time to redefine concrete and its constituents with such additional materials that will help to improve its strength and other properties, one such component is steel fiber. Steel fibers were added in different percentage i.e. 0.1 %, 0.5 % and 1 % along with control samples (0% Fibers). Tensile and Compressive strength calculation of all samples and their comparison with conventional concrete strength calculations was the primary objective of the authors carrying out research. Short beams and cylinders were casted & tested under Universal Testing Machine (UTM) for tensile and compressive strength. Authors evaluated results and compared with the conventional sample. Authors concluded that there was slight increase in the compressive strength (Fig 35) while increase in tensile strength (Fig 36) was on higher side due addition of steel fibers.

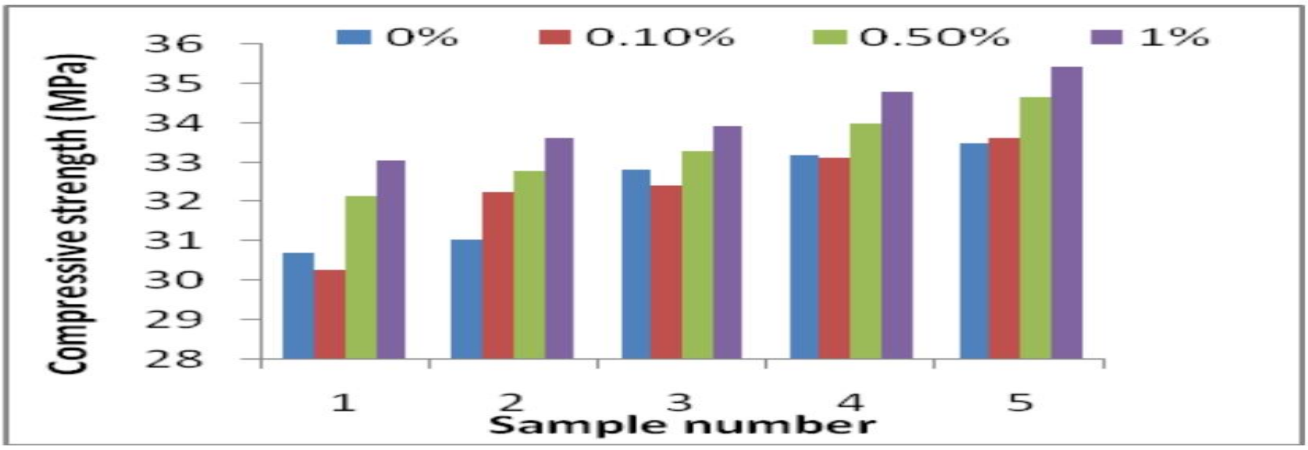


Figure 35: Compressive strength v/s Sample number

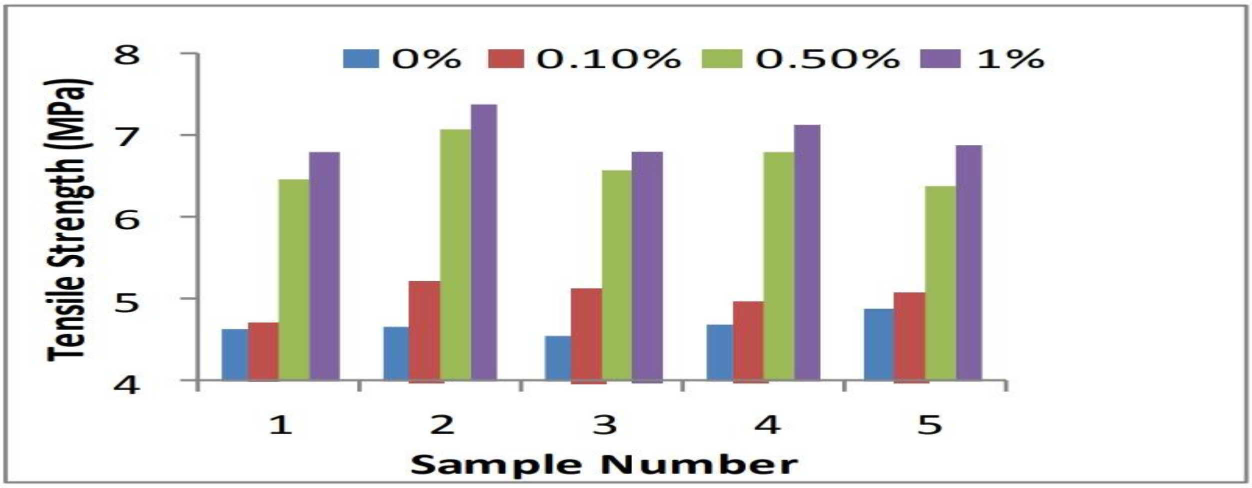


Figure 36: Tensile strength v/s fine aggregate replacement(%)Sample number

[2.22]. Xinxin Ding, Changyong Li, Minglei Zhao, Jie Li, Haibin Geng and Lei Lian: In this research paper authors has been studied that due to the mechanical properties related to distribution of steel fibers in concrete matrix and study of tensile strength of self-compacting steel fiber reinforced concrete (SFRC) is significant for the civil engineering application. The volume fraction varied from 0.4% to 1.4% of the hooked-end steel fibers with length of 25.1 mm, 29.8 mm and 34.8 mm were used. The splitting tensile test of cube specimen and the axial tensile test of notched sectional prism specimen were carried out. Authors have concluded that the axial tensile strength was higher than the splitting tensile strength for the same self-compacting SFRC, the axial tensile work and toughness was not related to the length of steel fiber. Finally, the equations for the prediction of tensile strength of self-compacting SFRC are proposed considering the fiber distribution and fiber factor (Fig 37), and the adaptability of splitting tensile test for self-compacting SFRC is discussed.

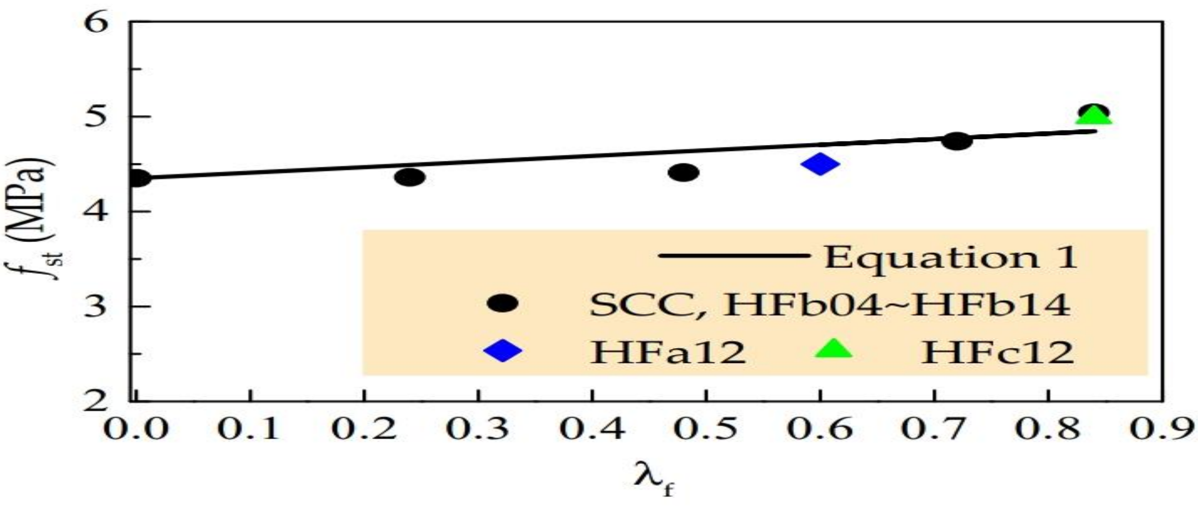


Figure 37: Changes of Split-Tensile strength v/s fiber factor

[2.23]. Og˘uz AkNn Du¨zgu¨n, Ru¨stem Gu¨l, Abdulkadir Cu¨ neyt Aydin: In this research paper author has been studied the effect of steel fibers on the mechanical properties of pumice aggregate concrete was investigated. To determine the effect of steel fiber ratio on the strength properties of concrete, natural aggregate by volume was substituted with (1) 25%, 50%, 75%, and 100% pumice ratios (2) 0.5%, 1.0%, and 1.5% steel fiber ratios were used by volume of the sample and (3) also, 300 kg/m3 cement dosage and 3T0.5 cm slump were used. Authors have concluded that increasing pumice aggregate ratio decreased the unit weight and the strength properties of the concretes when compared to the conventional sample that contains no fiber, with the increase of steel fiber ratio in the mixtures unit weight, compressive strength (Fig 38), splitting-tensile strength (Fig 39) and flexural strength of concretes increased up to 8.5%, 21.1%, 61.2% and 120.2%, respectively. Modulus of elasticity and deformation capability was decreased with increase of pumice aggregate and steel fiber ratio in the mixture.

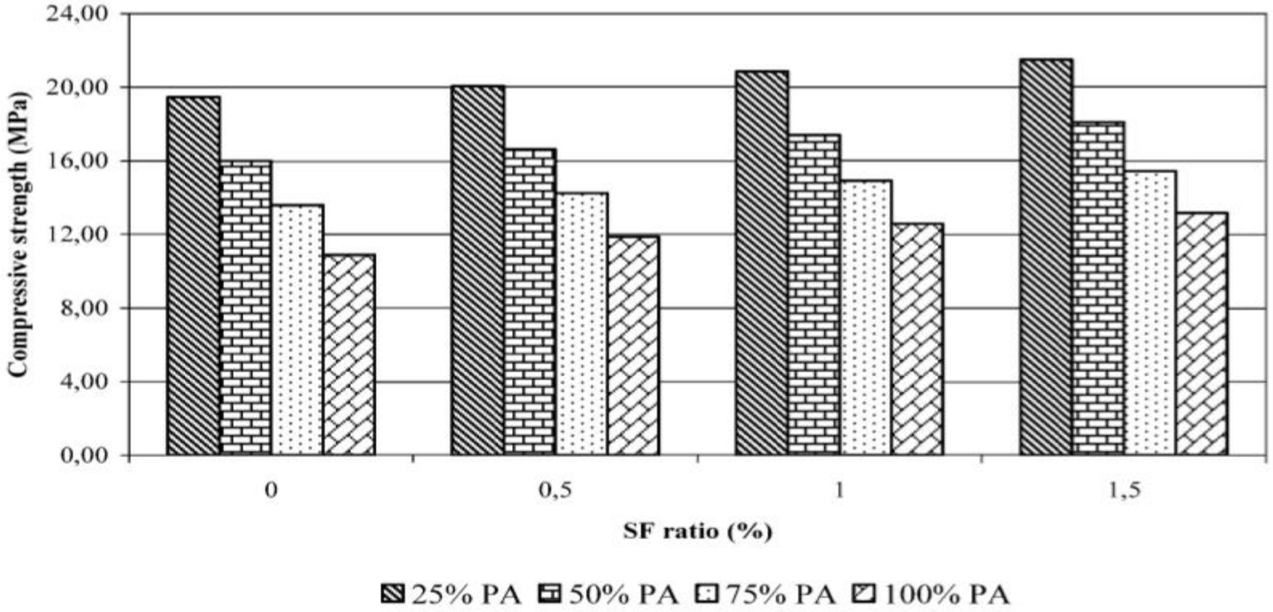


Figure 38: Compressive strength v/s SF Ratio(%)

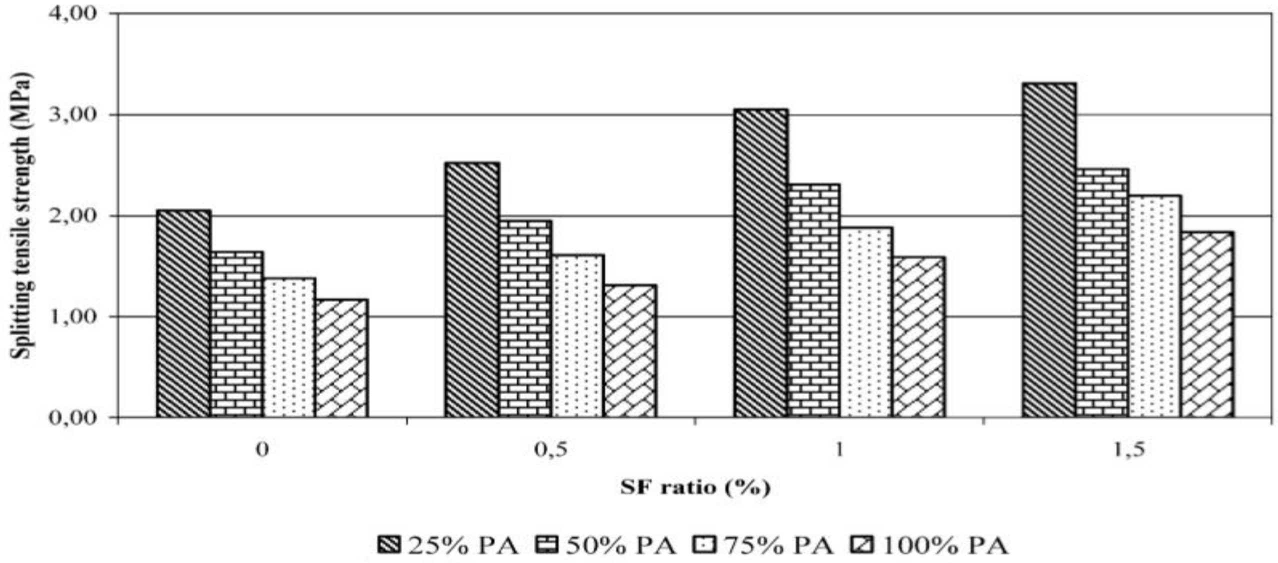


Figure 39: Split-Tensile strength v/s SF Ratio(%)

[2.24]. Ahsana Fathima K M & Shibi Varghese: In this research paper author has been studied the results of an experimental study investigating the effects of steel fibers and polypropylene fibers on the mechanical properties of concrete. Experimental program consisted of split tensile strength test, compressive strength test and flexural strength tests on polypropylene fiber reinforced concrete and steel fiber reinforced concrete. Three types of fibers used are crimped steel fiber of length 25mm, hooked end steel fiber of length 30mm and enduro-600 polypropylene of length 50mm with aspect ratio 50. This study consisted of compressive strength test (Fig 40) and split tensile strength test (Fig 41) on hybrid fiber reinforced concrete with 0.5% polypropylene fibers and 0.75% steel fibers at 7th & 28th day. Authors have concluded that the results indicate that indeed the tensile strength increases in SFRC as compared to conventional concrete.

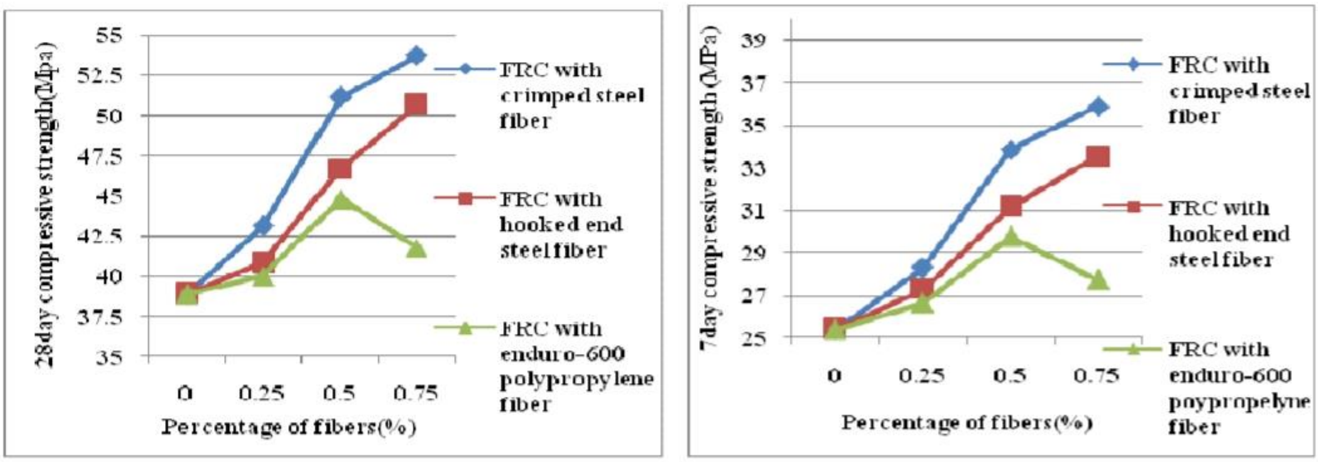


Figure 40: 7th & 28th day Compressive strength v/s Steel Fiber(%)

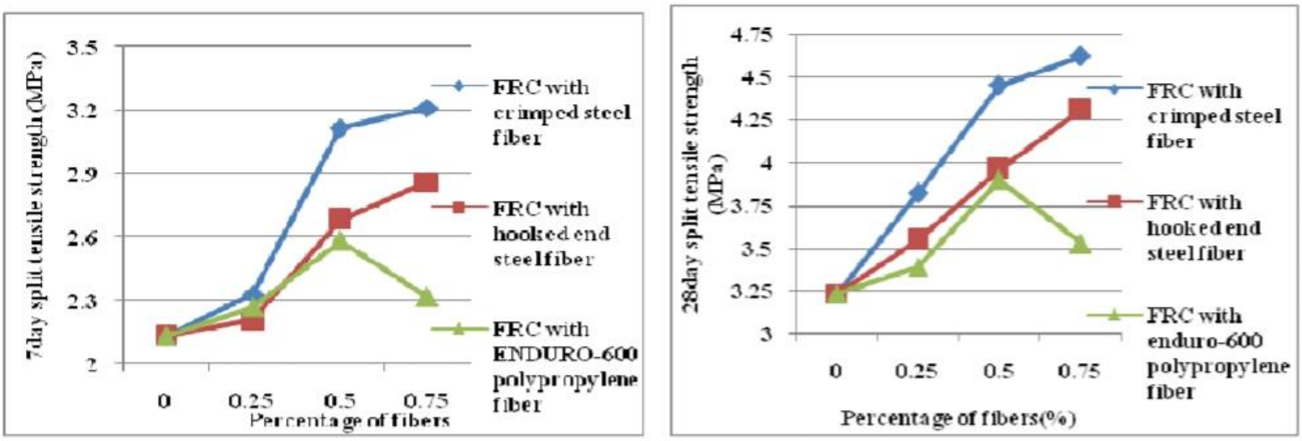


Figure 41: Variation of 7th & 28th day split tensile strength with Different Percentage of Steel and Polypropylene fiber

[2.25]. Lucyna Domagała: In this research paper author has been studied the Structural light-weight aggregate concrete (SLWAC) is an alternative building material to normal-weight. This paper focuses on the influence of steel fibers on modification of properties of structural lightweight concrete with sintered fly ash aggregate. Two different concrete mixtures, producing various levels of compressive strength and matured composite density, were modified with three addition of fibers: 30, 45 and 60 kg/m3. The authors have concluded that despite relatively low volume content of fibers, a considerable increase of flexural and tensile splitting strength (Fig 42) was observed. Fibers also improved concrete shrinkage as well as post-peak deformability in uni-axial compression. However, the modulus of elasticity of SLWAC was not affected by fiber addition.

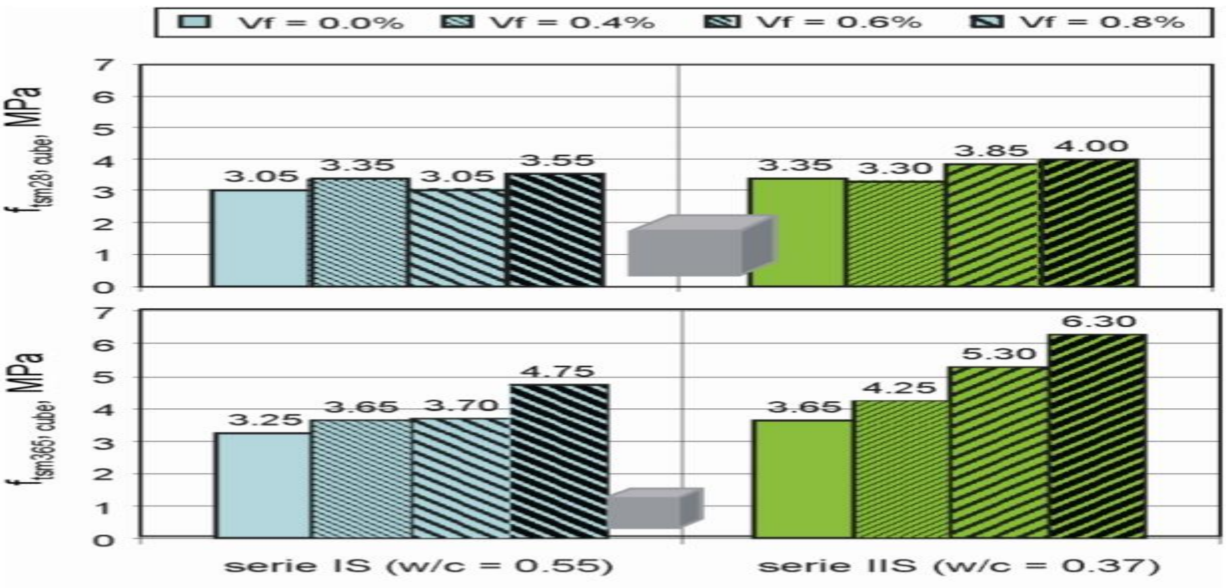


Figure 42: Mean tensile splitting strength of plain lightweight concrete and steel fiber reinforced lightweight concrete

III. CONCLUSION

From the review of the literature collection, it is observed that the percentage of Copper Slag and Steel Fiber added plays an important role in increment or decrement of Compressive Strength and Tensile Strength. From all these research papers some conclusions are drawn:

1. From this study authors has been conclude that indeed the compressive strength increases compared to conventional concrete up to 60% replacement of CS after that the strength decreases due to lack of cohesiveness; the tensile strength also increases at a certain level. And it has been also concluded that flow of concrete reduces with time as the copper slag content increases the flow increases comparatively. Authors have concluded that keeping in view the strength and other important requirement of PQC such as cohesiveness, segregation, finishing, texturing, shrinkage and abrasion resistance, it was concluded that a blend of stone dust with copper slag content up to 40% could be used as fine aggregate for PQC as well as DLC.
2. Authors has concluded that a mixture of stone dust with copper slag content up to 40% could be used as partial replacement for fine aggregate for PQC as well as DLC.
3. Authors have concluded that the maximum compressive strength of concrete attained at 40% replacement of fine aggregate at 7 and 28 days (Fig 5). The split tensile strength (Fig 6) and the flexural strength (Fig 7) were also obtained higher strength at 40% replacement level at 28 days. At 40% fine aggregate replacement the rebound hammer test showed higher compressive strength, this is due to uniformity of the concrete. For 40% CS replacement for fine aggregate the pulse wave velocity is higher, it is understood that it is free from pores the density of the mix is high.
4. The authors have concluded that the compressive strength of concrete is generally improved, compared with the control mix, with the increase of copper slag up to a certain copper slag content beyond which the strength generally reduces (Fig 8). Segregation and bleeding due to the significant increase of workability was seen in concrete mixes because of high copper slag percentage.
5. Authors have been concluded that at 40% Copper Slag replacement maximum compressive strength is achieved and beyond that strength deteriorate.
6. Therefore, for conclusion authors has recommended that 40 wt% of copper slag can use as replacement of sand in order to obtain HPC with good strength and durability properties.
7. After test results, authors have been concluded that indeed the maximum strength achieved at 30&15% of copper slag and GGBS (in %) replaced with sand and cement respectively.
8. The authors have concluded that workability increased significantly as copper slag percentage increase compared with the control mixture. A substitution of up to 40 to 50% copper slag as a fine aggregate yielded comparable strength to that of the control mixture. However addition of copper slag more than 50% resulted in strength reduction compared to conventional concrete.
9. The authors have conclude that the mix with Copper slag shows maximum compressive strength (Fig 16) (Fig 17) and split tensile strength (Fig 18) (Fig 19) of 71.2 N/mm2 and 4.95 N/mm2 respectively which was cured at 60 ˚C, while the mixes cured at ambient temperature attains a maximum compressive strength and split tensile strength of 38.90 N/mm2 and 3.87 N/mm2 respectively.
10. Authors have concluded that the compressive strength test (Fig 20) and split tensile strength (Fig 21) test results indicate that the strength properties are not affected by 40% or 100% replacement of quarry sand with iron slag or copper slag. However, 40% replacement of quarry sand with iron slag or copper slag in concrete is recommended by authors considering the durability aspects of concrete.
11. Authors have concluded that the all results of replacement of CS indicate that the overall strength increased (Fig 22) is more than the control mix. However the strength peaks between 30-50% of CS replacements.
12. Form the test results authors have concluded that the 50%CS+50%S gives optimum proportional of CS that can be used as a replacement material for fine aggregate in concrete mixture (Fig 23). We can use any proportion of CS replacement as per our requirement for creating concrete mixture, because authors have concluded that the all result of replacement of CS is more than control mix.
13. Authors have concluded that at 60% CS replacement maximum compressive strength (Fig 24) and tensile strength (Fig 25) is obtained.
14. Authors have concluded that steel fibers do increase strength for a certain limit depending upon size and shape of the concrete.
15. Authors have concluded that result data clearly shows percentage increase in 28 days Compressive strength, Flexural strength and Split Tensile strength for M-40 Grade of Concrete.
16. The authors have concluded to impart to the fiber composite pronounced post – cracking ductility which is unheard of in ordinary concrete. The concrete's characteristic change from a brittle to a ductile type of material behavior would increase the energy absorption drastically as the ability of fiber composite to resist repeatedly applied load, shock or impact load changes drastically.
17. Authors concluded that the shear strength and ductility are affected and have been improved very significantly by the fiber contents, fiber aspect ratio and concrete strength. As the compressive strength (Fig 30) and the volume fraction of fibers increase, the shear strength increases. However, yield stress of concrete has an important influence on the orientation and distribution of the fibers in the matrix. Due to Concrete with good workability the ductility was much greater for ordinary and self-compacting concretes. When the fibers are perpendicular to the shear plane it has significantly improved the ductility in direct shear as it depends on the fiber orientation. On the contrary, for concrete with poor workability, an inadequate distribution and orientation of fibers occurred, leading to a weak contribution of the fibers to the direct shear behavior.
18. Authors have concluded that SFRC are indeed more effective than conventional concrete for greater compressive stress (Fig 31) and increase in overall strength (Fig 32).

19. Authors have concluded that at 3% aspect ratio (50) maximum tensile strength is obtained.
20. Authors have concluded that the effect of fiber volume fraction (v) and aspect ratio on flexural strength and fracture toughness is extremely prominent, compressive strength is only slightly improved, and tensile (Fig 34) & compressive strength ratio is obviously enhanced. Authors observed that the flexural deflection corresponded to ultimate load increased with the increase of V and I due to fiber arresting cracking, the shape of the descending branch of load-deflection tend towards gently.
21. Authors concluded that there was slight increase in the compressive strength (Fig 35) while increase in tensile strength (Fig 36) was on higher side due to addition of steel fibers.
22. Authors have concluded that the axial tensile strength was higher than the splitting tensile strength for the same self-compacting SFRC, the axial tensile work and toughness was not related to the length of steel fiber. Finally, the equations for the prediction of tensile strength of self-compacting SFRC are proposed considering the fiber distribution and fiber factor (Fig 37), and the adaptability of splitting tensile test for self-compacting SFRC is discussed.
23. Authors have concluded that increasing pumice aggregate ratio decreased the unit weight and the strength properties of the concretes when compared to the conventional sample that contains no fiber, with the increase of steel fiber ratio in the mixtures unit weight, compressive strength (Fig 38), splitting-tensile strength (Fig 39) and flexural strength of concretes increased up to 8.5%, 21.1%, 61.2% and 120.2%, respectively. Modulus of elasticity and deformation capability was decreased with increase of pumice aggregate and steel fiber ratio in the mixture.
24. Authors have concluded that the results indicate that indeed the tensile strength increases in SFRC as compared to conventional concrete.
25. The authors have concluded that despite relatively low volume content of fibers, a considerable increase of flexural and tensile splitting strength (Fig 42) was observed. Fibers also improved concrete shrinkage as well as post-peak deformability in uni-axial compression. However, the modulus of elasticity of SLWAC was not affected by fiber addition.

IV. COMMENTS

1. Compressive strength can be increased by replacement of Copper Slag with sand but after a certain limit of replacement the strength deteriorates.
2. Tensile strength can be increased to a certain limit. If the alignment, spacing and placement of Steel Fibers are maintained, the tensile strength highly increases.
3. Copper Slag and Steel Fiber together can increases both compressive and tensile strength which can pave way for new developments of high strength concrete.
4. The pits and dump yards used for dumping wastes like Copper Slag can be saved and used for other purposes. Usage of these materials ensures reuse of the metals and metal wastes to help curb down environmental impact.

REFERENCES

[1] Alaa M. Rashad. “A Brief Review On Blast-Furnace Slag And Copper Slag As Fine Aggregate In Mortar Andconcrete Based On Portland Cement”, Building Materials Research and Quality Control Institute, Housing & Building National Research Center, HBRC, Cairo, Egypt, Rev.Adv.Mater.Sci. 44(2016)221-237.
[2] Binod Kumar. “Properties of pavement quality concrete and dry lean concrete with copper slag as fine aggregate”, International Journal of Pavement Engineering, 2013, ISSN: 1029-8436, Vol. 14, No. 8, 746–751.
[3] Tamil Selvi P*, Lakshmi Narayani P and Ramya G. “Experimental Study on Concrete Using Copper Slag as Replacement Material of Fine Aggregate”, J Civil Environ Eng, ISSN: 2165-784X JCEE, an open access journal, Volume 4 • Issue 5 • 1000156.
[4] K. S. Al Jabri. “Copper slag as fine aggregate for high performance concrete”, WIT Transactions on The Built Environment, ISSN 1743-3509, Vol 85, © 2006 WIT Press.
[5] Binaya PatnaikȦ*, Seshadri Sekhar.TȦ and Srinivasa RaoḂ. “An Experimental Investigation on Optimum Usage of Copper Slag as Fine Aggregate in Copper Slag Admixed Concrete”, International Journal of Current Engineering and Technology, E-ISSN 2277 – 4106, P-ISSN 2347 - 5161 ©2014 INPRESSCO®.
[6] Khalifa S. Al-Jabri a,*, Makoto Hisada b, Salem K. Al-Oraimi a, Abdullah H. Al-Saidy a. “Copper slag as sand replacement for high performance concrete”, Elsevier Ltd, K.S. Al-Jabri et al. / Cement & Concrete Composites 31 (2009) 483–488.
[7] M. Pavan Kumar1, Y.Mahesh2. “The Behavior of Concrete by Partial Replacement of Fine Aggregate with Copper Slag and Cement with GGBS”, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 3 Ver. III (May. - Jun. 2015), PP 51-56.
[8] Jayapal Naganur1, Chethan B. A.2. “Effect of Copper Slag as a Partial Replacement of Fine Aggregate on the Properties of Cement Concrete”, International Journal of Research (IJR), ISSN 2348-6848Vol-1, Issue-8, September 2014.
[9] K.Mahendran1, N.Arunachelam2. ” Study on Utilization of Copper Slag as Fine Aggregate in Geopolymer Concrete”, International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.53 (2015).
[10] Job Thomas, Nassif N. Thaickavila and Mathews P. Abrahamb. “Copper or ferrous slag as substitutes for fine aggregates in concrete”, Advances in Concrete Construction, ISSN: 2287-5301 Vol. 6, No. 5 (2018) 545-560.
[11] Zine Kiran Sambhaji, Prof. Pankaj B. Autade. “Effect of Copper Slag as a Fine Aggregate on Properties of Concrete”, International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2763 Issue 08, Volume 3 (August 2016).
[12] Bhosale Mahesh Bhimarao1, Sathe Akash Shrikant2, Dr.Santosh K Patil3. “Replacement Of Copper Slag With Fine Aggregate”, International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395-0056 p-ISSN: 2395-0072 Volume: 07 Issue: 03 | Mar 2020.

[13] V.Karthik, Dr.G.Baskar. "Investigation On Strength Properties Of Self Compacting Concrete With Copper Slag As Fine Aggregate", International Journal Of Civil Engineering Research And Development (IJCERD), ISSN 2248 – 9428(Print) ISSN-2248-9436 (Online) Volume 5, Number 1, January - April (2015), pp. 18-25.
[14] R.V. Balendran _, F.P. Zhou, A. Nadeem, A.Y.T. Leung. " Influence of steel fibers on strength and ductility of normal and lightweight high strength concrete", Elsevier Science Ltd., Building and Environment 37 (2002) 1361–1367, PII: S0360-1323(01)00109-3.
[15] A.M. Shende1, A.M. Pande2, M. Gulfam Pathan3. " Experimental Study on Steel Fiber Reinforced Concrete for M-40 Grade", International Refereed Journal of Engineering and Science (IRJES), ISSN (Online) 2319-183X, (Print) 2319-1821 Volume 1, Issue 1 (September 2012), PP. 043-048.
[16] Nguyen Van CHANH. "Steel Fiber Reinforced Concrete", 1Dr.Eng. Deputy Dean, Faculty of Civil Engineering, Ho Chi Minh City University of Technology, email: nvchanh@hcmut.edu.vn.
[17] Bensaid Boulekbache a, Mostefa Hamrat a, Mohamed Chemrouk b, Sofiane Amziane. "Influence of yield stress and compressive strength on direct shear behavior of steel fiber-reinforced concrete", Elsevier Ltd., Construction and Building Materials 27 (2012) 6–14.
[18] Hamid Pesaran Behbahani, Behzad Nematollahi, Majid Farasatpour. "Steel Fiber Reinforced Concrete: A Review", Azad University-Shahr-e-kord Branch, Islamic Republic of Iran.
[19] Shende.A.M. 1 , Pande.A.M 2. "Experimental study and prediction of tensile strength for steel fiber reinforced concrete", International Journal Of Civil And Structural Engineering, ISSN 0976 – 4399 Volume 1, No 4, 2011.
[20] Jianming Gao, Wei Suqa & Keiji Morino. "Mechanical Properties of Steel Fiber-reinforced, High-strength, Lightweight Concrete", Elsevier Science Ltd., PII: S0958-9465(97)00023-1.
[21] WAQAS ARSHAD TANOLI, AMJAD NASEER, FAZLI WAHAB. "Effect of Steel Fibers on Compressive and Tensile Strength of Concrete", International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol. 03, No. 04, October 2014.
[22] Xinxin Ding 1,*, Changyong Li 1 , Minglei Zhao 2, Jie Li 2,* , Haibin Geng 1 and Lei Lian 3. "Tensile Behavior of Self-Compacting Steel Fiber Reinforced Concrete Evaluated by Different Test Methods", Crystals 2021, 11, 251.
[23] Og˘uz AkNn Du¨zgu¨n *, Ru¨stem Gu¨ l, Abdulkadir Cu¨ neyt Aydin. "Effect of steel fibers on the mechanical properties of natural lightweight aggregate concrete", Elsevier B.V., Materials Letters 59 (2005) 3357 – 3363.
[24] Ahsana Fathima K M1 & Shibi Varghese2. "Behavioural Study Of Steel Fiber And Polypropylene Fiber Reinforced Concrete", IMPACT: International Journal of Research in Engineering & Technology (IMPACT: IJRET), ISSN(E): 2321-8843; ISSN(P): 2347-4599 Vol. 2, Issue 10, Oct 2014, 17-24.
[25] Lucyna Domagała. "Modification of Properties of Structural Lightweight Concrete with Steel Fibres", Journal of Civil Engineering and Management, ISSN 1392-1541 print/ISSN 1822-3605 online 2011 Volume 17(1): 36–44 10.3846/13923730.2011.553923.