AN EXPERIMENTAL INVESTIGATION ON M30 CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT WITH RECYCLED FINE RUBBER POWDER AND ADDITION OF POLYPROPELENE FIBERS

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Abstract: *The concrete is one of the most widely used construction materials consist of cement, fine aggregate, course aggregate due to scarcity of construction material available in market. Now a day we go for replacement methods in cement (or) either in sand. These replacement methods are done by supplementary materials (or) waste materials generated from various industries. This paper represents the study of replacements materials called rubber powder (RP). Which is generated in large scale from industries. The wastage of rubber materials is hazardous to environment and disposal is difficult, in this case we can replace the waste materials of rubber powder form in place of cement partially 0%,5%,10%,15%,20%,25% and addition of Poly Propylene Fibre's.*

In addition to this rubber powder (RP), Super Plasticizer is added to the concrete, for better workability and also acts as water reducing agent in order maintain water cement ratio. In this work the Workability, Compressive Strength, Spilt Tensile Strength, Flexural Strength of concrete was Studied by with Different percentages of Rubber Powder and Super Plasticizer.

Keywords: **Rubber Powder, Compressive Strength, Split Tensile Strength, Flexural strength.**

1. INTRODUCTION

Sustainable development and environmental conservation became essential priorities of modern society at the end of the twentieth century. Civil engineering, especially the construction materials industry, plays a critical role in building sustainability, pollution reduction, natural resource conservation, and energy conservation. In this context, the primary issues confronting the construction materials industry are primarily linked to high OPC usage and associated high carbon dioxide emissions. Regarding the first point, concrete has been for decades the commonly used material for construction in the world, and the global production of concrete has reached a value of more than 1 ton of concrete per person on the planet. Overall, the cement companies are producing nearly 3 billion tons/year [2]. this led to the emission of almost 2 billion tons of CO2 (6–7% of global emissions from CO2) in the process. Several studies have described the enhancement of process efficiency and the increase in usage of different waste materials as a cement substitute as ways to mitigate the greenhouse effect of cement production. According to a recently announced TechSci report, the tire marketplace in Egypt is anticipated to cross USD 1 billion through 2020. Egypt's automotive marketplace is one of the conspicuous markets in the African mainland because of its huge marketplace size and its geological area which spans Asia. Arab Republic of Egypt was the 3rd biggest vehicle creating the marketplace in Africa, after Morocco and South Africa in 2013. Arab Republic of Egypt produces 20 million waste tires/year and barely 10% of those are recycled [8]. Because of their three-dimensional cross linked structure, which makes them non-biodegradable, used tyres pose a significant challenge for developed countries around the world in terms of use and disposal.

The most noticeable hazard accompanying with the abandoned disposal and buildup of a bulky number of tires is the motivator for huge fires, a fact tremendously harmful to the environment. Because of the environmental concerns associated with the global disposal of these tyres, there is a growing interest in tyre rubber recycling for economic reasons. The rubber in tires is vulcanized and cannot be melted or dissolved, which makes recycling challenging. As a result, a huge number of used, worn-out tires are ground for the benefits of expanding their applications. Outdoor flooring and pavements, sports tracks, road building, and other applications including ground or powdered tire rubber fell into the sectors with minimal demand and added value. Rubber components have been used as a basic part of the structure in a variety of building industries. This material has been used as an acoustic absorber in concert hall buildings, bridges (buffer), waterproofing, and road filling, among other applications. Research to date on the replacement of aggregates by discarded tire rubber is known as "Rubcrete". Rubcrete has provided contradictory findings. Some properties are boosted in Rubcrete in comparison to concrete, including ductility, damping ratio, energy dissipation, toughness, and impact resistance. The modulus of elasticity, compressive and tensile strength, on the other hand, are limited.

Owing to the differences in chemical composition and physical properties of admixtures such as silica fume, fly ash, marble dust and rubber particles, they have diverse effects on the durability, mechanical, physico-chemical and rheological properties on concrete matrix. Although there are many ways to recycle tyres, recent research in the structural materials field has concentrated on using crumb rubber from recycled tyres as a partial substitute for coarse aggregates. It is determined that a waste material like worn-out tires may enhance the basic properties of concrete. The data presented in this research showed that there is great potential for the utilization of tires as aggregates. Used tyres were thought to provide much more potential for value-adding and cost recovery because they could be used to substitute more costly materials like rock aggregates.

1.1 Rubber Powder:

Rubber has the potential to become a permanent member of the concrete family due to a wide range of desirable properties such as flexibility, light weight, and ease of availability. Using rubber aggregates decreased the workability of the resultant mix, but this problematic issue can be dealt with the usage of certain plasticizers. The impact of partial replacement of coarse aggregates in concrete is studied by untreated tire rubber aggregates. Rubber aggregates have a lower specific gravity and bulk density than natural coarse aggregates, according to research. When the use of rubber granules in concrete is increased, the density of the concrete decreases. Correspondingly, lightweight concrete was acquired which assists to decrease the weight of the structure.

Using rubber aggregates in concrete, resulting in decreasing the compressive strength but increasing toughness of concrete. It was discovered that the optimal percentage of rubber aggregate replacement can be up to 15%. It was discovered that this form of concrete could not be used in structural elements requiring high strength. However, it is possible using it in further construction essentials like pavements, road barriers, partition walls, sidewalks, etc. which have huge demand in construction industries. As fine aggregates are replaced with crumb rubber, the properties of concrete are tested. With a marginal increase in concrete workability, up to 15% of fine aggregates can be covered with an equivalent amount of crumb rubber, according to the findings. The compressive strength of the rubcrete contained 15% crumb rubber was increased by over 5%. The splitting tensile strength reduced as the amount of crumbed rubber increased, and the modulus of rupture dropped by an average of 12%. Rubberized concrete, conversely, showed increased strain at failure, strong energy absorption, better modulus of hardness, and ductility in the absence of any typical concrete brittle failure.

The partial effect of crumb tyre particle size as a fine aggregate substitute on compressive strength and time-dependent deformations of structural concrete is investigated. Rubcrete had lower compressive strength than the control concrete mix for all crumb rubber sizes, according to preliminary time-dependent and compressive performance. Concrete strength is affected by crumb rubber size; as crumb rubber gets smaller, compressive strength decreases. As mentioned before most of the research papers used rubber particles in form of fine or coarse aggregates in some cases it was used as an additive in concrete application but was limited to be used as a replacement of cement percentage in a mix design. The novelty of this work is studying the impact of partial replacement of cement by fine recycled rubber particles (RRP) on compressive strength of different hardened cement pastes at different water to binder ratios (W/B ratio = 0.3 and 0.4). This was coupled with an extensive ESEM micrographs study.

1.2 Types of rubber:

Ground rubber particles are intermediate in size between tire chips and crumb rubber. Ground rubber ranging in size vary from big 19mm as to small as 0. 15mm.The is depends upon the size reduction equipment and intending application. Ground rubber tire as asphalt binder, consuming on estimate 220million pounds, or approximately 12million tires. Crumb rubber is nothing but the fine granular or powdered particles is called crumb rubber. It is the processing of the tire into fine particles using cryogenic or mechanical process. This process is also used to remove the still and fabric component of the tire crumb rubber ranging size vary from 4.75mm to less than 0.075mm. Generally 3 methods are used to convert the waste tire into crumb rubber. Thus the methods are cracker mill process, granular process, micro mill process. The cracker mill process is used to reduce the size of tire. The material are passing between the rotating corrugated steel drums by this process used to an irregularly shaped torn particles having large surface. The size of these particles are vary from 5mm to 0.5mm and are commonly known as ground crumb rubber. If the granular process shears are using to rubber with revolving steel plates, producing the granulated rubber particle size ranging vary from9.5mm to 0.5mm

1.3 Characteristics:

MRP is a free flowing, black rubber powder that disperses into a multitude of systems and applications. Due to its micron size, MRP can be incorporated into multiple polymers, and provides a smooth surface appearance on finished products. In some cases, in order to improve compatibility with host materials, the MRP is given a chemical treatment to activate, or "make functional" the surface of the powder particles. This is referred to as functionalized MRP or FMRP.

MRP represents an evolution over previous post-manufactured rubber technologies. The most basic rubber processing technology converts end-of-life tire and post- industrial rubber material into rubber chips that are typically one inch or larger in size. These chips are then used in tire-derived fuel and civil engineering projects. A second- generation processing technology converts end-of-life tire and rubber material into crumb rubber, also known as ground tire rubber (GTR). GTR typically comprises chips between one inch and 30 mesh in size, with the associated fiber and steel mostly removed. This material is used in asphalt, as garden mulch and in playgrounds.

MRP is a micron-size material that is produced in various sizes, including 80 mesh and down to 300 mesh. MRP is virtually metal and fiber-free, enabling its use in a wide range of advanced products.

1.4 Physical properties:

The used specimens don't contain steel but contain less than 2% of textile fiber. Since it was not possible to determine the gradation curve of the rubber powder as for normal aggregates, a microscope examination was done. Dimensions of rubber powder vary from 1.6 mm to 0.8 mm with an average particle size of 1 mm. The density of the rubber powder is determined using helium pycnometer and it's about 0.83. Rubber powder is also characterized by an insignificant water absorption less than 3%. Table I resumes some characteristics of the used waste tire powder rubber.

PROPERTIES	RUBBER POWDER
Density	0.83
Elongation (%)	420
Steel	80 µm – 1.6 mm
Rate of steel fiber	0

Table-1Physical Properties of Rubber Powder

1.5 Chemical analysis:

The tire is made up mainly by rubber. Its constitution varies a little between the car tires and heavy truck tires. Rubber consists of a complex mixture of elastomers, polyisoprene, polybutadiene and styrene-butadiene. Stearic acid (1.2%), zinc oxide (1.9%), extender oil (1.9%) and carbon black (31.0%) are also, important components of tires. Chemical composition of the used rubber powder is presented. The quantity of steel is generally about 15%, and it's more important for the heavy truck's tires. For this study steel and one part of textile was removed by magnetic separation and density.

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Material/element	Mass Percentage
Rubber	54%
Carbon black	29%
Textile	2%
Oxidize zinc	1%
Additives	13%
Sulfur	1%

1.6 Role of Fibers

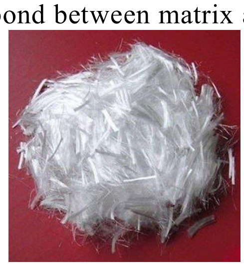
Cracks play an important role as they change concrete structures into permeable elements and consequently with a high risk of corrosion. Cracks not only reduce the quality of concrete and make it aesthetically unacceptable but also make structures out of service. If these cracks do not exceed a certain width, they are neither harmful to a structure nor to its serviceability. Therefore, it is important to reduce the crack width and this can be achieved by adding polypropylene fibers to concrete.

Thus, addition of fibers in cement concrete matrix bridges these cracks and restrains them from further opening. In order to achieve more deflection in the beam, additional forces and energies are required to pull out or fracture the fibres. This process, apart from preserving the integrity of concrete, improves the load-carrying capacity of structural member beyond cracking. Reinforcing steel bars in concrete have the same beneficial effect because they act as long continuous fibres. Short discontinuous fibres have the advantage, however, of being uniformly mixed and dispersed throughout the concrete.

1.7 Properties of Polypropylene Fibers

The raw material of polypropylene is derived from monomeric C_3H_6 which is purely hydrocarbon. Its mode of polymerization, its high molecular weight and the way it is processed into fibers combine to give polypropylene fibers very useful properties as explained below

- There is a sterically regular atomic arrangement in the polymer molecule and high crystallinity. Due to regular structure, it is known as isotactic polypropylene.
- Chemical inertness makes the fibers resistant to most chemicals. Any chemical that will not attack the concrete constituents will have no effect on the fiber either. On contact with more aggressive chemicals, the concrete will always deteriorate first.
- The hydrophobic surface not being wet by cement paste helps to prevent chopped fibers from balling effect during mixing like other fibers.
- The water demand is nil for polypropylene fibers.
- The orientation leaves the film weak in the lateral direction which facilitates fibrillations. The cement matrix can therefore penetrate in the mesh structure between the individual fibrils and create a mechanical bond between matrix and fiber.



Polypropylene Fibers

1.8 Super Plasticizer:

Superplasticizers (SPs), also known as high range water reducers, are additives used in making high strength concrete. Plasticizers are chemical compounds that enable the production of concrete with approximately 15% less water content. Superplasticizers allow reduction in water content by 30% or more. These additives are employed at the level of a few weight percent. Plasticizers and superplasticizers retard the curing of concrete.

Generally, superplasticizer can be classified into such types: purified lignosulfonates, carboxylate synthetic polymers, sulfonated synthetic polymers and synthetic polymers with mixed functionality cementitious materials.

SPs are used where well-dispersed particle suspension is required to improve the flow characteristics (rheology) of suspensions such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio without negatively affecting the workability of the mixture, and enables the production of self-consolidating concrete and high-performance concrete. They greatly improve the performance of the hardening fresh paste. The strength of concrete increases when the water to cement ratio decreases.

The addition of SP in the truck during transit is a fairly modern development within the industry. Admixtures added in transit through automated slump management systems, such as Verify, allow concrete producers to maintain slump until discharge without reducing concrete quality

Super Plasticizer

Properties:

Appearance: Brown liquid

Specific gravity: Typically, 1.20 at 20°CChloride content: Nil to BS 5075

Air entrainment: Typically, less than 2% additional air is entrained at normal dosages.

Alkali content: Typically, less than 72.0 g. Na2 O equivalent/litre of admixture. A fact sheet on this subject is available

2. LITERATURE REVIEW

Tushar R More, Pradip D Jadhao and SM Dumme 2015: In their study the aim was to study of waste tyre as partial replacement of fine aggregate to produce rubberizes concrete in M20 grade of mix. Different partial replacement of crumb rubber i.e., 0%, 5%,10%, 15% and 20% by volume of fine aggregate are casted and tested for flexural strength and split tensile strength. The result shows that there is a reduction in all type of strength for crumb rubber mixture, but crumb rubber content concrete become more lean due to increase in partial replacement of crumb rubber as fine aggregate ie.,3%, 6%, 9% and 12%. Flexural strength of concrete decreases with 3% replacement of sand and further decrease in strength with the increase in percentage of crumb rubber. For split tensile strength decreases with 3% replacement of sand and further decrease in strength with the International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST) ISSN (Online) : 2456-5717 211 Vol.3 Special Issue 35 April 2017 increase in percentage of crumb rubber. This is mainly due to lower bond strength between cement paste and rubber tyre aggregate

Prof. M. R. Wakchaura and Mr. Prashant. A. Charan: In this study they did partial replacement of fine aggregate as crumb rubber as 0.5%, 1%, 1.5% and 2% in M25 grade of concrete and its effects on concrete properties like compressive strength, flexural strength were investigated. Addition to this combination of glass fibre at ratio 0.4% and 0.5% addition to the weight of cement are used to regain the reduced strength due to use of waste tyre crumb rubber particle. Results indicate that replacement of waste tyre crumb rubber particle to the fine aggregate in concrete at ratio 0.5% and 1% there is no effect on the concrete properties would occur, but there was a considerable change for 1.5% and 2% replacement ratio.

Dr. B. Krishna Rao: In this investigation he did casting and testing of cubes, cylinders, and prisms for M20 grade of concrete and added 5% and 10% of rubber fibre by volume of concrete. There the specimens are tested for compression, split tensile and flexural strength. The test results were done and noted that due to addition of rubber fibre, strength of concrete decreases, but as observing ductility is improving. Hence it is used for medium grade of concrete. The various rubberised concrete mixes were designed in accordance with standard mix design procedure for normal concrete with grade of M20. As expected the target strength were not achieved for the mixes incorporating rubber fibre.

Er. YogenderAntil: The primary objective of their investigation is to study the strength behaviour i.e., compressive strength and flexural strength of rubberised concrete with different volume of crumb rubber. Parameter to be varied in Investigation is volume variation of crumb rubber. The proposed work is aimed to study the effect of volume variation of crumb rubber on the compressive strength, flexural strength and slump test. So they founded that strength of modified concrete is reduced with an increase in rubber content. The Flexural strength of the concrete decreases about 69% when 20% of sand is replaced by crumb rubber. The compressive strength of the concrete decreases about 37% when 20% of sand is replaced by crumb rubber. So overall large percentage of crumb rubber the lower the compressive strength and flexural strength as compared to conventional concrete.

Sulagno Banerjee, Aritra Mandal, Dr.Jessy Robby The aim of their investigation was studies on mechanical properties of tyre rubber concrete. In their study they made a concrete of M25 grade by replacing 5%, 10%, 15%, 20% and 25% of tyre conc rete with coarse aggregate and compared with regular M25 grade concrete. The properties of fresh concrete and flexural strength of hardened concrete were identified. So they concluded that flexural strength decreases in concrete. In 7 days' flexure strength, there is not much variation seen between conventional and rubberized concrete. So there was not much difference in strength of rubberized and conventional concrete.

Nithiya P and Portchejian G: It this research paper the mix design was done as per IS:10262-2009 to achieve the target strength. The concrete mixes were made by replacing fine aggregate with 5%, 10%, 15% and 20% for M20 grade concrete. So they founded that compressive strength decreases with the replacementof crumb rubber increased and 5% replacement of crumb rubber proves exceptionally well in compressive strength and tensile strength. It also gives more strength at 28th days for 5% replacement for M20 grade of cement and split tensile strength decreases at the maximum at the maximum of 25% when crumb rubber is replaced up to 10% of fine aggregate. Thus by replacing fine aggregate by crumb rubber safeguard the environment.

Jaylina Rana and Reshma Rughooputh: The broad aim of this work was to investigate the effects of partially substituted fine aggregate by rubber on the properties of fresh and hardened concrete. Different tests were performed to determine slump, compressive strength, tensile splitting strength, flexural and initial surface absorption of the concrete mixes. The compressive, tensile splitting strength, flexural decreases with increasing rubber content. Rubber fails the initial surface absorption test that is the surfaces of their concrete mixes are almost impermeable. However, partial replacement of fine aggregate with 5% of rubber can potentially be used in low strength concrete applications.

S. Selvakumar and R. Venkatakrishnaiah: They did concrete mix as per IS:10262-2009 for M30 grade of concrete for their investigation. The specimen was casted and used to determine the compressive strength, split tensile strength and flexural strength of concrete. They were tested for 7 and 28 days with replacement of fine aggregate with 5%, 10%, 15%, 20% of crumb rubber. Finally, they concluded that compressive strength of crumb rubber concrete with 5% replacement is 38.66 N/mm2 , it is higher than the strength of normal concrete ie.,36.73 N/mm2 on the 28 days. The compressive strength of crumb rubber concrete with 10% replacement it gives acceptable strength of 33.47 N/mm2 . In flexural strength of crumb rubber is lower than the strength of normal concrete and it was seen the same lowering of strength as compared to normal concrete in splitting tensile strength. So crumb rubber possess less bonding ability which effected on the strength of the concrete.

A Mansoor Ali and A. Sarvanan: This paper is the experimental study on waste rubber tire concrete. The mechanical and durability properties of concrete withcomposition of crumb rubber replacing part of the fine aggregate and cement with silica fumes were investigated for M25 grade as per IS:10262-2009. Compressive strength, flexural strength and split tensile strength was conducted for each sample by these authors. Finally they concluded that there was a reduction in compressive strength and split tensile strength and increase in flexural strength when the rubber content is increased. But the target strength was achieved by addition of silica fume and rubber in the concrete as compared to the addition of rubber without silica fumes. Therefore, this study has been focused on strength and durability requirement which shows that the concrete is sustainable and use for non-structural element where the low strength is required.

Kotresh K.M and Mesfin Getahun Belachew: In this present generation the disposal of waste tyres normally used in vehicle is becoming a serious issue for waste management problem in the world. It is estimated that 1.2 billion of waste tyre rubber produced globally per year. It is estimated that 11% of post-consumer tyres are exported and 27% are sent to landfill, stockpiled or dumped illegally when they have no use and only 4% is used for civil engineering projects. Hence major steps have been taken to find the potential application of waste tyre in civil engineering projects. In this investigation, our present study aims to investigate the optimal use of waste tyre rubber as coarse aggregate in concrete composite. A total of 24 cubes and 12 prisms are casted of M25 grade by replacing 10%, 20% and 30% of tyre aggregate as a coarse aggregate and compared with regular M25 grade concrete. Fresh and hardened concrete strength were identified. Finally, it was found that the strength was not achieved as targeted. But still it can be used for low strength structure as using crumb rubber can help in maintaining the environment.

GintautasSkripkiunas, AudriusGrinys, Benjaminascernius: The aim of investigation was to study the deformation properties of Portland cement concrete with rubber waste additive. Concrete mixtures with the same compressive strength as concrete without this additive were tested. Used tires rubber wastes were crumbed into fraction 0/1. The rubber additive was used as fine aggregate replacement in concrete mixtures by 3.2 % of aggregates mass. The effect of rubber waste additive on technological properties, air content in fresh concrete, density and deformation properties under the static and dynamic load of concrete was investigated

3. MIX DESIGN

Stipulation for Proportioning Concrete Ingredients

(a) Characteristic compressive strength required in the field at 28 days grade designation - M 30
(b) Type of Cement : OPC 53 Grade confirming to IS 12269
(c) Maximum Nominal size of aggregate — 20 mm
(d) Shape of CA — Angular
(d) Workability required at site — 100 mm (slump)
(e) Type of exposure the structure will be subjected to (as defined in IS: 456) — Moderate
(f) Method of concrete placing: pump able concrete

(ii) Test data of material

The following materials are to be tested in the laboratory and results are to be ascertained for the design mix
(a) Cement Used : OPC 53 Grade Confirming to IS 12269
(b) Specific Gravity of Cement : 3.15
(c) Chemical admixture : Super plasticizer confirming to IS 9103
(d) Specific gravity
Specific gravity of Fine Aggregate (sand) : 2.70
Specific gravity of Coarse Aggregate : 2.80
(e) Water Absorption
Coarse Aggregate: 0.4%
Fine Aggregate : 1.0%
(f) Free (surface) moisture
Coarse Aggregate : Nil
Fine Aggregate : Nil
Aggregate are assumed to be in saturated surface dry condition usually while preparing design mix.
(g) Sieve Analysis
Fine aggregates : Confirming to Zone I of Table 4 IS – 383

Mix Design of M30 Grade Concrete

Step 1: Determining the Target Strength for Mix Proportioning
Fck = fck + 1.65 x S
Where,
F'ck = Target average compressive strength at 28 days
Fck = Characteristic compressive strength at 28 days
S = Assumed standard deviation in N/mm2 = 5 (as per table -1 of IS 10262- 2009)
= 30 + 1.65 x 5.0 = 38.25 N/mm_2

Table 1 Assumed Standard Deviation
(*Clauses* 3.2.1.2, A-3 *and* B-3)

Sl No. (1)	Grade of Concrete (2)	Assumed Standard Deviation N/mm^2 (3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

Step 2 Selection of water-cement ratio:-
From Table 5 of IS 456, Maximum water-cement ratio = 0.50
Note: Do not start with w/c ratio above 0.50, even though the other desired results like Strength, workability could be achieved.

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(*Clauses* 6.1.2, 8.2.4.1 *and* 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m'	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m'	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

Step 3 Selection of Water Content

Maximum water content for 20 mm aggregate = 186 Kg (for 25 to 50 slump)

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate

(*Clauses* 4.2, A-5 *and* B-5)

Sl No.	Nominal Maximum Size of Aggregate mm	Maximum Water Content [1)] kg
(1)	(2)	(3)
i)	10	208
ii)	20	186
iii)	40	165

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1)] Water}content corresponding to saturated surface dry aggregate.

We are targeting a slump of 100mm, we need to increase water content by 3% for every 25mm above 50 mm i.e. increase 6% for 100mm slump

I.e. Estimated water content for 100 Slump = 186+ (6/100) X 186 = 197litres

Water content = 197 liters

STEP 4 – Calculation of Cement Content

Water-Cement Ratio = 0.50

Water content from Step – 3 i.e. 197 liters

Cement Content = Water content / “w-c ratio” = (197/0.50) = 394 kgs

From Table 5 of IS 456,

Minimum cement Content for moderate exposure condition = 300 kg/m3

394 kg/m3 > 300 kg/m3, hence, OK.

As per clause 8.2.4.2 of IS: 456

Maximum cement content = 450 kg/m3, hence ok too.

STEP 5: Proportion of Volume of Coarse Aggregate and Fine aggregate Content

From Table 3 of IS 10262- 2009, Volume of coarse aggregate corresponding to 20 mm size and fine aggregate (Zone I) = 0.60

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate
(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate	Volume of Coarse Aggregate[1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
	mm	Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

[1] Volumes are based on aggregates in saturated surface dry condition.

Note 1: In the present case water-cement ratio is 0.5.So there will be no change in coarse aggregate volume i.e. 0.60.
Note 2: Incase the coarse aggregate is not angular one, then also volume of coarse aggregate may be required to be increased suitably based on experience.

STEP 6: Estimation of Concrete Mix Calculations

The mix calculations per unit volume of concrete shall be as follows:

1. Volume of concrete = 1 m3
2. Volume of cement = (Mass of cement / Specific gravity of cement) x (1/100)
= (39/3.15) x (1/1000) = 0.125 m3

3. Volume of water = (Mass of water / Specific gravity of water) x (1/1000)
= (197/1) x (1/1000) = 0.197 m3
4. Total Volume of Aggregates = 1- (b+c) =1- (0.125+0.197) = 0.678 m3
5. Mass of coarse aggregates = d X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000
= 0.678 X 0.60 X 2.80 X 1000
= 1139 kgs/m3
6. Mass of fine aggregates
= d X Volume of Fine Aggregate X Specific Gravity of Coarse Aggregate X 1000
= 0.678 X 0.40 X 2.70 X 1000 = 732 kgs/m3

STEP-7: Concrete Mix proportions for Trial Number 1

Cement = 394 kg/m3
Water = 197 kg/m3
Fine aggregates = 732 kg/m3
Coarse aggregate = 1139 kg/m3
Water-cement ratio = 0.50

Final trial mix for M30 grade concrete is 1:1.86:2.89 at w/c of 0.50

Mix Design of M40 Grade Concrete

Step 1: Determining the Target Strength for Mix Proportioning
Fck = fck + 1.65 x S
Where,
Fck = Target average compressive strength at 28 days
Fck = Characteristic compressive strength at 28 days
S = Assumed standard deviation in N/mm2 = 5 (as per table -1 of IS 10262- 2009)
= 40 + 1.65 x 5.0 = 48.25 N/mm2

Table 1: ASSUMED STANDARD DEVIATION

Table 1 Assumed Standard Deviation
(*Clauses* 3.2.1.2, A-3 *and* B-3)

Sl No.	Grade of Concrete	Assumed Standard Deviation N/mm^2
(1)	(2)	(3)
i)	M 10	3.5
ii)	M 15	
iii)	M 20	4.0
iv)	M 25	
v)	M 30	5.0
vi)	M 35	
vii)	M 40	
viii)	M 45	
ix)	M 50	
x)	M 55	

Step 2 Selection of water-cement ratio:-
From Table 5 of IS 456, Maximum water-cement ratio = 0.45
Note: Do not start with w/c ratio above 0.45, even though the other desired results like Strength, workability could be achieved.

Table 2: WATER CEMENT RATIO AS PER IS 456:2000

Table 5 Minimum Cement Content, Maximum Water-Cement Ratio and Minimum Grade of Concrete for Different Exposures with Normal Weight Aggregates of 20 mm Nominal Maximum Size

(*Clauses* 6.1.2, 8.2.4.1 *and* 9.1.2)

Sl No.	Exposure	Plain Concrete			Reinforced Concrete		
		Minimum Cement Content kg/m^3	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete	Minimum Cement Content kg/m^3	Maximum Free Water-Cement Ratio	Minimum Grade of Concrete
1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Mild	220	0.60	–	300	0.55	M 20
iii)	Moderate	240	0.60	M 15	300	0.50	M 25
iii)	Severe	250	0.50	M 20	320	0.45	M 30
iv)	Very severe	260	0.45	M 20	340	0.45	M 35
v)	Extreme	280	0.40	M 25	360	0.40	M 40

NOTES

1 Cement content prescribed in this table is irrespective of the grades of cement and it is inclusive of additions mentioned in 5.2. The additions such as fly ash or ground granulated blast furnace slag may be taken into account in the concrete composition with respect to the cement content and water-cement ratio if the suitability is established and as long as the maximum amounts taken into account do not exceed the limit of pozzolona and slag specified in IS 1489 (Part 1) and IS 455 respectively.

2 Minimum grade for plain concrete under mild exposure condition is not specified.

Step 3 Selection of Water Content
Maximum water content for 20 mm aggregate = 186 Kg (for 25 to 50 slump)

Table 3: MAXIMUM WATER CONTENT AS PER IS 456:2000

Table 2 Maximum Water Content per Cubic Metre of Concrete for Nominal Maximum Size of Aggregate
(*Clauses* 4.2, A-5 *and* B-5)

Sl No.	Nominal Maximum Size of Aggregate mm	Maximum Water Content [1)] kg
(1)	(2)	(3)
i)	10	208
ii)	20	186
iii)	40	165

NOTE — These quantities of mixing water are for use in computing cementitious material contents for trial batches.

[1)] Water}content corresponding to saturated surface dry aggregate.

We are targeting a slump of 100mm, we need to increase water content by 3% for every 25mm above 50 mm i.e. increase 6% for 100mm slump
STEP 4 – Calculation of Cement Content
Water-Cement Ratio = 0.45

Water content from Step – 3 i.e. 197 liters
Cement Content = Water content / "w-c ratio" = (197/0.45) = 438 kgs
From Table 5 of IS 456,
Minimum cement Content for moderate exposure condition = 300 kg/m3
438 kg/m$_3$ > 300 kg/m$_3$, hence, OK.
As per clause 8.2.4.2 of IS: 456
Maximum cement content = 450 kg/m3, hence ok too.
STEP 5: Proportion of Volume of Coarse Aggregate and Fine aggregate Content
From Table 3 of IS 10262- 2009, Volume of coarse aggregate corresponding to 20 mm size and fine aggregate (Zone I) = 0.60

Table 4: VOLUME OF COARSE AGGEREGATE AS PER DIFFERENT ZONES

Table 3 Volume of Coarse Aggregate per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate
(*Clauses* 4.4, A-7 *and* B-7)

Sl No.	Nominal Maximum Size of Aggregate mm	Volume of Coarse Aggregate[1] per Unit Volume of Total Aggregate for Different Zones of Fine Aggregate			
		Zone IV	Zone III	Zone II	Zone I
(1)	(2)	(3)	(4)	(5)	(6)
i)	10	0.50	0.48	0.46	0.44
ii)	20	0.66	0.64	0.62	0.60
iii)	40	0.75	0.73	0.71	0.69

[1] Volumes are based on aggregates in saturated surface dry condition.

Note 1: In the present case water-cement ratio is 0.45.So there will be no change in coarse aggregate volume i.e. 0.60.
Note 2: Incase the coarse aggregate is not angular one, then also volume of coarse aggregate may be required to be increased suitably based on experience.
STEP 6: Estimation of Concrete Mix Calculations
The mix calculations per unit volume of concrete shall be as follows:
1. Volume of concrete = 1 m3
2. Volume of cement = (Mass of cement / Specific gravity of cement) x (1/1000)
= (438/3.15) x (1/1000) = 0.139 m3
3. Volume of water = (Mass of water / Specific gravity of water) x (1/1000)

= (197/1) x (1/1000) = 0.197 m3
4. Total Volume of Aggregates = 1- (b+c) =1- (0.139+0.197) = 0.664 m$_3$
5. Mass of coarse aggregates = d X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000
= 0.664 X 0.60 X 2.80 X 1000
= 1115 kgs/m3
6. Mass of fine aggregates
= d X Volume of Fine Aggregate X Specific Gravity of Coarse Aggregate X 1000
= 0.664 X 0.40 X 2.70 X 1000 = 717.12 kgs/m3

STEP-7: Concrete Mix proportions for Trial Number 1
Cement = 438 kg/m$_3$
Water = 197 kg/m$_3$
Fine aggregates = 717.12 kg/m$_3$
Coarse aggregate = 1115 kg/m$_3$
Water-cement ratio = 0.45

Final trial mix for M40 grade concrete is 1:1.63:2.54 at w/c of 0.45

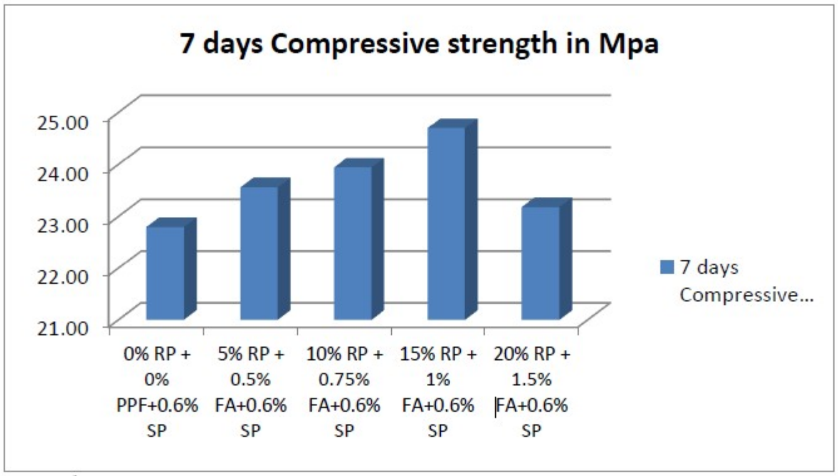
MATERIAL	**CEMENT**	**FINE AGGREGATES**	**COARSE AGGREGATES**	**WATER**
Density	438 kg/m3	717.12 kg/m3	115 kg/m3	97 kg/m3
Proportions	1	1.63	2.54	0.45

IV. TESTS ON HARD CONCRETE

4.1 Compressive Strength

Table 4.1 Compressive strength test values at 7 days for all the mix proportions

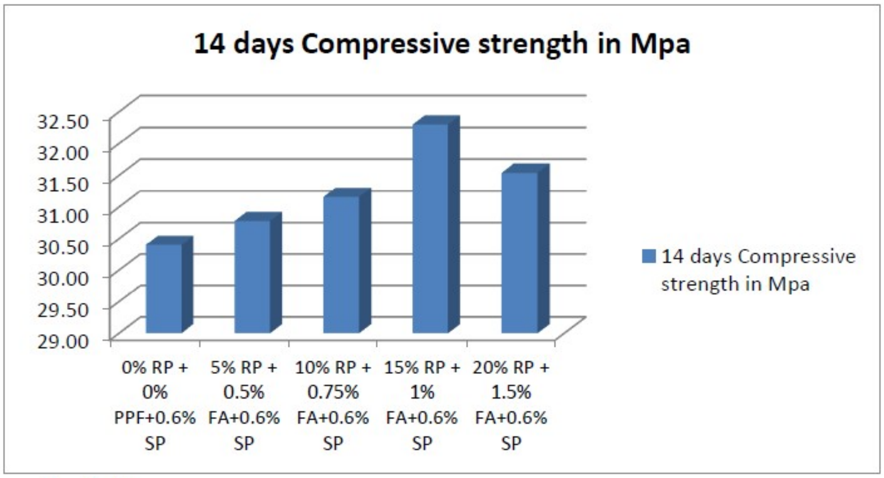
S. No	Mix ID	7 days Compressive strength in Mpa
1	0% RP + 0% PPF+0.6% SP	22.80
2	5% RP + 0.5% FA+0.6% SP	23.56
3	10% RP + 0.75% FA+0.6% SP	23.94
4	15% RP + 1% FA+0.6% SP	24.70
5	20% RP + 1.5% FA+0.6% SP	23.18



Graph 4.1 Variation of Compressive strength After Curing 7 days for all mix proportions

Table 4.2 Compressive strength test values at 14 days for all the mix proportions

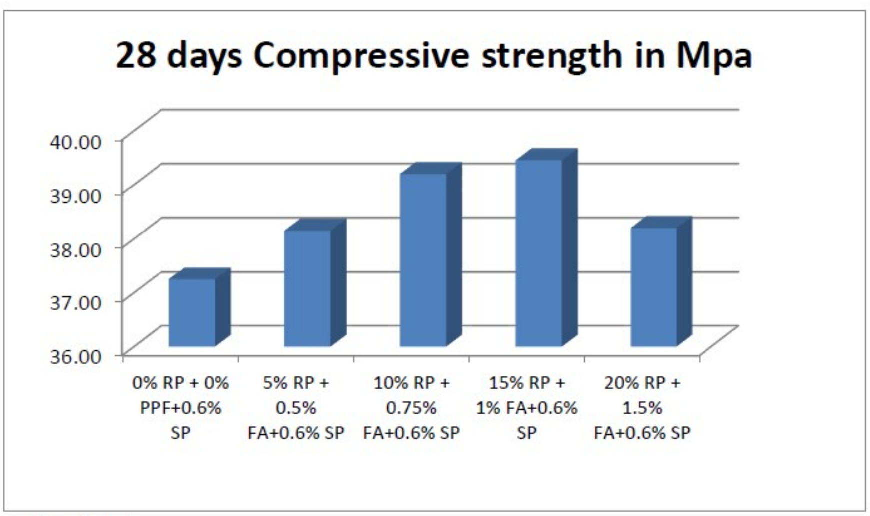
S. No	Mix ID	14 days Compressive strength in Mpa
1	0% RP + 0% PPF+0.6% SP	30.40
2	5% RP + 0.5% FA+0.6% SP	30.78
3	10% RP + 0.75% FA+0.6% SP	31.16
4	15% RP + 1% FA+0.6% SP	32.30
5	20% RP + 1.5% FA+0.6% SP	31.54



Graph 4.2 Variation of Compressive strength After Curing 14 days for all mix proportions

Table 4.3 Compressive strength test values at 28 days for all the mix proportions

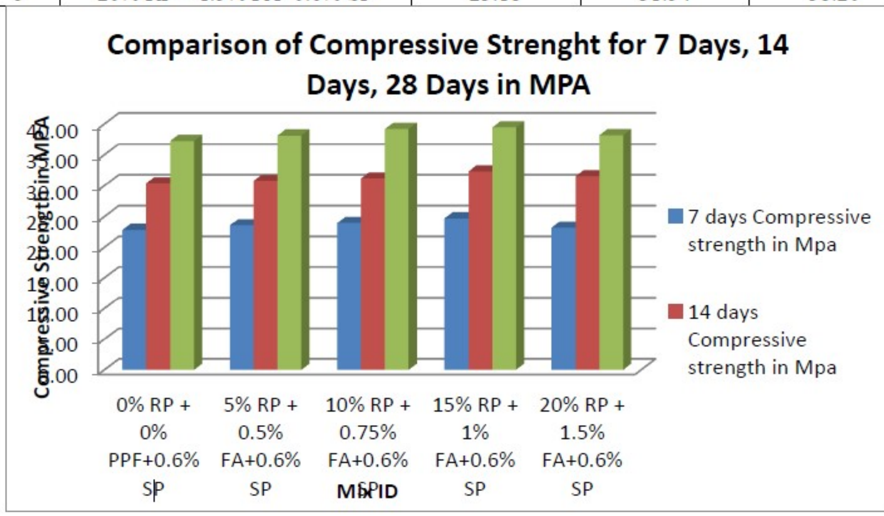
S. No	Mix ID	28 days Compressive strength in Mpa
1	0% RP + 0% PPF+0.6% SP	37.25
2	5% RP + 0.5% FA+0.6% SP	38.15
3	10% RP + 0.75% FA+0.6% SP	39.20
4	15% RP + 1% FA+0.6% SP	39.45
5	20% RP + 1.5% FA+0.6% SP	38.20



Graph 4.3 Variation of Compressive Strength After Curing 28 days for all mix proportions

Table 544 Compressive strength test values at 7 Days, 14 Days, & 28 days for all the mix proportions.

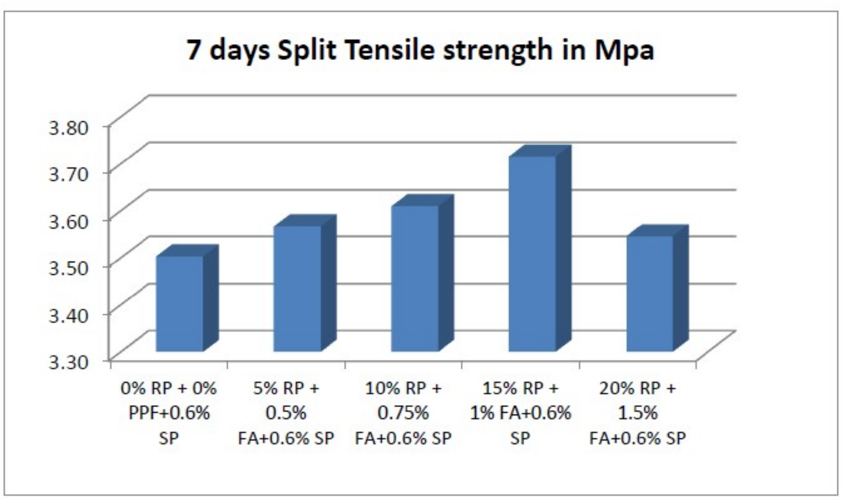
S. No	Mix ID	7 days Compressive strength in Mpa	14 days Compressive strength in Mpa	28 days Compressive strength in Mpa
1	0% RP + 0% PPF+0.6% SP	22.80	30.40	37.25
2	5% RP + 0.5% FA+0.6% SP	23.56	30.78	38.15
3	10% RP + 0.75% FA+0.6% SP	23.94	31.16	39.20
4	15% RP + 1% FA+0.6% SP	24.70	32.30	39.45
5	20% RP + 1.5% FA+0.6% SP	23.18	31.54	38.20



Graph 4.4 Variation of Compressive strength after Curing 7,14 & 28 days for all mix proportions

Table 4.5 Split Tensile strength test values at 7 days for all the mix proportions

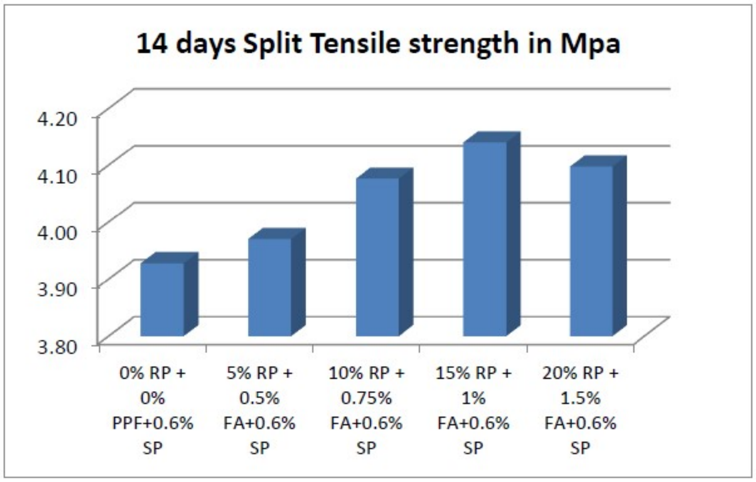
S. No	Mix ID	7 days Split Tensile strength in Mpa
1	0% RP + 0% PPF+0.6% SP	3.50
2	5% RP + 0.5% FA+0.6% SP	3.57
3	10% RP + 0.75% FA+0.6% SP	3.61
4	15% RP + 1% FA+0.6% SP	3.72
5	20% RP + 1.5% FA+0.6% SP	3.55



Graph 4.5 Variation of Split Tensile strength after Curing 7 days for all mix proportions

Table 4.6 Split Tensile strength test values at 14 days for all the mix proportions

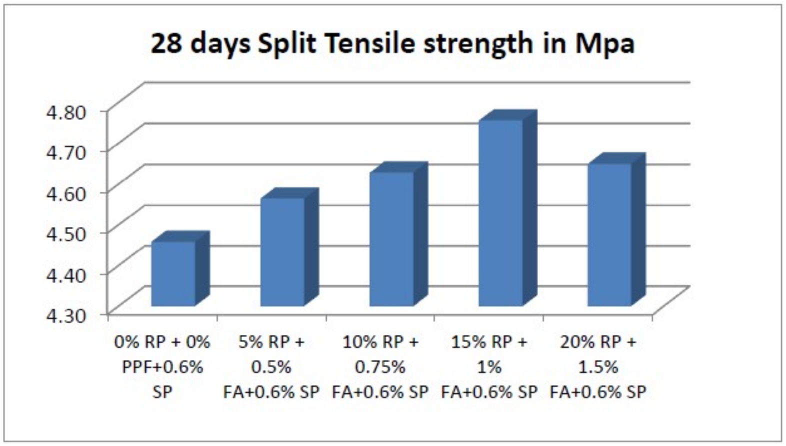
S. No	Mix ID	14 days Split Tensile strength in Mpa
1	0% RP + 0% PPF+0.6% SP	3.93
2	5% RP + 0.5% FA+0.6% SP	3.97
3	10% RP + 0.75% FA+0.6% SP	4.08
4	15% RP + 1% FA+0.6% SP	4.14
5	20% RP + 1.5% FA+0.6% SP	4.10



Graph 4.6 Variation of Split Tensile strength after Curing 14 days for all mix proportions

Table 4.7 Split Tensile strength test values at 28 days for all the mix proportions

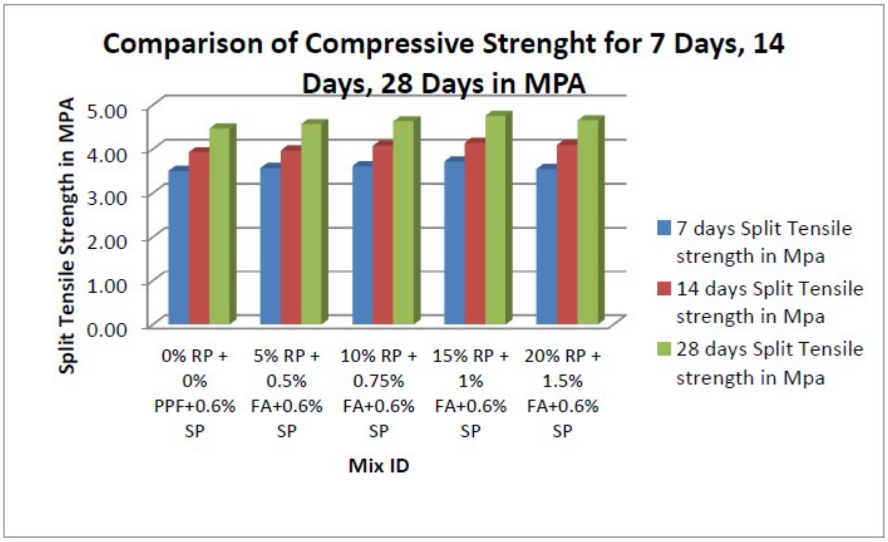
S. No	Mix ID	28 days Split Tensile strength in Mpa
1	0% RP + 0% PPF+0.6% SP	4.46
2	5% RP + 0.5% FA+0.6% SP	4.56
3	10% RP + 0.75% FA+0.6% SP	4.63
4	15% RP + 1% FA+0.6% SP	4.76
5	20% RP + 1.5% FA+0.6% SP	4.65



Graph 547 Variation of Split Tensile strength after Curing 28 days for all mix proportions

Table 4.8 Split Tensile strength test values at 7 Days, 14 Days, & 28 days for all the mix proportions

S. No	Mix ID	7 days Split Tensile strength in Mpa	14 days Split Tensile strength in Mpa	28 days Split Tensile strength in Mpa
1	0% RP + 0% PPF+0.6% SP	3.50	3.93	4.46
2	5% RP + 0.5% FA+0.6% SP	3.57	3.97	4.56
3	10% RP + 0.75% FA+0.6% SP	3.61	4.08	4.63
4	15% RP + 1% FA+0.6% SP	3.72	4.14	4.76
5	20% RP + 1.5% FA+0.6% SP	3.55	4.10	4.65



Graph 4.8 Variation of Split Tensile strength after Curing 7,14 & 28 days for all mix proportions

CONCLUSION:

It can be concluded from this study that fine aggregates can be replaced by rubber power unto some extent. The higher amount of crumb rubber reduces the strength of concrete which may not be desirable, but, the rubber-based concrete has good toughness and deformability. So, this kind of concrete may be used in the structures (road foundations and bridge barriers) where toughness and deformability is more important than strength. This kind of concrete may also use to decrease the vibrations coming on the base of the structures because rubber-based concrete has reversible elasticity property.

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