Mechanical Properties of Concrete using Crumb Rubber, GGBS & TiO2

[1]Shreyas L. Bedagkar, [2]Sudhanshu S. Pathak
[1]*Student, Department of Civil Engineering, D. Y. Patil College of Engineering, Akurdi, Pune, India*
[2]*Assistant Professor, Department of Civil Engineering, D. Y. Patil College of Engineering, Akurdi, Pune, India*

Abstract **- Nowadays there may be one of the most important environmental demanding situations is to dispose waste rubber tyres. To kind with this situation numerous research and assessments are being performed at the waste rubber tyres. The assessments are accomplished at the rubber granulates and crumb rubber in partial replacements or additions withinside the concrete. These waste rubber tyres accumulate landfill spaces, so scientist and engineers are wearing out have a look at on the usage of crumb rubber in production constructing materials. Cement Concrete in one of the essential cloth in constructing production which includes cement, coarse mixture, excellent mixture and water. The use of crumb rubber in partial substitute with excellent mixture in concrete can lessen the value and beautify the overall performance of concrete. Ground granulated blast furnace slag (GGBS) is relatively cementitious cloth excessive in calcium silicate hydrate that is power improving compound which improves sturdiness and look of concrete. Replacement of most 50% of concrete with GGBS presents excessive sturdiness and power of concrete. Nano- TiO2, a nano cloth which in powder shape used withinside the concrete for growing the price of hydration because of which the porosity withinside the concrete decreases and turns into greater denser and durable. In this experimental technique Crumb rubber and GGBS is partial changed with Fine Aggregate and Cement. Nano- TiO2 is used for higher overall performance of the concrete. Customized Concrete is studied with mechanical residences of concrete and Workability of concrete. The Partial Replacement are carried with substitute of Crumb Rubber (5%, 10%, 15%, 25%) with excellent aggregates, GGBS (30%) and Fly-Ash (25%) with cement and TiO2 as a extra to enhance the first-class of organized concrete. The essential thing of this have a look at is to waste control of rubber tyres and right use of the identical in development in first-class of cement. This have a look at concludes that the power of concrete step by step will increase after 28 days of curing below water with assessment to standard concrete.**

Index Terms **- Fine aggregate, GGBSS, Crumb rubber, TiO2, Mechanical Properties, Partial Replacement.**

I.INTRODUCTION

Concrete is one of the maximum broadly used creation nowadays. More than 90% of the systems starting from buildings, bridges, roads, dams, maintaining partitions etc. utilise the concrete for his or her creation. The versality and mildew cap potential of this material, its excessive compressive power and discovery of reinforcing and prestressing approach has won its significant use, power, sturdiness and workability can be taken into consideration as the primary homes of concrete. In addition properly concrete is capable of withstand put on and corrosion and it have to be water- tight and economical. The Concrete should be robust sufficient to face up to without harm all of the imposed stresses with required element of safety. To broaden a given power longer time of moisture curing is needed at decrease temperature than is important even as curing is accomplished at better temperature. Crumb Rubber Concrete is the concrete produced from piece elastic tyre chips and scrap elastic wherein applied to supplant mineral nowadays in cement. The not un-usua lplace use of waste rubber mainly tyre chips had been in toll road asphalt mixes. Material characterization experiments had been performed to decide the practicality of the use of rubber in Concrete. Research has proven that substitute of traditional aggregates with rubber consequences in a lower in compressive power and tensile power and stiffness. Eldin and senouci (1993) done anxiety and compression check on styles of cylinders, with potions of the coarse or excellent combination changed with rubber. They located tensile power decreases of 50%

and compressive power discount of as much as 85% but mentioned that the rubberized concrete absorbed a superb quantity of plastic power. Based at the posted literature on crumb rubber concrete (CRC) it's far obvious that the ductility and power absorption is better over that of the traditional concrete. These traits may also show useful for packages wherein dynamic blast stress needs are a concern. Concrete may be made inexpensive through changing a hard and fast percent of excellent combination with crumb rubbers from rubber waste. These rubber crumbs may be executed via the technique known as non-stop shredding, that's accomplished to create crumbs small sufficient to update aggregates as excellent as sand effectively. Such form of concrete may be utilized in production technique of bolstered pavement and bridge systems due to the fact this behaviour resistance to frost and ice thawing.

In Present scenario, the disposal of waste tyre rubber is a chief situation in waste control all through the world. It is anticipated that round 1.2 billion of waste tyre rubber is produced in keeping with 12 months across the world. It is likewise anticipated that round 11% of tyres are exported submit intake and 27% are piled as landfill, stockpiled or dumped illegally and simplest 4% of it's miles applied for civil engineering works. Hence, efforts had been made to discover the ability of this waste tyre rubber in civil engineering projects. Our gift take a look at goals to research withinside the equal context i.e. the best use of crumb rubber as excellent mixture in concrete composite. With the growth in urbanization in international locations like India the environmental threat. This take a look at indicates us an opportunity manner of recycling tyres with the aid of using incorporating them into the concrete. The Concept that if trouble emerges from urbanization and the answer should go together with it have to additionally be appreciated. Therefore, the goal of this take a look at is to added an environmental pleasant technology, in an effort to gain the society and the nation.

II.METHOD AND MATERIALS

A. Cement

Cement used on this observe is normal Portland cement acquired from neighborhood dealer and of 53 grade as according to IS 11269 it has a selected gravity of 3.15 with fineness (IS:4031-PART 1-1996) is much less than 5% and feature suitable unique floor place of extra than 600 m2/ kg. The cement acquired is saved in hermetic surroundings with out moisture access and formation of lumps is avoided.

B. Fine Aggregate

Fine combination used on this look at is received from close by supply and its smooth river sand adhering to the norms prescribed in IS:383 and it confirms to Zone-II with a particular gravity of 2.68 and loose from any overseas particles. Sand received is saved in big packing containers with out moisture access and its controlled as smooth and dry to control the water content material withinside the blend design.

C. Coarse Aggregate

Coarse mixture followed on this paintings is received from close by crusher unit that is derived from basalt rock and it's miles non flaky with clean edges. The aggregates are sieved on crusher give up with nominal length of 20 mm as in step with IS 383 it adheres strictly to the protocols. The coarse mixture has a selected gravity of 2.65 and abrasion cost of much less than 6% with suitable effect crushing electricity of much less than 3% which indicates that it may be even used for dual carriageway pur- pose. The received cloth is saved in a concrete tank with refuge to keep away from water access and clean, dried mixture simplest is used all through the study.

D. Water

The water used withinside the complete procedure is faucet water and the density is taken as 1000 kg/m3 and a pH of 6.2 with TDS of much less than 500 ppm with clean and no color. The water is saved in plastic bins and closed with a cap to keep away from dirt or overseas debris access earlier than blending with concrete. According to IS: 2386 (Part I 1963) the fineness modulus variety for medium sand the cost is 2.6 to 2.9, Thus we will update the first-rate mixture with crumb rubber as medium sand. For casting of cubes, moulds of length (150X150X150) mm manufactured from forged iron are used. These Cubes are used to achieve compressive electricity. For casting beam moulds of (150X150X700) mm manufactured from forged iron is used. These Beams specimens are used to achieve flexure electricity of concrete.

E. Crumb Rubber:

Crumb Rubber is recycled rubber constructed from car and truck scrap tyres. During the recycling system metallic and tyre wire are removed, leaving the rubber

with a granular consistency. Continued processing with a granulator or cracker mill, probable with the resource of cryogenics or mechanical means, reduces the dimensions of debris further. The debris are sized and labelled primarily based totally at the numerous standards together with color. The granulate is sized through passing through a screen, the dimensions primarily based totally on a dimension (1/4 inch) or mesh (holes in keeping with inch: 10 20).

When handling asphalt overlays, mirrored image cracks can rise up and motive an undesirable cracks sample below the pavement. Rubber changed asphalt makes use of the pressure soaking up membranes that reduces the reflective cracking due to its elastic properties. With fewer cracks, there are fewer repairs, so crumb rubber assists in decreasing renovation costs. The pavement has an elevated lifespan due to the fact after more than one makes use of and exposures to specific elements, normal asphalts losses elasticity over time. The use of the synthetic rubber resists the formation of cracks and has an anti-getting old impact that continues the asphalt in a higher condition. The tyre crumbs are poured in among the synthetic grass blades, giving the synthetic fields extra cushion and support.

Contents of Crumb Rubber:

Component	Content
Relative density	1.3
Acetone extract	10
Carbon black content	21.7
Rubber hydrocarbon content	36
Ash content	5.7
Natural rubber content	26.0

Table no. 1 Content of Crumb Rubber

F. Ground Granulated Blast Furnace Slag (GGBS)

Ground-granulated blast furnace slag (GGBS) is acquired through quenching molten iron slag (a spinoff of iron and metal making) from a blast furnace in water or steam, to supply a glassy, granular product this is then dried and floor right into a satisfactory powder. From structural factor of view, GGBS substitute complements decrease warmth of hydration, better sturdiness and better resistance to sulphate and chloride assault while as compared with regular regular concrete. On the opposite hand, it additionally contributes to environmental safety as it minimizes the usage of cement all through the manufacturing of concrete. The chemical compositions range as in keeping with composition of uncooked material. It is locate to make long lasting concrete systems in aggregate of OPC/PPC. Concrete with GGBS units slowly than regular however concurrently profits energy over lengthy period. Replacement stage range from 30% as much as 85%. Strength will increase over the time.

G. Nano- Titanium Dioxide (TiO_2)

Incorporation of Nano- Titanium dioxide in cement well-knownshows substantial development in homes of cement composites. Increased studies withinside the use of nano- titanium dioxide in production enterprise is attributed to its nano length that speeds up hydration of cement, reduces placing time and complements the mechanical homes. The dimensional balance if cement blend suffering from extra addition of nano- titanium dioxide is mitigated with the aid of using top of the line choice of length of nano- titanium dioxide. The recognition is on impact nano- titanium dioxide on warmness of hydration, workability, placing time, mechanical strength, microstructure and permeability of cement mixed mixes. About an most excellent substitute percent of round 2.0- 3.0% well-known shows great influences in enhancing the pleasant of cement matrix. Photocatalytic concrete is a component of concrete used as pavers and different structural concrete that consists of titanium dioxide as an admixture or superficial layer. Titanium dioxide is a heterogenous image catalyst that makes use of daylight and moisture to soak up and renders oxides of nitrogen in to nitrates ions. Which are then both washed away with the aid of using rain or soaked into the concrete to shape solid compounds.

H. Fly- Ash

Fly ash, additionally referred to as "pulverized gasoline ash", is one of the residues generated through coal combustion, and consists of the pleasant debris which are pushed out of the boiler with the flue gases. fly ash consists of big quantities of silico dioxide (SiO2) (each amorphous and crystalline), aluminium oxide (Al2O3) and calcium oxide (CaO), the principle mineral compounds in coal-bearing rock strata . fly ash debris are normally round in form and variety in length from 0.5 µm to 300 µm. Two lessons of fly ash are described through Class F fly ash and Class C fly ash. The leader distinction among those lessons is the quantity of calcium, silica, alumina, and iron content material withinside the ash. Fly ash is normally captured through electrostatic precipitators or different particle filtration system earlier than the flue gases attain the chimneys of coal-fired strength plants, and

collectively with backside ash eliminated from the lowest of the boiler is referred to as coal ash.

III.CASTING AND TESTING

Concrete is a composite fabric which is ready the usage of blending of diverse admixtures and putting it nicely withinside the organized mold, curing it for the specified period, it is able to be in laboratory or in subject this manner has effect at the concrete electricity. In this studies we had taken cautious strive in getting ready the concrete, it is ready in a levelled watertight metal platform which does now no longer take in the water introduced withinside the concrete. The floor is levelled and wiped clean nicely the combination is performed for this paintings in a wiped clean tiltable concrete mixer (electric powered operated). Before casting of the specimen, the floor is wiped clean, watered, the substances are measured in weight batching and saved prepared close to the mixer. Moulds are nicely oiled and bolted to keep away from cement and water get away, the vibration is performed via way of means of the usage of desk vibrator for dice mold and electric powered operated want vibrator with out segregation.

Ingredients are combined withinside the mixer system the usage of general blending protocols via way of means of putting combination first, then excellent combination with including 1/2 of of required water, allowed to combine nicely. Then cement is introduced withinside the blend with crumped rubber being introduced slowly and allowed to combine duly with the addition of closing water required. Then the concrete is poured to metal buckets and then the flowability checks have been conducted, then they're located withinside the mold the usage of general putting strategies via which care is taken to keep away from segregation and get away of water.

The entire blending and putting platform are loose from direct daylight and additionally moisture, the room temperature at some stage in blending is 29°c. Once the concrete is located within side the mold and vibration is performed nicely the floor is levelled and the mildew with concrete is included with polythene sheets to keep away from water get away. The setup is saved for twenty-four h for correct putting and prepared for demoulding, it's miles performed after making sure the putting of concrete. Demoulded specimens have been saved in clean and adulterant loose water which has a pH of 6.9 and no different fabric is present. maintaining idle for 1h, floor cleansing is likewise performed with cotton cloth. The specimens are then painted with white cement to notice the crack propagation and marked as according to the specimen number. Testing is performed in precalibrated checking out device such as compressive electricity checking out system that's digitally managed with 2000 KN ability. The organized specimens are examined as according to Indian general code provisions with the specified loading sample and timing of load applications. Flexure checking out is performed in an electrically operated Universal checking out system with one thousand KN ability which includes pressure controlling mechanism.

IV.RESULTS

The cubes, cylinders and beam specimens have been casted for M40 grade of concrete with 5%, 10%, 15% and 20% alternative of pleasant combination with crumb rubber through extent fraction, GGBS & Fly Ash to get replaced partly with cement with percentage of 30% & 25% respectively with inclusion of TiO2 5%. Above specimens have been examined to acquire the most reliable alternative of crumb rubber with pleasant combination withinside the concrete for Compressive strength, Workability and Flexural strength.

Combinations	
Conventional concrete	M40 Grade of Normal Concrete
Combination 1	GGBS 30% TiO2 5% Crumb Rubber (5, 10, 15, 20) %
Combination 2	Fly Ash 25% TiO2 5% Crumb Rubber (5, 10, 15, 20) %
Combination 3	Fly Ash 25% GGBS 30% TiO2 5% Crumb Rubber (5, 10, 15, 20) %

Table no. 2 Combinations of testing concrete

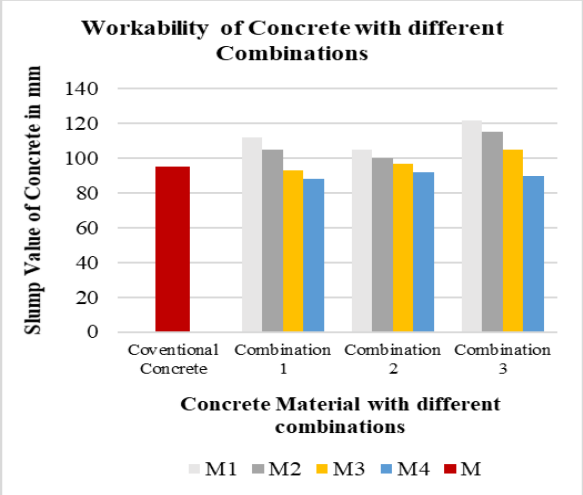
A. Workability on Fresh Concrete

Concrete droop take a look at is to decide the workability or consistency of concrete blend organized on the laboratory or the development web website online all through the development of the work. Concrete droop take a look at is finished from batch to batch to test the uniform best of concrete all through construction. concrete droop fee is used to discover the workability, which shows water-cement ratio, however there are numerous elements consisting of residences of materials, blending methods, dosage, admixtures etc. additionally have an effect on the

concrete droop fee. Keeping water to cement ratio regular this is 0.3 for all combos it's miles been located that the workability of concrete for every aggregate elevated via way of means of 16 % and in addition step by step reduced for all of the combos. The maximum droop become determined for the aggregate three become 121 mm with admire to standard concrete 95 mm. For every aggregate the clean concrete is been organized with regular M40 grade of concrete.

Concrete Material	Slump Value (mm)
Water-Cement Ratio- 0.35	
Conventional Concrete	93
Combination 1	
M1	111
M2	104
M3	92
M4	87
Combination 2	
M1	104
M2	101
M3	96
M4	91
Combination 3	
M1	121
M2	114
M3	102
M4	91

Table no. 3 Workability on Fresh Concrete

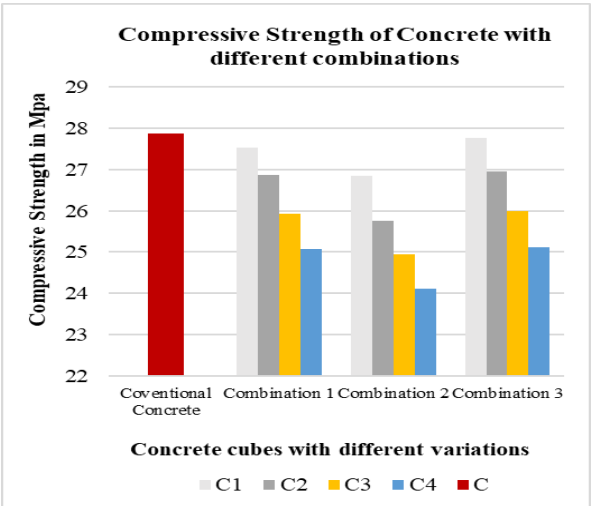


B. Compressive Strength on Concrete Specimen

The compressive energy of concrete turned into located on (150X150X150) mm cubes under the compression checking out system with consistent loading. M40 grade of concrete turned into saved consistent for every dice casted. Compressive energy is located after the water curing duration of seven days and 28 days. It is been located that the compressive energy for all of the combos turned into low with appreciate to the traditional concrete examined on the seventh day of curing. It is been located that the compressive energy turned into steadily lowering with growth in alternative of crumb rubber with pleasant aggregate. The maximum compressive energy turned into located 27.84 Mpa with appreciate to traditional concrete 27.88 Mpa with lack of 0.4 % of energy at 7th day of curing.

Concrete Specimen	Compressive Strength (N/mm^2)
Conventional Concrete	27.88
Combination 1	
C1	27.52
C2	26.08
C3	25.93
C4	25.06
Combination 2	
C1	26.44
C2	25.75
C3	24.97
C4	24.11
Combination 3	
C1	27.84
C2	26.56
C3	26
C4	25.12

Table no. 4 Compressive Strength (7 Days)

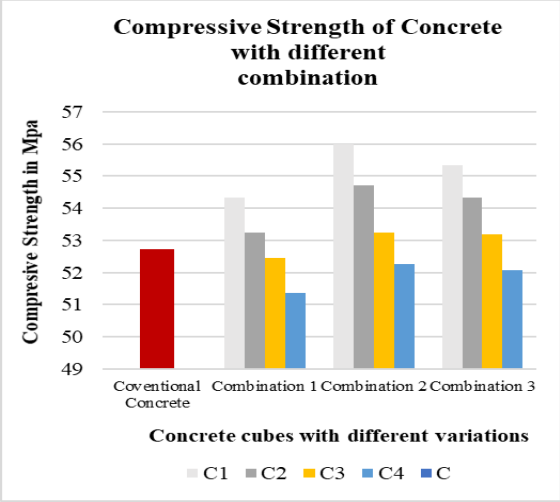


At 28th day of water curing it's miles been determined that the compressive power of concrete specimen step by step improved as compared with the traditional concrete. The compressive power first of all improved after which step by step reduced with boom similarly of crumb rubber. The maximum compressive power

become determined at 28th day of curing become 55.96 Mpa with appreciate to the traditional concrete 52.72 Mpa with boom in 5.9 % of Strength of concrete. It is likewise been determined that as much as 10% to 15% of substitute of crumb rubber with first-rate combination is acceptable.

Concrete Specimen	Compressive Strength (N/mm^2)
Conventional Concrete	52.72
Combination 1	
C1	54.31
C2	53.22
C3	52.45
C4	51.35
Combination 2	
C1	55.96
C2	54.71
C3	53.24
C4	52.25
Combination 3	
C1	55.34
C2	54.31
C3	53.17
C4	52.06

Table no. 5 Compressive Strength (28 Days)



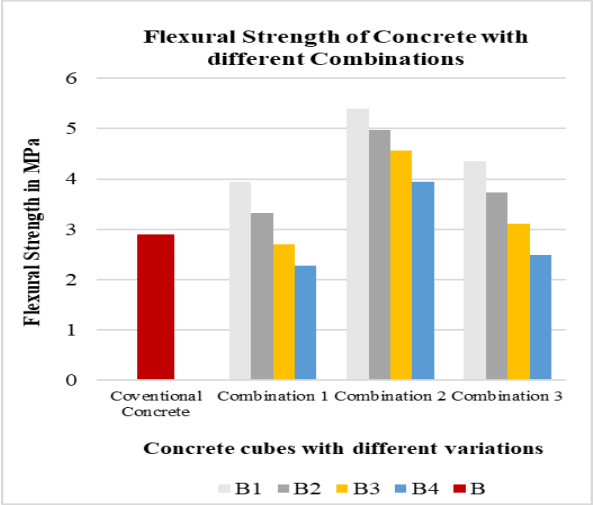
C. Flexural Strength on Concrete Specimen

The flexural power of concrete become discovered on (150X150X700) mm beams below the generic checking out gadget with consistent loading. M40 grade of concrete become stored consistent for every dice casted. Flexural power is discovered after the water curing length of seven days and 28 days. It is been discovered that the Flexural power for all of the combos become excessive with appreciate to the traditional concrete examined on the 7th day of curing.

It is been discovered that the flexural power become step by step reducing with growth in substitute of crumb rubber with best aggregate. The maximum flexural power become discovered 5.353 Mpa with appreciate to standard concrete 2.902 Mpa with growth of 46.15 % of power at 7th day of curing.

Concrete Specimen	Flexural Strength (N/mm^2)
Conventional Concrete	2.902
Combination 1	
B1	3.941
B2	3.317
B3	2.695
B4	2.280
Combination 2	
B1	5.353
B2	4.620
B3	4.351
B4	3.276
Combination 3	
B1	4.353
B2	3.732
B3	3.110
B4	2.487

Table no. 6 Flexural Strength (7 Days)

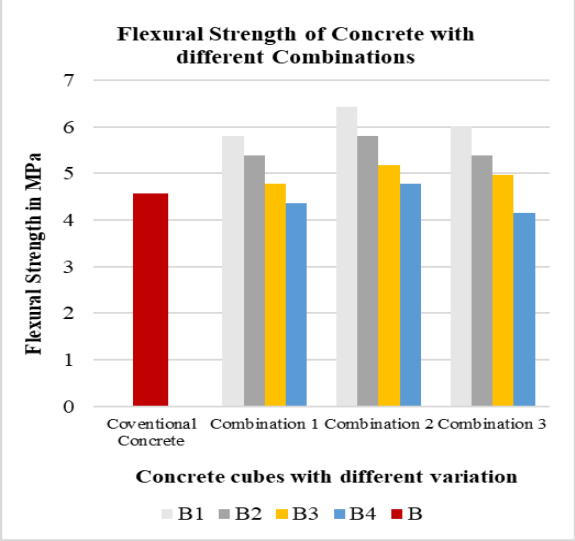


At 28th day of water curing it's far been discovered that the flexural electricity of concrete specimen regularly elevated in comparison with the traditional concrete. The flexural electricity first of all elevated after which regularly reduced with growth further of crumb rubber. The maximum flexural electricity became discovered at twenty eighth day of curing became 6.428 Mpa with admire to the traditional concrete 4.561 Mpa with growth in 29.01 % of Strength of concrete. It has likewise been discovered

that as much as 10% to 15% of substitute of crumb rubber with exceptional combination is acceptable.

Concrete Specimen	Flexural Strength (N/mm^2)
Conventional Concrete	4.561
Combination 1	
B1	5.806
B2	5.391
B3	4.78
B4	4.354
Combination 2	
B1	6.428
B2	5.806
B3	5.184
B4	4.76
Combination 3	
B1	6.013
B2	5.3924
B3	4.976
B4	4.147

Table no. 7 Flexural Strength (28 Days)



CONCLUSION

With the final results of experimental consequences authors are pretty assured that utilization of crump rubber is feasible thinking about the want of development in concrete specializing in unique criteria. With the consequences acquired thru layout of experiments we had delivered crump rubber from five to 20% on the subject of the load batching and carried out experiments in M40 grade concrete. Strength of concrete specimen turned into step by step extended first and with addition of crumb rubber the energy step by step reduced after one limit. The compressive energy turned into extended as much as 6 % with addition of 10% to 15% of crumb rubber. The flexural energy turned into extended as much as 46% with addition of 10% to 15% of crumb rubber and the after it commenced lowering under 15%. So it's far concluded that 5% to 15% of crumb rubber is suitable in concrete to keep away from the waste tyre rubber in environment. With this its very obvious that:

- Usage of crump rubber is prescribed however simplest at an best stage above which the energy will begin dropping,
- A best cost of 20 percent addition is usually recommended that allows you to growth the energy values considerably.
- Effect of crump rubber on one sort of energy (compressive/tensile/flexural) isn't always reciprocating in different energy which must be studied further.

REFERENCE

[1] Malek K. Batayneh, Iqbal Marie, Ibrahim Asi, “Promoting use of crumb rubber concrete in developing countries”, Waste Management 28 (2008) 2171–2176, PP. 1-6, 2008.

[2] Ayesha Siddika, Farhad Aslani, “properties and utilizations of waste tyre rubber in concrete”, Construction and Building Materials 224 (2019) 711–731, PP. 1-21, 2019

[3] Piti Sukontasukkal, Charelmphol Chaikaew, “Properties on concrete pedestrian block mixed with crumb rubber”, Construction and Building Materials 20 (2006) 450–457, PP. 1-8, 2006.

[4] Udomvit Chaisakulkiet, Vanchai Sata, Prinya Chindaprasirt, “Properties of Concrete Pedestrian Blocks Containing Crumb Rubber from Recycle Waste Tyres Reinforced with Steel Fibres”, Case Studies in Construction Materials, CSCM 304, S2214-5095(19)30406-1, PP. 1-28, 2019.

[5] Mohammed Rizwan Ali, Salah Uthman Al-Dulaijan, “Properties of Concrete with Treated and Untreated Crumb Rubber”, Journal of materials research and technology 2021;11:1753-1798, PP.1-46, 2021.

[6] Basher S. Mohammed, Khandekar M. Anwar Hossain, “Properties of Crumb Rubber Hollow

Concrete Block", Journal of Cleaner Production 23 (2012) 57e67, PP. 1-11, 2012.

[7] Jie XU, Ziyi Yao, Guang Yang, "Research on Crumb Concrete: from a multi-scale view", Construction and Building Materials 232 (2020) 117282, PP. 1-25, 2020.

[8] G. Venkatesan, M. Saravaranakumar, Bharat P. Kapgate, "Laboratories studies on Strength behaviour of concrete added with tyre derived products", Materials Today: Proceedings, PP. 1-6, 2019.

[9] Mohamed Thameen Ansari, N. Sathieswaran, O. Ganesh Babu, "Experimental study of an Eco-Friendly concrete by inbuilt with treated crumb rubber", Materials Today: Proceedings, PP. 1-4' 2020.

[10] R. Gajendra Rajan, N. Sakthieswaran, "Experimental Investigation of sustainable concrete by partial replacement of fine aggregate with treated waste tyre rubber by acidic nature", Materials Today: Proceedings, PP. 1-4, 2020.

[11] Camille A. Issa, George Salem, "Utilization of recycled crumb rubber as fine aggregate in concrete mix design", Construction and Building Materials 42 (2013) 48–52, PP. 1-5, 2013.

[12] Xing Ma, Rajeev Roychand, "A comprehensive review on the mechanical properties of waste tyre rubber concrete", Construction and Building Materials 237 (2020) 117651, PP. 1-20, 2020.