EXPERIMENTAL STUDY ON PROPERTIES OF CRUMB RUBBER ASSIST ENHANCEMENT IN CONCRETE

[1]Uday Chaudhary,[2]Ramashish Sah,[3]Humaib Nasir

[1]Research Scholar, School of Civil Engineering, Lovely professional University, Phagwara, Punjab.

[2]Junior Engineer , Mudhbary and Joshi Constructions,
[3]Assistant Professor, School of Civil Engineering
[1]Lovely professional University, Phagwara, Punjab.

Abstract :Morsel elastic cement in which a bit of the mineral totals in concrete is supplanted by the crumb rubber, has pulled in incredible exploration consideration as an economical structure material. It is a promising It is a answer for the over-misuse of waterway sand and the reusing of the waste tire elastic. Nonetheless, the quality solid reduction fundamentally when morsel rubbers were utilized to supplant the fine totals. A solid quality decrease model for the piece elastic cement is basic for its handy use in building structures. This paper decide ideal level of supplanting of coarse total with morsel elastic and fine total with weight powder and mechanical properties of cement with Rubber chips and Ballast powder as swap for common totals. The experimental program consists of casting and testing of 12 cubes, 12 cylinders, and 3cubes and 3 cylinders without rubber chips. The dimensions of cubes used for the tests were 150mmx150mmx150mm & that of cylinder was 150mmx300mm.

IndexTerms - Crumb rubber, concrete, replacement of coarse aggregate, fine aggregate and strength reduction

1. INTRODUCTION

As the auto-mobiles industries increased rapidly in the world number of wastes tire increased every year. 1,034 million tons and 4.19 million tons waste tire were in 2017 delivered to japan and united states respectively. 3.9 million tons to Europe in 2016. 5.12 million tons to china in 2018. The tremendous measure of squander tires has made huge harm the eco-condition, which has drawn around the world consideration on the misuse of elastic assets and the dark contamination brought about by it. The notoriety of reasonable turn of events, ecological agreeable, minimal effort development materials in development industry has driven us to examine the need of utilizing waste materials to profit the earth and keeping up the norm asserted in the norm. The use of waste produced from mechanical also, farming waste ends up being a suitable answer for expanding an unnatural weather change just as eco-accommodating plan for the structures. Blocks are one such class of development material utilized for building internal and external segment of the dividers. Because of exorbitant use of crude materials by block industry it ends up being one of the most dynamic segments to retain the creation of strong waste. Specialists are as of now researching different waste materials for the creation of lightweight structure materials like fly-debris, ground granulated impact slag, EPS dots, glass powder, scrap elastic, PET filaments and some more. Among such waste materials, elastic tire offers an adaptable alternative to be used in solid items. Because of unreasonable deals of vehicles, there is a sharp increment in the aggregation of worn tires. The collection of these waste tires which are considered non-rotting material, getting unloaded in landfills bringing about antagonistic impacts on the biological system. Risky constituents of such waste reason genuine dangers to condition the world over. India delivered over 6% of worldwide waste tire each year which drives organizations like National green council (NGT) to raise worries over safe removal of waste tire and their resulting use in ventures. Endeavor's have been made to utilize tire squander in different ventures, for example, concrete creation, tire-inferred items, ground elastic creation thus on. These businesses are devouring waste tire item yet not in a genuinely ecologically amicable way and speak to different sources of contamination.

Eldin and Senouci initial found huge decreases of the CRC quality through tests. At the point when the elastic totals totally supplanted the fine totals, the compressive and rigidity of the CRC diminished by 65% and half, separately. As of late, numerous analysts have led test examinations on the influencing components of the compressive quality of the CRC, including substitution sum, substitution strategy and size of the elastic, pretreatment strategy for the elastic surface, type and measure of concrete, and blending of minerals. As has been shut by analyses, the compressive nature of the CRC decreases basically when the basically replacement extent of the flexible aggregates increases. Additionally, the compressive nature of the CRC with a with a more noteworthy versatile size is lessened more than with more diminutive flexible size. Improved pre-treatment of the flexible surface and mixing minerals can improve the nature of the CRC. The replacement extent of the versatile aggregates is prescribed to be under 25% in usages of planning structures. Incidentally, the improved introduction of the CRC, for instance, lightweight, pliability, damping, paralyze and sway resistance, warm and sound insurance, make it material for non-fundamental people and essential people with lower limit demand.As a result, reusing remains the best choice to diminish the sway that nature regarding the utilization of crude materials, CO2 emanation, and the collection of waste materials. In such manner, the development and solid industry can be considered as probably the best choice to devour reused materials and mechanical side-effects.

2. LITERATURE REVIEW

2.1 Huang. W et al, 2020 was investigated the Piece elastic cement, in which a part of the mineral totals in concrete is supplanted by the squander tire elastic, has pulled in extraordinary examination consideration as a manageable structure material. Natural aggregates are in limited amount so for protection of it, use the over-burned of earth is plastics tyre which have similar property like natural aggregates. Notwithstanding, the quality cement diminishes fundamentally when scrap rubbers were utilized to supplant the fine totals. A dependable quality decrease model for the scrap elastic cement fundamental for its reasonable use in building structures. This paper investigates the relation between the ratio of compaction and the quality decrease factor of the crumb rubber cement. At the point when the volume substitution proportion R of the elastic totals is under 20%, the quality decrease of the piece elastic cement can be all around anticipated by the proportionate level of compaction. A new quality decrease factor model of the piece elastic cement was created dependent on the largescale porosity hypothesis of cement. Compressive trials of the scrap elastic cement directed by various specialists were utilized to fit the overall boundaries of the proposed model. At long last, the proposed quality decrease model was contrasted with existing models with approve its exactness against the results.

2.2 Thakur. A et al, 2020 investigated there is an exponential improvement in vehicle part inciting growing solicitations of tires which further results in massive tire waste after their organization life. Thinking about use of this waste tires being developed industry, the assessment basically based on the usage of waste piece versatile as a partial replacement of fine sums in the formation of lightweight stone work blocks. Furthermore, all together to support the affordable condition, an undertaking has been made to utilize tire waste as piece versatile for the making of squares. In this assessment, waste piece flexible tires were used in inadequate replacement of fine aggregates for making blocks. The squares were made with changing paces of piece versatile for instance 5%, 10%, 15% and 20% by volume of fine aggregates taking care of water/solid extent as 0.43 for all picked mixes. The effect of piece versatile was focused on both new mixes similarly as set squares. The new properties, for instance, hang and thicknesses were thought of and assessed the stream limit. The mechanical properties as compressive quality, unbending nature and impact resistance of hardened strong squares were thought about and backslide examination were finished to survey the malleable quality. It is seen that the hang and water osmosis extended energetic with increase in pace of piece flexible. Up to 10% of piece versatile, starting movement of water absorption was found extended from that point on it is viewed as reduced with augmentation of piece flexible. It was similarly observed that compressive moreover, versatility showed direct decrement with increase in level of scrap flexible. It was seen that the imperativeness maintenance extended by 3.66 events for CR20 mix when appeared differently in relation to CM. It was also observed that the exploratory association helps in predicting the unbending nature and found planning extraordinary.

2.3 Tseng. M-L, et al 2019 was investigated brisk advancement in vehicle creation in China during the past moderately barely any many years has caused various tires to be exonerated, and their release has become an essential test. This assessment proposes a Triple Exponential Smoothing check model to predict the deftly of waste tires in 2019–2023, and the essentialness for these tires in three street progress conditions. In like manner, execution assessment is facilitated to survey the carbon releases passed on in the creation approach of piece versatile, changed faint top, and styrene–butadiene–styrene balanced faint top. The decreasing uttermost compasses of carbon discharges when utilizing piece versatile for street improvement is evaluated to add to the reasonable relationship of waste tires. The outcomes show that the measure model utilized for requirement for waste tire creation is immense, and the check results can be utilized to review squander tire reusing. In like manner, scrap flexible can be utilized as a beneficial and normally kind strategy for reusing end-of-life tires. Extending the level of adaptable powder dull top application is a sensible structure for changing the deftly and arrangements peculiarity of piece flexible. Furthermore, the potential for vitality experience assets and outpourings rot, paying little heed to the cash related focal reasons for using piece adaptable balanced faint top, are by and large higher than those using styrene–butadiene–styrene adjusted faint top. These results show the opportunity of a roaming economy and decreased dependence on non-practical faint top resources.

2.4 Wang. G et al, 2018 investigated the asphalt layers must be adequately solid to convey all traffic loads and oppose the collection of lasting disfigurements, for example, rutting and dodge untimely disappointments including top-down splitting during their administration lives. Lately, the usage of reused development and destruction (C&D) materials in common and transportation foundation development has been considered as a huge answer for supplant regular and characteristic totals, in this way to accomplish the objective of building low-carbon impression developed offices. Sadly, restricted information have yet covered the perpetual twisting conduct of the reused materials in asphalt, particularly the impact of morsel elastic and elastic size with C&D totals on the lasting twisting conduct in base and subbase layers. This paper gives remarkable research facility data and testing brings about this respect. In this examination, two unique gatherings of scrap elastic particles with sizes ran from 400 to 600 mm (fine) and 15–20 mm (coarse) were independently added to 20 mm reused solid total (RCA) and 20 mm squashed stone (CR) at 0.5, 1 and 2% by weight of the totals to examine the impacts of morsel elastic and elastic size on lasting twisting conduct of RCA and CR totals. Specifically, the perpetual distortion conduct of the RCA/CR with morsel elastic was examined through the rehashed load triaxial tests. It was seen that the CR tests ought to be stayed away from for use in base and subbase courses.

2.5 Meddah. A et al, 2014 investigated the Reusing of waste elastic tires in asphalts is considered as natural and prudent arrangements due to their points of interest. It might help protecting common assets and delivering an eco-accommodating material. In asphalts (RCCP) has similar essential fixings as in standard cement with utilizing of roller compacted concrete. Be that as it may, in contrast to the regular solid, it is due to drier compacted by vibratory rollers. This examination expects to tentatively explore the chance of utilizing destroyed elastic tire in RCCP. The elastic materials are put into mixture as an incomplete substitution by volume of certain pieces of normal squashed totals. Unit weight, mechanical properties, modulus of versatility and porosity are assessed and contrasted agreeing with the elastic substance in the solid blend. The impacts of compaction vitality and harshness of elastic surfaces are additionally contemplated. The outcomes acquired indicated that the incorporation of elastic particles in RCCP blends will change their attributes in new state just as solidified state. Indeed, in spite of the fact that the mechanical properties decline when elastic substance in the blend is expanding, it ought to be noticed that it is conceivable to utilize elastic particles in low rush hour gridlock asphalts venture. Other side, rubber materials may become better some ideal specialized attributes, for example, porosity, pliability and splitting obstruction execution. Notwithstanding that, it might be all the more naturally productive to utilize elastic totals in RCCP, on the grounds that this assists with eliminating a few pieces of these squanders and secure the earth. The presentation of RCCP with destroyed elastic increases can be improved by adjusting the unpleasantness of elastic molecule surfaces, at the point when the ideal elastic substance relies upon specialized prerequisites and the objective of undertaking.

2.6 Roychand. R et al, 2019 investigated the Reusing of 'End of Life Tires' (ELT) is one of the major ecological concerns looked by the logical network and the administration associations, around the world. Consistently, an expected one billion tires arrive at their finish of life, out of which just about half are presently being reused and the rest of the structure part of the landfills. Consequently, there is a dire need to improve the current and grow new applications of reused tire items to address this shortage in the use pace of the ELT. One application which is effectively being explored is the utilization of waste tire elastic as a halfway substitution of regular totals in solid applications. In spite of the fact that it shows huge potential, it accompanies its own difficulties for example, feeble innate quality of the elastic and helpless bond execution with the concrete grid, which impedes its utilization as a total in enormous amounts. To conquer this test, scientists have taken a gander at different elastic treatment techniques that improve the bond execution as well as altogether improve the mechanical properties of elastic cement. This survey paper considers the impact of elastic molecule size, rate substitution and different treatment strategies on various mechanical properties of elastic concrete, concentrated throughout the most recent 30 years. Notwithstanding, to be acknowledged by the solid industry, the scientists need to think of an elastic treatment technique that can address the worries of high combustibility and the resultant arrival of harmful gases from the elastic particles, when uncovered to fire.

2.7 Varela. F et al, 2018 investigated the taking care of and capacity of end-of-life tires is an ecological issue and establishes an extensive overall test. This paper explores the appropriateness of utilizing disposed of waste tire elastic particles in concrete inflexible street asphalts. The goal is to advance size and extent of elastic molecule to improve the materials exhibition. An experiment was conducted to determine the elastic size on elastic substance on mechanical properties of solid asphalts. Blends with elastic particles of variables sizes (1-4,10 and 16mm) included various extents (10, 20 and 30%) are thought of. A novel test to assess misshaping (as far as cross-over miniature breaks) endured by the material under recurrent endeavours like traffic loads is proposed. A unique mix of size and degree of adaptable materials betterment of particles under cyclic weight stresses, can be used for inflexible strong pavements.

3. Material and Methodology

3.1 Program of Experimental work

The trial program comprises of projecting and testing of 12 3D squares, 12cylinders, and 3cubes and 3 cylinders without rubber chip. The elements of 3D shapes utilized for the tests were 150mmx150mmx150mm and that of chamber was 150mmx300mm.The rubber treated solid examples in every class contains elastic chips at 10%,20%, 30% and 40& volume division of coarse totals alongside 20%,30%,40% and half weight powder separately.

3.2 Materials Used

Materials involved in this experiment are

- 53 Grade Ordinary Portland cement
- Fine Aggregate
- Coarse Aggregate
- Water
- Rubber chips
- Ballast powder

- **Cement**

Concrete utilized in the assessment was 53 evaluation standard Portland concrete attesting to IS: 12269. Customary Portland concrete is used for general turns of events. The rough materials required for gathering of Portland concrete are calcareous materials, for instance, limestone or chalk and argillaceous materials, for instance, shale or mud. The amassing of cement contains beating the rough materials, mixing them actually in explicit degrees depending on their flawlessness and structure and expending them in a stove at a temperature of about 13000C to 15000Cat the temperature, the materials sinters and fairly circuits to outline nodular shaped clinker. The clinker is cooled and ground to a fine powder with development of around 2 ton 3% of gypsum. The thing formed by using the technique is a “Portland concrete".

Physical properties of cement

S. No	Property	Test results
1	Normal consistency	30%
2	Specific gravity	3.06
3	Initial setting time	35 minutes
4	Final setting time	8 hours

- **Fine Aggregate:**

The fine total adjusting to Zone-3 as per IS: 10262-2009 were utilized. The fine total utilized was gotten from a close by stream source. 2.47 is the specific gravity of sand which is involved in this experiment. The sand got was sieved according to IS strainers (for example 4.75, 2.36, 1.18). Sand passing 4.75mm sifter were kept independently for use.

- **Coarse Aggregate**

The coarse total gotten from a neighborhood smashing unit having differing sizes. Those totals were sieved and 20mm held totals were stacked independently for use. 20mm very much reviewed total as indicated by IS: 383-1970 was utilized in this examination. Explicit gravity of the coarse total is 2.82.

- **Water:**

Consumable water was utilized in the test work for blending and restoring.

- **Crumb Rubber**

The Crumb rubbers used were of size 20mm-30mm so that it can easily replace the coarse aggregates of 20 mm size.

- **Ballast powder**

Ballast powder is gathered from neighborhood stone squashing unit. It was at first dry in condition when gathered and as sieved by IS: 4.75-micron sifter before blending in concrete. Explicit gravity watched for quarry dust is 2.56.

Figure 2.1 Ballast powder

3.3 Moulds and equipment's for casting

3.3.1 Molds

For casting **cubes**, standard cast iron cube of 150mmx150mmx150mm were used. For casting **cylinders** standard mold of 150mmx300mm size were used.

3.3.2 Concrete Mixer

Prior to projecting the shapes, the materials were gauged and saved prepared for blending. The necessary amounts of materials for 3cubes of every percent variety were blended in a plate blender. For chambers additionally each specific rate was done in turn to keep away from inappropriate blending. Elastic chips, Coarse total, fine total, weight powder and concrete were placed into the plate and water was added to the blend during blending and hand blending was finished. Subsequent to accomplishing a uniform blend, concrete was set quickly in the 3D shape or chamber as appropriate. Vibrating table was utilized for compaction of shapes and chambers.

3.3.3 Vibrator

Compaction of 3D shapes and chambers were finished by vibrating table. The vibrating table comprises of an unbendingly fabricated steel stage mounted on adaptable springs and is driven by an electric engine.

3.4 Mix proportions:

The path toward picking fitting components of concrete and choosing their relative totals with objective of conveying a strong of the required, quality, quality, and value as financially as could sensibly be normal, is named as strong mix plan. M40 Grade of Concrete was utilized in the examination. A blend of M40 goes under Standard Concrete as Specified by IS 456-2000 and were planned by utilizing IS 10262-2009.The blend extents comparing are 1:1.14:1.84:0.4. The constituents of mix proportion were shown in the Table below.

Table 3. 4: Mix proportion for 1 cubic meter of concrete (M40)

Mix proportion	Waterkg/m$^{3)}$	Cement (kg/m$^{3)}$	Fine aggregate (kg/m$^{3)}$	Coarse aggregate (kg/m$^{3)}$
By weight (kg)	213.9	534.75	611.95	984.87
By volume	0.4	1	1.14	1.84
For 1 bag cement	20	50	57	92

3.5 Design of M40 grade of concrete

A. stipulations for proportioning:

Grade designation : M40

Type of cement : OPC (53grade)

Maximum nominal size of aggregates : 20mm

Minimum cement content : 300kg/m3

Maximum water-cement ratio : 0.45

Workability : 175mm (slump)

Exposure condition

Maximum cement content : 534.75kg/m3

Degree of supervision : good

Type of aggregate : crushed angular aggregates

B. Test data for materials

a) cement used : OPC53 grade IS: 12269
b) specify gravity of cement : 3.06
c) Specific gravity of
1) Coarse aggregates 2.82
2) Fine aggregates 2.47

C. Target strength for mix proportioning

$f'_{ck} = f_{ck} + 1.65\times$ standard deviation
$= 40+1.65\times5$

= 48.25 N/mm2

Where, f'_{ck}= target average compressive strength at 28 days

f_{ck}= characteristics compressive strength at 28 days

s= standard deviation

From table 8, IS 456:2000,

Standard deviation = 5 N/mm^2

Target strength = 48.25 N/mm^2

D. Determination of water-cement ratio

From table 5 IS:2000, maximum water cement ratio= 0.45

But we adopt w/c =0.4

0.4<0.45, hence ok

E. Determination of water content

From table 2 of **IS 10262:2009**

We get maximum water content for 20mm coarse aggregates = 186 liters (for 25 to 50mm slump range)

Estimated water content for 175mm slump = 186+ (15÷100) ×186 =213.9 liters

(3% increase for every 25mm slump over 50mm slump)

F. Calculation of cement content

From table 5 of IS 456 :200, for moderate exposure condition

Cement= 300 kg/m3

Water cement ratio = 0.4

Water used = 213.9 liters

Cement content = (water content/water-cement ratio)

=213.9/0.4

=534.75 kg/m^3

534.75kg/m^3> 300kg/m^3, hence, ok

G. proportion of volume of coarse aggregates and fine aggregates

With the increase in coarse aggregates proportion to reduce fine aggregates due to decrease in water cement reduced.

The coarse aggregate is increased at the rate of 0.01 for every decrease in w/c ratio of 0.05.

For decrease of every 0.05w/c ratio = coarse aggregates increased by 0.01

For decrease of every 0.05 w/c ratio = $\frac{0.01}{0.05} \times 0.05$ = 0.01

Corrected proportion of volume of coarse aggregate = 0.6+0.01 = 0.65

Since, it is angular aggregate and concrete is to be pumped, the coarse aggregate can be reduced by 10% (IS 10262:2009, clause 4.4.1)

By reducing 10%, we get = 0.65× 0.9

= 0.585

Therefore,

Volume of coarse aggregates = 0.585

Volume of fine aggregates = 1-0.585

= 0.415

H. Design mix calculation (IS 10262:2009)

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

(a) Volume of concrete = 1 m^3

(b) volume of cement =$\frac{\text{mass of cement}}{\text{specific gravity of cement}} \times \frac{1}{1000}$

$= \frac{534.75}{3.06} \times \frac{1}{1000}$

= 0.17m^3

(c) volume of water

$$= \frac{\text{mass of water}}{\text{specific gravity of water} \times 1000}$$

$$= \frac{213.9}{1 \times 1000} = 0.213\ m^3$$

(d) volume of entrapped air = 2% for 20mm coarse a= 0.02 m^3

(As per IS 10262:2009, the percentage of entrapped air is zero, still 2% is considered on practical experience)
(a) volume of all aggregates = volume of concrete –(volume of cement+ volume of water+ volume of entrapped air)
= (0.17+0.213+0.02)= 0.597 m^3
(b) mass of coarse aggregates = e× volume of coarse aggregates × specific gravity of coarse aggregates × 1000
= 0.597 × 0.585 × 2.82 ×100
= 984.87kg
(c) mass of fine aggregates = e× volume of fine aggregates × specific gravity of fine aggregates × 100
= 0.597× 0.415 ×2.47×1000 = 611.95kg

MIX PROPORTIONS BECOMES

WATER: CEMENT: FINE AGGREGATES: COARSE AGGREGATES

213.9lit: 534.75 kg: 611.95 kg: 984.87kg

0.4: 1: 1.14: 1.84

Design mix for M_{40} = 0.4:1:1.14:1.84

3.6 Preparation of the specimens

3.6.1 Casting of Specimens:

Shapes having standard molds of size 150mmx150mmx150mm were fitted sothat no holes were left between the plates. At that point the molds were oiled and saved prepared for projecting. The evaluation of cement was casted with 10%, 20%, 30% and 40% expansion of Rubber chips and 20%, 30%, 40% and half stabilizer powder. Vibrating table was utilized for compaction. Toward the end the top surface were done with the assistance of scoop. Following 24 hours the 3D squares were demolded and kept in the tank for restoring for the necessary number of days before testing.

Chambers having standard molds of size 150mmx300mm were fitted so that no holes were left between the plates. At that point the molds were oiled and saved prepared for projecting. Whole projecting was finished.

For M40 evaluation of cement was casted with 10%, 20%, 30% and 40% expansion of Rubber chips and 20%, 30%, 40% and half stabilizer powder. Vibrating table was utilized for compaction.at the end the top surface was done with the assistance of scoop. Following 24 hours the shapes were demolded & kept in the tank for relieving for the necessary number of days before testing.

3.6.2Curing:

After the fruition of projecting all the examples were kept to keep up the encompassing conditions viz. temperature of 27±C and 90% relative stickiness for 24hours. The examples were taken out from the shape and lowered in clean new for 28 days. The temperature of water wherein the shapes were lowered was kept up at 27± 2 C.

3.7 Testing of Cubes:

After examples were relieved for 7, 14 and 28 days, the blocks and chambers for M40 evaluation of cement were taken out and dried for testing. Blocks are tried for compressive quality test while Cylinders are tried to quantify the split rigidity.

3.8 Tests performed

3.8.1 Compressive Strength Test:

The strong shape models were taken a stab at pressure testing machine cut-off 3000kN. The bearing surface of machine was tidied up great and any free sand or other material disposed of from an external perspective of the model. The model was set in the machine so that the pile was applied to converse sides of the 3D shapes as standing that is by all accounts, not top and base. The center of the model was intentionally balanced at the point of convergence of the stacking layout. The pile applied was extended incessantly at a reliable rate until the block of the guide to the growing burden isolates and not, now proceeded. By then most outrageous weight applied on the modelwas recorded. The nuances of compressive quality results for M40 assessment of all gatherings without and with flexible chips were taken a gander at.

Fig. Compressive strength test of cubes

3.8.2 Split Tensile Strength Test:

Compression test was conducted on the cylinder specimens having capacity of 3000 tons. The bearing surface of the machine was wiped off clean in case of cylindrical specimen the test was carried out by placing the specimen horizontally between the loading surfaces of the compression testing machine for split tensile strength and the axis of the specimen was carefully aligned at the centre of loading frame. The load applied was increased continuously at a constant rate until the resistance of the specimen to the increasing load breaks down and no longer can be sustained. The maximum load applied on the specimen was noted.

The split Tensile Strength is obtained as

$$2P/(\pi * LD)$$

Where,
P is the max load carried by the cylinder
L is the length of the cylinder
D is the diameter of cylinder

Fig. Testing of cube for compressive strength

3.7. ESTIMATION OF QUANTITIES

Table No. 4.7 Estimation Of M40 Cubes Quantity

ELEMENTS(all in kg)	RC10% & 20%BP	RC 20% & 30%BP	RC 30%& 40%BP	RC 40% & 50%BP
Cement	5.2	5.2	5.2	5.2
Fine aggregates	4.96	4.34	3.72	3.1
Coarse aggregates	8.973	7.976	6.97	5.98
Rubber chips	0.997	1.994	2.99	3.988
Ballast powder	1.24	1.86	2.48	3.1
Water	0.4	0.4	0.4	0.4

4. TESTS AND RESULTS

4.1 TESTING ON CEMENT

4.1.1 FINENESS OF CEMENT

OBSERVATION:

1. Weight of cement taken on the sieve = 100gm
2. Weight of residue after sieving = 6gm
3. Percentage of fineness $= \frac{\text{weight of residue}}{\text{weight of cement}} \times 100$

$$= \frac{6}{100} \times 100$$

$$= 6\%$$

RESULTS: Fineness of given sample of cement is 6%.

4.1.2. NORMAL CONSISTENCY OF CEMENT

OBSERVATION FOR NORMAL CONSISTENCY OF CEMENT

S.NO	Percentage of water added	Quantity of water added in ml	Vicat's plunger reading
1.	28%	112	19
2.	30%	120	6

Results: Normal consistency for the given sample of cement is 30%.

4.1.3 INITIAL SETTING & FINAL SETTING TIME

OBSERVATION AND CALCULATIONS

Weight of cement taken = 400gm

Water required for normal consistency = 30% (112ml)

Weight of water taken for making specimen = 102ml

Initial setting time = 35 minutes

RESULT: The initial setting time of given sample is 35 minutes.

FINAL SETTING TIME

RESULTS: The final setting time of given sample is 8 hours.

4.1.4 SPECIFIC GRAVITY OF CEMENT

OBSERVATION:

Weight of empty flask (W1) = 0.080kg

Weight of flask + cement (W2) = 0.130kg

Weight of flask + cement + kerosene (W3) = 0.190 kg

Weight of flask + kerosene (W4) = 0.160kg

CALCULATION:

Specific gravity of cement = $\frac{(W2-W1)}{(W2-W1)-(W3-W4)}$

$=\frac{(0.130-0.080)}{(0.130-0.080)-(0.190-0.160)}$

$=\frac{0.05}{0.02} = \frac{2.5}{0.82} = 3.06$

Here, 0.82 is density diesel.

RESULTS: Specific gravity of given sample of cement is 3.06.

4.1.5 TESTING ON FINE AGGREGATES

4.1.5.1 SPECIFIC GRAVITY OF SAND

OBSERVATIONS:

Weight of empty Pycnometer (W1) = 0.61kg

Weight Pycnometer + sand (W2) = 1.130kg

Weight of Pycnometer + sand + water (W3) = 1.67 kg

Weight of Pycnometer + water (W4) = 1.36kg

CALCULATIONS:

Specific gravity of sand $=\frac{(W2-W1)}{(W2-W1)-(W3-W4)}$

$=\frac{(1.130-0.61)}{(1.130-0.61)-(1.67-1.36)}$

$=\frac{0.52}{0.21}$

= 2.47

RESULTS: Specific gravity of sand is **2.47.**

4.1.5.2 SIEVE ANALYSIS OF SAND

TABLE No4.1.1.2 OBSERVATIONS OF SIEVE ANALYSIS OF SAND

sieve size (mm)	weight retained (gm)	Percentage weight retained (gm)	Cumulative percentage of weight retained	Cumulative percentage of weight passed
4.75	22	0.6	0.6	99.4
2.36	32	1.32	1.32	98.68
1.18	144	4.92	4.92	95.08
600µ	973	12.28	17.2	82.8
300µ	2000	57.5	74.7	25.3
150µ	1170	24.1	98.8	1.2
75µ	480	1.2	99.99	0.01
Pan	5	0.033	100	0
Total			**297**	

RESULT: Fineness modulus

$$= \frac{\text{sum of cumulative \% of weight retained}}{100}$$

$$= \frac{297}{100}$$

= 2.97

4.1.6 TESTING OF COARSE AGGREGATES

4.1.6.1 SPECIFIC GRAVITY OF COARSE AGGREGATE

OBSERVATION:

Weight of empty bucket (W1) = 2.12kg
Weight of bucket + gravel (W2) = 10.56kg
Weight of bucket + gravel + water (W3) = 20.16kg
Weight of bucket + water (W4) = 14.71kg

CALCULATION:

Specific gravity of gravel

$$= \frac{(W2-W1)}{(W2-W1)-(W3-W4)}$$

$$= \frac{(10.56-2.12)}{(10.56-2.12)-(20.16-14.71)}$$

= 2.82

RESULTS: Hence, specific gravity of coarse aggregate is **2.82.**

4.1.7 TESTING ON CRUMB RUBBER

4.1.7.1 SPECIFIC GRAVITY OF CRUMB RUBBER

OBSERVATION:

Weight of empty bucket (W1) = 2.12kg
Weight of bucket + rubber chips (W2) = 5.38kg
Weight of bucket + rubber + water (W3) = 14.87 kg
Weight of bucket + water (W4) = 14.71kg

CALCULATION:

Specific gravity of Crumb rubber

$$= \frac{(W2-W1)}{(W2-W1)-(W3-W4)}$$

$$= \frac{(5.38-2.12)}{(5.38-2.12)-(14.87-14.71)}$$

$=\frac{3.26}{3.1}$

= 1.05

RESULTS: Hence, specific gravity of Crumb rubber is **1.05**.

4.1.8 TEST ON BALLAST POWDER
4.1.8.1 SPECIFIC GRAVITY OF BALLAST POWDER
OBSERVATIONS:

Weight of empty Pycnometer (W1) = 0.61kg
Weight Pycnometer + ballast powder (W2) = 1.25kg
Weight of + ballast powder + water (W3) = 1.75 kg
Weight of Pycnometer + water (W4) = 1.36kg

CALCULATIONS:

Specific gravity of sand

$=\frac{(W2-W1)}{(W2-W1)-(W3-W4)}$

$=\frac{(1.25-0.61)}{(1.25-0.61)-(1.75-1.36)}$

$=\frac{0.64}{0.25}$

= 2.56

RESULTS: Specific gravity of sand is **2.56**.

4.1.9 TEST ON FRESH CONCRETE
4.9.1.1 SLUMP CONE TEST

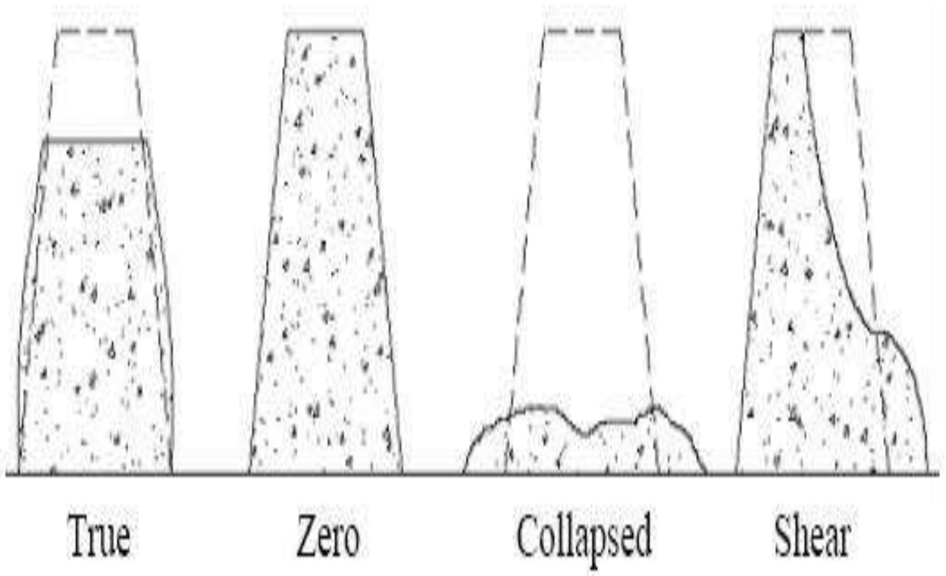


Fig. 3.5: Types of slumps

RESULTS: The slump value is **160.**

4.2 Mechanical Test Results

4.2.1 Compressive Strength Results

M40 grade of concrete with and without crumb rubber compressive strength value tabulated below

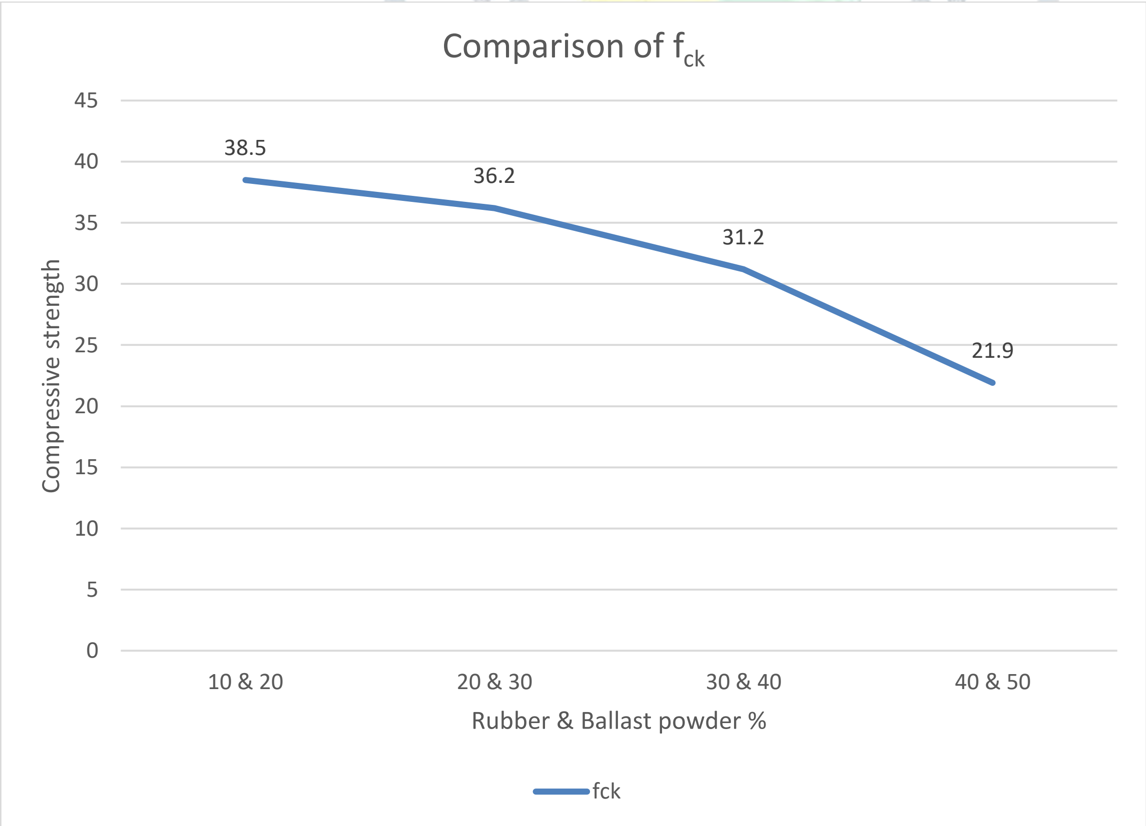
TABLE No4.2.1 COMPREESIVE STRENGTH VALUES

MIX	% OF RC	% OF BP	Compressive strength values in KN			f_{ck} in N/mm2			Target Mean strength in N/mm2
			7days	14days	28days	7days	14days	28days	
M40	0	0	705.65	977.06	1074.06	31.36	43.41	47.76	48.25
	10	20	618.85	844.17	866.25	27.5	37.5	38.5	48.25
	20	30	558.88	789.93	813.38	24.84	35.1	36.2	48.25
	30	40	477.72	645.83	701.82	21.23	28.7	31.2	48.25
	40	50	358.47	463.12	493.31	15.9	20.58	21.92	48.25

5. DISCUSSION

Compressive strength values were obtained by dividing the loads the cubes can sustain by the area of cubes (15cmx15cm). From the table no.8 it is evident that compressive strength of specimen decreased compared to the controlled specimen. Decrease in compressive strength is 19.4%, 24.2%, 34.6& and 54.1% for 10%,20%,30% and 40% rubber chips replacement along with20%,30%,40% and 50% ballast powder respectively for M_{40} grade of concrete.

The maximum decrease in compressive strength is observed for 40% & 50% of rubber chips and ballast powder replacement combined. The values obtained showed that there is continuous decrease in compressive strength with increase in rubber and ballast powder content for each mix of concrete. The comparison of actual fck obtained is as shown in figure.



.Fig. 5 Comparison of f_c

6. CONCLUSION

6.1 Addition of rubber chips & ballast powder to the mineral coarse aggregates & fine aggregates resulted in a decrease of **compressive strength** of specimen for the grade of concrete. Maximum decrease in strength was for 40 percentage replacement of rubber chips & 50 percentage of ballast powder.

6.2 **Split tensile strength** also decreased with increment in addition of rubber chips & ballast powder.

6.3 As the specific gravity of rubber chips was found to be quite less than that of conventional coarse aggregates, the **density** decreased for each grade of concrete. With increment in rubber chips replacement, the density decrement occurred accordingly.

6.4 In fact, the inclusion of rubber chips implies defects in the internal structure of the composite material, producing a reduction of strength and a decrease of stiffness.

7.Reference

7.1 Wei Huang Xiege Huang,Qiong Xing and ZhiZhou,Strength reduction factor of crumb rubber as fine aggregate"Journal of Building Engineering, 2020.

7.2 Mohammad SaberianJie Li, Bao Nguyen and George Wang , Permanent deformation behaviour of pavement base and subbase containing recycle concrete aggregate, coarse and fine crumb rubber, Construction and Building Materials 178 (2018) 51–58.

7.3 Ankush Thakur, K. Senthil, Rachit Sharma and A.P. Singh, Employment of crumb rubber tyre in concrete masonry bricks, Materials Today: Proceedings xxx (xxxx) xxx.

7.4 Qing-Zhou Wang, Nan-Nan Wang, Ming-Lang Tseng, Yu-Man Huang and Ning-Li Li, Waste Tire Recycling Assessment: Road Application Potential and CarbonEmissions Reduction Analysis of Crumb Rubber Modified Asphalt in China, Journal of Cleaner Production,2019.

7.5 Abdelaziz Meddah ,MiloudBeddar and Abderrahim Bali, Use of shredded rubber tire aggregates for roller compacted concrete pavement, Journal of Cleaner Production 72 (2014) 187e192.

7.6 Rajeev Roychand a, Rebecca J. Gravina , Yan Zhuge, Xing Ma, Osama Youssf and Julie E. Mills, A comprehensive review on the mechanical properties of waste tire rubber concrete, Construction and Building Materials 237 (2020) 117651.

7.7 Tian Chen, Tao Ma, Xiaoming Huang, Yongsheng Guan, Zhixiang Zhang, Fanlong Tang, The performance of hot-recycling asphalt binder containing crumb rubber modified asphalt based on physiochemical and rheological measurements, Construction and Building Materials 226 (2019) 83–93.

7.8 C.A. Alves, A.M.P. Vicente, A.I Calvo, D. Baumgardner, F. Amato, X. Querol, C. Pio, M. Gustafsson, Physical and chemical properties of non-exhaust particles generated from wear between pavements and tyres, Atmospheric Environment (2020).

7.9 GuillianaAgudelo, Sergio Cifuentes, Henry A. Colorado, ground tire rubber and bitumen with wax and its application in a real highway, Journal of Cleaner Production 228 (2019) 1048e1061.

7.10 Abbas Mohajerani, Lucas Burnett, John V. smith, Glen Rodwell, recycling waste rubber tyres in construction materials and associated environmental considerations: A review, Resources, Conversation and Recycling 155(2020) 104679.

7.11 Filipe d's. Autrliano, Ariellan Ap. F. coasta, Ivan F. Junior, Rafael d' O. Pedroso, Manufacture of structural blocks of concrete with tire rubbers, Procedia Manufacturing 38(2019) 464-470.

7.12 A. Rangaraj, P. Mukesh, An experimental investigation on partial replacement of bitumen using rubber tyre, Materials Today: Proceedings xxx (2019) xxx.

7.13 D. Lo Presti, M.A. Izquierdo, A jimenez Del Barco carrion, Towards Storage-stable high-content recycled tyre rubber modified bitumen, Construction Materials 172(2018) 106-111.

7.14 Rosalia Pacheco-Torres, Elena Cerro-Prada, Felix Esolano, FemandoVerela, Fatigue performance of waste rubber concrete for rigid road pavements, Construction and Building Materials, 176(2018)539-548.