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EFFECT OF RUBBER POWDER ON MECHANICAL PROPERTIES OF M25 GRADE CONCRETE USING RECYCLED AGGREGATES ALONG WITH STEEL FIBERS

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Abstract: This present paper deals with the concrete mix of M25 grade which was made using OPC 53 grade of cement and in which , rubber particles, recycled aggregates and steel fibers are used to replacing the cement, natural coarse aggregates and natural fine aggregates. and Rubber particles in structural concrete is a sustainable solution to dealing with solid waste. This technology reduces the serious impact on ecological environments caused by a shortage of natural mineral resources. The aim of the present study is to investigate the coupling effects of incorporating and rubber particles on the compressive and split tensile performances of selected M25 grade concrete. Casting of Cubes and Cylindrical Specimens of (150*150 mm) and (150 mm diameter and 300 mm Height) in Sizes to find out the fresh and hardened properties of M25 grade concrete mix for 7 and 28 days.

Index Terms **, rubber particles, recycled aggregates, steel fibers, Concrete Mix, Compressive strength, Split Tensile strength and Ordinary Portland Cement.**

I INTRODUCTION

1.1 INTRODUCTION TO CONCRETE:

The most widely used construction material in the world is probably the concrete because Concrete makes a building fire safe due to its non-combustible nature and is free from defects and flaws and is more economical, maintenance cost is almost negligible. The key to achieving a strong, durable concrete rests in the careful proportioning and mixing of the ingredients.

A mixture that does not have enough paste to fill all the voids between the aggregates will be difficult to place and will produce rough surfaces and porous concrete. A mixture with an excess of cement paste will be easy to place and will produce a smooth surface; however, the resulting concrete is not cost-effective and can more easily crack.

1.1.1 CEMENT

Cement is a binding material and is responsible for interlock between constituents present in concrete. Cement is a basic ingredient of concrete, plaster and mortar and is formed by calcinations of Argillaceous, calcareous and siliceous compounds and which responsible for formation of calcium hydrates in cement hydration and which affects the strength and setting time of concrete.

1.1.2 FINE AGGREGATES

Fine aggregates/sand that have been sorted out and isolated from the natural material by the activity of streams of water or by winds crosswise over bone-dry grounds are by and large entirely uniform in size of grains. Generally business sand is acquired from waterway beds or from sand rises initially framed by the activity of winds. Natural sand means River sand collected from near and is passing through 4.75mm and is free from clay, silt and other organic matters does not exceed the specified limit.

1.1.3 COARSE AGGREGATES

Coarse aggregates are classified based on its shape, size and texture etc. Depends on it, the volume of this occupies in the concrete varies. A continuous gradation of particle sizes is desirable for efficient use of the paste. In addition, aggregates should be clean and free from any matter that might affect the quality of the concrete. Which is angular in shape and size about 20mm is taken for experimental investigation. This is having particle size as are retained on I.S. sieve 4.75mm and which occupies large portion of concrete.

1.1.4 WATER

The amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life. Ordinary potable tap water available in laboratory was used for mixing and curing of concrete and is free from impurities and micro-organisms.

1.2 NEED OF ALTERNATIVE MATERIALS IN CONSTRUCTION FIELD

The Demand of building materials like cement, sand and coarse aggregates are increases rapidly due to industrial, constructional and domestrial expansion by increasing population. Tones of these material requires to fulfill the needs of people and these material are responsible for some problems like cement manufacturing increases air pollution due to emission of co_2 in to atmosphere and the natural sand is generally collecting from beds of lakes and rivers etc and it's usage increase the economical and geological problems that means both the materials are responsible for economical and environmental problems so alternatives of these materials are required.

1.3.1 RUBBER POWDER

The use of rubber product is increasing every year in worldwide. Waste tyres are major environmental problem for many metropolitan areas in the India. There are more than 1 billion scrap tires, approximately one tire per person, generated each year in the India. This creates a major problem for the earth and their livings. For this issue, the easiest and cheapest way of decomposing of the rubber is by burning it. This creates smoke pollution and other toxic emission and it create global warming. Currently 75-80% of scrap tyres are buried in landfills. Burying scrap tyres in landfills is not only wasteful, but also costly.

Fig 1: Rubber power

1.3.1.1 ADVANTAGES OF RUBBER IN CONCRETE:

From the literature, the following are some of advantages when we compare physical and engineering properties of the concrete mix with the standard mix.

a) The rubber in concrete is affordable and cost effective.
b) It resists the high pressure, impact and temperature.
c) They have good water resistance with low absorption, improved acid resistance, low shrinkage, high impact resistance, and excellent sound and thermal insulation.

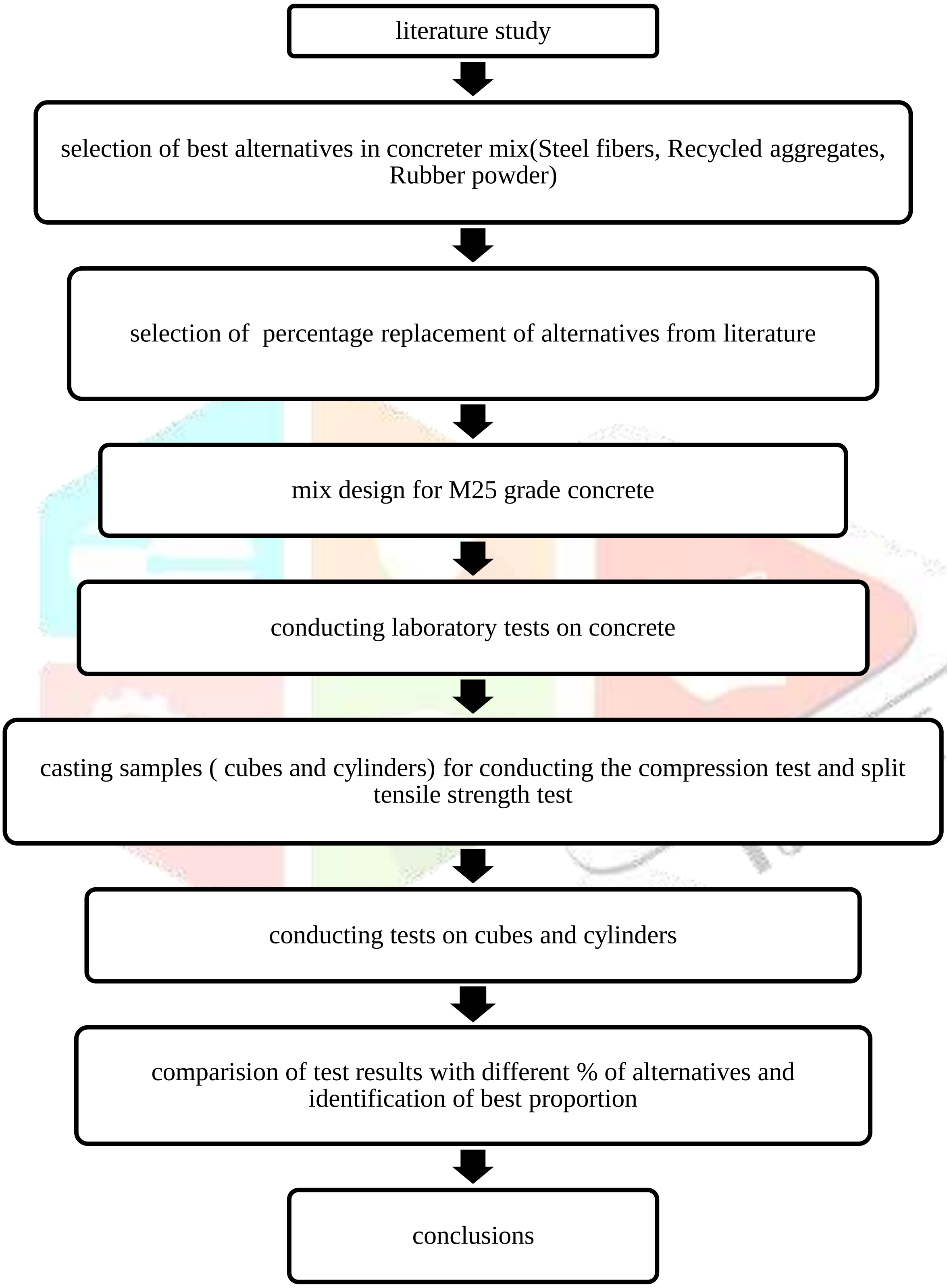
d) If we use magnesium ox chloride cement instead of Portland cement it gives more compressive and tensile strength.

e) Also, if we react this rubber in concrete with hot sulphur under temperature about 140ºC it shows increase in strength of concrete.

CHAPTER III

METHODOLOGY

The methodology adopted for completion the project is as shown in below flow chart.



2.1 PERCENTAGE OF ALTERNATIVE MATERIALS

FIVE concrete mixes have been made and the ratios of the mixes are given in the Table 2.

Table 2: Design mix ratios proposed for the tests

S NO.	% OF CEMENT	% OF STEEL FIBERS
1	100	0
2	100	1
3	100	2
4	100	3
5	100	4

S NO.	% OF NATURAL COARSE AGGREGATES	% OF RECYCLED AGGREGATES
1	100	0
2	90	10
3	80	20
4	70	30
5	60	40

S NO.	% OF NATURAL SAND	% OF RUBBER POWDER
1	100	0
2	95	5
3	90	10
4	85	15
5	80	20

2.2 SLUMP CONE TEST

Slump test was carried out to determine the workability of each mix. The tests were carried out in all cases in accordance with the requirements of BS 1881: Part 102(1983) for slump test and BS 1881: Part103 (1983) for compacting factor tests.

2.3 CASTING OF SPECIMENS

The concrete cubes were prepared in accordance to IS: 516.The binder, sand and aggregates first premixed dry for 1 min. to ensure homogeneity. Then Wet mixing with a total mix time of 4.5 min. Cast the concrete in a steel molds with the dimensions of (150 x 150 x 150) mm and cylinders with dimensions of (150mm*300mm) then Remold the concrete specimens after 24 hours, and then keep the cubes for water-curing in an opened container. Test the three cubes to check its compressive strength after 7 and 28 days.

2.4 COMPRESSIVE STRENGTH TEST

By testing the concrete cubes using CTM with constant loading rate find the average of the strength of three cubes per test.

2.5 TENSILE STRENGTH TEST

The tensile strength are found by conducting split tensile test of the concrete cylinders at 7 and 28 days respectively according to IS 516-1959 after taking their weights in order to ascertain their densities. Results were recorded based on the average tensile strength.

2.6 MIX PROPORTIONS

Mix proportion for trial mix 1 (Control Sample) for $1m^3$ in kg (weight batching)

CHAPTER III

LITERATURE REVIEW

3.1 DESCRIPTION

This chapter deals with the review of the existing literature on the employ of properties of concrete. The most important investigations, related to the current investigation, are summarized and salient facts which seem to emerge from the research discussed. The discussion is generally confined to the stress strain behavior of the M25 grade concrete.

3.2 PERTINENT STUDIES

Biel Lee [1] in 1994, in this paper authors have published that used recycled tire rubber in concrete mixes made with magnesium oxychloride cement, where the aggregate was replaced by fine crumb rubber up to 25% by volume. The results of compressive and tensile strength tests indicated that there is better bonding when magnesium oxychloride cement is used. The researchers discovered that structural applications could be possible if the rubber content is limited to 17% by volume of the aggregate.

IlkerBekirTopcu [2] in 1995 'the properties of rubberized concretes', proposed the concrete was modified by mixing with crumb rubber in coarse aggregate in the ratio of 15%, 30% and 45%. In this study the changes of the properties of rubberized concrete were investigated according to the terms of both size and amount of rubber chips added. In this the physical and mechanical properties were determined according to that the stress strain diagram were developed from that the toughness value and the plastic and elastic energy capacities were determined.

Fattuhi] [3] in 1996, proposed that, the cement paste, mortar, and concrete (containing OPC or grade rubber obtained from shredding scrap tyres. Properties examined for the 32 mixes prepared included density, compressive strength, impact and fire resistances, and nailability. Results showed that density and compressive strength of various mixes were reduced by the addition of rubber. (Rubber type had only marginal effect.) Density varied between about 1300 and 2300 kg/m3. Compressive strength reduced by 70% when the proportion of rubber to total solid content by mass

G.Senthil Kumaran, et al [6], proposed that, Recycling technology for concrete has significantly developed in the recent years, making the material sufficiently recyclable. It is evident that from the above discussion, the reduction of compressive and tensile strength can be increased by adding some super plasticizers and industrial wastes as partial replacement of cement will definitely increase the strength of waste tyre rubber modified concrete. Many studies reveal that there will be increase in strength enhancements as well as environmental advantages. The future NGC using waste tyre rubber could provide one of the environmental friendly and economically viable products. Though problems remain regarding the cost of production and awareness among the society the wastes can be converted into a valuable product. But further research is needed to increase performance against fire.

CHAPTER IV
OBJECTIVES AND DETAILS OF INVESTIGATION

4.1 DESCRIPTION:

To achieve the objectives of the study, an extensive experimental program was planned and which included evaluation of best and Economical proportion of the concrete mix having materials rubber powder as partially replacement of materials such as natural sand, cement and coarse aggregates respectively at 7 and 28days of age of concrete. Initially rubber powder used in different proportions means 0%, 5%, 10%, 15% and 20% as partial replacement of natural sand and find out the best proportion. For that proportion of rubber powder based concrete added in 0, 1, 2, 3 & 4 percentages to find out the best proportion at which concrete shows optimum results. Similarly the best proportions of steel fibers and Recycled aggregates also determined.

4.2 OBJECTIVES OF THE STUDY:

Mechanical properties such as hardening and fresh properties those are displayed by concrete to be obtained, all tests are conducted for concrete mix. Which is done by using concrete specimens means cylindrical concrete specimens that it shows less strains, high modulus of elasticity and the concrete also having good strength and slump of concrete using slump cone shows good workability of concrete that mix of concrete find out and it will be discussed and investigated within this thesis and the following overall primary objectives have been selected.

The objectives of the present research work are

1. Mix design of M25 grade of concrete

2. Workability of concrete mix at various proportions of steel fibers, recycled aggregates, Rubber powder.
3. Compressive and Split tensile strength properties
4. Addition of steel fibers to the concrete mix (1%, 2%, 3%, 4% and 5%) of cement weight.
5. Partial Replacement a fine aggregate of standard concrete mix with different weight ratios of scrap tires (both crumb and chipped rubber) as (0%, 5%, 10%, 15%, and 20%)
6. Partial Replacement a Coarse aggregate of standard concrete mix with different weight ratios of Recycled aggregates as (0%, 10%, 20%, 30%, and 40%)
7. Respectively and partial replacement of cement of standard concrete with different weight ratios of as (0%, 1%, 2%, 3% and 4%)
8. To find which one of additive has excellent properties for civil construction applications.

4.3 RESEARCH SIGNIFICANCE:

The research work done for M25 grade of concrete to find out the best mix of concrete having steel fibers as additional admixture, Recycled aggregates, Rubber particles and as partial replacement of materials such as coarse aggregates, natural sand and cement respectively that it shows good compressive and split tensile strength and is also workable. For this the concrete mix was prepared initially without replacement of materials and tests are conducted to get results and After that steel fibers as additional admixture and Recycled aggregates are added in various proportions to find best proportion of it. For that proportion of Rubber powder And are added in different percentages to find out the best proportion at which concrete shows optimum results.

CHAPTER V

MATERIAL PROPERTIES

4.1 MATERIALS:

Raw materials required for the concreting operations of the present work are

- Cement
- Natural Fine aggregates
- Rubber powder
- Steel fibers
- Natural Coarse aggregates
- Recycled aggregates
- Water

4.1 MIXING OF MATERIALS:

The raw materials for the proposed concrete mix should be available in the required proportion. After this the mixing of concrete is carried out. It is of two types: Mixing by Hand and Mixing by Machine. For mixing by hand, the material should be kept in a water proof tank. Before adding water, the material should be properly/thoroughly mixed till the color of the mix becomes uniform in dry state and only after that the suitable amount of water should be added to make the mix workable one.

4.1 ORDINARY PORTLAND CEMENT:

Cement is a binding material and is responsible for interlock between constituents present in concrete. Cement is a basic ingredient of concrete, plaster and mortar and is formed by calcinations of Argillaceous, calcareous and siliceous compounds and which responsible for formation of calcium hydrates in cement hydration and which affects the strength and setting time of concrete. The ordinary Portland cement is shown in the following figure-5.1.

Fig 5.1: Ordinary Portland cement

5.3.1 PROPERTIES OF PORTLAND CEMENT:

This was done by taking the location of various standard books, journals and some standard code. Here our aim is to determine actual chemical work of the sample provided by the company. The chemical analysis of Portland cement is listed in Table No.3

Table No 3: The chemical analysis of Portland cement

S. No.	Compounds	Percentage
1	Cao	64.00
2	Sio_2	22.00
3	$Al2o_3$	4.10
4	Fe_2o_3	3.60
5	Mgo	1.53
6	So_3	1.90

The following details are taken from the information gained from the laboratory experiments done on this in the laboratory. The Physical properties of Portland cement are listed in the Table No. 4 this is shown in below.

Table No 4: Physical properties of cement

S.NO		PROPERTY	VALUE
1		Specific gravity	3.15
2		Normal Consistency	32%
3		Fineness of cement	7%
4	I) ii)	Setting time Initial Setting time Final setting time	30 min 358 N

5.6 Fine Aggregates:

Fine aggregates/sand that have been sorted out and isolated from the natural material by the activity of streams of water or by winds crosswise over bone-dry grounds are by and large entirely uniform in size of grains. Generally business sand is acquired from waterway beds or from sand rises initially framed by the activity of winds. Natural sand means River sand collected from near and is passing through 4.75mm and is free from clay, silt and other organic matters does not exceed the specific limit.

The material Natural Sand is shown in the following figure-5.2.

Figure-5.2: Natural Sand

5.7 Sieve Analysis of sand

The Sieve Analysis of sand is carried out to know the zone of the sand. The results of sieve analysis are given in the below table no 7.

Table-7: Sieve Analysis of sand

Sieve size (mm)	Weight retained in gm	% passing
4.75	16	98.4
2.36	11	97.3
1.18	65	90.8
600 micron	391	51.6
300 micron	420	9.4
150 micron	82	1.2
Total	1000 gm	0

From the sieve analysis result, sand falls under zone II.

Table No 8: Properties of Fine Aggregate

S.NO	PROPERTY	VALUES
1.	Specific Gravity	2.77
2.	Water Absorption	NIL
3.	Bulk Density i. Loose State ii. Compacted State	 15.75 KN/mm^3 17.05 KN/mm^3
4.	Fineness modulus	2.6

5.8 Rubber powder:

River sand is used fine aggregate in mortar. This is formed by weathering of rocks over a period of millions of years and is becoming scarce commodity so need of alternatives of it. Rubber powder is taken as alternative of natural sand in this investigation because this is highly available at the quarry sites and which leads to disposal problems and general requirements and superiority of this than River sand is given below.

General Requirements of rubber powder:

1. All the sand particles should have higher crushing strength.
2. The surface texture of the particles should be smooth.
3. The edges of the particles should be grounded.
4. The ratio of fines below 600 microns in sand should not be less than 30%.
5. There should not be any organic impurities
6. Silt in sand should not be more than 2%, for crushed sand.
7. In manufactured sand the permissible limit of fines below 75 microns shall not exceed 15%

How Rubber powder superior than River sand

- particle size
- high compressive strength
- Truck loads of advantages
- Does away with construction defects
- Superior quality
- Great durability
- Great economic savings
- Easy availability

The Rubber powder is shown in the following figure-4.

Figure 5.3: Rubber powder

Rubber powder is collected from singarayakonda MRF Crum rubber factory and it was initially dry in condition when collected was sieved by IS: 90 microns sieve before mixing in concrete. The chemical composition of Rubber powder is taken from the laboratory and providers of Rubber powder in Chennai. The chemical composition of this is given in the below table 9.

Table 9: The chemical composition of Rubber powder

S. No.	Compounds	Percentage
1	Sio_2	62.48
2	$Al2o_3$	18.72
3	Fe_2o_3	3.606
4	Cao	4.83
5	K_2O	3.18
6	Na_2O	NIL
7	Tio2	1.21
8	Loss on Ignition	0.048

The following details are taken from the information gained from the laboratory experiments done on this in the laboratory. The Physical properties of Portland cement are listed in the Table No. this is shown in below.

Table No 10: Physical properties of Rubber powder

Specific gravity	2.66
Density	1810kg/m3
Absorption (%)	1.20-1.50
Moisture content	Nil
Fineness modulus	2.8
Fine particles	less than 0.075mm (%) 12-15

5.9 Coarse Aggregates:

Coarse aggregates are classified based on its shape, size and texture etc. Depends on it, the volume of this occupies in the concrete varies. The major portion of the concrete mix is occupied by the coarse aggregates.

The material Coarse aggregates is shown in the following figure-4.

Figure-5.4: Coarse aggregates

Which is angular in shape and size about 20mm is taken for experimental investigation. Which having particle size as are retained on I.S.sieve 4.75mm and which occupies large portion of concrete .The properties of coarse aggregates are given in the following table

Table No 11: Properties of coarse Aggregate

S.NO	PROPERTY	VALUES
1.	Specific Gravity	2.77
2.	Water Absorption	1%
3.	Bulk Density I. Loose State II. Compacted State	 14.13 KN/mm^3 16.88 KN/mm^3
4.	Fineness modulus	7.2

5.10Recycled aggregates

Recycled aggregate concrete (RAC) is concrete made with recycled concrete aggregate (RCA) instead of natural aggregate (NA). RCA are aggregates obtained by recycling of clean concrete waste where content of other building waste must be very low – less than a few percent. For example, British standard BS 8500–2 (BSI, 2006), defines RCA as recycled aggregate with maximum masonry/fines content of 5%, maximum lightweight material/asphalt content of 0.5% and maximum other foreign materials content of 1%.

Compared to natural aggregates, recycled concrete aggregates have (Marinković *et al.*, 2012):

- Decreased density up to 10%,
- Higher porosity and higher water absorption: for coarse RCA it ranges from 2% to 9% and for fine RCA from 5.5% to 13%,
- Increased Los Angeles abrasion loss up to 70%.

Figure-5.4: Recycled coarse aggregates

5.11Steel fibers

Steel fiber reinforced concrete is a castable or sprayable composite material of hydraulic cements, fine, or fine and coarse aggregates with discrete steel fibers of rectangular cross-section randomly dispersed throughout the matrix. Steel fibers strengthen concrete by resisting tensile cracking.

Fig. 5.5 steel fibers

5.12Water:

The amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. For these reasons, limiting and controlling the amount of water in concrete is important for both constructability and service life.

CHAPTER VI
MIX DESIGN OF CONCRETE

This chapter deals with the design procedure adopted for preparation of concrete.

5.6 MIX DESIGN OF CONCRETE:

The strength is mainly influenced by water cement ratio, and is almost independent of the other parameters the properties of concrete with a compressive strength of 20MPa,are influenced by the properties of aggregate in addition to that of water cement ratio.

5.6 MIX DESIGN PROCEDURE:

a) The strength of the cement as available in the country today has greatly improved since 1982. The 28-day strength of A, B, C, D, E, F. Category of cement is to be reviewed.

b) The graph connecting, different strength of cements and W/C is to be reestablished.

c) The graph between 28-day compressive strength of concrete and W/C ratio is to be extended up to 80Mpa, if this graph is to be cater for high strength concrete.

d) As per the review of 456-2000, the degree of workability is expressed in terms of slump instead of compacting factor. This results in change of values in estimating fairly accurate sand and water contents for normal concrete up to 35Mpa and high strength concrete above 35Mpa. The table giving adjustment of values in water content and sand % for other than standard conditions requires appropriate changes and modifications.

5.7 MIX DESIGN FOR M25 GRADE OF CONCRETE:

1) Design procedure:

Characteristic compressive strength required in the field at 28 days=25Mpa
Maximum Size of aggregate=20mm
Degree of Workability=0.9
Type of exposure = mild

2) Test Data for materials:

Specific gravity of cement=3.15
Specific gravity of fine aggregate=2.65
Specific gravity of coarse aggregate=2.77
From observing the code book zone-2 as per the IS-code 10262-2009 and IS456-2000 are considered for mix design.

Step-1

Determination of target strength

F_{tar} =f_{ck}+1.65*S
=25+1.65*4=31.6 N/mm^2

Where S=standard deviation as per table-1 of IS-code 10262-2009

Step-2

Selection of water/cement ratio
From table 5 of IS 456(page no 20)
Maximum water-cement ratio for mild exposure condition=0.50
We adopted w/c ratio=0.50, hence ok

Step-3

Selection of water content
From table 2 of IS-code 10262-2009,
Maximum water content=186litres (FOR NOMINAL Maximum size of aggregate-20mm)
We have taken 186litres, hence ok
Table for correction of water content

Parameters	Value as per standard reference condition	Value as per present Problem	Departure	Correction in water Content
Slump	25-50mm	50-75mm	25	+3/25*25=+3
Shape Of Aggregate	Angular	Angular	Nil	_

Estimated water content=186+ (3/100)*186=191.58kg/m^3
The cement content=191.58/0.50=383.16 kg/m^3

Step-4

Estimation of coarse Aggregate proportion
From Table 3 of IS-code 10262-2009,
For Nominal Maximum Size of aggregate=20mm,
Zone of fine Aggregate=zone 2 and w/c ratio=0.50
Volume of coarse Aggregate unit volume of total Aggregate=0.62 then sand content=0.38
There is no change required for coarse aggregate content because maximum water cement ratio that is 0.50 is taken in to consideration.

By considering 2% of entrapped air is then
(1-2/100)= (191.58+383.16/3.15+1/0.38*f_a/2.65)*1/1000
From that f_a=671.45kg/m^3
The coarse aggregates
(1-2/100)= (191.58+383.16/3.15+1/0.62*c_a/2.77)*1/1000
From that c_a=1145.125kg/m^3
The mix ratio
Water: Cement: F_a: C_a=191.8:383.16:671.45:1145.125=0.50:1:1.752:2.985

Step-5

The Final contents of mix proportion of M25 grade is
Water content=191.8 kg/m^3
Cement content=383.16 kg/m^3
Fine aggregate=671.45 kg/m^3
Coarse aggregate=1145.125 kg/m^3

Mix proportion of M25 mix concrete at various proportions of steel fibers is given below.

TABLE-12(a)

Mix	Water (lit/m3	Cement (kg/m3)	River Sand (kg/m3)	Coarse aggregates (kg/m3)	Percentage Steel fibers
M00	191.8	383.16	671.45	1145.13	1
M01	191.8	383.16	671.45	1145.13	2
M02	191.8	383.16	671.45	1145.13	3
M03	191.8	383.16	671.45	1145.13	4
M04	191.8	383.16	671.45	1145.13	5

Mix proportion of M25 mix concrete at various proportions of Recycled aggregates is given below.

TABLE-12(b)

Mix	Water (lit/m3	Cement (kg/m3)	River Sand (kg/m3)	Coarse aggregates (kg/m3)	% of Recycled aggregates(kg/m3)
M05	191.8	383.16	671.45	1145.13	0
M06	191.8	383.16	671.45	1030.60	10(114.53)
M07	191.8	383.16	671.45	916.11	20(229.02)
M08	191.8	383.16	671.45	801.60	30(343.53)
M09	191.8	383.16	671.45	687.08	40(458.05)

Mix proportion of M25 mix concrete at various proportions of Rubber powder given below.

TABLE-12(c)

Mix	Water (lit/m3)	Cement (kg/m3)	River Sand (kg/m3)	Rubber powder (kg/m3)	Coarse aggregates (kg/m3)
M1	191.8	383.16	671.45	0	1145.13
M2	191.8	383.16	637.87	33.572	1145.13
M3	191.8	383.16	604.30	67.145	1145.13
M4	191.8	383.16	570.73	100.717	1145.13
M5	191.8	383.16	537.16	134.290	1145.13

CHAPTER VII
EXPERIMENTAL INVESTIGATIONS

7.1 WORKABILITY OF CONCRETE:

Figure6 (a) Tampering of materials in the slump cone Figure6 (b) slump of concrete mix on the tray.

5.6 CASTING OF SPECIMENS:

1. In this investigation cylindrical specimens are used to study the tensile strength behavior and mechanical properties of M25 mix of concrete.
2. The Cylindrical Specimens are cleaned and oil is applied inside the specimens.
3. Hand mixing is preferred in this investigation.
   - Materials are taken for the 3 cylinders for each set of casting of 3 cylinders.
   - That means required amount of cement, sand, aggregates and the materials Rubber powder are taken by using weighing machine.
   - Cement is placed in the tray and after that Rubber powder; aggregates are added in required proportions.
   - All these building materials are mixed using trowel after adding of required amount of water.
4. These specimens are placed on table vibrator one by one to vibrate it for 3to4minutes.
5. After that, these are placed in dry place for 24 hours before placing in the curing tank.

The casting of cylindrical specimens is shown in the Figure 7.1(a) and 7.1(b).

Figure7.1 (a) concrete specimen filling

Figure 7.1 (b) concrete specimen on table vibrator

5.6 CURING OF CYLINDRICAL SPECIMENS:

After 24 hours from the casting cylindrical specimens are taken and these are placed in the curing tank. These cylindrical specimens which are casted and placed in the curing tank are taken after 7 and 28 days respectively to test them.

The specimens after casting and in the curing tank is shown in the below figures 7.2(a) and 7.2(b).

Figure 7.2 (a): specimens after casting

Figure 7.2 (b): specimens in the curing tank

7.3.1 PRECAUTIONS:

The below precautions should be followed during mixing and placing concrete:

1. The plastic straws and sheets taking should be cut up to our requirements without error.
2. The water used for curing should be examined every 7 days and its temperature must be at 27±2°Centigrade.
3. The hardened concrete should be carefully removed from moulds, placed in water without causing any failure.

7.4 TESTS ON HARDENED CONCRETE:

7.4.1 COMPRESSIVE TEST:

After curing, drying of these cylindrical specimens for 7 amd 28 days are taken to test them to get the peak load at which specimen fails. These specimens are placed in CTM and load is applied gradually until the specimen fails.

Compressive stress at this breaking load=P/A
Where P=Breaking load,
=Cross Sectional area of the specimen
The specimens before and after placing of loads are shown in below figures 7.3.

Figure 7.3: Compressive strength test setup

6.4.2 SPLIT TENSILE STRENGTH TEST:

Splitting tensile strength is an indirect method used for determining the tensile strength of concrete. After curing, drying of these specimens for 7, 28 and 60 days are taken to test them to get the peak load at which specimen fails. These specimens are placed with its axis horizontal between plates of the testing machine CTM and load is applied gradually until the specimen fails that means specimen split in to two pieces.

Split tensile strength at this breaking load=2P/**πDL** Where P=Spit tensile load,D=Diameter of the specimen,L=Length of the specimen

The specimens after placing of loads and placing on the ground are shown in below figures 10

CHAPTER VIII
TEST RESULTS AND DISCUSSIONS

8.1 NORMAL CONSISTENCY OF CEMENT:

Table: 13: Normal consistency of cement

Trail no.	Weight of Cement(gm)	% of Water added	Depth of Penetration (mm)
1	400	28	15
2	400	30	10
3	400	32	7

Hence the Consistency of cement is **32%**.

8.2 INITIAL SETTING TIME OF CEMENT:

Weight of cement sample taken = 400gms
Consistency of cement = 32% as obtained above
Volume of water to be added = 0.85*32/100*400=108.8m
Initial setting time obtained =**30 minutes.**

8.3 FINAL SETTING TIME OF CEMENT:

Weight of cement sample taken = 400gms
Consistency of cement = 32% as obtained above
Volume of water to be added = 0.85*32/100*400=108.8m
Final setting time = **358 minutes.**

8.4 WATER ABSORPTION TEST:

Weight of oven dried aggregate = 500g
Weight of aggregate soaked in water for 24 hours = 505g
Percentage of water absorbed = (505-500)/500*100= **1%**

8.5 SPECIFIC GRAVITY OF CEMENT:

Weight of empty specific gravity bottle W1 = 44.1 gm.
Weight of sp.gr bottle + wt. of cement W2 = 70.00gm (1/3 rd to 2/3 rd of bottle full)
Weight of specific gravity bottle + cement + kerosene (W_3) = 103.20 gm

Weight of specific gravity bottle+ kerosene (W4) = 83.80 gm
Specific gravity of kerosene = 0.79
Specific gravity of cement = (W2-W1)/{(W4-W1)-(W3-W2)} = **3.15**

8.6 SPECIFIC GRAVITY OF COARSE AGGREGATES:

Weight of saturated aggregates A = 500gms
Weight of dry aggregates D = 495gms
Weight of Pycnometer = 610gms
Weight of Pycnometer+ Water C = 1597gms
Weight of Pycnometer+ Water+ aggregates B = 1918gms
Specific gravity of coarse aggregates = D/ {A-(B-C)} = **2.77**

8.7 SPECIFIC GRAVITY OF FINE AGGREGATES:

Weight of empty Pycnometer W1 = 610 gm.
Weight of Pycnometer + fine aggregate W2 = 1110 gm.
Weight of Pycnometer + fine aggregate + water W3 = 1908 gm.
Weight of Pycnometer + water W4 = 1597 gm.

1) Dry weight of aggregate = W2-W1
2) Weight of equivalent volume of water = (W2-W1)-(W3-W4)

Specific gravity of fine aggregates = (W2-W1)/ {(W2-W1)-(W3-W4)} =**2.65**

8.8 WORKABILITY OF CONCRETE:

Table for Workability of concrete at various proportions of steel fibers is given below.

TABLE-14

%0f steel fibers	**Workability Slump(mm)**
0	60
1	58
2	56
3	52
4	51

By increasing percentage of steel fibers in concrete mix it reduces the workability and the values of compressive and split tensile strength at peak loads considered to decide the best proportion of mix at which that shows optimum results.

Table for Workability of concrete at various proportions of recycled agregates is given below.

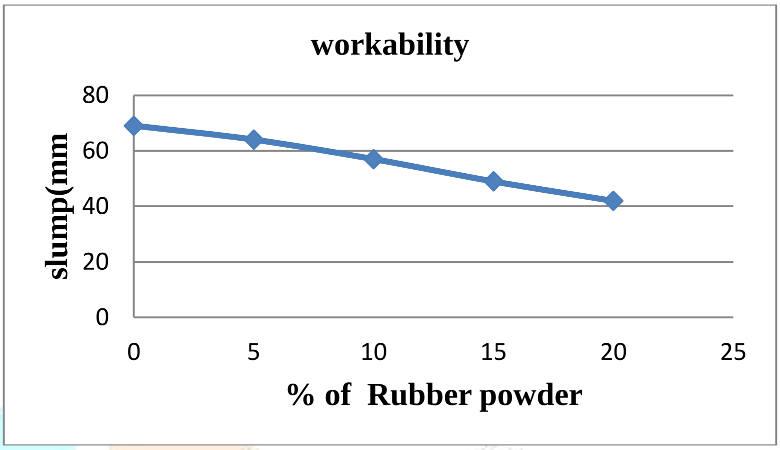
TABLE-15

% 0f Recycled aggregates	Workability Slump(mm)
0	61
10	58
20	54
30	52
40	49

Here at 20 percent of recycled aggregates in concrete mix shows good workability and optimum strength. Table for Workability of concrete at various proportions of Rubber powder is given below. TABLE-16

%0f Rubber powder	Workability Slump(mm)
0	69
5	64
10	57
15	49
20	42

GRAPH-1



By increasing percentage of Rubber powder in concrete mix it reduces the workability and the values of compressive and split tensile strength at peak loads considered to decide the best proportion of mix at which that shows optimum results.

Here at 10 percent of Rubber powder concrete mix shows good workability and optimum strength.

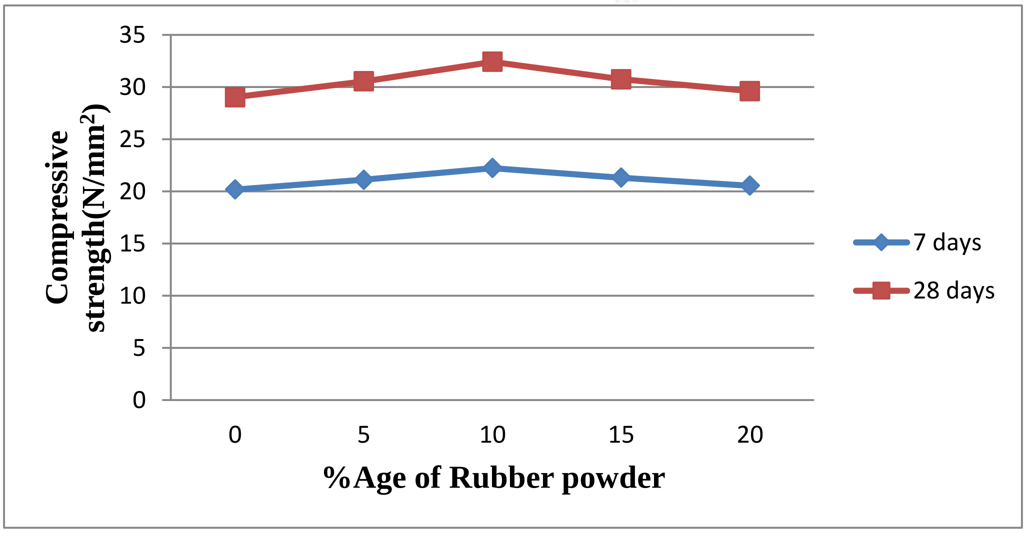
7.9 COMPRESSIVE STRENGTH OF CONCRETE:

The compressive strength values at various proportions of Rubber powder is given in the following Table16.

TABLE-18

%Age of Rubber powder	Compressive strength(N/mm^2)	
	7-Days	28-Days
0	20.182	29.037
5	21.117	30.557
10	22.249	32.430
15	21.315	30.746
20	20.560	29.614

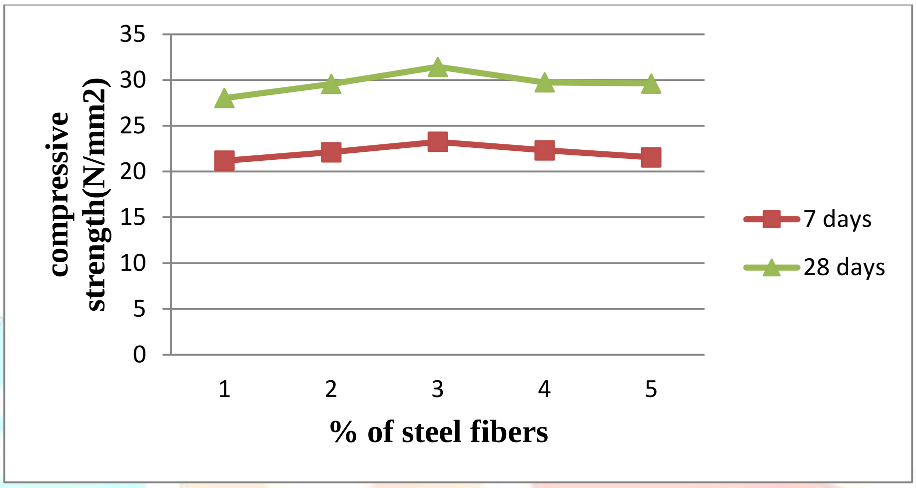
GRAPH-3



The compressive strength values at various proportions of steel fibers given in the following Table-15.

Table-20.

%Age of steel fibers	Compressive strength(N/mm²)	
	7-Days	28-Days
1	21.182	28.037
2	22.117	29.557
3	23.249	31.430
4	22.315	29.746
5	21.560	29.614



Graph plot for variation of compressive strength with different % of steel fibers

The compressive strength values at various proportions of Recycled aggregates given in the following Table-21.

%Age of Recycled aggregates	Compressive strength(N/mm²)	
	7-Days	28-Days
0	20.182	29.037
10	22.317	30.157
20	22.949	32.109
30	21.115	30.106
40	20.260	29.014

Graph plot for variation of compressive strength with different % of Recycled aggregates

7.10 SPLIT -TENSILE STRENGTH OF CONCRETE:

This Split tensile test values at various proportions of Rubber powder is given in the following TABLE-22

.%AGE OF Rubber powder	Split tensile strength(N/mm²)	
	7-DAYS	28-DAYS
0	1.980	2.829
05	2.122	3.018
10	2.310	3.348
15	2.169	3.018
20	2.027	2.923

GRAPH-7

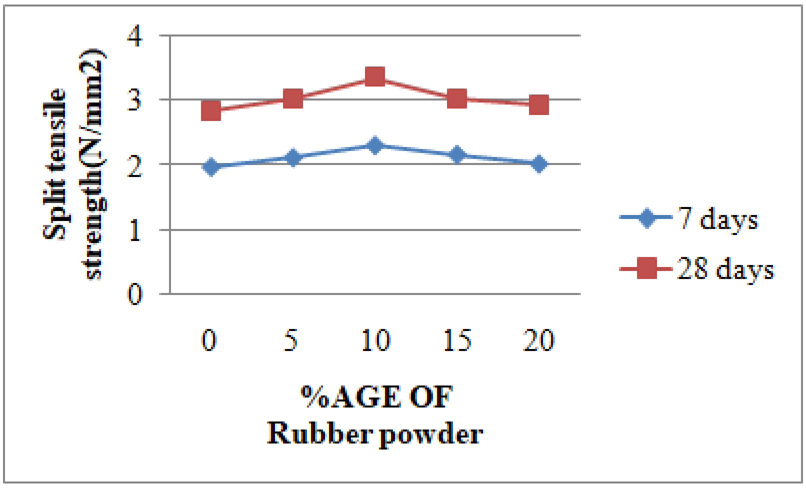


Table for split tensile strength of concrete at various proportions of steel fibers is given below.

Table -24

%AGE OF STEEL FIBERS	Split tensile strength(N/mm^2)	
	7-DAYS	28-DAYS
1	3.210	4.248
2	3.305	4.436
3	3.451	4.625
4	3.349	4.531
5	3.257	4.248

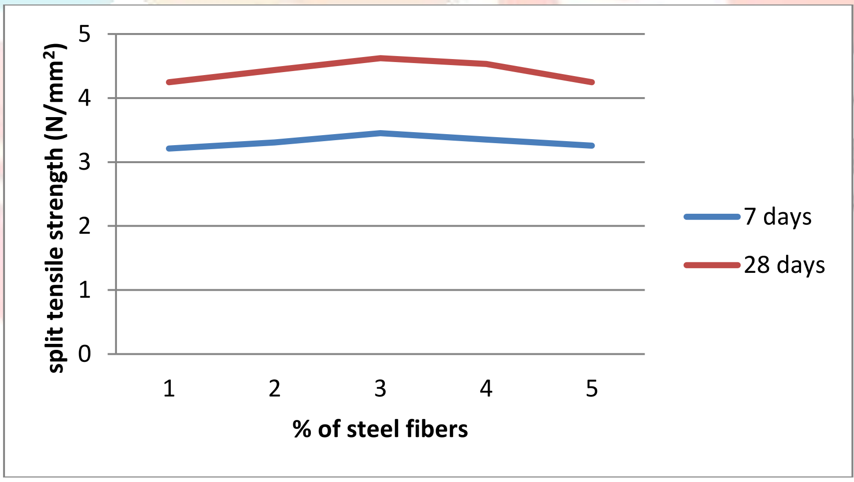
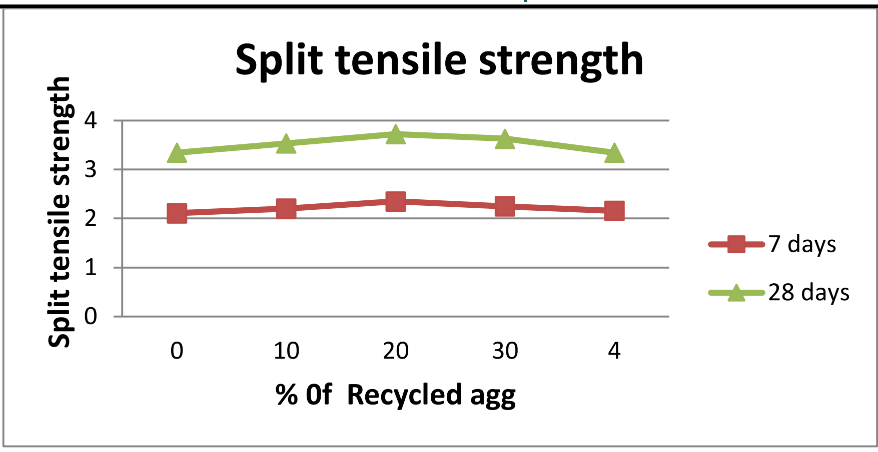


Table for split tensile strength of concrete at various proportions of Recycled aggregates is given below.

Table-25

%AGE OF Recycled agg	Split tensile strength(N/mm^2)	
	7-DAYS	28-DAYS
0	2.110	3.348
10	2.205	3.536
20	2.351	3.725
30	2.249	3.631
40	2.157	3.348



Final tables for concrete mix which shows fresh and hardening properties of concrete given below.

TABLE-26

Properties for Concrete mix for various proportions of Rubber powder

%0f Rubber powder	Workability Slump(mm)	Compressive Strength (N/mm^2)		Split tensile strength (N/mm^2)	
		7 days	28 days	7 days	28 days
0	69	20.182	29.037	1.980	2.829
5	64	21.117	30.557	2.122	3.018
10	57	22.249	32.430	2.310	3.348
15	49	21.315	30.746	2.169	3.018
20	42	20.560	29.614	2.027	2.923

From this table we get that workability of concrete decreases with the increase of Rubber powder content and the compressive strength and Split tensile strength increases up to 50 percent decreases more than that percent in early and lateral ages also.

At which percent that means 10 percent of Rubber powder properties of the concrete mix are given below.

The Workability of concrete mix by means of slump (mm) =57
At 7-Days, The % of increase of compressive strength =10.241%
The % of increase of Split tensile strength =16.666%
At 28-Days, The % of increase of compressive strength =11.688%
The % of increase of Split tensile strength =17.285%

Properties for Concrete mix for various proportions of steel fibers

% 0f steel fibers	Workability Slump(mm)	Compressive strength (N/mm^2)		Split tensile strength (N/mm^2)	
		7-DAYS	28-DAYS	7-DAYS	28-DAYS
1	60	21.182	28.037	3.210	4.248
2	58	22.117	29.557	3.305	4.436
3	56	23.249	31.430	3.451	4.625
4	52	22.315	29.746	3.349	4.531
5	51	21.560	29.614	3.257	4.248

From this table we get that workability of concrete decreases with the increase of steel fibers content and the compressive strength and Split tensile strength increases at 3 percent. At which percent that means 3 percent of steel fibers properties of the concrete mix are given below.

The Workability of concrete mix by means of slump (mm) =56
At 7-Days, The % of increase of compressive strength =14.180%
The % of increase of Split tensile strength =7.589%
At 28-Days, The % of increase of compressive strength =12.101%
The % of increase of Split tensile strength =8.870%

TABLE-29

Properties for Concrete mix for various proportions of Recycled aggregates

%0f Recycled aggregates	Workability Slump(mm)	Compressive strength (N/mm^2)		Split tensile strength (N/mm^2)	
		7-DAYS	28-DAYS	7-DAYS	28-DAYS
0	61	20.182	29.369	2.110	3.348
10	58	22.317	30.157	2.205	3.536
20	54	22.949	32.109	2.351	3.725
30	52	21.115	30.106	2.249	3.631
40	49	20.260	29.014	2.157	3.348

From this table we get that workability of concrete decreases with the increase of recycled aggregates content and the compressive strength and Split tensile strength increases up to 20 percent.

At which percent that means 20 percent of Recycled aggregates properties of the concrete mix are given below.

The Workability of concrete mix by means of slump (mm) =54

At 7-Days, The % of increase of compressive strength =13.71%

The % of increase of Split tensile strength =11.42%

At 28-Days, The % of increase of compressive strength =9.329%

The % of increase of Split tensile strength =11.26%

From the experimental investigation, consider 3 percent of steel fiber as admixture, 20 percent of recycled aggregates as replacement of coarse aggregates, 2 percent of as replacement of cement and 10percent of rubber powder as replacement of fine aggregates is chosen for this study and conducted test for determining compressive strength and split tensile strength for M25 mix.

THE AIM OF THIS RESEARCH IS TO:

APPLICATION OF RUBBER AND IN CONCRETE:

1. In non-load bearing members as lightweight concrete walls.
2. In highway constructions as a shock absorber.
3. In sound barriers as a sound absorber.
4. In buildings as an earthquake shock-wave absorber.
5. It may also used in runways and taxiways in the airport, industrial floorings and even as structural member.

CHAPTER-IX
CONCLUSION

From the investigations carried out, the following conclusions can be made:

1. The optimum addition of RHA as partial replacement for cement is in the range 0-4%.
2. For a design mix strength ranging between 30 MPa and 50 MPa, the reduction in the compressive strength is consistent and almost at a constant ratio with the increase in the percent of powdered rubber. The reduction in strength is an average of 30, 35, 50, and 63% against a powdered rubber replacement of fine aggregates at 5, 10, 15, and 20%, respectively.
3. The addition of powdered rubber yields a slight improvement in the concrete tensile strength at all rubber percentages but still results in less improvement compared to the compressive strength reduction rate.
4. The addition of powdered rubber to the concrete mix results in a negative effect on the modulus of elasticity. The decrease of elasticity reflects the capability of rubberized concrete to behave in an elastic manner when loaded in tension, thus improving the failure manners of typical concrete.
5. Rubberized concrete exhibits enhanced energy absorption since the concrete did not undergo a typical brittle failure yet it encountered a ductile, plastic failure mode. Concrete of compressive strength of 50 MPa, definitely displays a much better resiliency for rubberized concrete than plain concrete. This is not true for concrete of compressive strengths below 50 MPa, which displays a consistent reduction in resiliency.

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