STUDY OF STRENGTH AND DURABILITY CHARACTERISTICS OF RUBBERISED CONCRETE

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Abstract- The disposal of used tyres is a major environmental problem throughout the world which causes environmental hazards. Waste tyres rubber material is ideal for use in concrete applications. The main aim of this study is achieved to use of waste tyre rubber chips as partial replacement of coarse aggregate to produce rubberise concrete in M30 mix. Different partial replacements of Waste tyres rubber chips of both plain and reinforced (5, 10, 15 and 20%) by volume of coarse are cast and test for compressive strength, flexural strength and split tensile strength. The results showed that there is a reduction in all type of strength for waste tyres rubber mixture, this reduction in strength was about to 10 -23% for 10% replacement and 22-40% for 15 to 20% replacement and slump values decrease from 60 mm to 05 mm as the waste tyres rubber chips content increase from 0% to 20%.

Partial replacement of waste tyres rubber chips both plain and reinforced of (5%) by volume of coarse aggregate and GGBS of (0, 10, 20, 30,40and 50%) by weight of Cement are cast and test for compressive strength, flexural strength and split tensile strength. By replacing 5% volume of plain (or) reinforced rubber in 20mm coarse aggregates and 30% mass of GGBS in cement gives more strength for M30 GRADE concrete comparing to control mix results. The durability studies shows that HCl curing has more effect than H_2SO_4 curing. The young's modulus values of elasticity (E) also decreased with increase of percentages of tyre rubber chips. And also it is useful in making light weight concrete. It is recommended to use the rubberised concrete for non structural applications and structural applications.

Keywords- *Waste Tyre Rubber, Compressive Strength, Split Tensile Strength, Flexural Strength*.

1. INTRODUCTION

Due to environmental concern and to truncate the impact on raw materials, the usage of waste materials such as the tyre rubber and fine particles like Ground granulated blast furnace slag (GGBS) in concrete for partial supersession of aggregate i.e. Coarse Aggregate and cement, to make an eco-amicable building material. Considering the above aspect, the present work has been carried out to study the properties of concrete with tyre rubber waste, which does not have a proper disposal has been used as a partial substitution for coarse aggregate. Similarly, GGBS from blast furnaces used to make iron at viable supersession levels. Rubber aggregates from discarded tyre rubber in 0%, 5%, 10%, 15%, 20% can be partially replaced natural aggregates in cement concrete construction

1.1 Tyre waste management

1.1.1 Components of Rubber tyre

A tyre carcass is composed of several components: the tread, bead, sidewall, shoulder, and ply.

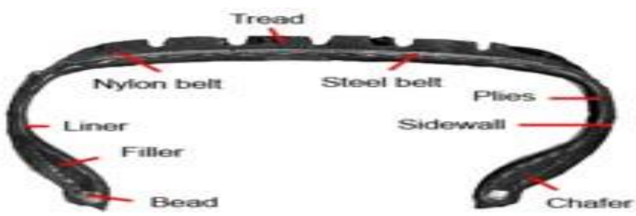

Figure 1.1: Tire cross-section showing components

1.1.2 CLASSIFICATION OF SCRAP-TYRES

Figure 1.2: Rubber tyre construction

The tyres can be managed into different types and the construction of tyre can be seen in figure 1.2.

Table 1.1: Materials and their sizes

Material	Size/mm
Cuts	>300
Shred	50–300
Chips	10–50
Grains	1–10
Powder	<1
Fine powder	<0.5
Polished	0–40
Recovery	Depends on input
Devulcanized	Depends on powder
Pyrolitic carbon	<10
Carbon products	<0.5

1.1.2 PLAIN RUBBER TYRE CHIPS

The scrap tyre are amassed and cut into scintilla. In the engenderment of chips, the results are that are more equidimensional than the more sizably voluminous size shreds that are engendered by the primary shredder. Chipped rubber is utilized to supersede gravel. The rubber pieces about 10– 50 mm astronomically immense are engendered.

The rubber chips are sieved through 20 mm and retained in 16 mm for the supersession of coarse aggregate as shown in fig 1.3

Table 1.3: Composition of plain tyre rubber chips

Material	Mass percentage
Natural Rubber	40%
Synthetic rubber	14%
Carbonblack	26%
Textile	2%
Oxidize zinc	1%
Sulphur	1%
Additives	13-15%

1.1.3 REINFORCED RUBBER TYRE CHIPS

The scrap tyre bead is typically reinforced with steel wire and compounded of high vigor, low flexibility rubber. These are accumulated and cut into scintilla. In the engenderment of chips the results are that are more equidimensional than the more sizably voluminous size shreds that are engendered by the primary shredder, but exposed steel fragments will still occur along the edges of the chips

Figure 1.4 : Reinforced Rubber Tyre chips

Chipped rubber is utilized to supersede gravel. The rubber pieces about 10–50 mm astronomically immense are engendered .The reinforced rubber tyre chips are sieved through 20 mm and retained in 16 mm for the supersession of coarse aggregate as shown in Fig 1.4

Material	Mass percentage (%)
Natural Rubber	14
Synthetic rubber	27
Carbon black	28
Steel	15
Oxidize zinc	1
Sulphur	1
Additives	14

1.1.4 Properties of rubber tyres

Since rubber tires are used as coarse aggregates, it is essential to study the properties of tires. Its physical, thermal and mechanical properties are listed below

General Characteristics

- Durometer range (Shore A) : 20-95
- Tensile Range (PSI) : 500-3000
- Compression Set : Good
- Resilience/ Rebound : Excellent

Resistance

- Abrasion resistance : Excellent
- Tear resistance : Good
- Solvent resistance : Fair
- Oil resistance : Fair
- Aging Weather/ Sunlight : Good
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Temperature Range

- Low Temperature Usage : 100 to -500 F or -120 to - 460 C
- High Temperature Usage : Up to 2500 F or up to 1210

Cement

Cement is binding material which is used for making any type of concrete. Among the various types of cement available in the market, Ordinary Portland Cement of 53 grade confirming to IS 269-1976, whose compressive strength at the end of 28th day is 54 N/mm2 when tested as per IS 4031-1988, from Jay Pee Company is used in this project work.

Table 1.3 PHYSICAL PROPERTIES OF CEMENT

S.NO:	PHYSICAL PROPERTIES	RESULTS
1	Fineness of cement	5%
2	Specific gravity of cement	3.13
3	Normal consistency	32%
4	Initial setting time(minutes)	30
5	Final setting time(minutes)	600
6	Compressive strength	54N/mm^2

TABLE 1.4: Physical characteristics of 53 grade OPC cement

z	Characteristics	Test results
1.	Normal consistency	28%
2.	Specific gravity	3.15
3.	Setting time:-	
	Initial setting time	35 min
	Final setting time	230 min
4.	Fineness of cement	285m2/kg
5.	Compressive Strength ofCement (28 Days)	53MPa

TABLE 1.5: chemical characteristics of 53 grade OPC cement

% by mass as per IS4032-1968	**ment**
Loss on Ignition	3.65
Silica as SiO_2	21.5
Iron as Fe_2O_3	0.55
Aluminum as Al_2O_3	5.50
Titanium as TiO_2	NILL
Calcium as CaO	63.5
Magnesium as MgO	2.15
Sodium as Na_2O	0.85
Potassium as K_2O	0.85

1.5 Ground Granulated Blast Furnace Slag(GGBS): Granulated ground blast furnace slag (GGBS) is a by-product of blast furnaces used to make iron. These operate at a temperature of approximately 1500 degrees Celsius and are fed by a meticulously controlled accumulation of iron ore, coke, and limestone. Iron ore is minimized into iron and the remaining materials from a slag that floats on iron. This slag is periodically extracted as a molten liquid and, if it is to be used for the manufacture of GGBS, it must be extinguished in huge astronomically volumes of dehydrogenate monoxide. Cooling optimizes cementations properties and generates coarse granule

TABLE 1.6: Chemical compositions of GGBS

Constituents	Percentage (%)
CaO	40
SiO_2	35
Al_2O_3	13
MgO	8

TABLE 1.7: Physical properties of GGBS

Characteristics	Value
Colour	off white
Specific gravity	2.90
Bulk density	1200 $kg.m^{-3}$
Fineness	430 $m^2.kg^{-1}$

In the engenderment of are commixed concrete, GGBS supersedes a substantial portion of the ordinary Portland cement, which was about 50%, but others were up to 70%. But the high place, the good durability. A disadvantage of the respective supersession level is that the number of vigor is hardly more expensive. The GGBS utilized as a direct supersession for the Portland cement, in one-on-a-half weight.

The country is meant to have the most dirt-on-the-ground vigor and support, and the high-supersession is conventionally as high as 30%. For underground concrete structures with average vigor support, the supersession ratio can be around 30 to 50%. For concrete state and national economic growth in the rigorous support standards, the supersession state customarily is 50 to 65%. Such special cement and high support in durability i.e. corrosion is important for marine infrastructure and sewage treatment stocks. The supersession customarily is 50 to 70%.

1.6 Plain Rubber Chips

The scrap tyres that we need is collected and are made into small pieces. The rubber pieces about 10–50 mm big are produced and it is sieved through 20 mm and retained in 16 mm for the replacement of coarse aggregate.

TABLE 1.8: PHYSICAL PROPERTIES OF PLAIN RUBBER CEMENT

PROPERTY	TEST RESUTS
Density	902.86 (kg/m^3)
Specific gravity	1.15
Elongation (%)	420 %
Rate of steel fibre (%)	0%

The scrap tyre beads of about 10-50mm are produced. It is thoroughly sieved through 20 mm and retained in 16mm sieve.

TABLE 1.9: PHYSICAL PROPERTIES OF REINFORCED RUBBER CHIPS

Characteristics	Value
Density	993.34(kg/m^3)
Specific gravity	1.50
Elongation (%)	420 %
Rate of steel fibre (%)	75%

II. STANDARD CONCRETE MIXDESIGN

M30 grade of concrete using natural sand was done according to IS: 10262-2019 and the final proportion are given.

TABLE 2.1 : MIX PROPORTIONS (M30)

cement	413.34 kg.m^{-3}	1
Fine aggregate	638.30 kg.m^{-3}	1.54
Coarse aggregate	1203.1 kg.m^{-3}	2.91
water	186.00 kg.m^{-3}	0.45

TABLE 2.2 : Reinforced rubber and corresponding coarse aggregates quantities

Percentage(%)of replacement of rubber chips in volume of Coarse aggregate.	Reinforced rubber (kg/m^3)	Coarse aggregate (kg/m^3)
0% volume	0	782.0
5% volume	23.24	742.9
10% volume	46.48	703.8
15% volume	69.73	664.7
20% volume	92.97	625.6
25% volume	116.2	586.5

TABLE 2.3 : Reinforced rubber and corresponding coarse aggregates quantities

Percentage replacement of rubber chips in volume of Coarse aggregate.	Plain rubber (kg/m^3)	Coarse aggregate (kg/m^3)
0% volume	0	782.0
5% volume	21.12	742.9
10% volume	42.25	703.8
15% volume	63.36	664.7
20% volume	84.50	625.6
25% volume	105.6	586.5

Figure 1.5 : casting of specimens

TABLE 2.4: Number of specimens

Sl. No	Specimens type of grade M30	Cubes of 150×150×150mm	Cylinders of 150 dia.and 300 mm height
1	0% RUBBER	3	3
2	5% RUBBER	3	3
3	10% RUBBER	3	3
4	15% RUBBER	3	3
5	20% RUBBER	3	3

III.. RESULTS AND DISCUSSIONS

The results obtained from concrete cubes, cylinders and prisms of different percentages of cement and tyre rubber chips are presented in tabular and graphical forms. Comments were made based on the test data collected throughout the tests.

3.0 TEST RESULTS

Table-3.1: Comparison of Compressive Strengths of Rubber (M30)

PERCENTAGES (%)	PLAIN RUBBER (N/mm^2)	REINFORCEDRUBBER(N/mm^2)
Control Mix	42.14	42.14
5%Rubber+0%GGBS	31.89	32.56
5%Rubber+10%GGBS	33.20	34.03
5%Rubber+20%GGBS	39.78	40.23
5%Rubber+30%GGBS	44.25	45.90
5%Rubber+40%GGBS	37.12	38.36
5%Rubber+50%GGBS	30.6	32.20

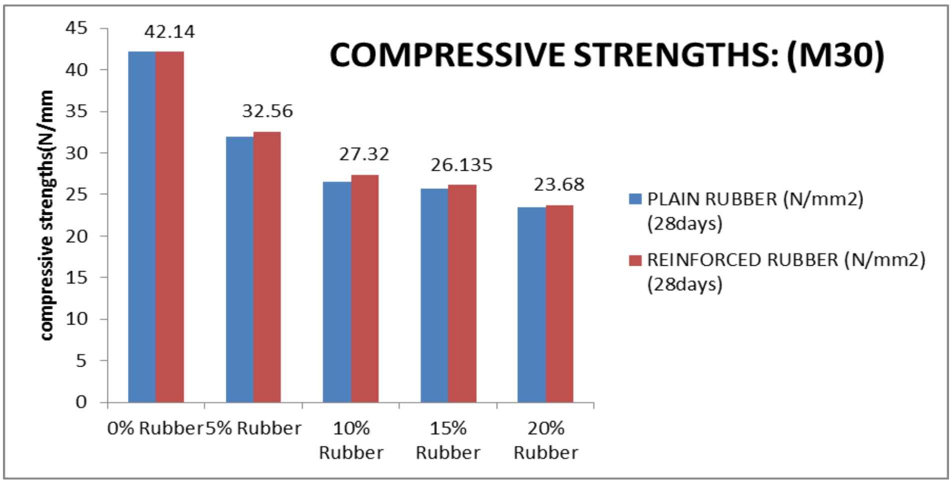

Fig.3.1: Comparison of compressive strengths of rubber

Table-3.2: Comparison of Compressive Strengths of Rubber with GGBS (M30)

PERCENTAGES (%)	**PLAIN RUBBER (N/mm^2)**	**REINFORCED RUBBER(N/mm^2)**
0% Rubber	3.20	3.20
5% Rubber	2.26	2.30
10% Rubber	2.12	2.15
15% Rubber	2.05	2.10
20% Rubber	1.56	1.83

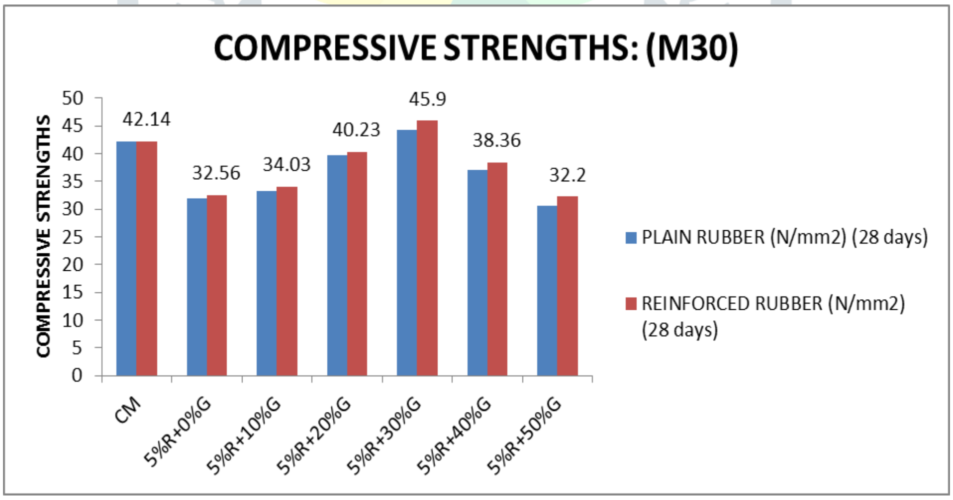

Fig.3.2: Comparison of compressive strengths of rubber with GG

Table-3.3: Comparison of Split Tensile Strengths of Rubber (M30)

PERCENTAGES (%)	PLAIN RUBBER (N/mm^2)	REINFORCED RUBBER (N/mm^2)
0% Rubber	42.14	42.14
5% Rubber	31.89	32.56
10% Rubber	26.50	27.32
15% Rubber	25.75	26.135
20% Rubber	23.51	23.68

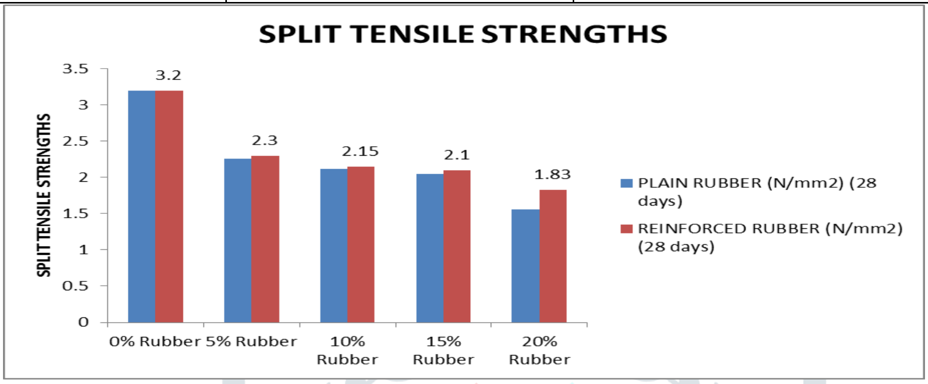

Fig.3.3: Comparison of split tensile strength of rubber

Table-3.4: Comparison of Split Tensile Strengths of Rubber with GGBS (M30)

RCENTAGES (%)	PLAIN RUBBER (N/mm^2)	REINFORCED RUBBER(N/mm^2)
Control Mix	3.20	3.20
5%Rubber+0%GGBS	2.26	2.30
5%Rubber+10%GGBS	2.38	2.47
5%Rubber+20%GGBS	3.02	3.25
5%Rubber+30%GGBS	4.225	4.46
5%Rubber+40%GGBS	3.75	3.96
5%Rubber+50%GGBS	2.41	2.74

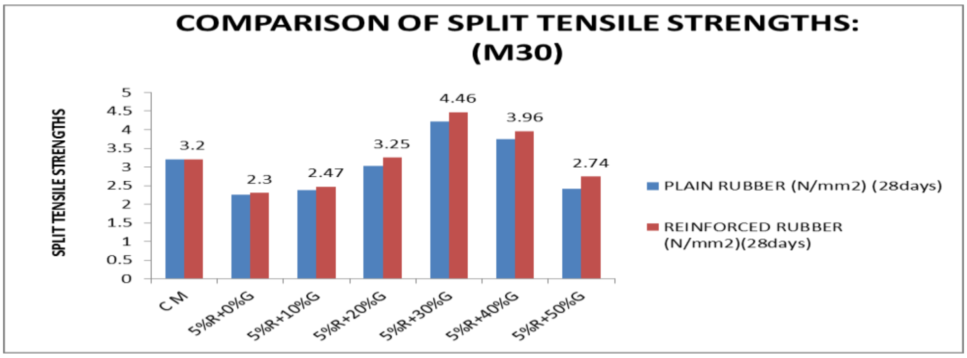

Fig 3.4 Comparison of split tensile strength of rubber with GGBS (M30

Table-3.5: Comparison of Flexural Strengths of Rubber (M30)

PERCENTAGES (%)	PLAIN RUBBER (N/mm^2)	REINFORCED RUBBER(N/mm^2)
0% Rubber	4.57	4.57
5% Rubber	3.56	3.84
10% Rubber	3.46	3.54
15% Rubber	2.80	3.12
20% Rubber	1.68	2.36

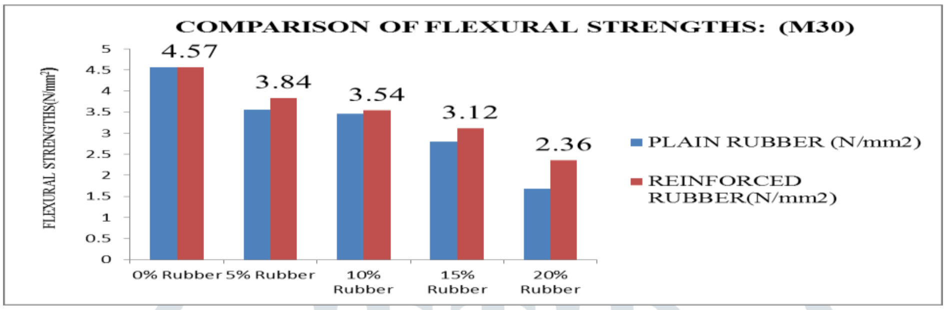

Fig 3.5 Comparison of flexural strength of rubber with GGBS (M30)

Table-3.6: Comparison of Flexural Strengths of Rubber with GGBS (M30)

PERCENTAGES (%)	PLAIN RUBBER (N/mm^2)	REINFORCED RUBBER(N/mm^2)
Control Mix	4.57	4.57
5%Rubber+0%GGBS	3.56	3.84
5%Rubber+10%GGBS	3.79	4.14
5%Rubber+20%GGBS	3.96	4.26
5%Rubber+30%GGBS	4.52	5.08
5%Rubber+40%GGBS	3.75	4.36
5%Rubber+50%GGBS	2.41	3.62

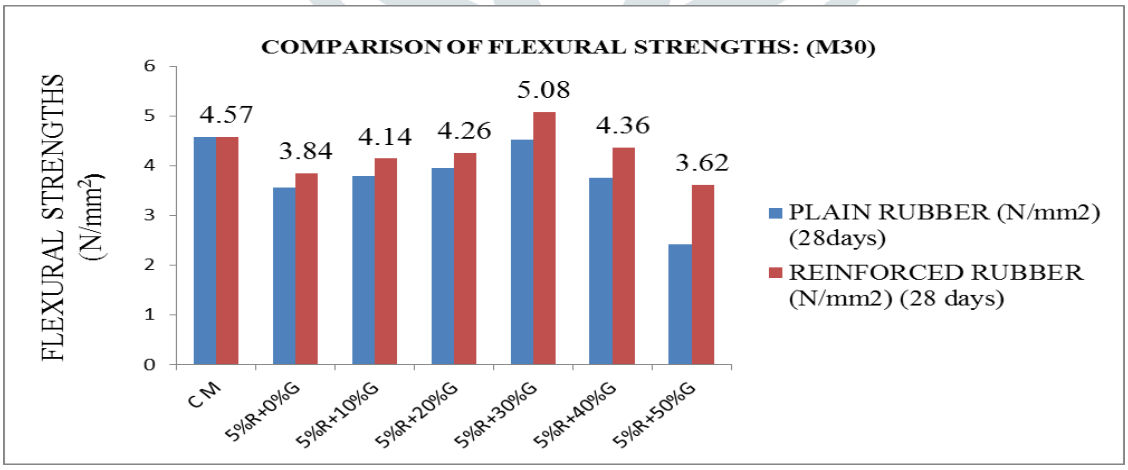

Fig 3.6 Comparison of flexural strength of rubber (M30)

4.0 DISCUSSIONS:

In this project we have used rubber tyre as a partial replacement of coarse aggregate. The rubber is pre-treated with sodium hydroxide solution because it modifies the rubber surface, affecting the interfacial transition zone and it allows the rubber to adhere with cement paste.

1. The workability has increased in nominal mix and it is adversely affected by the replacement of coarse aggregates with rubber tyre.
2. From the results of slump test, due to increase in percentage, the slump has been decreased. A slump of 05mm is shown when coarse aggregates are replaced with 25% chips.

The tests like compressive strength & split tensile and flexural strength of concrete decreased with increase in percentages of both plain and reinforced tyre rubber chips

1. By replacing 5% volume of plain (or) reinforced rubber in 20mm coarse aggregates and 30% mass of GGBS in cement gives more strength for M30 grade concrete comparing to control mix results
2. In comparing between replacing 5% volume of plain and reinforced rubber in 20mm coarse aggregates and 30% mass of GGBS in cement, reinforced rubber chips are obtained more strength for M30 grade concrete comparing to control mixresults.

5.0 Conclusions

1. The tests that are conducted like compressive strength split tensile & flexural strength of concrete reduced with increase in percentages of both plain and reinforced tyre rubber chips.
2. By replacing 5% volume of plain (or) reinforced rubber in 20mm coarse aggregates and 30% mass of GGBS in cement gives more strength for M30 Grade concrete comparing to control mix results.
3. The durability studies show that HCl curing has more effect than H_2SO_4curing.
4. The elasticity also decreased with increase of percentages.
5. The beam load bearing capacity increased for (5% RR + 30% GGBS) comparing to (5% PR + 30%GGBS).
6. Thus, the plain and reinforced rubber concrete is suitable for given M30 mix has some acceptable good compressive strength and sit can be used for construction purposes in buildings as light weight concrete an economical way.

6.0 FUTURE SCOPE OF THE WORK

1. Calculation of E values for reinforced rubber.
2. Durability studies for reinforced rubber concrete.
3. Study on columns and slabs.
4. By using of high percentages of rubber in replacing in coarse aggregates, we can make the concrete as light weight and use in architectural purposes.

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