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Experimental Studies and Behavior of Concrete On Performance of Steel Fiber and Polymer Modified Recycled Aggregate Concrete

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ABSTRACT

The amount of construction waste has been dramatically increased in the last decade due to increase of population & high rise building in the country. Recycled Course Aggregate (RCA) particles consist of substantial amount of relatively soft cement paste component also they are more porous and less resistant to mechanical actions. So there is an immediate need of using the aggregate from the old demolished buildings for other construction works such as roads, canals, retaining walls ...etc. In this project a study on Natural Aggregate, Recycled Aggregate, 30 Kg /m3 Steel Fiber Recycled Aggregate (aspect ratio=50), Modified Polymer Recycled Aggregate (Styrene butadiene rubber polymer and Poly chloroprene Rubber =5%) has been carried out with w/c =0.40 In this experimental investigation total number of 12 cubes ,12 beams & 12 cylinders of size 150x150mm , 150x150x700mm , 150x300mm specimens respectively were tested for 7,14 and 28 days & 3 cubes of Natural Aggregate, 3 cubes of Recycled Aggregate , 3 cubes of Steel Fiber Recycled Aggregate, 3 cubes of Modified Polymer Recycled Aggregate were tested in compressive testing machine for 7 , 14 and 28days
The following tests were carried out for the above specimens for 7, 14 and 28 days
1) Compressive test
2) Split tensile test
3) Flexure test
Keywords : Styrene Butadiene Rubber Polymer And Poly Chloroprene Rubber Compressive Test, Split Tensile Test, Flexural Test

I. INTRODUCTION

Concrete is the mixture of cement, coarse aggregates, fine aggregates, and water. It is widely used in construction industry. Cement is used as a binding material in concrete. After addition of water in concrete, chemical reaction takes palace and concrete sets rapidly. Concrete plays a vital role in the development of any nation or any human civilization from ancient times. Concrete is usually characterized by its compressive strength. Concrete is widely used for making architectural structures foundations, brick/block walls, bridges/overpasses, motorways/roads, runways, structures, dams, pools/reservoirs, pipes, fences and poles and even boats.

Modern structural concrete differs from Roman concrete in two important details. First, its mix consistency is fluid and homogeneous, allowing it to be poured into forms rather than requiring handlayering together with the placement of

aggregate, which, in Roman practice, often consisted of rubble. Second, integral reinforcing steel gives modern concrete assemblies great strength in tension, whereas Roman concrete could depend only upon the strength of the concrete bonding to resist tension. Smeaton's Tower.

After the Roman Empire, the use of burned lime and pozzolana was greatly reduced until the technique was all but forgotten between 500 and the 14th century. From the 14th century to the mid18th century, the use of cement gradually returned. The Canal du Midi was built using concrete in 1670, and there are concrete structures in Finland that date from the 16th century

SFRC is the developed by addition of steel Fiber with concrete at the time of mixing with definite proportions. There are many types of fibres such as steel fibre, glass fibre, rice husk etc. which are used in concrete. Steel fibres are mostly used now a day. These steel fibers are helpful to reduce the crack width in concrete member which results in reducing the permeability of concrete. Due to this concrete gains durability and strength for a very long time in compare to the concrete without steel fiber. Steel fiber also improves the toughness and load carrying capability in the concrete members

Now a days many polymers are using in concrete to improve the various properties of concrete. Peoples are taking advantages polymers in form of Oils, tars, and gums etc. Polymer modified concrete are prepared by mixing of Portland cement concrete with a advanced polymers such as Styrene butadiene rubber, polychoroprene rubber, polyvinyl acetate, acrylic latex polymer and ethylene vinyl acetate. There are various research work are done and going on due to the massive impact of polymer on concrete.

II. EXPERIMENTAL INVESTIGATION

The specific objective of the research work is to carry out comparative studies of NAC, RAC, SFRAC, and PMRAC. First of all physical and Mechanical Properties of NAC & RAC were studied. Later on mix design were prepared using NAC & RAC for Water/cement Ratio=0.50. Various tests like compressive test, split tensile test, Flexure test were carried out on these concrete.

The following mentioned physical and mechanical tests were carried out to compare NAC & RAC.

Physical Properties::

Table 1

Properties of aggregates	(NAC)	(RCA)
Specific gravity	2.70	2.42
Bulk density(kg/l)	1.446	1.286
Flakiness Index (%)	18	21
Elongation Index (%)	0.8	2
Water absorption (%)	0.70	2

Mechanical Properties For Nac & Rac::

Table 2

Properties of aggregates	(NAC)	(RCA)
Crushing strength (%)	8.205	11.8
Impact strength (%)	5	11.66

FINE AGGREGATE:

Fine aggregate used for medium and high strength concrete should be properly graded to give minimum void ratio and be free from deleterious materials like clay, silt content and chloride content. In present work fine aggregate was used locally available sand.

Table 3

SN.NO	TEST	RESULTS OBTAINED
1	Specific Gravity	2.6
2	Water absorption	1.01

Cement:

Factors which are important in selection of type of cement are compressive strength at various ages, heat of hyderation, alkali content,C_3 A content and compatibility with admixtures. Ordinary Portland cement (OPC) of 53 grades was used for preparing concrete throughout the concrete.

Table 4

Properties of aggregates	NAC	RAC
Specific gravity of cement	3.05	3.05

MIX DESIGN

Based on the Physical Properties of fine aggregate confirming to M30 grade of NAC using Indian standard recommended method of mix design .The mix was for NAC the same mix design were prepared for RAC, SFRAC, and PMRAC as to compare the various concrete properties of NAC with it. It was decided from past research work to use 40 kg/m3 steel fiber volume and SBR latex dosage in terms of polymer/cement ratio of 10%in RAC.

Mix design for medium strength concrete of grade M30

Mix design for M30 grade of concrete (NAC)

I) Data for mix design:

1) Characteristic strength 30 MPA
2) Maximum Size of Aggregate 20mm
3) Degree of workability (in terms of slump) 50100mm
4) Compaction factor 0.85
5) Degree of Quality Good
6) Type of Exposure Mild

Specific Gravity of:

Cement used = OPC PENNA CEMENT 53 grade

Specific gravity of cement = 3.05

Specific gravity of sand = 2.69

Specific gravity of coarse aggregate = 2.61

Target Mean Strength

Characteristic strength fck = 30

Target mean strength f'ck = fck + 1.65 x s

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30 + 1.65 x 5

F'ck = 38.25 MPA

Water/Cement Ratio

Water/cement ratio is taken from the experience of the mix designer based on his experience of similar work elsewhere

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Water/Cement Ratio

Water/cement ratio is taken from the experience of the mix designer based on his experience of similar work elsewhere

W/c ratio = 0.4

W/c ratio mentioned in Table 5 of IS 456 is 0.4

Selection Of Water Content

Maximum water content as per table 11.23 is 186 litre. This is for 50 mm slump.

Estimated water content for 100 mm slump = 186 X 6/100 + 186= 197.16 litters

Calculation Of Cement Content

W/c ratio = 0.4

Water used 197.16 litres

Cement content = W/C = 0.4

C = 152/0.40

C = 492.9 kg/m3

Calculation Of Coarse Aggregate And Fine Aggregate Content

From table 11.24 volume of coarse aggregate corresponding to 20 mm size aggregates and fine aggregate zone II. For w/c ratio of 0.5 is found out to be 0.62

= 0.02/0.05 X 0.10

Volume of coarse aggregates = 0.62

Corrected proportion of C.A = 0.04

.'. Volume of C.A = 0.64

Volume of F.A = 0.36

Calculation Of Mix Proportion

Volume of concrete = 1 m3

Absolute volume of cement = 492.9/3.05 X 1/1000 m3

= 0.161 m3

Volume of water = 0.186 m3

Absolute method of total aggregates = 1 [0.161+0.186]

= 0.653 m3

Mass of C.A = 0.653 X 2.61 X 0.66 X 1000

= 1124.86 kg/m3

Mass of F.A = 0.653 X 2.69 X 0.34 X 1000

= 597.24 kg/m3.

Mix Ratio = 1:1.21:2.28

The mix proportion then becomes:

Table 1. Mix proportion

Water	Cement	FA	CA
197.6	492.9	596.38	1123.8
0.40	1	1.21	2.28

The following strength tests were carried out on NAC, RAC, SFRRAC, PMRAC in order to carry out the comparative studies of the concrete.

Mix proportion for investigation:

Table 2. Natural Aggregate Concrete

Specimen(mm)	Total number of specimen	Cement in Kgs	Fine Aggregate in Kgs	Natural Coarse Aggregate in Kgs
Cubes(150x150x150)	6	9.981	12.077	22.757
Beam(150x700)	3	23.215	28.091	52.931
Cylinder(150x300)	3	7.838	9.485	17.872
Total	12	41.034	49.653	93.56

Calculations:

Volume of cube = 0.150x0.150x0.150 =3.375 x 10^3 mm3

Cement = (3.375 x 10^3) 492.9 x 6

Cement = 9.981 kg

Fine Aggregate = (3.375 x 10^3) x596.38 x6 = 12.076 kg

Coarse Aggregate = (3.375 x 10^3) x1123.8 x6 =22.757 kg

Table 3. Recycled Aggregate Concrete

Specimen(mm)	Total No. of specimens	Cement	Fine Aggregate	Recycled Coarse Aggregate
Cubes(150x150x150)	6	9.981	12.077	22.756
Beam(150x700)	3	23.215	28.090kg	52.930kg
Cylinder(150x300)	3	7.852 kg	9.501 kg	17.902kg
Total	12	41.048	49.668	93.588

Calculations:

Volume of cube = 0.150x0.150x0.150 =3.375 x 10^3 mm3

Cement = (3.375 x 10^3) 492.9 x 6

Cement = 9.981 kg

Fine Aggregate = (3.375 x 10^3) x596.38 x6 = 12.076 kg

Coarse Aggregate = (3.375 x 10^3) x1123.8 x6 =22.757 kg

Table 4. Steel Fiber Recycled Aggregate Concrete

Specimen(mm)	TotalNo.of Specimens	Cement(kg)	Fine Aggregate(kg)	Coarse Aggregate(kg)	Steel Fibers (a/d=50)gms
Cubes(150x150x150)	6	9.981	12.077	22.757	607.5
Beam(150x700)	3	17.784	26.099	57.136	1417.5
Cylinder(150x300)	3	7.852	9.510	17.902	477.09
Total	12	35.617	47.686	97.795	2502.09

Calculations:

Volume of cube = 0.150x0.150x0.150 =3.375 x 10^3 mm^3

Cement = (3.375 x 10^3) x492.9 x 6

Cement = 9.981 kg

Fine Aggregate = (3.375 x 10^3) x596.38 x6 = 13.418 kg

Coarse Aggregate = (3.375 x 10^3) x1123.8 x6 =25.285 kg

Volume of Beam = 0.150 x 0.700 =0.0157 mm^3

Cement = (0.0157) x492.9 x 3 =17.784

Fine Aggregate = (0.0157) x596.38 x 3 = 28.089kg

Coarse Aggregate = (0.0157) x1123.8 x 3 =52.931 kg

Table 5. Polymer Modified Recycled Aggregate Concrete

Specimen(mm)	TotalNo.of Specimens	Cement(kg)	Fine Aggregate(kg)	Coarse Aggregate(kg)	Polymer(ACSBR&CR=5%of cement)
Cubes(150x150x150)	6	9.981	13.418	21.285	0.382
Beam(150x700)	3	17.784	26.099	57.136	0.889
Cylinder(150x300)	3	7.838	6.038	11.378	0.300
Total	12	35.60 1.571 34.30	45.555	89.799	1.571

III. RESULTS AND DISCUSSIONS

3.1 Compressive strength for 7days

Results of the experimental investigation

The compressive test was carried out after 7, 14 and 28 days on cube of 150x150x150mm for NAC, RAC, SFRAC, & PMRAC on compression testing machine and the values are tabulated below

Cubes after Curing

(a)

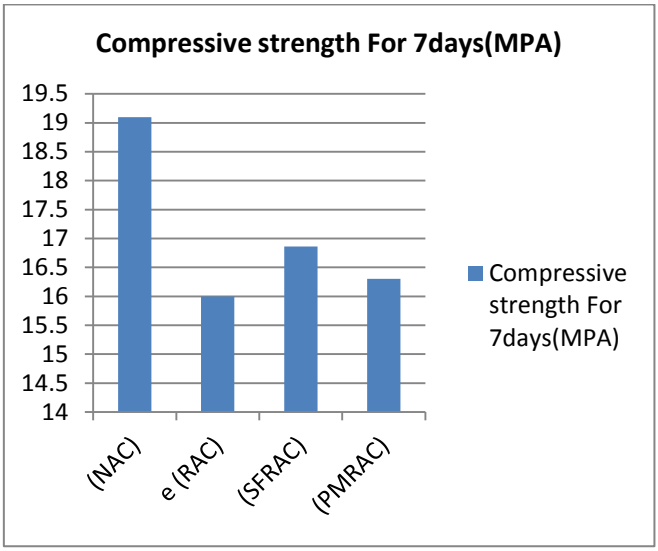
Cubes Testing

(b)

Figure 1 (a) (b)

Table 6. Compressive strength for 7 days

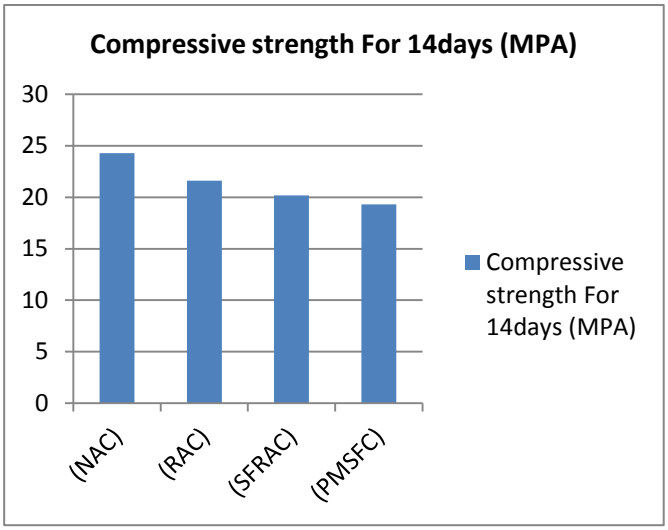
Nature of Aggregate	Compressive strength (MPA)
Natural Aggregate Concrete (NAC)	19.1
Recycled Aggregate Concrete (RAC)	16
Steel fibre Recycled Aggregate Concrete (SFRAC)	16.86
Polymer Modified Recycle Aggregate Concrete (PMRAC)	16.3



Graph 1

Table 7. Compressive strength for 14 days

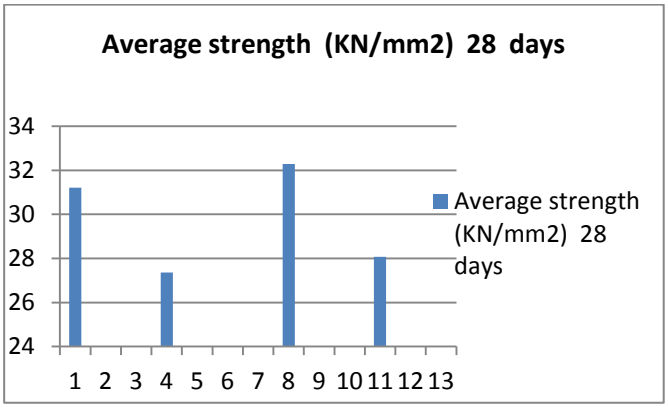
Nature of Aggregate	Compressive strength (MPA)
Natural Aggregate Concrete (NAC)	24.3
Recycled Aggregate Concrete (RAC)	21.6
Steel fibre Recycled Aggregate Concrete (SFRAC)	20.2
Polymer Modified Recycle Aggregate Concrete	19.3



Graph 2

Table 8. Compressive strength for 28 days

Nature of Aggregate	Compressive strength (MPA)
Natural Aggregate Concrete (NAC)	31.217
Recycled Aggregate Concrete (RAC)	27.36
Steel fibre Recycled Aggregate Concrete (SFRAC)	32.295
Polymer Modified Recycle Aggregate Concrete	28.08



Graph 3

3.2 split tensile test For 28 Days For tensile test the specimen of size 150mmx300mm is tested in CTM. The specimens were demoulded after 24 hrs and was transferred to curing for 28 days.

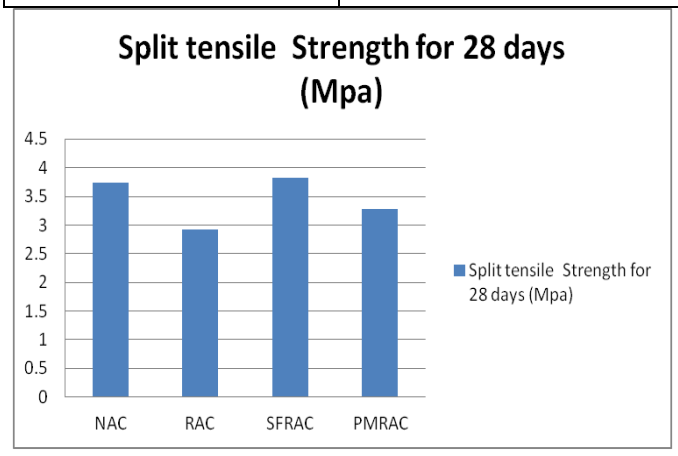
Split tensile strength of concrete = 2P / πDL

Testing of cylinders Under UTM Machine

Figure 2

Table 9. Split tensile test for 28 days

Nature of Aggregate	Compressive strength (MPA)
Natural Aggregate Concrete (NAC)	3.93
Recycled Aggregate Concrete (RAC)	2.94
Steel fibre Recycled Aggregate Concrete (SFRAC)	3.93
Polymer Modified Recycle Aggregate Concrete	3.34



Graph 4

From the graph if we compare Natural Aggregate Concrete (NAC) with Recycled Aggregate Concrete (RAC) the strength of RAC is reduced by **28.0%** so to

increase the strength of RAC we have added Steel fiber of aspect ratio (a/d=50) and polymer as (ACSBR & CR =apple chemist styrene butadiene rubber and Poly chloroprene Rubber) and there was an increase by **31.16%** in SFRAC and **12.15%** in PMRAC.

3.3 Flexural test For 28 Days: The flexural strength of the specimen is expressed as modulus of rupture which depends on the dimension of the beam and the type of loading . The size of specimen is 150x150x700mm and 3 point loading.
The modulus of rupture fb = PL / bxd2

Curing of Specimens

(a)

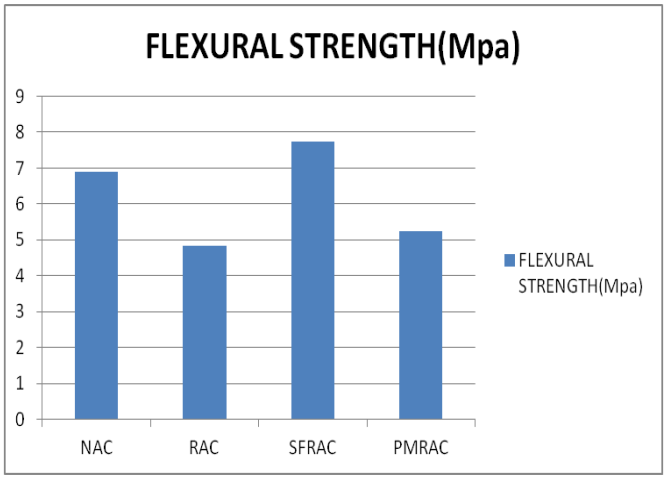
Failure of Beam

(b)

Figure 3 (a)(b)

Table 10. Flexural test for 28 days

Nature of Aggregate	Compressive strength (MPA)
Natural Aggregate Concrete (NAC)	6.9
Recycled Aggregate Concrete (RAC)	4.836
Steel fibre Recycled Aggregate Concrete (SFRAC)	7.73
Polymer Modified Recycle Aggregate Concrete	5.25



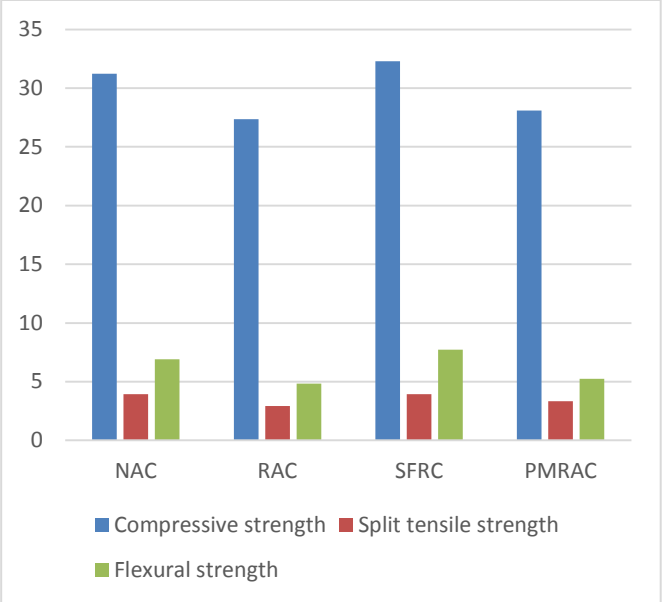
Graph 5

Flexural strength for Recycled aggregate concrete(RAC) has decreased by **27.46%** when compared with Natural Aggregate concrete(NAC) and so to improve the Flexural strength of RAC , 30 Kg/m3 of steel fiber with aspect ratio (a/d=50) was added and there was an increase in strength by **33.26%** and even styrene butadiene rubber & Poly chloroprene Rubber polymer of 5% of cement was added to RAC and there was an increase of strength by **14.12%.**

3.4 consolidated report: The report consist of all the 3 test i.e, compressive test , split tensile test and flexural test for 28 days and its graphical representation is given below with tabular column.

Table 11. consolidated report

Nature of concrete	Compressive strength	Split tensile strength	Flexural strength
NAC	31.217	3.93	6.9
RAC	27.36	2.94	4.83
SFRC	32.295	3.93	7.73
PMRAC	28.08	3.34	5.25



Graph 6

IV. CONCLUSIONS

- It has been observed that the specific gravity of Natural Coarse Aggregate is more than the Recycled Coarse Aggregate
- Compressive test was carried out for 7 days on cube of dimensions 150x150x150mm and found that Natural Aggregate Concrete is having more compressive strength when compared with Recycle Aggregate Concrete and there is an increase of 21%with addition of Steel Fibers in Recycle Aggregate and a Decrease of 12% in Polymer Modified Recycled Aggregate Concrete.
- Compressive test was carried out for 14 days on cube of dimensions 150x150x150mm and found that Natural Aggregate Concrete is having more compressive strength when compared with Recycle Aggregate Concrete and there is an increase of 28%with addition of Steel Fibers in Recycle Aggregate and a Decrease of 13% in Polymer Modified Recycled Aggregate Concrete.
- Compressive strength was carried out for 28 days for Natural aggregate concrete (NAC) Recycled aggregate concrete(RAC), Steel Fiber Recycled Aggregate Concrete(SFRAC) & Polymer Modified Recycled aggregate Concrete (PMRAC) and the strength of SFRAC is more when compared by NAC by 4.80% and there is a decrease in RAC by 16.18% so to improve the strength of RAC 30 kg/m^3 of Steel fiber and 5 % of cement as polymer **(Styrene Butadiene Rubber And Poly chloroprene Rubber**)was added and the strength was increased by 21.66% & 4.83%.
- Split tensile test was also carried out for 28 days and the strength of Recycled aggregate was less when compared to Natural aggregate concrete by 28% so to improve the strength we have added Steel fibers and polymer and there was an improvement in concrete by 31.16% for steel fiber and it was observed that SFRAC was having more strength then NAC but polymer modified recycled aggregate concrete has less strength compared to NAC by 14.37% but there is an increase when compared with RAC by 12.15%
- Flexural test was carried out for 28 days under CTM with 3 point loading and it was observed that strength of recycled aggregate is very less when compared with NAC by 42.85% so to improve the strength RAC 30 kg/^{m3of} Steel fiber and 5 % of cement as polymer (Styrene Butadiene Rubber & Poly chloroprene Rubber) was added and the strength was improved by 59.84% and 8.69% when compared with RAC.

Overall view of the project was that the strength of Recycled Aggregate concrete was less when compared with Natural aggregate concrete and to improve the

strength we have added 30 kg/^{m3of} Steel fiber and 5 % of cement as polymer (Styrene Butadiene Rubber and Poly chloroprene Rubber)

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