# Synergic Effects of Recycled Concrete Aggregate and Styrene Butadiene Rubber (SBR) Latex on Mechanical Properties of Concrete

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**Abstracts:** These days Sustainable advancement is picking up notoriety all around the globe. To hold characteristic assets, reuse and reusing of development and annihilation squander is the clearest approach to achieve manageability in the development division. Presently, reused aggregate RA is been generating and CDW is its source. As of late, these squanders are reused in present day reusing offices, under great quality control arrangements which could prompt enhance its execution. An investigation is completed about the characteristics of Recycled Aggregate Concrete RAC by utilizing squashing and breaking of concrete waste got from various obliteration locales & junkyard. With the end goal to upgrade the characteristics of RAC there are a few additives called as super plasticizer which are adjoined with concrete. Fixings utilized in particularly this investigation were ordinary sand, common & reused aggregate & additive namely Styrene Butadiene Rubber latex (SBR). Those aggregates are acquired from various assets. Sum of 144 concrete molds in system of 4 collections was framed. Gatherings were structured in such a route along these lines, to the point that the impact of reused coarse aggregate (half, 75 percent, and 100 percent), cement dose and expansion of latex of SBR in factor amounts by the cement weight of (0.5 percent, I percent, 1.5 percent) ought to be appropriately decided. For compressive quality and rupture modulus MOR, tests were done. Prior to the tests performance in the research center a diminishing pattern of twenty five (25) percent in compressive quality was taken note. An impressive decrease was seen in the properties of RAC by utilizing 100% reused aggregate when contrasted with Natural Aggregate Concrete NAC. There was negligible change in Recycled Aggregate Concrete RAC made of 75 percent (%) NA and 25 percent (%) RCA. Yet, there was ideal properties differences of concrete ended with the blend of half NA and half RCA. It was seen in the outcomes that concrete squanders might be used in arrangement of concrete subsequent to reusing them which at that point can be utilized in many concrete structures.

**Keywords:** Concrete, Recycled Aggregate, Styrene Butadiene Rubber, Compressive Strength, Modulus of Rupture, Bulk Density, Specific Gravity, Fineness Modulus.

## 1. INTRODUCTION

Despite the fact that reused concrete aggregate (RCA) are exceptionally valuable in each respect yet there are some important problems with Recycled Aggregate Concrete RCA [1-5]. Reused aggregate retain a lot of carbon dioxide from the abutting condition. The procedure of carbonation happens in cement from the internal surface. Whereas smashing the concrete to get Recycled Aggregate Concrete RCA, at times zones of the concrete stays un carbonated. There is overall conviction about the undesirable impact of utilizing RCA in generation of concrete [6-9]. Nonetheless, researchers have examined mechanical and strength characteristics of Recycled Aggregate Concrete. The outcomes acquired repudiate this thought. For improved comprehension the mechanical and new concrete features, it is clear to examine its sturdiness since this decides enduring execution of concrete. It is indicated that there is broad conviction about the undesirable impact of utilizing Recycled Aggregate Concrete RCA in concrete generation [10-13]. Be that as it may, Scientists have considered the mechanical and sturdiness properties of Recycled Aggregate Concrete RCA. The outcomes acquired repudiate this thought. For well comprehension the mechanical properties and properties of fresh concrete, it is clear to examine its stability since this decides enduring execution of concrete [14].

### 1.1. Recycled Aggregates RA

Reused aggregates must be imperative wellspring of aggregates of concrete got from smashing and using the remains from concrete constructions [15]. Concrete reusing can suggest a bolstered source of aggregate of concrete. Be that as it may, the RAC at present, arranged isn't as successful as readied by utilizing NA. Subsequently they are not considered in auxiliary cement. RACs arranged in the wake of utilizing exceptional workmanship for reusing the aggregate frequently have bring down thickness, higher water retention, and lower scraped spot opposition contrasted with NA [16]. The lake in nature of RAC contrasted with Natural Aggregate concrete is credited to the nearness of cementitious mortar in Recycled Aggregate Concrete. It has been depicted the mechanical characteristics of Recycled Aggregate Concrete as appeared in Figure 2.3. Also, it is indicated that reused aggregates are a critical wellspring of aggregates of concrete acquired from smashing and using the rubble from concrete constructions. Concrete reusing can have an upheld source of aggregates of concrete. Be that as it may, the RAC presently, readied isn't as powerful as readied by utilizing NA. Henceforth they are not considered in auxiliary concrete. RACs arranged in the wake of utilizing exceptional workmanship for reusing the aggregates frequently have lesser thickness, advanced water assimilation, and minor scraped spot opposition contrasted with NA [17]. It is said that in light of nature of mortar in Recycled Aggregate Concrete RCA, extra water is obligatory for those aggregates. Moreover it is delineated that an abatement happens in nature of concrete if upsurge in Recycled Aggregate Concrete RCA is done [18]. Research techniques were approached to understand that parental concrete having no impact on nature of fresh concrete. As Recycled Aggregate Concrete are accumulated from junkyards, subsequently they are weak against pollution in light of biological presentation and pernicious matters.

### 1.2. Admixtures

It depicts that the use of additives happens to be consistent component of late concrete arena. No only gathering of materials has added to growing the abilities of concrete of hydraulic cement greater than substance additives. Preceding the presentation of concoction additive, high-quality concrete more often than not implied concrete of zero slump. It was impractical to deliver present day high quality cement without joining high-go water decreasing, impeding, and hydration settling admixtures [19].

### 1.3. High Range Water Reducers SBR Latex

SBR Latex is used in entire uber expands wherever entire through the sphere. It is used in elevated structures, thickly stuffed reinforcement, pre-thrown components, pre-focused on concrete, slim segments with clogged and; shaft and chunks, and long thin segments. The extension of SBR Latex results in fewer usage of cement and conveys common quality yet with high usefulness. In view of its characteristics to manufacture handiness, its usage got more thought. They exceptionally decline the water-cement extent of mortar of concrete. It doesn't affect functionality of concrete; accordingly convey first class & concrete of self-cementing. Latex of SBR impacts diversified properties of concrete both in the new and furthermore in cemented solidified structure and this is an immediate consequence of following guideline causes [20].

## 2. MATERIAL AND METHODS

The going with 3 properties was consolidated into this examination.

- A nearby look was provided to the deviance of compressive quality and concrete rupture modulus.
- To get the sum latex of SBR is productive at 7, 14 and 28 days when added to Recycled Concrete Aggregate RCA.
- Afterward, make an association among Modulus of Rupture & compressive quality of the blends.

Right when concrete was prepared consuming Natural Aggregate & Recycled Aggregate with extension of latex of SBR at that slump test were coordinated on primer concrete blends with twenty eight (28) MPa for compressive quality and four (4) MPa for flexural quality. To assist control blend configuration value of slump was kept and kept up at 75 mm-100 mm.

At Leads University (UCEST), Lahore, different bunches of cylinders were constructed. Each bunch/batch has an assortment in proportion of Natural Aggregate & Recycled Aggregate with latex of SBR development. In method of cylinders casting, water-cement extent was decreased by accepting hit and fundamental reason procedure to get the finest usefulness. To make a volume of unit $m^3$, concrete blend configuration is done at an extent of (1:2:4) with latex of SBR & its belongings were tested for compressive and furthermore rupture quality. In Pakistan as a rule to use (1:2:4) extents as concrete blending for fitting decision of concrete ingredients (aggregate, sand, cement) & their planned sums. To research the mechanical characteristics of concrete that is compressive quality and rupture modulus, accompanying technique has polished. Different blends holding an expansion of latex of SBR in NA and RA were made for above stated assignment. The accompanying 3 properties were incorporated into this examination.

- A sharp observation was being kept on deviancy in compressive power and concrete rupture modulus.
- To perceive the amount latex of SBR is successful at 7, 14 and 28 days when added to Recycled Aggregate Concrete RCA.
- Afterwards build up a connection among Rupture Modulus MOR and compressive power of the blends.

At the point when concrete was set up utilizing NA and RA with expansion of latex of SBR at that slump test was directed on preliminary mixes od concrete with twenty eight (28) MPa for compressive power and four (4) MPa for the strength of flexure. To assist a controlled mix design, slump value was preserved and sustained at 75 mm - 100 mm.

At Lahore Leads University (UCEST), various cylinders batches were prepared. Every batch had a variety in measure of NA & RA with latex of SBR expansion. In procedure of setting up cylinders water-cement proportion was diminished by receiving hit and preliminary premise technique to acquire the most ideal functionality. To set up unit $m^3$ volume, mix design of concrete has done at a proportion of (1:2:4) with latex of SBR and its results were examined for the quality of rupture and compressive. In Pakistan usually to utilize (1:2:4) proportions as concrete intercourse for appropriate choice of concrete ingredients (aggregate, sand, cement) and their projected amounts.

### 2.1. Concrete Combinations

In concrete testing procedure, blend diverse measure of NA and RA were summed to concrete with the different doses of latex of SBR. These practices of performance were completed in research center of Leads University (UCSET) Lahore. All the prepared mixes are given below

- First of all a clump/batch of concrete is made utilizing 100 % of characteristic aggregate.
- Second one clump/batch comprises of 50 % NA and 50 % RA.
- In third clump NA aggregate diminishes further and prepare blend having 25 % NA + 75 % RA
- In clump Number four concrete mixes is set up by utilizing 100 % of RA.

No batch has the SBR latex rate in above four groups. After that SBR latex is joined as

- First of all a batch of concrete is made utilizing 100 % of natural aggregate with 1% expansion of SBR latex.

- Second one cluster comprises of 50 % NA and 50 % RA with 1% expansion of SBR latex.

- In third batch NA aggregate decreases further and get ready blend having 25 % NA + 75 % RA with 1% expansion of SBR latex.

- In cluster Number four concrete mixes is set up by utilizing 100 % of RA with 1% expansion of SBR latex.

Next four clumps have the accompanying mixes

- First of all a group of concrete is made utilizing 100 % of natural aggregate with 1.5 % expansion of SBR latex.

- Second one bunch comprises of 50 % NA and 50 % RA with 1.5 % expansion of SBR latex.

- In third bunch NA aggregate lessens further and prepare mixes having 25 % NA + 75 % RA with 1.5 % expansion of SBR latex.

- In batch Number four concrete blends is set up by utilizing 100 % of RA with 1.5 % expansion of SBR latex.

## 3. RESULTS AND DISCUSSIONS

These five regular tests i.e. the fineness modulus, bulk density, specific gravity, rupture modulus and compressive strength were done. Those characteristics were experienced for Natural Aggregate NA and Recycled Aggregate RA.

### 3.1. Bulk Density

**Table 1: Data of the test for the calculation of Bulk Density**

| State | Weight of Cylinder | Weightt of cylinder of Aggregate | Weight of Aggregate | Volume of Cylinder | Density (Bulk) | (Average Value) |
|---|---|---|---|---|---|---|
| | Kilogram | Kilogram | Kilogram | $m^3$ | Kilogram/$m^3$ | (Kg/$m^3$) |
| Compressed | 5.883 | 13.96 | 8.072 | 0.0055 | 1452.01 | |
| Soft | 5.883 | 13.43 | 7.544 | 0.0055 | 1357.11 | Compressed = 1433 |
| Compressed | 5.883 | 13.23 | 7.324 | 0.0055 | 1317.23 | |
| Soft | 5.883 | 12.587 | 6.68 | 0.0055 | 1203.71 | |
| Compressed | 0.869 | 2.47 | 1.576 | 0.0010 | 1529.43 | |
| Soft | 0.869 | 2.24 | 1.383 | 0.0010 | 1345.22 | Soft = 1301 |

### 3.2. Specific Gravity

**Table 2: Specific Gravity Test Results for Aggregates**

| Computations | CA | FA | RA |
|---|---|---|---|
| Weight of oven dried specimen (g) | 981 | 497 | 1951 |
| Weight of Saturated Surface Sample (g) | 989 | 501 | 1981 |
| Weight of container + water (g) | 2753 | 1539 | 2796 |
| Weight of water soaked specimen (g) | 3371 | 1827 | 4049 |
| Sp. Gravity | 2.63 | 2.31 | 2.701 |
| Apparent Wt | 2.66 | 2.37 | 2.802 |
| Absorption, % | 0.810 | 0.802 | 1.50 |

### 3.3. Fineness Modulus

**Table 3: FM of Sargodha Crush**

| Sieve No. | Sizes of Sieves mm or μm | Retained Mass, gm | Retained mass, % | Cumulative percent of Retained, % | Cumulative percent of Passing, % |
|---|---|---|---|---|---|
| 3 | 75.00 | 0.00 | 0.00 | 0.00 | 100 |
| 1½ | 37.50 | 0.00 | 0.00 | 0.00 | 100 |
| 3/4. | 19.00 | 97.02 | 2.424 | 2.424 | 97.571 |
| 3/8. | 9.50 | 3552.01 | 88.801 | 91.222 | 8.772 |
| 3/16. | 4.750 | 336.03 | 8.402 | 99.629 | 0.376 |
| 3/32. | 2.360 | 1.04 | 0.024 | 99.650 | 0.352 |
| Pan | Pan | 14.00 | 0.351 | 100 | 0 |

Cumulative % retain up to size of particle 150 μm = 292.932
FM = 2.931

**Table 4: FM of Chenab Sand**

| Sieve # | Sizes of Sieves, mm or μm | Retained Mass, gram | Retained Percentage, % | Cumulative Percentage Retained, % | Cumulative Percent Passing, % |
|---|---|---|---|---|---|
| 4 | 4.750 | 0.00 | 0 | 0 | 100 |
| 8 | 2.34 | 4.05 | 0.40 | 0.401 | 99.60 |
| 16 | 1.180 | 7.11 | 0.71 | 1.10 | 98.91 |
| 30 | 600 μm | 9.06 | 0.92 | 2.02 | 98.02 |
| 50 | 300 μm | 490.1 | 49.04 | 51.1 | 49.01 |
| 100 | 150 μm | 437.04 | 43.70 | 94.72 | 5.30 |
| Pan | Pan | 53.00 | 5.31 | 100 | 0 |

Retained Cumulative % up to the size of particle 150μm = 149.20
FM = 1.491

**Table 5: FM of RA**

| Sieve # | Sizes of Sieves, mm or μm | Retained mass, Gram | Percent Retained, % | Cumulative Percentage Retained, % | Cumulative Percent Passing, % |
|---|---|---|---|---|---|
| 3 | 75.00 | 0 | 0 | 0 | 100 |
| 1½ | 37.50 | 0 | 0 | 6.35 | 93.65 |
| 3/4. | 19 | 97 | 2.425 | 18.425 | 81.575 |
| 3/8. | 9.5 | 3502 | 88.8 | 91.225 | 8.775 |
| 3/16. | 4.75 | 386 | 8.4 | 99.625 | 0.375 |
| 3/32. | 2.36 | 1 | 0.025 | 99.65 | 0.35 |
| Pan | Pan | 14.00 | 0.34 | 100 | 0 |

Retained Cumulative % up to the size of particle 150 μm = 315.25

Fineness Modulus = 3.15

### 3.4. Mix Design of concrete

(1) Sp. Gravity of Fine Aggregate= 2.7

(2) Density (Bulk) of Coarse Aggregate = 1405

(3) Slump= 50.00 mm

(4) Sp. Gravity of Coarse Aggregate= 2.64

(5) FM of Fine Aggregate = 1.5

(6) Absorption of Water (RA) = 1.5%

**Step No. 1**

**Choice of W/C proportion using ACI table 11.60**

For 50.00 (mm) slump & 20.00 (mm) size of Aggregate;    Water to cement ratio = 0.55

**Step No. 2**

Content of water using ACI table 11.80;    Content of water = 185.010 kg/$m^3$

**Step No. 3**

Content of Cement = 185.010/0.550 = 336.01 kg / $m^3$

**Step No. 4**

Rodded Dry volume (bulk) of Coarse Aggregate CA = 0.680/unit concrete volume using ACI table 11.40

Weight of Coarse Aggregate C.A = 0.680 *1437 = 956 kg / $m^3$

Water absorbed by Coarse Aggregate C.A = 1.5 %

Hence Weight of Coarse Aggregate C.A = 956 - (1.5/100 * 956) = 942 kg / $m^3$

**Step No. 5**

To explore Weight of Fine Aggregate by Method of Absolute Volume

(Cement) = 336/3.150*$10^3$ = 107 * $10^3$ $cm^3$;    (Water) = 185.00/1*$10^3$ = 185.00*$10^3$ $cm^3$

Coarse Aggregate (CA) = 956/2.64*$10^3$ =362*$10^3$ $cm^3$;    (Air) = 2.00/100*$10^6$ = 20.00 * $10^3$ $cm^3$

(Total) = 672 * $10^3$

Hence Fine Aggregate = 1000-672 = 328 * $10^3$;    Weight of F.A = 328 *1.5 = 492.5 kg / $m^3$

Absorbed water by FA= 0.8 %;    Weight of Fine Aggregate = 492.5 - (0.8/100 * 492.5) = 489

**Step No. 6**

**Table 6: Design Mix Proportions**

| Cement | F.A | C.A | Water |
|---|---|---|---|
| 336 | 489 | 942 | 0.55 |
| 1 | 1.46 | 2.8 | 0.55 |

**Table 7: Materials and its source for 3 cylinders**

| Sr. | Resources | Amount | Source |
|---|---|---|---|
| 1 | Cement | 7.89 kilogram | (Lakki Cement) |
| 2 | Fine Aggregate | 11.60 kilogram | Sand of Chenab |
| 3 | Recycle Aggregates | 22.48 kilogram | Maki Enterprises |
| 4 | LATEX (SBR) | 80 ml | Chermrite NN |

### 3.5. Different Concrete Combinations Casting

These are details of several factors that utilized in the lab for performance of investigates to achieve the necessities of the project.

**Table 8: Size particulars, Vol and Magnitude of Cylinders**

| Dimensions | Cylinder |
|---|---|
| Dimension | 150.00 mm×300.00 mm |
| Vol | 0.00555 $m^3$ |
| Samples | 3.00 |

### 3.6. Compressive Strengths for Concrete Combinations

Concrete compressive quality is forbearance ability of material to stand loads that act on it. The compressive quality for dissimilar grouping of latex of SBR is given in Table 4.9.

**Table 9: Compressive Strengths of concrete**

| Mix Type | 28 days compressive strength | |
|---|---|---|
| SBR (%) | Psi | % increase |
| CM (0% SBR) | 2993 | 0 |
| Mix A (1% SBR) | 3272 | 9.3 |
| Mix B (1.5% SBR) | 3489 | 16.57 |

**Table 10: Concrete Compressive Strengths with various combinations of RA and NA**

| SBR Dosage | Days | Compressive Strengths (fc') (MPa) | | | |
|---|---|---|---|---|---|
| (%) | | NA (100%) | NA (50%) +RA (50%) | NA (25%) +RA (25%) | RA (100%) |
| 0% | 7 | 16. 6 | 15. 5 | 15. 4 | 13. 2 |
| | 14 | 23. 2 | 19. 8 | 19. 6 | 17. 3 |
| | 28 | 26. 4 | 22. 1 | 21. 8 | 19.0 |
| 1% | 7 | 16.7 | 15.8 | 15. 5 | 14. 21 |
| | 14 | 23. 7 | 21. 7 | 20. 4 | 16. 5 |
| | 28 | 27. 45 | 23. 2 | 22. 6 | 20.4 |
| 1.5% | 7 | 17. 53 | 16. 6 | 15. 9 | 15 |
| | 14 | 24. 4 | 23. 2 | 22. 63 | 17. 7 |
| | 28 | 28. 6 | 27. 2 | 25. 2 | 22. 1 |

### 3.7. Rupture modulus for Combinations of Concrete

Rupture Modulus (MOR) otherwise called flexural quality speaks to quality of concrete sample testing prior to failure.

**Table 11: Rupture Modulus**

| Dosage of SBR | Time (Days) | Rupture Modulus, (fr) | | | |
|---|---|---|---|---|---|
| | | NA (100%) | NA (50%) +RA (50%) | NA (25%) +RA (75%) | RA (100%) |
| 0% | 7 | 5. 14 | 3. 14 | 3. 07 | 2. 44 |
| | 14 | 5. 65 | 3. 49 | 3. 16 | 2. 70 |
| | 28 | 6. 28 | 4. 23 | 3. 33 | 2. 95 |
| 1% | 7 | 5. 77 | 4. 00 | 3. 44 | 2. 54 |
| | 14 | 5. 76 | 4. 21 | 3. 65 | 3. 10 |
| | 28 | 6. 45 | 4. 33 | 3. 79 | 3. 27 |
| 1.5% | 7 | 6. 09 | 4. 25 | 3. 53 | 2. 77 |
| | 14 | 6. 46 | 4. 45 | 3. 67 | 3. 20 |
| | 28 | 6. 75 | 4. 96 | 4. 18 | 3. 37 |

### 3.8. Statistical Approaches

Statistical considerations are done to display the compressive quality for numerous amounts of latex of SBR.

#### 3.8.1. Materials properties

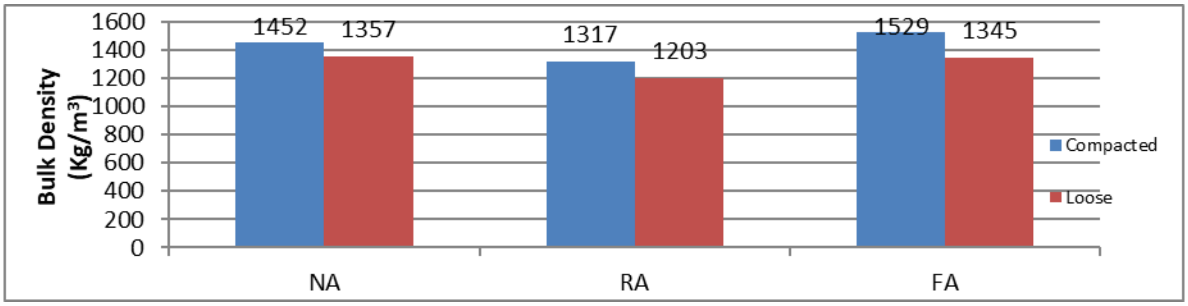


**Fig 1: Bulk Density of NA, RA and FA**

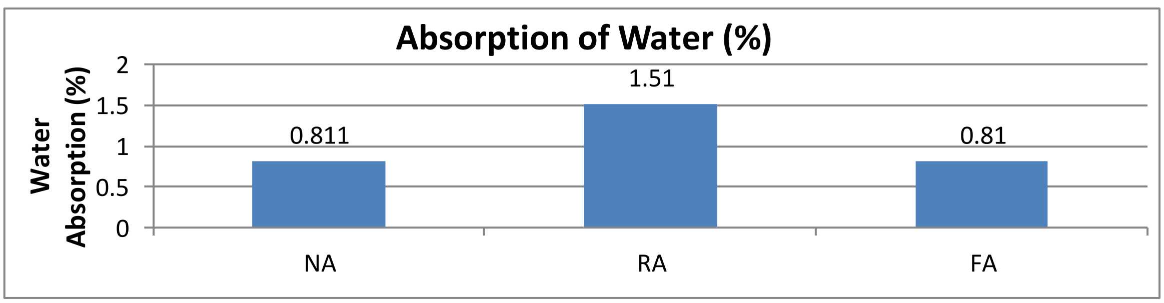


**Fig 2: Percentage of Absorption of water of NA, RA and FA**

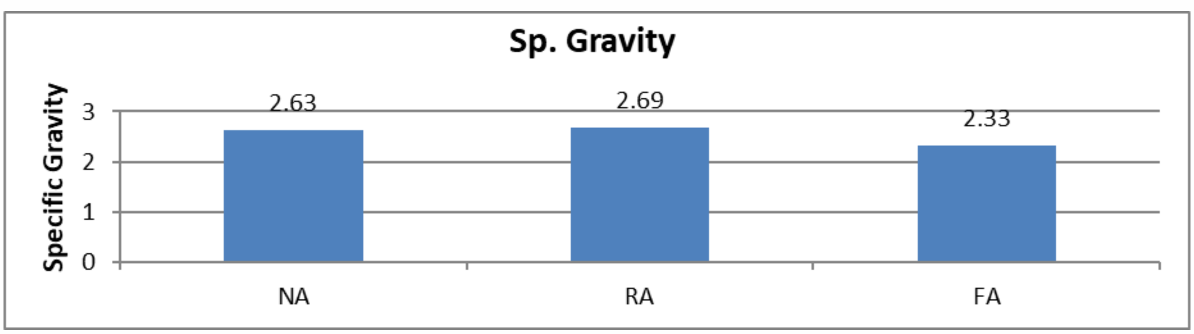


**Fig 3: Sp. Gravity of NA, RA and FA**

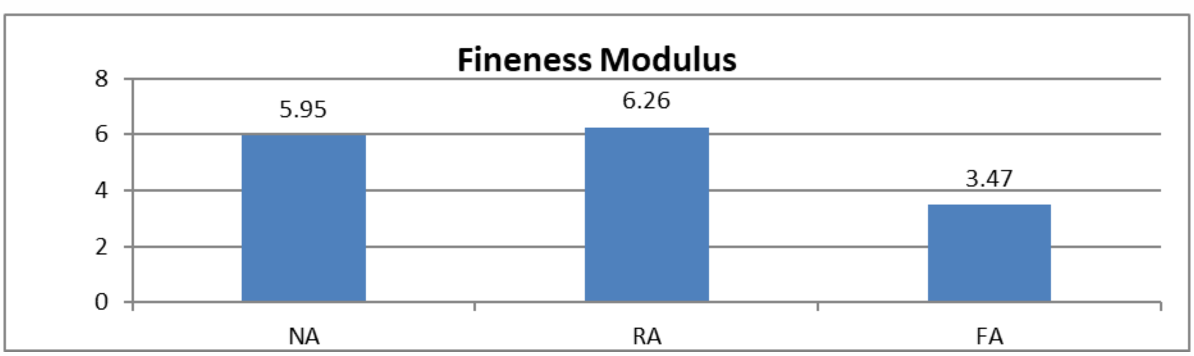


**Fig 4: Fineness Modulus of NA, RA and FA**

### 3.8.2. Compressive Strength Variations using (RA) and (NA) with different amounts of SBR Latex at 28 days.


**Fig 5: Compressive Strength at (0%, 1% and 1.5%SBR LETEX+ 100% of NA and RA)**

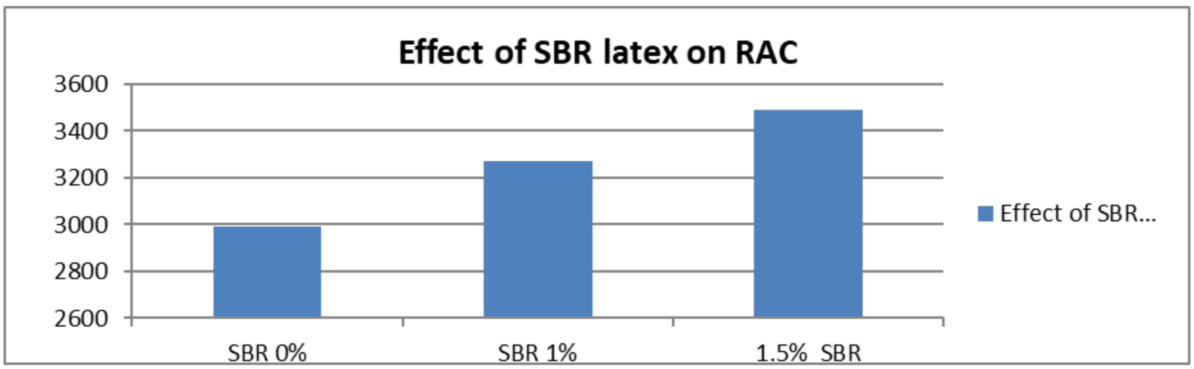


**Fig 6: Compressive Strength of RAC at (0%, 1% and 1.5%SBR LETEX)**

SBR LETEX at 0%, a reduction of 23% in Compressive Strength is detected in addition of RA up to 100% within our concrete mix.

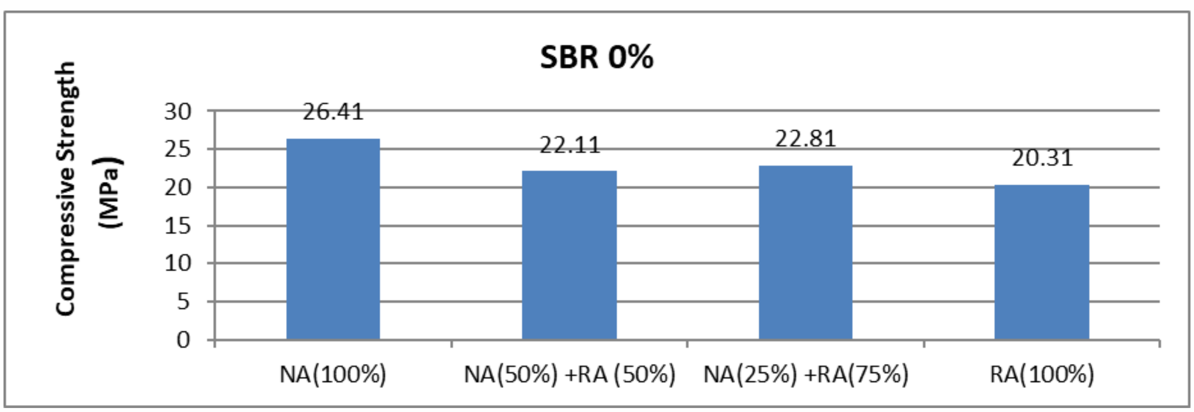


**Fig 7: Compressive Strength at (SBR LETEX 0% + Contents of RA)**

SBR LETEX at 1%, a reduction of 25% in Compressive Strength is detected in addition of 100% RA within concrete mixture.

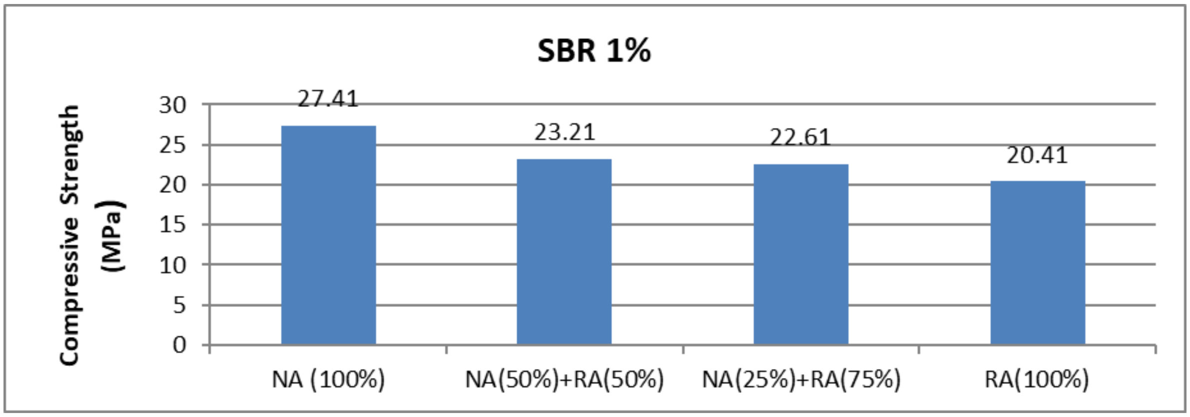


**Fig 8: Compressive Strength (SBR 1% + Contents of RA) at 28 days.**

SBR LETEX at 1.5%, reduction of 23% in Compressive Strength is detected by adding up to 100% RA in the mix of concrete.

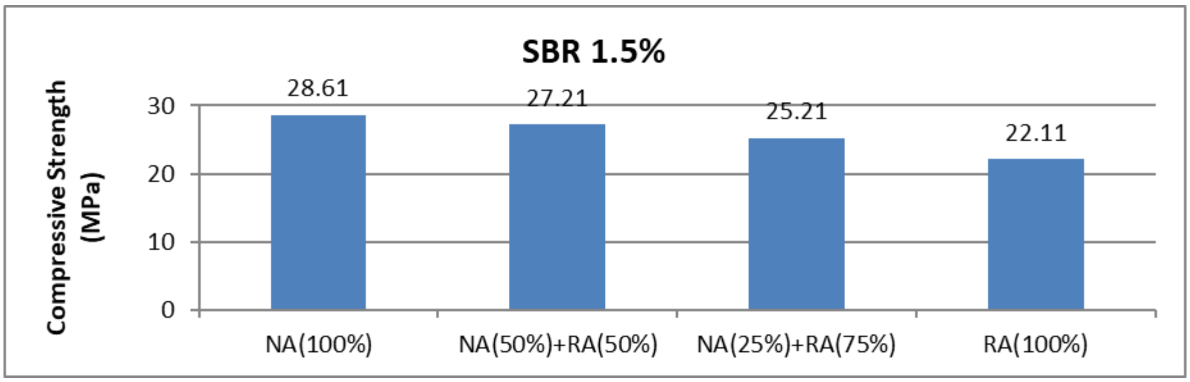


**Fig 9: Compressive Strength (SBR 1.5% + Contents of RA) at 28 days.**

### 3.8.3. Variation in Modulus of Rupture with RA Content at 28 days

SBR Latex at 0%, a reduction of 53% in the rupture modulus (MOR) is observed by the 100% addition of RA in the mixture of concrete.

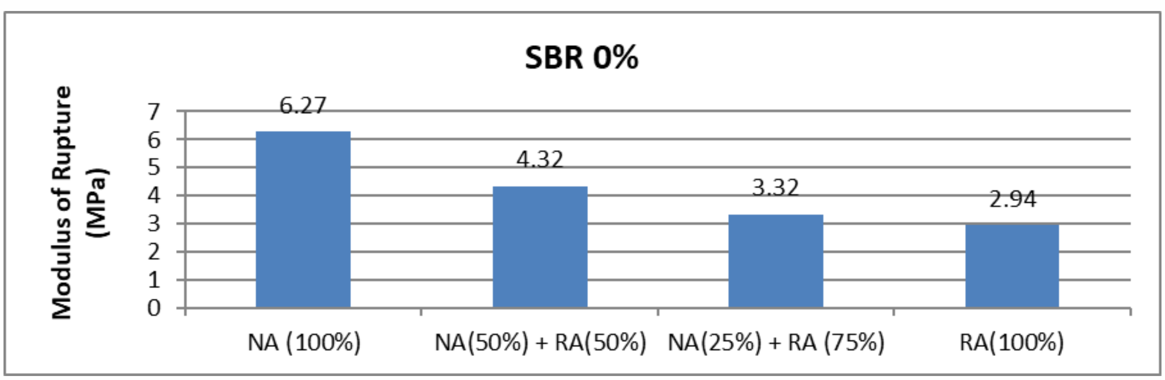


**Fig 10: Rupture Modulus (SBR 0% +Contents of RA)**

SBR LETEX at 1%, a reduction of 49% in the rupture modulus (MOR) is detected by the 100% addition of RA in the mixture of concrete.

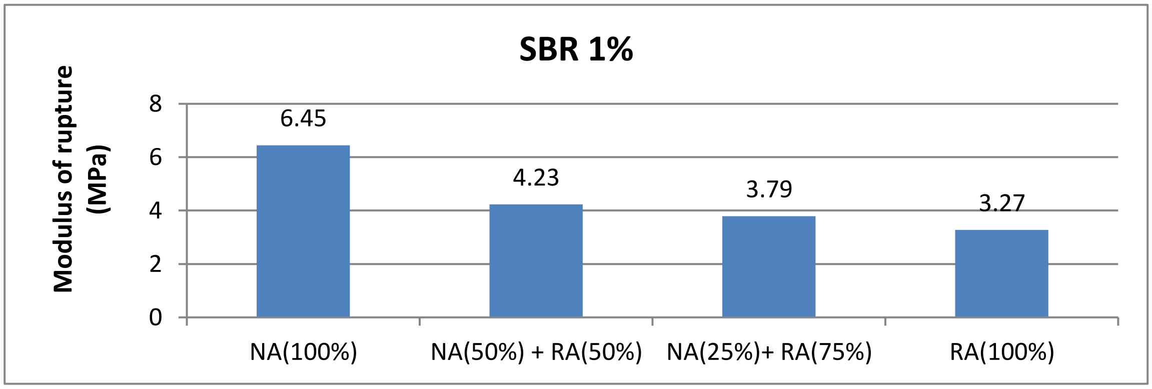


**Fig 11: Rupture Modulus (SBR 1% + Contents of RA)**

SBR Latex at 1.5%, a reduction of 50% in rupture modulus (MOR) is observed by the 100% addition of RA in the mixture of concrete.

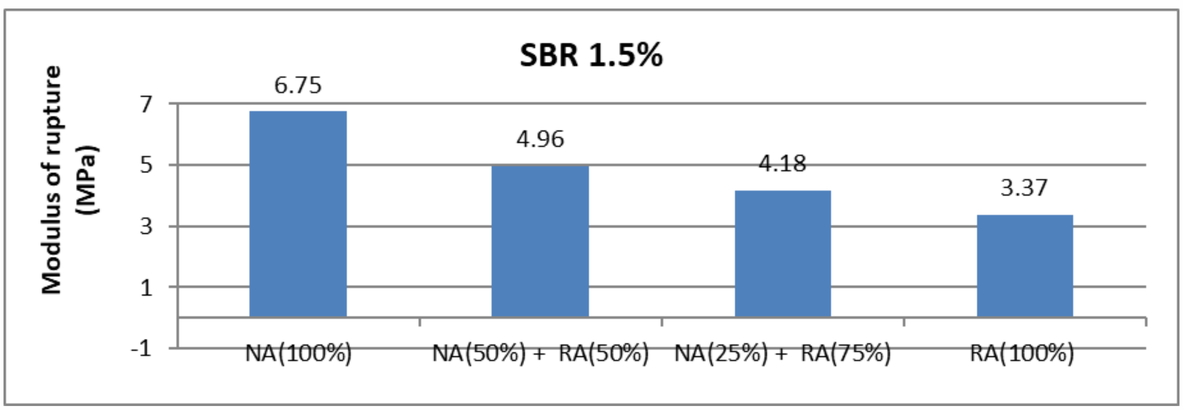


**Fig 12: Rupture Modulus (SBR 1.5% + Contents of RA)**

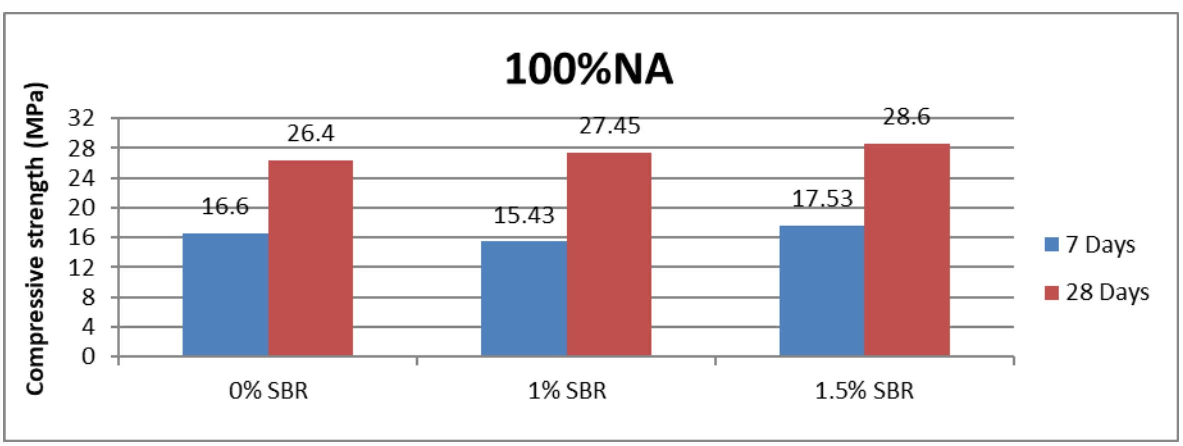


**Fig 13: Compressive Strength (NA 100% + LETEX of SBR)**

For NA 50% +RA 50% the compressive strength at 0% LETEX of SBR increased by 23% for the mixture made with 1.5% LETEX of SBR.

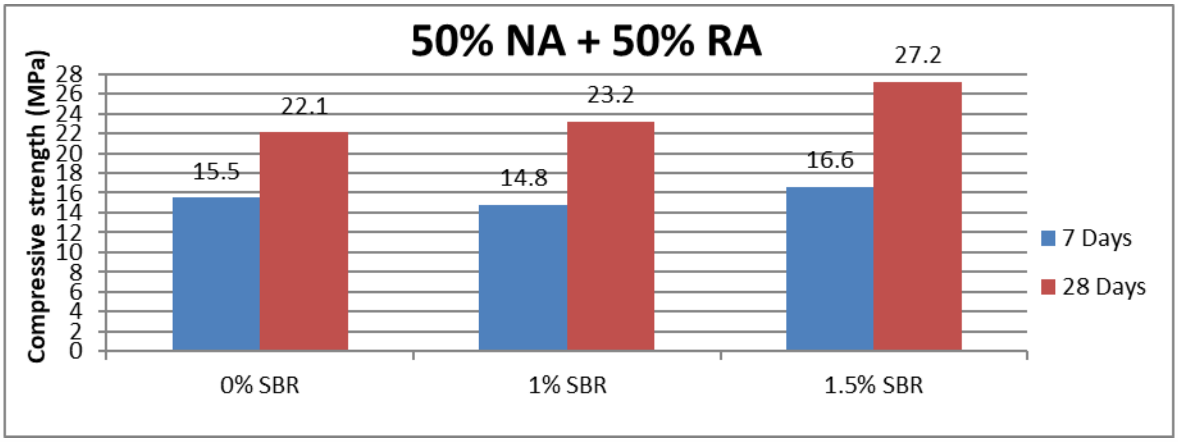


**Fig 14: Compressive Strength (50% NA + 50% RA + SBR LETEX)**

For NA 25% + RA 75% the compressive strength at 0% LETEX of SBR is improved by 15% for the mixture made with 1.5% LETEX of SBR.

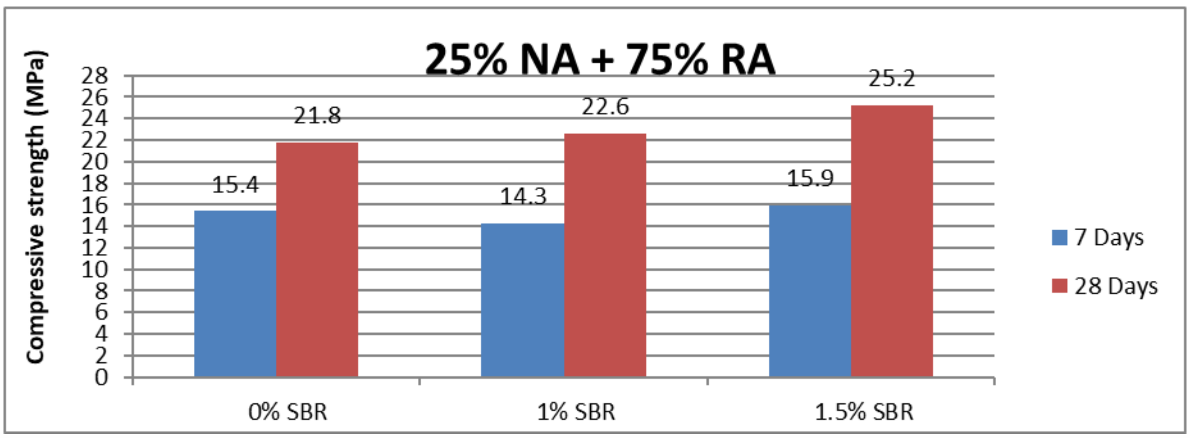


**Fig 15: Compressive strength (NA 25% + RA 75% + LETEX of SBR)**

For 100% RA the compressive strength at 0% SBR LETEX is improved by 9% for the mix prepared with 1.5% LETEX of SBR.

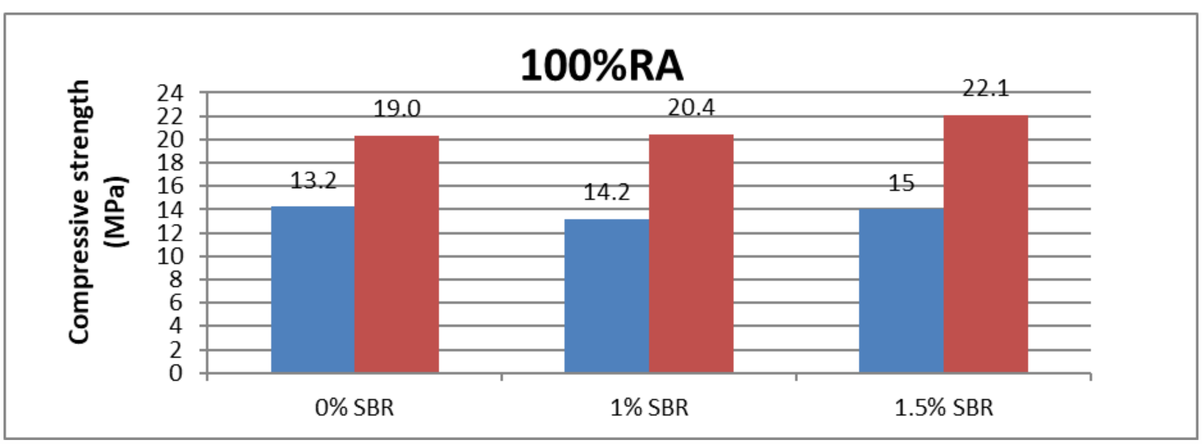


**Fig 16: Compressive strength (RA 100% + LETEX of SBR)**

#### 3.8.4. SBR Latex Effect on compressive strength

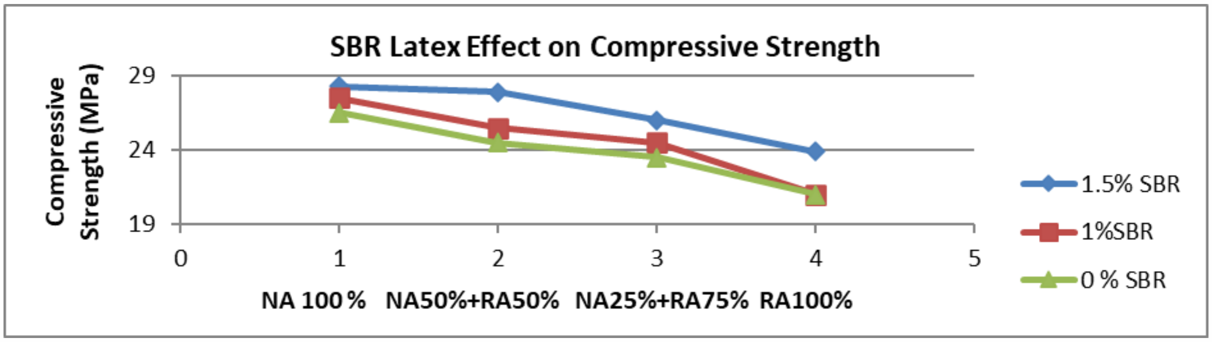


**Fig 17: LETEX of SBR Effect on Compressive Strength**

#### 3.8.5. Effect of SBR LETEX on Modulus of Rupture at 7 and 28 days

For NA 100% the Rupture Modulus at 0% SBR LETEX is improved by 7% for the mixture made with 1.5% LETEX of SBR.

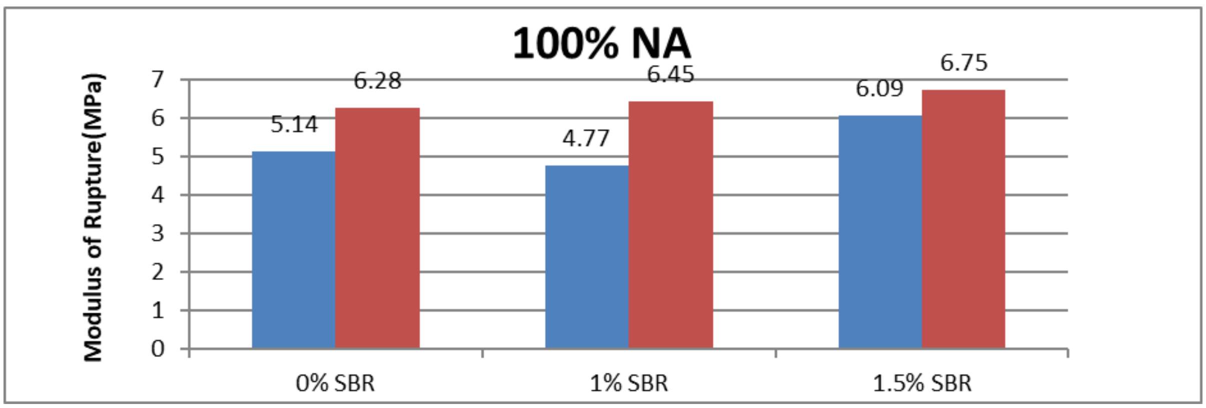


**Fig 18: Modulus of Rupture (100%NA+SBR LETEX)**

For NA 50%+ RA 50%, the Rupture Modulus at 0% LETEX of SBR is improved by 15% for the mixture made with 1.5% LETEX of SBR.

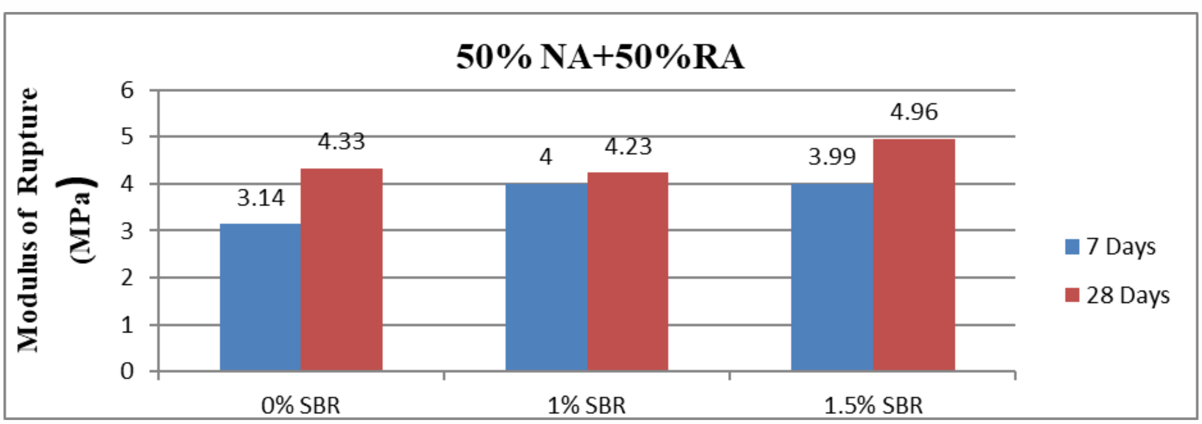


**Fig 19: Rupture Modulus (NA 50%+RA 50%+SBR LETEX)**

For NA 25%+RA 75%, the Rupture Modulus at 0% LETEX of SBR is improved by 25% for the mixture made with 1.5% LETEX of SBR.

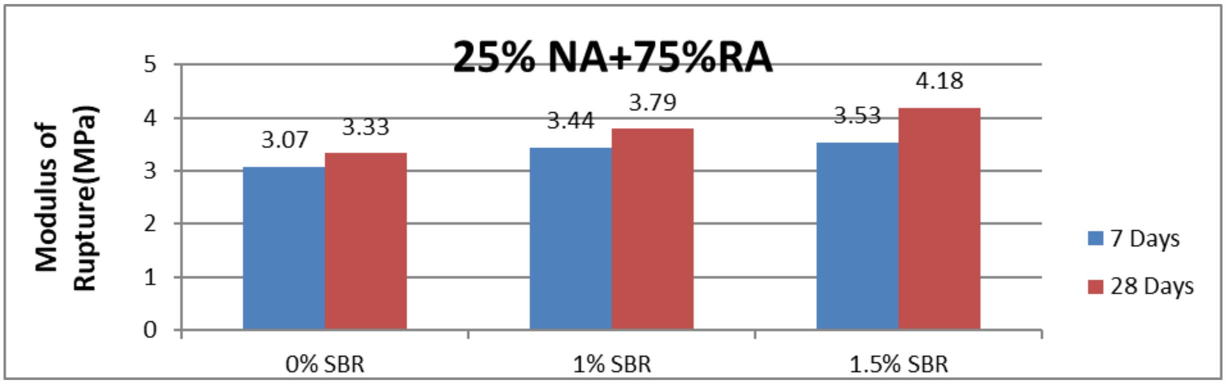


**Fig 20 Rupture Modulus (NA 25%+RA 75%+LETEX of SBR)**

For RA 100%, the Rupture Modulus at 0% LETEX of SBR is improved by 15% for the mixture made with 1.5% LETEX of SBR.

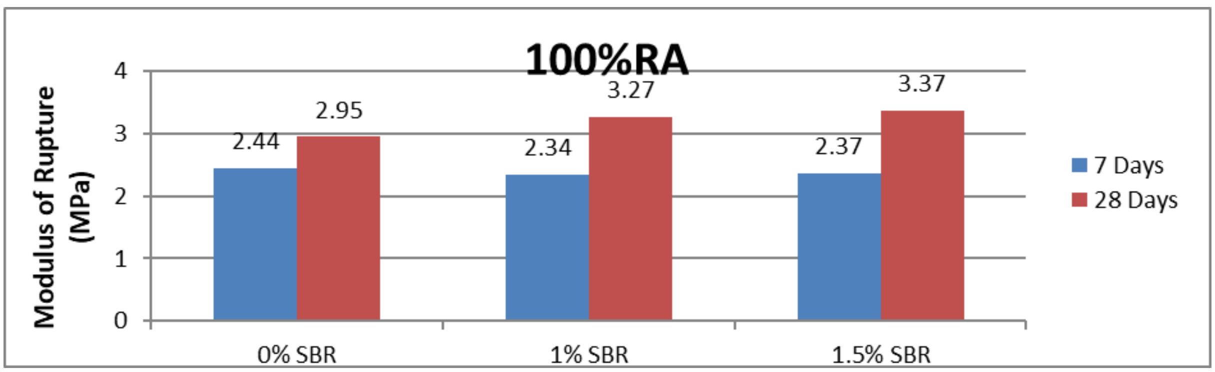


**Fig 21 Rupture Modulus (RA 100%+SLETEX of SBR)**

### 3.8.6. SBR Latex Effect on Rupture Modulus

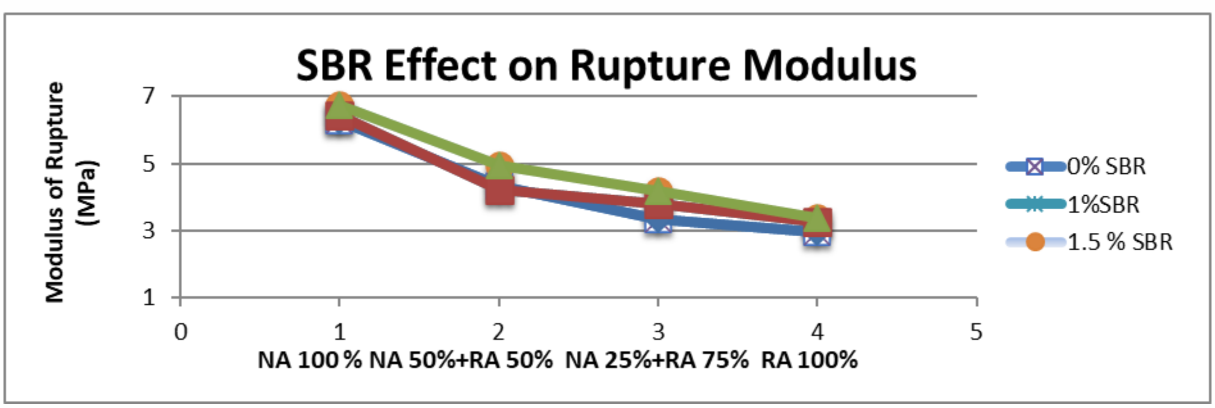


**Fig 22: Effect of LETEX of SBR on Rupture Modulus**

### 3.8.7. Relation between Compressive quality and Modulus of Rupture at 1.5% LETEX of SBR.

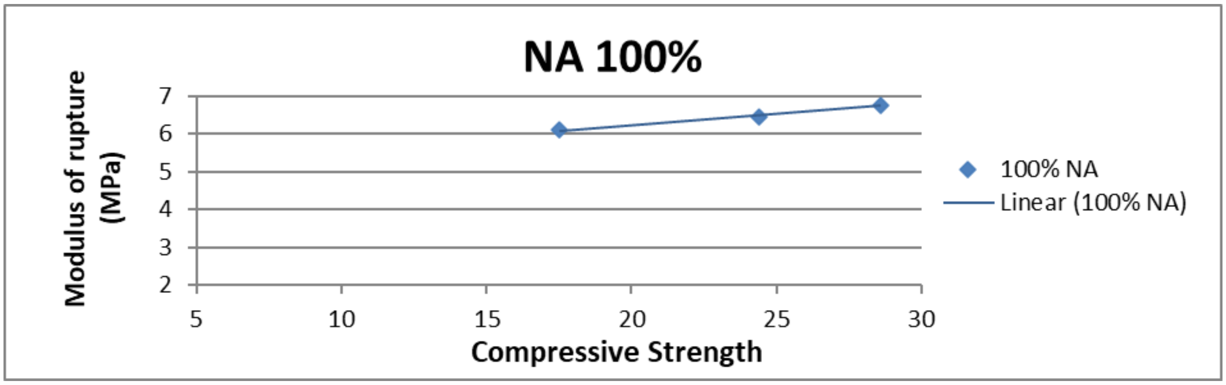


**Fig 23: Rupture Modulus VS Compressive Strength (NA100%)**

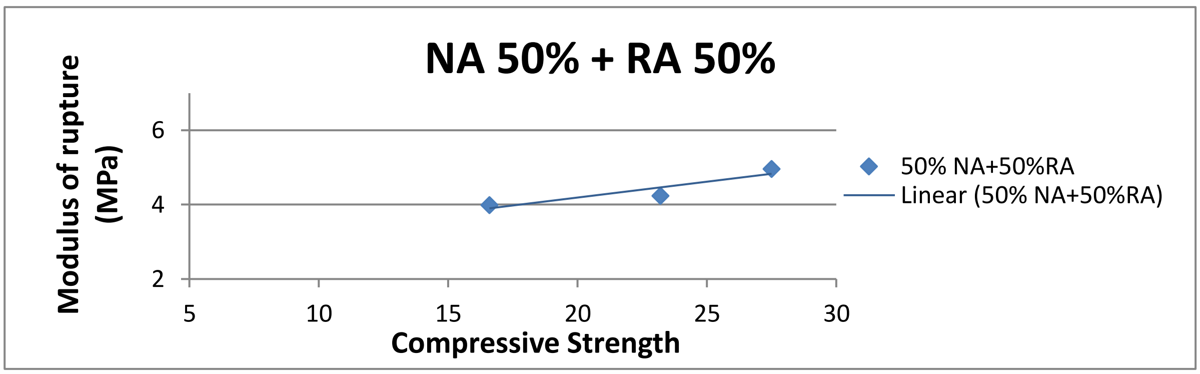


**Fig 24: Rupture Modulus VS Compressive Strength (NA 50%+RA 50%)**

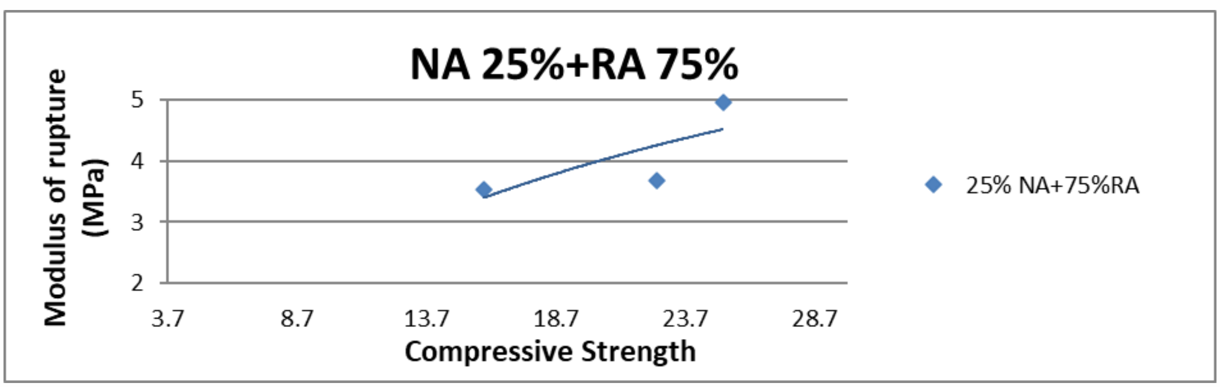


**Fig 25 Modulus of Rupture VS Compressive Strength (NA 25%+RA 75%)**

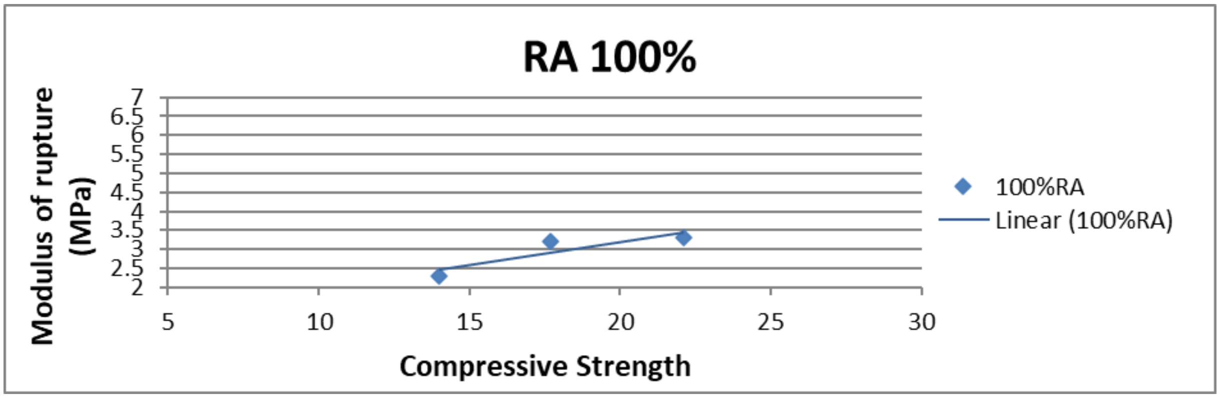


**Fig 26: Rupture Modulus VS Compressive Strength (RA 100%)**

## CONCLUSIONS

1) Rise of SBR latex has good effect on co-matrix arrangement & its mechanical characteristics.

2) Instead of utilizing dissimilar cement fillings, SBR sources, ratios of water-cement and achieved slump standards, the concrete of water/latex ratio is a leading feature that significantly influences diverse properties of concrete mortars.

3) Flexural strength of SBR latex altered concrete increases as latex solid/water ratio increases.

4) It is investigated that with the increase of SBR latex in concrete having 100 % RA both flexure and compressive strength of concrete increases. And keep on increasing with the age (checked up to 28 days).

5) It also concludes that flexural strength drops more than compressive strength by incorporating SBR latex in RAC.

The research also proves that SBR latex addition to the various combinations of NA and RA enhances both compressive and flexural strength. But the maximum suitable combinations were NA 50% +RA 50% and NA 25% +RA 75% for compressive strength and flexural strength respectively.

## Recommendations

Recommendations on Latex of SBR by utilizing it with RA are as follows.

- To think better about the mechanical characteristics of Recycled Concrete Aggregate RAC, the Rupture Modulus, and Compressive power should be additionally tried utilizing assortments of RCA.
- Various synthetic properties of cement ought to likewise be analyzed, for example, carbonation, chloride infiltration, and penetrability coefficient to set up the concrete parts of cement arranged from reused aggregates RA.
- Different strategies can likewise be adjusted for mechanical correlation, for example, by keeping water-cement proportion steady and differing the slump standard.
- Advance study should concentrate on setting up a blend proportion for NA 25% +RA 50% substitution reused aggregates utilizing SBR LETEX of 2% amount.

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## REFERENCES


[1] Schmidt, W. and Msinjili, N.S., 2014. SCC: a solution to the challenges of concrete construction in Africa. Concrete trends-Journal of the African cement and concrete industry, pp.16-20.

[2] Xu, X., Luo, Y., Sreeram, A., Wu, Q., Chen, G., Cheng, S., ... & Chen, X. (2022). Potential use of recycled concrete aggregate (RCA) for sustainable asphalt pavements of the future: A state-of-the-art review. Journal of Cleaner Production, 344, 130893.

[3] Ahimoghadam, F. (2018). Effect of recycled concrete aggregate properties on the behaviour of new concrete (Doctoral dissertation, Université d'Ottawa/University of Ottawa).

[4] Nedeljković, M., Visser, J., Šavija, B., Valcke, S., & Schlangen, E. (2021). Use of fine recycled concrete aggregates in concrete: A critical review. Journal of Building Engineering, 38, 102196.

[5] Miraldo, S., Lopes, S., Pacheco-Torgal, F., & Lopes, A. (2021). Advantages and shortcomings of the utilization of recycled wastes as aggregates in structural concretes. Construction and building materials, 298, 123729.

[6] Dhir, R.K. 2004. Suitability and practical use of coarse RCA in normal and high strength concrete. J.Construction and Building materials. 21 (10): 1928-1939.

[7] Rout, M. D., Biswas, S., Shubham, K., & Sinha, A. K. (2023). A systematic review on performance of reclaimed asphalt pavement (RAP) as sustainable material in rigid pavement construction: Current status to future perspective. Journal of Building Engineering, 76, 107253.

[8] Abut, Y., & Yildirim, S. T. (2022). An investigation on the durability properties of RAP-containing roller compacted concrete pavement. European Journal of Environmental and Civil Engineering, 26(2), 802-818.

[9] Webb, R. (2020). The law of enhanced weathering for carbon dioxide removal. Sabin Center for Climate Change Law, Columbia Law School.

[10] Rahman, M., 2014. Engineering Characterisation of Construction and Demolition Materials Reinforced with Geogrids in Pavement Applications (Doctoral dissertation, Swinburne University of Technology, Melbourne Australia).

[11] Evangelista, L., and J.de Brito. 2007. Mechanical behavior of concrete made with fine recycled concrete aggregates. J.Cement and Concrete composites.29 (5): 397-401.

[12] Bai, G., Zhu, C., Liu, C., & Liu, B. (2020). An evaluation of the recycled aggregate characteristics and the recycled aggregate concrete mechanical properties. Construction and building materials, 240, 117978.

[13] Ozbakkaloglu, T., Gholampour, A., & Xie, T. (2018). Mechanical and durability properties of recycled aggregate concrete: effect of recycled aggregate properties and content. Journal of Materials in Civil Engineering, 30(2), 04017275.

[14] Matias, D., A. Rosa, and D.Pedro. 2013. Mechanical properties of concrete produced with recy-cled coarse aggregates - influence of the use of super-plasticizers. J.concrete and building materials. *44* (6):101-109.

[15] Shruthi, V. L., Kalpana, M., & Vijayan, D. S. (2020). An overview of experimental investigation on mechanical properties of bitumen added with industrial waste–Steel stag. Materials Today: Proceedings, 33, 112-115.

[16] Qasim, O.A. and Al-Quraishy, Q.A., 2018. A Review Paper on Using of Waste and Recycled Materials in Performance of Concrete Structures. International Journal of Recent Advances in Science and Technology, 5(1), pp.8-25.

[17] Matias, D. 2013. Mechanical properties of concrete produced with recycled concrete aggregates-inflence of the use of superplastizer. J.Construction and building materials. 44: 101-109.

[18] Padmini, A. K., K. Ramamurthy, and M.S. Mathews. 2009. Influence of parent concrete on the properties of recycled aggregate concrete. J.Constructuin and Building materials. 23 (2):829-836.

[19] Verian, K.P., Whiting, N.M., Olek, J., Jain, J. and Snyder, M.B., 2013. Using recycled concrete as aggregate in concrete pavements to reduce materials cost.

[20] Huseien, g.f., 2017. Durability performance of ternary blend alkali activated mortars for concrete surface damage repair.


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