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# Recycled Asphalt Pavement Mixtures For Road Construction

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**Abstract**
Recycled Asphalt Pavement (RAP) is the most recycled product in the United States, with 80 million tonnes recycled each year, saving taxpayers $1.5 billion. The feasibility of using 100 percent RAP materials in asphalt pavement is investigated in this research. In a typical asphalt factory, asphalt mixes are made at 135°C. However, not all RAP materials' binder may become effective for coating aggregates at 135°C. The study's major goal is to visualise how much effective binder is accessible from RAP inside the asphalt plant. The aged binder in the 100 percent RAP combines can affect the design of the combines and how they interact with virgin binder. To test temperature cracking resistance and fatigue performance, samples were made using a 100 percent RAP mix with no virgin binder and a 100 percent RAP mix with virgin asphalt binder to identify the mix's optimal binder composition. Second, compaction experiments were done on RAP materials to assess the efficacy of the binder. RAP materials were heated at various temperatures and with varied percentages of RAP (10%, 20%, 30%, and 40%). It was discovered that if any virgin binder is used to achieve the optimal asphalt concentration, 100 percent RAP mixtures cannot be produced for field usage. The low temperature grade wasn't within correct limits based on restricted look at findings, but the beam fatigue testing findings were acceptable. Additional heating is required to extend the efficacy of the asphalt binder from RAP materials, based on compaction data.

## 1. Introduction

Asphalt has been utilised as a construction material since the dawn of civilization, but it was first utilised as a waterproofing substance in shipbuilding and hydraulic components, and only recently as a road construction material. The original roads were most likely built over animal paths, with the only features along the way being marks to avoid wetlands and other friendly terrain. To provide the passenger unobstructed view and, hence, safety, roads of the time tended to cling to high terrain, such as the Downs in the United Kingdom. In metropolitan locations, the early roads were made of bricks and stones, while in soft ground regions, corduroy or logs were used. The use of binders as a bonding medium appears to have begun in the Middle East with brick and stone pavements. The processional roads of Babylon, which were built around 620 BC, are an example (Nicholls 1997). Dry stone combinations produced by two pioneers, Telford and Macadam, evolved into bituminous mixes used in roadways today. Individually dry bound formulations for pavements were invented by these innovators, which were then sprayed with a sealing tar blend to bind the aggregates together and give a medium with strong water proofing capabilities. The strength of these composite combinations was based on stone interlocking.

### *1.1 Recycle Asphalt Pavement (RAP)*

Reuse and recycle A removed material made up of aggregates and asphalt is known as asphalt material. It has been widely grown, minimising the use of virgin resources and aiding in the preservation of land space. When asphalt pavement materials are removed from construction or resurfacing, recycled pavement materials are created. The use of RAP in road building lowers waste, protects the environment, and improves performance. The primary goal of this study is to compare the qualities of recycled aggregates and natural aggregates pavements. For both RAP and natural aggregates, to investigate aggregate impact, crushing, abrasion, specific gravity, water absorption, and other factors.

## 2. Materials and mix ratio used

*2.1 Recycled aggregates*

Recycled materials, according to engineering, industrial, and transportation structures, must not include unwanted organic compounds or compounds that, when exposed to water and climatic effects, change in volume, strength, and form excessively, and/or undergo chemical changes (wood, gypsum, masonry unit and plaster, metal waste, etc.). The utilization of recycled material in earth building, as well as the application of unbound and bound layers, must all fulfill the standards. Recycled aggregates, according to the standard, are aggregates that have been processed from inorganic or mineral materials that have previously been used in building. Recycled aggregates can be utilized in the same way as natural aggregate if the standards are met. To examine geometrical, physical, and chemical qualities, the tests are organized into three groups.

*2.2 Natural Coarse aggregates*

Coarse aggregate is one of the most important components of concrete, accounting for the majority of the volume in the mix. As a result, it has a significant impact on concrete mix design. Water demand, cement and fine aggregate amount, and water absorption are all influenced by its qualities, which include strength, maximum size, form, and water absorption.

*2.3 Maximum Aggregate Size*

One of the parameters that affects water requirement to achieve specified workability is the maximum size of coarse aggregate. It also determines the amount of fine aggregate material required for a cohesive mix. Higher the maximum size of aggregate, lower the surface area of coarse aggregates for a given weight, and vice versa. The surface area of coarse aggregate grows as the maximum size of coarse aggregate decreases. The more surface area there is, the more water is required to coat the particles and create workability. To cover particles and preserve the cohesion of the concrete mix, a smaller maximum size of coarse aggregate would necessitate a higher fine aggregate concentration. When compared to 20mm down aggregate, 40mm down aggregate has a lower water/cement ratio and consequently stronger strength for the same workability.

Coarse Aggregates

*2.4 Reclaimed Asphalt Pavement aggregates*

The number of cores collected at each location is determined by the amount of laboratory testing required and the type of mix design testing required. The core samples should be examined for various pavement layers, previous surface treatments, interlayer paving fabrics, specialty mixes, and evidence of stripping, disintegration, or moisture retention.

*2.5 Mix design consideration*

The complexity of a mix design process varies with the level and type of recycling selected. Study reveals that Hot Mix Recycling where 40 % or less RAP is blended with new aggregate and virgin asphalt required little change from the mix design procedure used on the virgin mix because the added RAP is not expected to significantly alter the properties of the final mix. However, for higher RAP contents (>25%), a more comprehensive mix design process is needed, Blend charts need to be developed using the asphalt recovered from RAP and virgin asphalt of recycling agent to determine the percentage of RAP that provides the desired binder and mix properties in the final recycled pavement. The mix design process for hot in-place Recycling is, in many ways, similar to that used for high content RAP Hot Mix Recycling. Hot In-place recycling generally involves the use of 60-100% RAP.

*2.6 As Constituent of Flexible Pavements*

After characterization of reclaimed asphalt pavements performance material will be planned to check in design mix suitability in laboratories for

1) Wearing Course (PC,SDBC,BC)
2) Binder Course( BM, DBM)
3) Base Course (WMM,WBM,CT base)
4) Granular Sub Base(GSB)
5) Stabilization of Sub grade (SOIL)

For use in bituminous mix different percentage of RAP, virgin aggregates, virgin Bitumen and Rejuvenators if required will mix in different proportions and test for

1) Marshal Stability
2) Stripping Value
3) Water Retention
4) Density

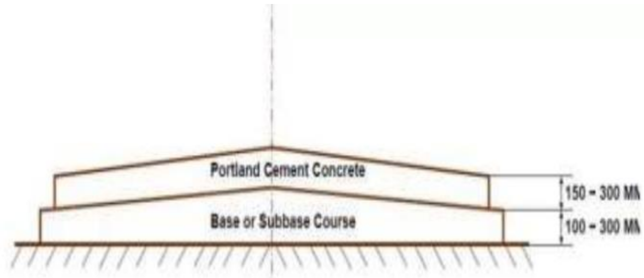
With RAP innovative techniques such as

1) Waste Plastic Technology
2) Nano Technology
3) Cold Mix Technology

May apply to enhance the mix design properties and to overcome environmental issues for different traffic conditions pavement layers. For use in Sub Base and Base Course gradation of characterized material obtained in FDR modified with mix design using some part of virgin aggregates and if needed stabilization may do with appropriate additives like Cement, Lime, Emulsion or Fly Ash etc. Impact Value of mix aggregate will recheck before design.

*2.7 Constituent of Rigid Pavements*

A typical section of Rigid Pavement in India is Shown below




Typical Cross Section of a Flexible Pavement

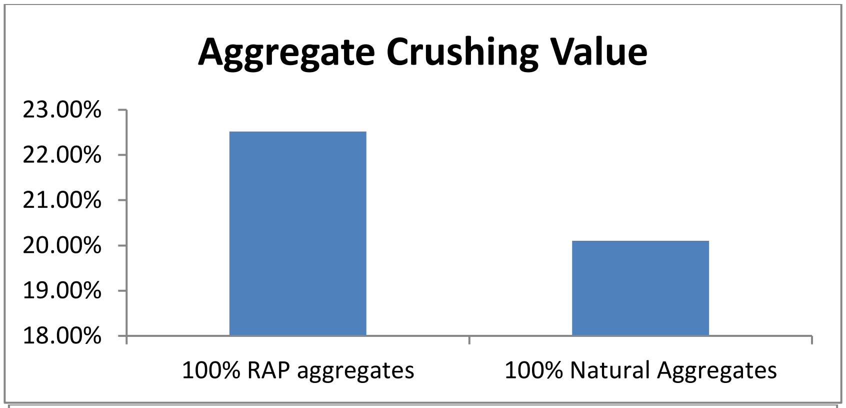
Recycled asphalt Pavement (RAP) is the reclaimed and reprocessed pavement material containing asphalt and aggregate. Most RAP is recycled back into flexible pavements, and as a result there is a general lack of data pertaining to the mechanical properties for RAP in other applications such as Portland cement concrete for Pavement Quality Concrete (PQC). Study of mechanical properties of Portland cement concrete containing RAP as coarse aggregate Should be investigate in the laboratory. Different concrete mixes widely differing water/cement ratios and mix proportions will design using RAP as coarse aggregate. Different additives and admixture and methodology may be try to enhance the properties of PQC produced using RAP, such as

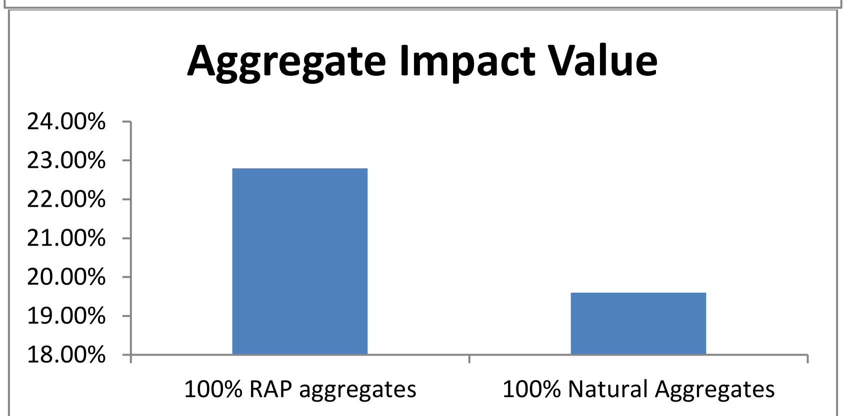
- Fly Ash
- Fibers
- RCCP

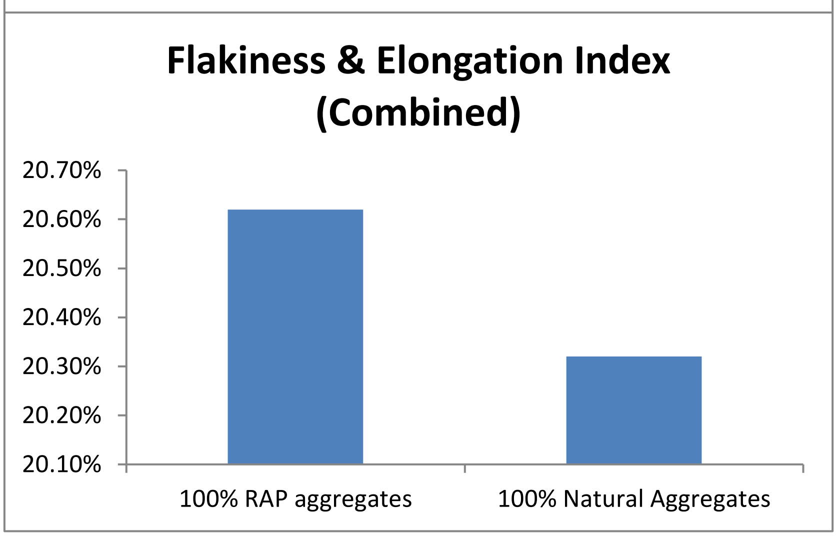
The RAP coarse aggregate will consist “asphalt-mortar” (asphalt binder-sand-filler matrix). The properties of produced PQC for rigid pavement by using RAP as coarse aggregate will be tested will include

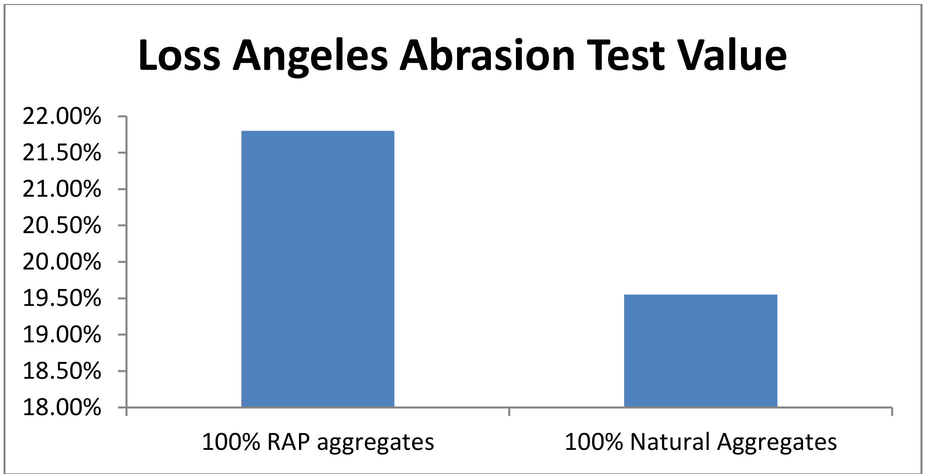
- Physical properties of RAP aggregate
- Compressive strength
- Flexural strength

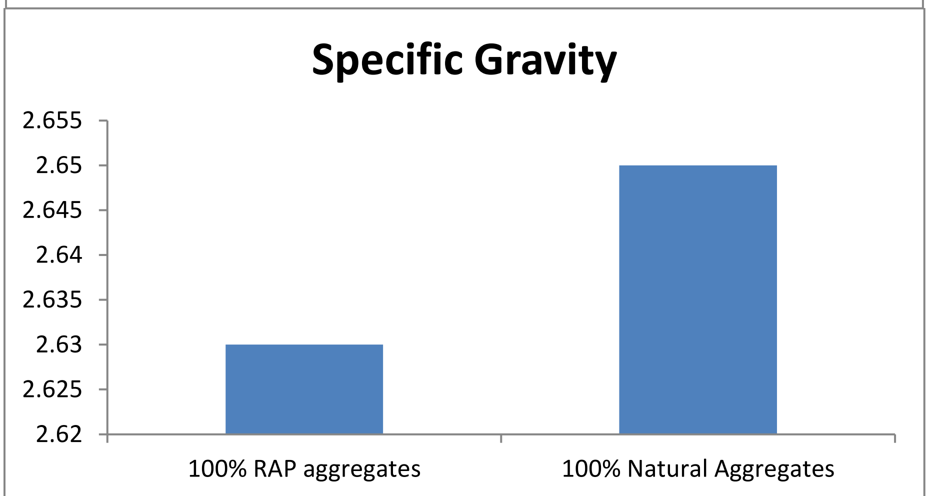
**3. Test Results**

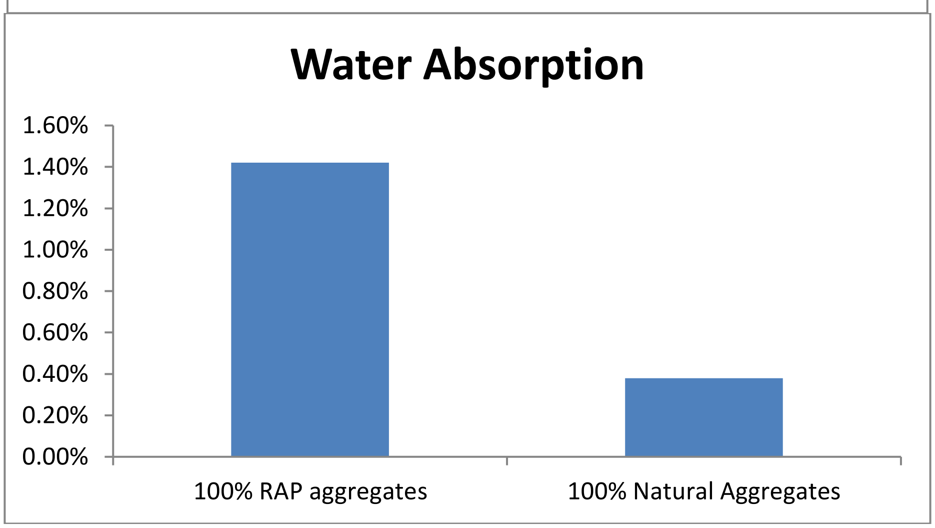

Aggregate Crushing Value
23.00%
22.00%
21.00%
20.00%
19.00%
18.00%
100% RAP aggregates
100% Natural Aggregates

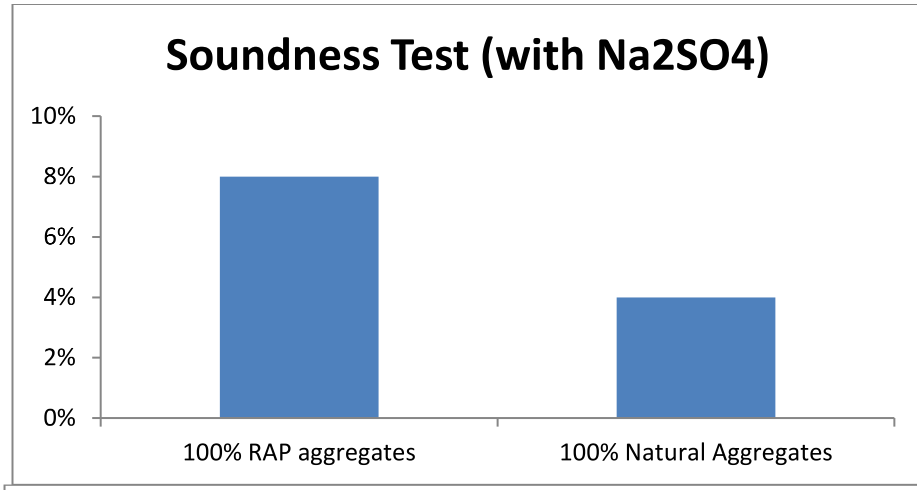

Aggregate Impact Value
24.00%
23.00%
22.00%
21.00%
20.00%
19.00%
18.00%
100% RAP aggregates
100% Natural Aggregates

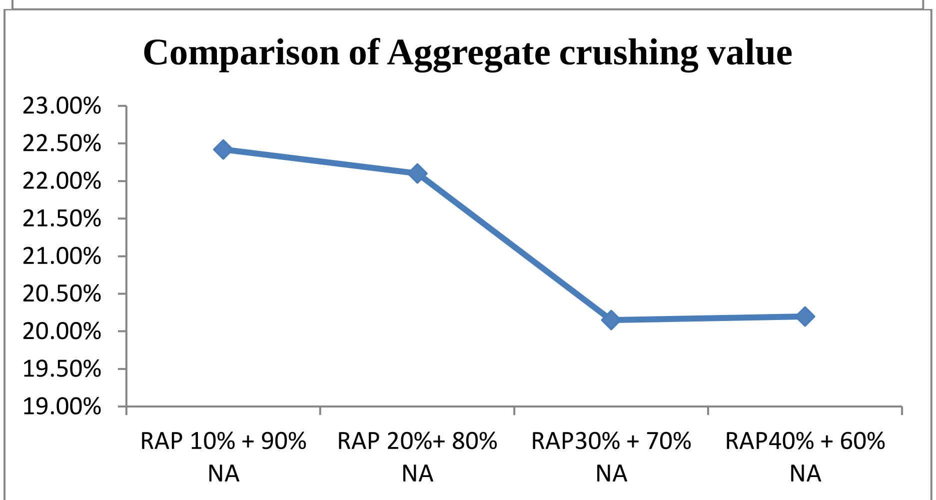

Flakiness & Elongation Index (Combined)
20.70%
20.60%
20.50%
20.40%
20.30%
20.20%
20.10%
100% RAP aggregates
100% Natural Aggregates

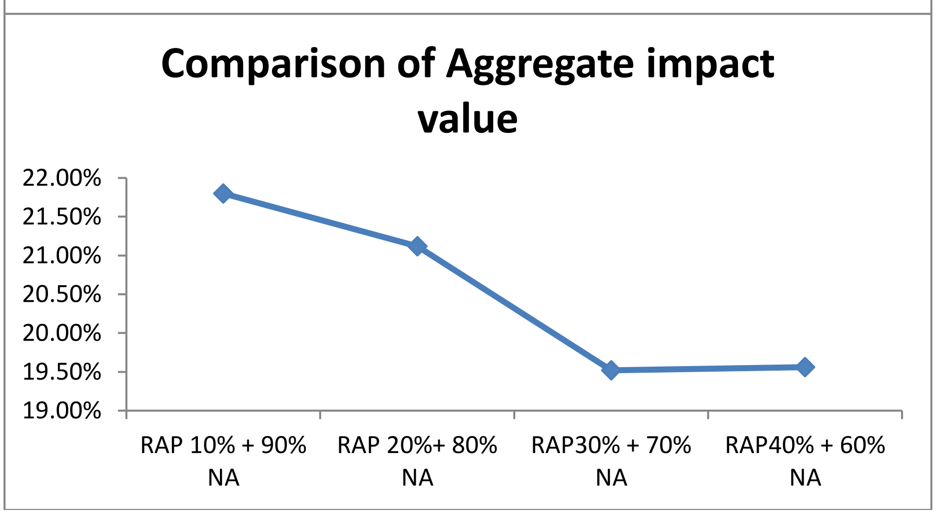

Loss Angeles Abrasion Test Value
22.00%
21.50%
21.00%
20.50%
20.00%
19.50%
19.00%
18.50%
18.00%
100% RAP aggregates
100% Natural Aggregates

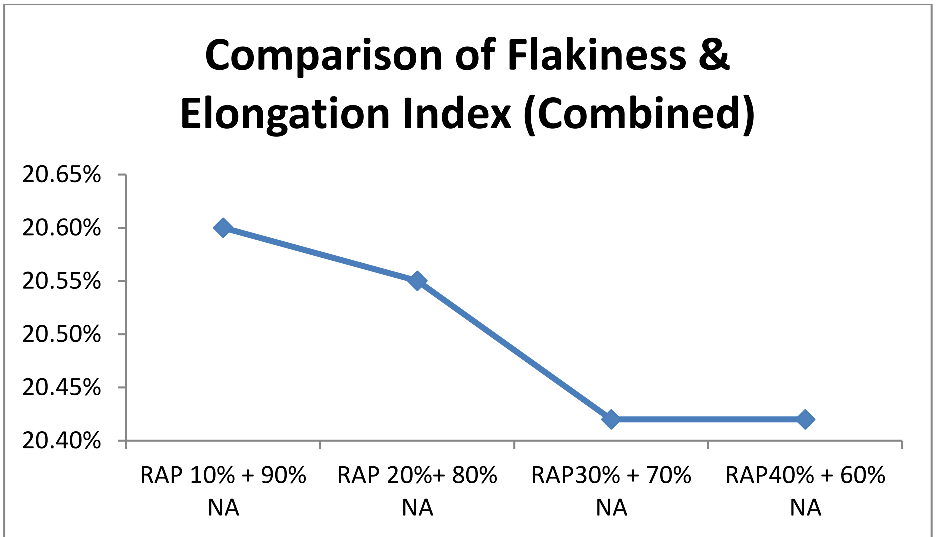

Specific Gravity
2.655
2.65
2.645
2.64
2.635
2.63
2.625
2.62
100% RAP aggregates
100% Natural Aggregates

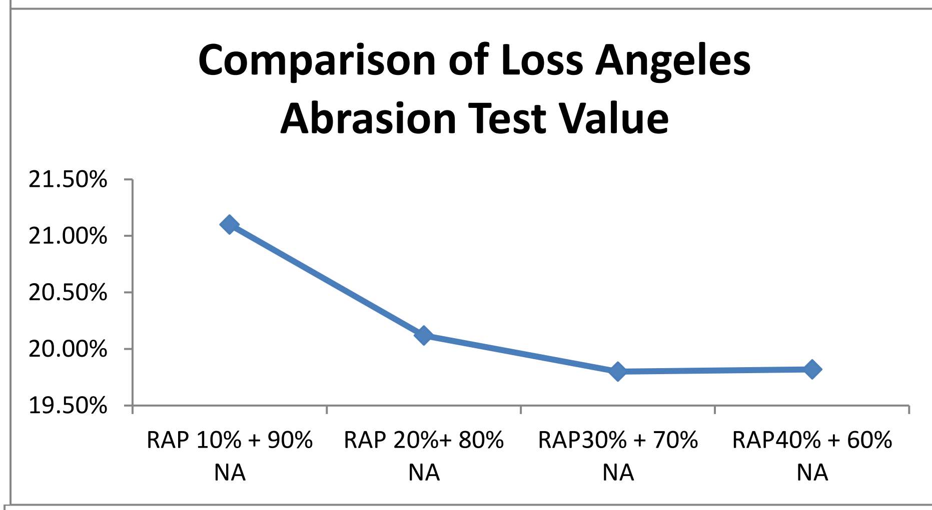

Water Absorption
1.60%
1.40%
1.20%
1.00%
0.80%
0.60%
0.40%
0.20%
0.00%
100% RAP aggregates
100% Natural Aggregates

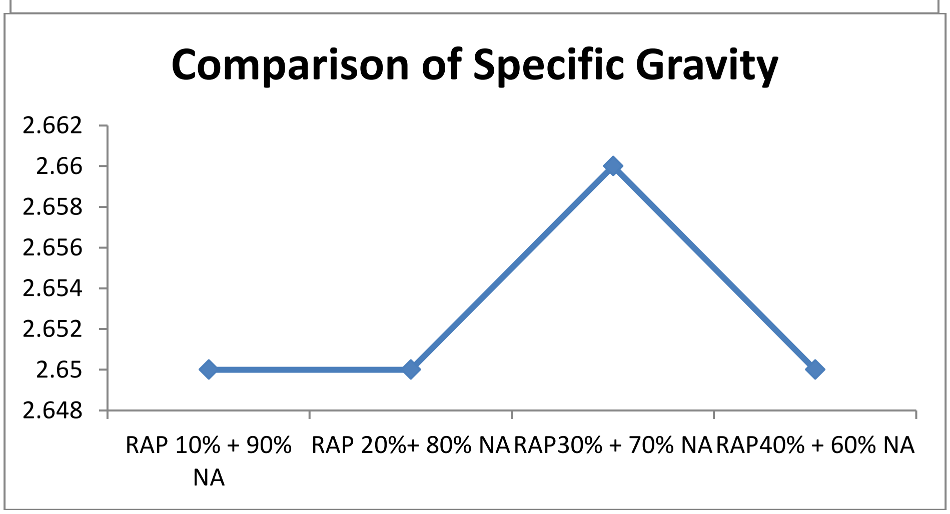

Soundness Test (with Na2SO4)
10%
8%
6%
4%
2%
0%
100% RAP aggregates
100% Natural Aggregates

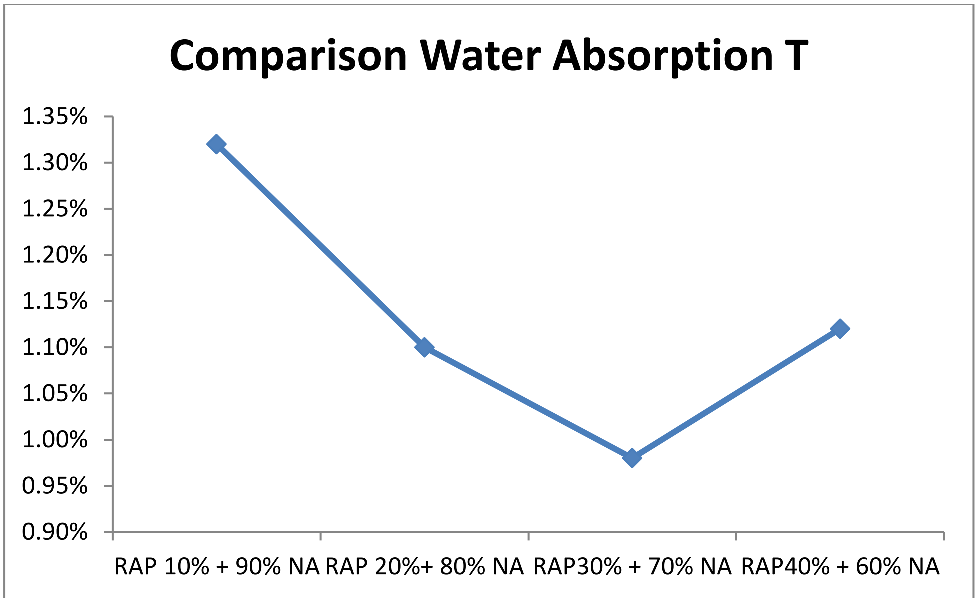

Comparison of Aggregate crushing value
23.00%
22.50%
22.00%
21.50%
21.00%
20.50%
20.00%
19.50%
19.00%
RAP 10% + 90% NA
RAP 20%+ 80% NA
RAP30% + 70% NA
RAP40% + 60% NA

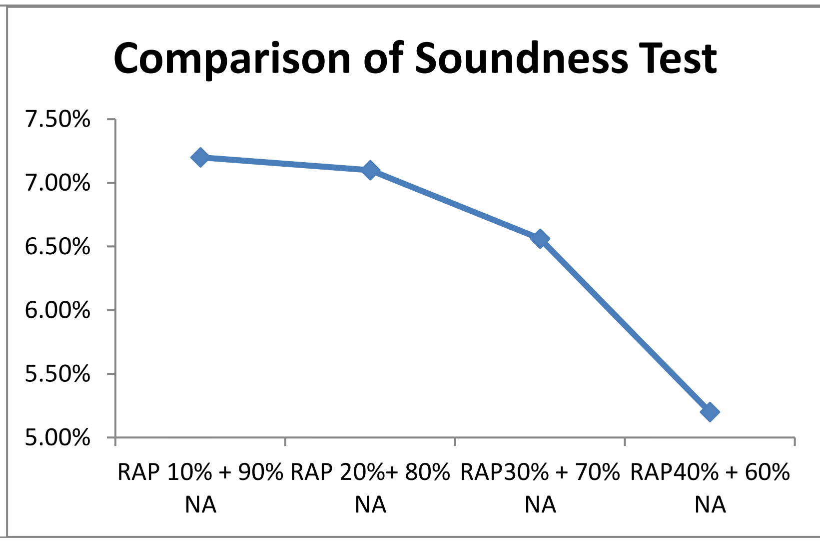

Comparison of Aggregate impact value
22.00%
21.50%
21.00%
20.50%
20.00%
19.50%
19.00%
RAP 10% + 90% NA
RAP 20%+ 80% NA
RAP30% + 70% NA
RAP40% + 60% NA

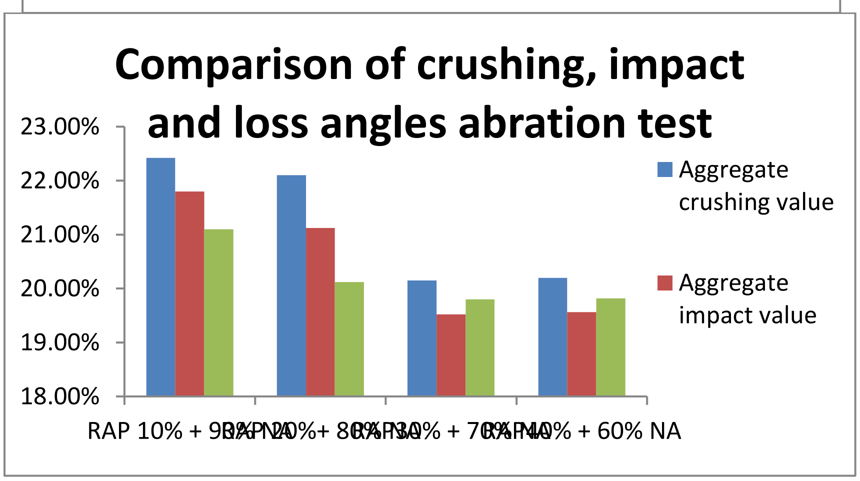

Comparison of Flakiness & Elongation Index (Combined)
20.65%
20.60%
20.55%
20.50%
20.45%
20.40%
RAP 10% + 90% NA
RAP 20%+ 80% NA
RAP30% + 70% NA
RAP40% + 60% NA

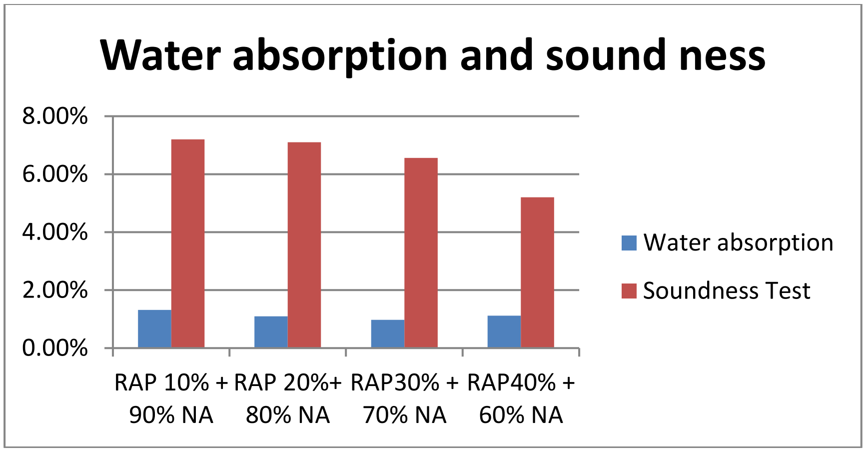

Comparison of Loss Angeles Abrasion Test Value
21.50%
21.00%
20.50%
20.00%
19.50%
RAP 10% + 90% NA
RAP 20%+ 80% NA
RAP30% + 70% NA
RAP40% + 60% NA


Comparison of Specific Gravity
2.662
2.66
2.658
2.656
2.654
2.652
2.65
2.648
RAP 10% + 90% NA
RAP 20%+ 80% NA
RAP30% + 70% NA
RAP40% + 60% NA


Comparison Water Absorption T
1.35%
1.30%
1.25%
1.20%
1.15%
1.10%
1.05%
1.00%
0.95%
0.90%
RAP 10% + 90% NA
RAP 20%+ 80% NA
RAP30% + 70% NA
RAP40% + 60% NA


Comparison of Soundness Test
7.50%
7.00%
6.50%
6.00%
5.50%
5.00%
RAP 10% + 90% NA
RAP 20%+ 80% NA
RAP30% + 70% NA
RAP40% + 60% NA


Comparison of crushing, impact and loss angles abration test
23.00%
22.00%
21.00%
20.00%
19.00%
18.00%
Aggregate crushing value
Aggregate impact value
RAP 10% + 90% NA
RAP 20%+ 80% NA
RAP30% + 70% NA
RAP40% + 60% NA




**4. Conclusions**

On the basis of study and experimental investigations following conclusions were drawn

1. After blending to match the appropriate grade as per MORTH standards for sub base material, RAP materials were found to be successful in granular sub base layer of flexible pavements.
2. It was also discovered that RAP materials in conjunction with natural aggregate in various proportions may be easily employed in the base courses of flexible pavements after mixing to match the requisite grading as per MORTH standards.
3. It is obvious from the above inquiry results that a 30 percent replacement of natural aggregate in the base course of flexible pavements may be done effectively, resulting in a construction cost reduction of roughly 25- 30 percent.
4. Because RAP has a larger percentage of fines as a result of material degradation during milling and crushing processes, it may be easily employed for soil stabilisation to enhance the CBR value of the sub-grade and therefore reduce the road's crust thickness, lowering construction costs.
5. Above all, by employing RAP materials in flexible pavement construction, the problem of RAP waste disposal can be readily handled, and negative environmental effects can be avoided.

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