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Evaluation of Pavement Performance Using Recycled Concrete Aggregate

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ABSTRACT:
The evaluation of pavement using recycled aggregates obtained from construction and demolition (C&D) waste. Due to the rapid growth in infrastructure development, the demand for natural aggregates has increased significantly, leading to environmental issues such as resource depletion and pollution. At the same time, large quantities of construction waste are generated, creating disposal problems. To address these issues, recycled concrete aggregates (RCA) are considered as an alternative material in pavement construction.

In this project, a comparative analysis was carried out between natural aggregates and recycled aggregates. Various laboratory tests such as sieve analysis, specific gravity, water absorption, aggregate impact value, aggregate crushing value, Los Angeles abrasion test, and California Bearing Ratio (CBR) test were conducted to evaluate their physical and mechanical properties.
The results showed that recycled aggregates have slightly lower strength and higher water absorption compared to natural aggregates due to the presence of adhered mortar. However, the test values were found to be within acceptable limits as per standard specifications for sub-base layers. The CBR values confirmed that recycled aggregates can safely be used in pavement sub-base construction, especially for low and medium traffic roads.

KEYWORDS: Pavement Construcion, Recycled Concrete Aggregate, Natural aggregates, waste Management

1. INTRODUCTION

Transportation infrastructure plays a major role in the economic development of any country. Roads are the most widely used mode of transportation, especially in developing countries like India, where road networks connect rural, urban, and industrial regions. For the construction of any pavement layer whether it is the sub-base, base course, the most important material used is **aggregate**. Natural aggregates are normally obtained from riverbeds, quarries, or crushed stones. With the increasing demand for new roads and widening of existing roads, the consumption of natural aggregates has grown rapidly. This has led to excessive quarrying, causing environmental degradation, depletion of natural resources, and an overall increase in construction costs.

At the same time, a large quantity of **construction and demolition (C&D) waste** is generated every year due to rebuilding, renovation, and demolition activities. Most of this waste ends up in landfills or open dumping sites, which creates serious environmental and disposal problems. One of the major components of C&D waste is old concrete from demolished buildings, pavements, and structures. If this concrete waste is collected, crushed, cleaned, and graded, it can be converted into **Recycled Concrete Aggregate (RCA)**. RCA can be used as a partial or full replacement for natural aggregate in pavement layers, backfilling, and even low-strength concrete applications.

Using RCA in pavement construction is an emerging and sustainable solution. It reduces the demand for natural resources, minimises landfill requirements, and helps in waste management. Many countries have already adopted recycled aggregates in road construction due to their environmental and economic benefits. In India also, the Ministry of Road Transport and Highways and the Indian Roads Congress (IRC) have encouraged the use of C&D waste and recycled materials in road works. However, in many cases, the practical implementation is still limited due to a lack of awareness, limited research, and doubts about material performance.

Recycled concrete aggregates have different properties compared to natural aggregates because they contain a layer of old mortar attached to the stone particles. This attached mortar makes more porous and less dense. As a result, RCA generally has **higher water absorption**, **lower specific gravity**, and **lower density** than natural aggregates. These properties affect the compaction behaviour, durability, and strength of pavement layers. Therefore, before using RCA in pavement construction, it is important to test and evaluate its engineering properties through laboratory tests.

The pavement layers, especially the sub-base and base course, require materials with good strength and stability. One of the most important tests used to evaluate the suitability of materials for pavement construction is the **California Bearing Ratio (CBR) test**. CBR gives an indication of how well a pavement layer can support loads from traffic. If the CBR value of RCA or RCA-mixed aggregate meets the standard requirements, it can be considered suitable for use in road construction. In addition to CBR, other tests such as **sieve analysis**, **specific gravity**, **water absorption**, and **Proctor compaction** provide essential information about grading, strength, moisture requirements, and compaction characteristics.

2. SYSTEM MODEL AND ASSUMPTIONS

The “Evaluation of Pavement Using Recycled Aggregate” is carried out based on certain assumptions to simplify the analysis and ensure consistency in results. These assumptions are necessary due to limitations in time, resources, and laboratory conditions at the polytechnic level.
It is assumed that the recycled aggregates (RA) collected from construction and demolition (C&D) waste are representative of typical demolition waste available in the local area. The quality of recycled aggregates may vary depending on the source; however, for this study, the collected sample is considered uniform and suitable for testing.

It has assumed that the processing of recycled aggregates—such as removal of impurities, crushing, and sieving—is done properly and uniformly. Any remaining minor impurities are considered negligible and do not significantly affect the test results.

The all laboratory tests such as sieve analysis, specific gravity, water absorption, Aggregate Impact Value (AIV) and Aggregate Crushing Value (ACV) are assumed to be conducted under standard conditions as per IS codes. It is also assumed that the testing equipment is properly calibrated and provides accurate results.

It is important assumption is that the environmental conditions during testing, such as temperature and humidity, do not significantly influence the behavior of aggregates. Since the tests are conducted in controlled laboratory conditions, external environmental effects are considered minimum.

It is assumed that the natural aggregates (NA) used for comparison are of standard quality and represent typical aggregates used in pavement construction.

It assumes that the performance of aggregates in laboratory tests reflects their actual performance in field conditions. However, real-life factors such as traffic load variations, weather conditions, and long term wear and tear are not considered in this project.

Furthermore, it is assumed that the mix proportion used is properly prepared and mixed uniformly to avoid segregation or inconsistency in results.

Lastly, it is assumed that the guidelines and limits provided by MoRTH, BIS, and relevant IS codes are valid and applicable for evaluating the suitability of recycled aggregates in pavement construction.

3. EFFICIENT COMMUNICATION

It plays an important role in personal life, education, and professional work. Good communication helps avoid misunderstandings, saves time, and improves teamwork.

Communication can be of different types such as verbal (spoken), non-verbal (body language, gestures), and written (emails, reports, messages). For communication to be efficient, the message should be simple, clear, and to the point. The sender must choose the right words and medium depending on the situation.

One of the key elements of efficient communication is clarity. The message should be easy to understand and free from confusion. Using simple language and avoiding unnecessary technical terms helps in better understanding. Another important element is conciseness, which means delivering the message in fewer words without losing its meaning.

Active listening is also very important. Communication is not only about speaking but also about understanding the response of the other person. Good listeners pay attention, ask questions, and give proper feedback. This improves the overall communication process.

Non-verbal communication also plays a major role. Body language, eye contact, facial expressions, and tone of voice can affect how a message is received. Positive body language helps in building trust and confidence.

In professional environments like engineering projects, efficient communication is very important for coordination between team members. Clear instructions, proper documentation, and timely reporting ensure smooth project execution and reduce errors.

Barriers to communication such as language differences, lack of attention, noise, and misunderstandings should be minimized. Using proper channels, confirming messages, and maintaining feedback can help overcome these barriers.

In conclusion, efficient communication is essential for success in both academic and professional fields. It improves understanding, increases productivity, and helps in achieving goals effectively.

4. RESULT AND DISCUSSION

This chapter presents the results obtained from various laboratory tests conducted on **Recycled Aggregates (RA)** and **Natural Aggregates (NA)**. The tests performed include physical and mechanical tests commonly used in pavement material evaluation. The results are tabulated for easy comparison.

4.1 Sieve Analysis

Observation Table – Sieve Analysis (for 20 mm down aggregate)

IS Sieve Size (mm)	Wt. Retained (NA) (g)	% Retained (NA)	Wt. Retained (RA) (g)	% Retained (RA)
20	10	2	20	4
16	50	10	80	16
12.5	130	26	160	32
10	150	30	140	28
4.75	120	24	80	16
Pan	40	8	20	4
Total	**500 g**	**100%**	**500 g**	**100%**

Result

- Both aggregates follow well-graded distribution.
- Recycled aggregates show slightly higher fines due to attached mortar.

Material	Empty Pycnometer Weight (W1)	W1 + Dry Sample (W2)	W1 + Sample + Water (W3)	W1 + Water (W4)	Specific Gravity
NA	650 g	1150 g	2000 g	1850 g	2.70
RA	650 g	1150 g	1980 g	1850 g	2.55

Result

- Natural Aggregates SG ≈ **2.70**
- Recycled Aggregates SG ≈ **2.55**

- Slightly lower SG for RA due to old mortar and porosity.

4.3 Water Absorption Test

Material	Wt. of Dry Sample (W1)	Wt. after 24 hr Soaking (W2)	Water Absorption (%)
NA	2000 g	2020 g	1.0 %
RA	2000 g	2080 g	4.0 %

Result

- RA shows higher absorption due to porous nature and attached cement mortar.

4.4 Aggregate Impact Value (AIV)

Material	Weight of Sample (g)	Wt. Passing 2.36 mm Sieve (g)	Impact Value (%)
NA	400 g	70 g	17.5 %
RA	400 g	110 g	27.5 %

Result

- AIV for NA = **17.5%**
- AIV for RA = **27.5%**
- RA has lower toughness than natural aggregates but within limits for sub-base layers.

4.5 Aggregate Crushing Value (ACV)

Material	Weight of Sample (g)	Wt. Passing 2.36 mm Sieve (g)	Crushing Value (%)
NA	400 g	80 g	20 %
RA	400 g	130 g	32.5 %

Result

- NA exhibits better crushing resistance.
- RA shows higher crushing value but acceptable for lower pavement layers.

4.6 Los Angeles Abrasion Test

Material	Initial Weight (g)	Final Weight (g)	Loss (%)
NA	5000 g	4450 g	11 %
RA	5000 g	4200 g	16 %

Result

- RA has slightly higher abrasion loss due to weaker old mortar.

4.7 CBR (California Bearing Ratio) Test

Unsoaked CBR Values

Material	Penetration (mm)	Load (kg)	CBR (%)
NA	2.5	80	12 %
NA	5.0	110	14 %

RA	2.5	65	10 %
RA	5.0	85	12 %

Result

- CBR (NA) = **12–14%**
- CBR (RA) = **10–12%**
- RA is suitable for **sub-base** layers based on CBR > 10%.

4.8 Summary of Results

Property / Test	Natural Aggregates (NA)	Recycled Aggregates (RA)	Remarks
Specific Gravity	2.70	2.55	RA slightly lighter
Water Absorption	1.0 %	4.0 %	RA more porous
Impact Value	17.5 %	27.5 %	RA weaker but acceptable
Crushing Value	20 %	32.5 %	RA lower strength
Abrasion Value	11 %	16 %	RA moderate durability
CBR Value	12–14 %	10–12 %	RA suitable for sub-base

4.9 Interpretation

- Recycled aggregates show slightly lower strength due to attached mortar.
- Still, they meet requirements for **pavement sub-base construction**.
- Water absorption and crushing/impact values are higher, but within acceptable limits for low & medium traffic roads.

5. CONCLUSION

The study on Evaluation of Pavement Using Recycled Aggregate shows that recycled aggregates (RA) obtained from construction and demolition waste can be effectively used in pavement construction, especially in sub-base layers.

Although recycled aggregates have slightly lower strength and higher water absorption compared to natural aggregates, their properties are still within acceptable limits as per standard guidelines. The laboratory tests such as CBR, impact value, and crushing value confirm that RA has sufficient load-bearing capacity for low to medium traffic roads.

The study also highlights that using recycled aggregates offers major advantages like:

- Reduction in construction cost
- Conservation of natural resources
- Proper waste management
- Environmental protection

However, due to their lower strength, recycled aggregates are not recommended for high-strength base layers or heavy traffic roads without proper modification or mixing..

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