

# Performance Evaluation of Cement-Stabilized RAP–Aggregate Mixtures for Sustainable Pavement Base Applications

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## ABSTRACT

The use of reclaimed asphalt pavement (RAP) in base course layers provides significant environmental and economic benefits; however, increasing RAP content may lead to a reduction in strength and load-bearing capacity. This study investigates the effectiveness of cement stabilization in improving the engineering performance of a RAP–aggregate mixture used in base course applications. Based on a previous experimental evaluation of RAP–aggregate mixtures, the mixture containing 30% RAP was selected for the present study due to its reduced strength performance, with an untreated California Bearing Ratio (CBR) value of 58.3%. To enhance its performance, the selected mixture was stabilized with cement contents of 4%, 5%, and 6%. The results demonstrated a significant improvement in strength with increasing cement content. The CBR increased from 58.3% for the untreated mixture to 84.6%, 94.33%, and 101.9% at cement contents of 4%, 5%, and 6%, respectively. The Modified Proctor test results showed that the maximum dry density (MDD) increased from 2.10 g/cm<sup>3</sup> for the untreated mixture to 2.13, 2.15, and 2.17 g/cm<sup>3</sup> at 4%, 5%, and 6% cement, respectively, while the optimum moisture content (OMC) increased from 3.94% to 4.24%, 4.60%, and 5.12%. Furthermore, the 7-day Unconfined Compressive Strength (UCS) increased progressively with cement content, reaching 386.4, 445.3, and 491.7 psi at 4%, 5%, and 6% cement, respectively. The findings demonstrate that cement stabilization is an effective technique for improving the engineering performance of RAP–aggregate mixtures. Although the improvement in dry density was relatively small, substantial increases in both CBR and UCS were achieved with increasing cement content, indicating significant enhancement in load-bearing capacity and compressive strength. The results support the use of cement stabilization as a practical approach for improving RAP-containing materials for pavement base course applications while contributing to more sustainable and cost-effective pavement construction.

**Keywords:** Reclaimed Asphalt Pavement (RAP), Cement Stabilization, Base Course, Modified Proctor, Maximum Dry Density (MDD), Optimum Moisture Content (OMC), California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS), Pavement Engineering.

## 1. Introduction

The increasing demand for sustainable pavement construction has encouraged the use of reclaimed asphalt pavement (RAP) as an alternative material in base course layers. RAP contributes to reducing the consumption of natural aggregates and minimizing the environmental impacts associated with road construction. Previous studies have demonstrated that RAP can be successfully incorporated into pavement base layers, particularly when blended with natural aggregates and appropriately designed to achieve the required engineering performance (Saha & Mandal, 2017).

The engineering performance of RAP–aggregate mixtures is significantly influenced by RAP content. Experimental investigations on RAP blended with natural crushed aggregate have shown that increasing RAP content affects the compaction and strength characteristics of the resulting mixtures, including maximum dry density (MDD), optimum moisture content (OMC), and California Bearing Ratio (CBR). These findings emphasize the importance of selecting an appropriate RAP content to maintain adequate mechanical performance for pavement base and subbase applications (Mousa et al, 2021).

To overcome the mechanical limitations associated with RAP incorporation, different treatment and stabilization techniques have been investigated to improve the performance of RAP-containing base materials. Cement treatment is considered an effective stabilization approach because the development of cementitious bonding can enhance the strength and stiffness of RAP–aggregate mixtures, thereby improving their mechanical performance and suitability for roadway applications (Thakur & Han, 2015).

Recent research has further highlighted the potential of RAP as a sustainable granular material for pavement construction. The utilization of RAP can reduce the consumption of virgin aggregates and contribute to more sustainable pavement systems. However, the engineering properties and mechanical performance of RAP-containing materials must be carefully evaluated to ensure their suitability for the intended pavement layer and structural requirements (Guerrero-Bustamante et al, 2025).

The effectiveness of cement stabilization can be evaluated through Unconfined Compressive Strength (UCS), which provides an important measure of the compressive strength developed within cement-treated materials. Experimental investigations on cement-stabilized RAP and RAP–virgin aggregate mixtures have demonstrated that cement addition improves compressive strength through the development of cementitious bonds. Strength development is also influenced by cement content and curing period, highlighting the importance of these parameters in the performance of stabilized RAP mixtures (Taha et al, 2002).

The combined influence of RAP content and cement content on the compressive strength of stabilized aggregate base materials has also been investigated using UCS testing. Previous experimental results demonstrated that increasing RAP content generally reduces UCS, whereas increasing cement content substantially improves compressive strength. These findings demonstrate the effectiveness of cement stabilization in compensating for the strength reduction associated with RAP incorporation (Guthrie et al, 2007).

More recent investigations of cement-treated RAP–natural aggregate blends have further demonstrated the beneficial influence of cement stabilization on mechanical performance. Cement addition was found to considerably improve the strength characteristics of RAP–aggregate blends, while UCS development was influenced by cement dosage, RAP–aggregate blend composition, and curing period. These findings emphasize the importance of selecting appropriate cement contents and curing conditions when designing cement-stabilized RAP materials for pavement base and subbase applications (Arshad, 2020).

Based on the findings reported in the literature, the present study investigates the engineering performance of a selected mixture containing 30% RAP and 70% natural dolomite aggregate, stabilized with 4%, 5%, and 6% cement. The investigation focuses on evaluating the influence of cement content on compaction characteristics, load-bearing capacity, and 7-day Unconfined Compressive Strength (UCS). The main objective is to assess the effectiveness of cement stabilization in improving the engineering performance of the selected RAP–aggregate mixture and its potential application in pavement base course layers.

## 2. Materials and Methods

### 2.1. Materials

Dolomite aggregate obtained from the *Ataka* quarry, Suez Governorate, Egypt, was used as the primary virgin material in this study due to its widespread application in local base course construction. The physical properties of the crushed dolomite aggregate were evaluated through standard laboratory tests, including bulk specific gravity, saturated surface-dry specific gravity, apparent specific gravity, water absorption, and Los Angeles abrasion resistance. These tests were conducted to ensure the suitability of the material for pavement base applications, and the corresponding results are presented in Table (1).

**Table (1):** Properties of Dolomite Aggregate.

| Test                                   | AASHTO Designation No. | Result | Specification Limits (%) |
|----------------------------------------|------------------------|--------|--------------------------|
| Bulk specific gravity                  | T-85                   | 2.66   | -                        |
| Saturated surface-Dry specific gravity | T-85                   | 2.70   | -                        |
| Apparent specific gravity              | T-85                   | 2.76   | -                        |
| Water absorption                       | T-85                   | 1.24 % | $\leq 5$                 |
| Loss Angeles Abrasion                  | T-96                   | 32.8   | $\leq 40$                |

Reclaimed Asphalt Pavement (RAP) was collected from the Almalaha region in Ismailia Governorate, Egypt. The RAP material was processed to remove oversized particles and foreign matter prior to use. Based on a previous experimental evaluation of RAP–aggregate mixtures, the mixture containing 30% RAP was selected for the present study due to its reduced strength performance. The selected mixture consisted of 30% RAP and 70% natural dolomite aggregate by total mixture weight and was subsequently stabilized with different cement contents to investigate the effectiveness of cement stabilization in improving its engineering performance.

Cement was used as a stabilizing agent to improve the engineering performance of the selected 30% RAP–aggregate mixture. Cement was incorporated at contents of 4%, 5%, and 6% to evaluate its effect on the compaction characteristics, load-bearing capacity, and compressive strength of the mixture. The effectiveness of cement stabilization was assessed through Modified Proctor, California Bearing Ratio (CBR), and Unconfined Compressive Strength (UCS) tests.

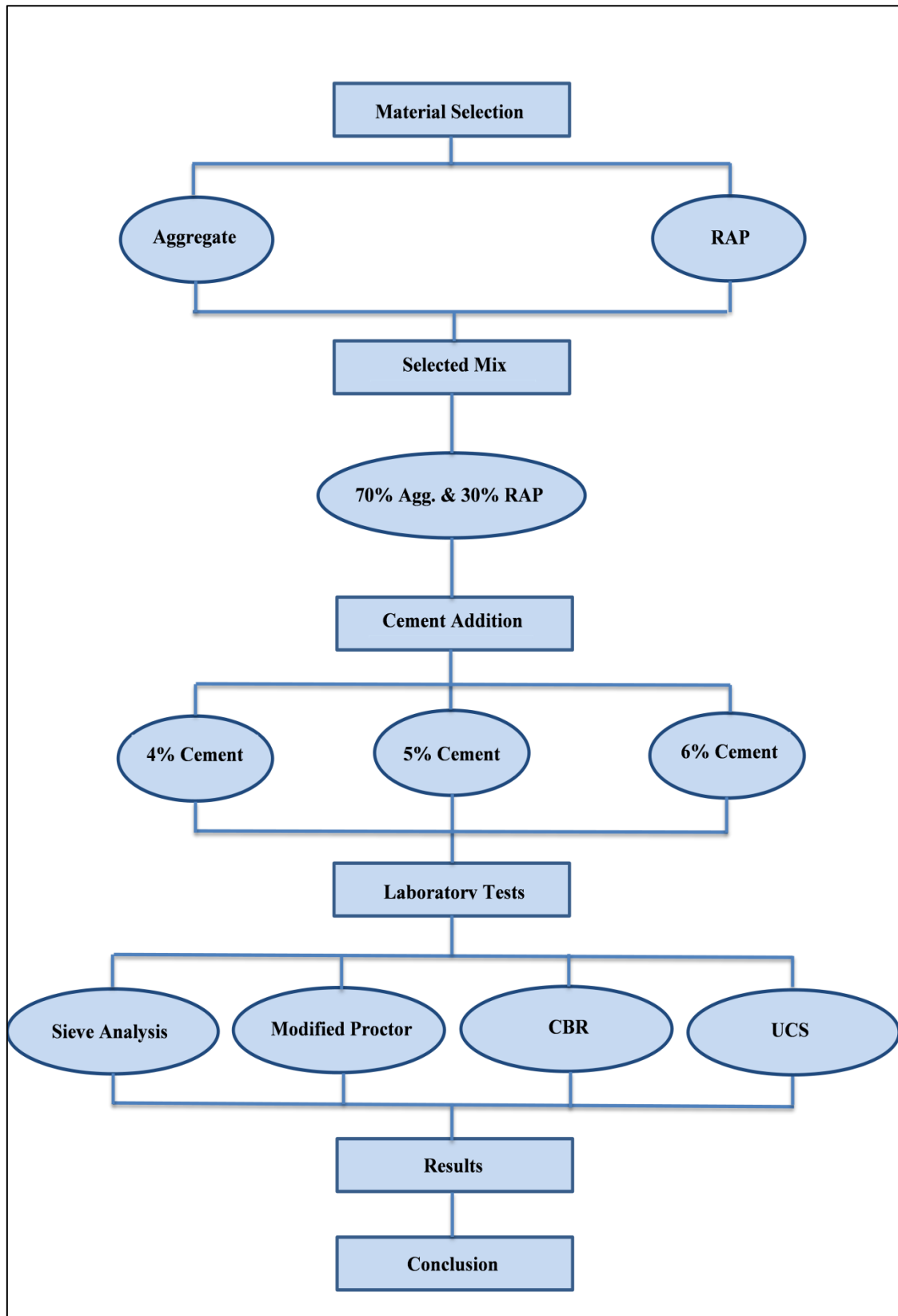
All materials were prepared and handled in accordance with standard laboratory procedures to ensure consistency and reliability of the experimental results.

### 2.2. Experimental Laboratory Program

The experimental laboratory program adopted in this study was designed to evaluate the effectiveness of cement stabilization in improving the engineering performance of a RAP–aggregate mixture for base course applications. Based on a previous experimental evaluation, a mixture containing 30% reclaimed asphalt pavement (RAP) and 70% natural dolomite aggregate was selected for the present investigation due to its reduced strength performance. The selected mixture was initially evaluated in its untreated condition and subsequently stabilized with 4%, 5%, and 6% cement to investigate the influence of cement content on its engineering properties.

The laboratory program included material preparation, mixture proportioning, and testing of the untreated and cement-stabilized mixtures. The Modified Proctor test was conducted to determine the maximum dry density (MDD) and optimum moisture content (OMC), while the California Bearing Ratio (CBR) test was performed to evaluate the load-bearing capacity of the mixtures. In addition, the Unconfined Compressive Strength (UCS) test was conducted on the cement-stabilized mixtures after a 7-day curing period to assess their compressive strength and strength development with increasing cement content. The obtained results were then analyzed to evaluate

the overall effectiveness of cement stabilization in improving the compaction and strength characteristics of the selected RAP–aggregate mixture.



**Figure (1):** Experimental Methodology Flowchart for Cement-Stabilized RAP–Aggregate Base Mixtures

The overall experimental methodology adopted in this study is illustrated in Figure (1). As shown in the flowchart, the methodology begins with the selection and preparation of the constituent materials, including natural aggregate and RAP. The selected mixture consisted of 30% RAP and 70% natural dolomite aggregate, which was subsequently stabilized with cement contents of 4%, 5%, and 6%. The prepared mixtures were then subjected to a laboratory testing program to evaluate the effect of cement stabilization on their engineering performance.

The laboratory testing program included sieve analysis, Modified Proctor, California Bearing Ratio (CBR), and Unconfined Compressive Strength (UCS) tests. Sieve analysis was used to evaluate the particle size distribution and verify compliance with the required base course gradation. The Modified Proctor test was conducted to determine the maximum dry density (MDD) and optimum moisture content (OMC), while the CBR test was performed to assess the load-bearing capacity of the mixtures. In addition, the UCS test was conducted on the mixtures containing 4%, 5%, and 6% cement after a 7-day curing period to evaluate their compressive strength and the effect of cement content on strength development.

All testing procedures were conducted in accordance with the relevant standards, and consistent sample preparation and testing procedures were followed to ensure the reliability of the experimental results. The obtained results were subsequently analyzed to assess the effectiveness of cement stabilization in improving the compaction characteristics, load-bearing capacity, and compressive strength of the selected RAP–aggregate mixture for base course applications.

### 2.3. Test Methods

Four laboratory tests were carried out to assess the physical and mechanical characteristics of the selected RAP–aggregate mixture and to evaluate the effect of cement stabilization on its engineering performance.

The first test conducted was the sieve analysis according to ASTM C136, aimed at determining the particle size distribution of the natural aggregate, reclaimed asphalt pavement (RAP), and the selected blended mixture containing 30% RAP. This analysis was essential to evaluate the gradation characteristics of each component and to ensure that the combined mixture complied with the specified limits for base course applications. The results of the sieve analysis provided a clear understanding of the gradation characteristics of the selected mixture and confirmed its compliance with the required specifications.

The second test conducted was the Modified Proctor compaction test according to ASTM D1557, which was used to determine the maximum dry density (MDD) and optimum moisture content (OMC) of the untreated and cement-stabilized mixtures. This test provided important information regarding the compaction behavior of the mixtures and the influence of increasing cement content on their density and moisture requirements.

The third test was the California Bearing Ratio (CBR) test according to ASTM D1883, which was conducted to evaluate the load-bearing capacity of the untreated and cement-stabilized mixtures. The CBR results were used to assess the effectiveness of cement stabilization in improving the strength and load-bearing performance of the selected 30% RAP mixture for base course applications.

The fourth test was the Unconfined Compressive Strength (UCS) test according to ASTM D1633, Method A, which was conducted on the 30% RAP mixtures stabilized with 4%, 5%, and 6% cement. The specimens were tested after a 7-day curing period to evaluate their compressive strength and investigate the effect of increasing cement content on strength development. The UCS results provided an additional measure of the effectiveness of cement stabilization in developing stronger cementitious bonds and improving the mechanical performance of the RAP–aggregate mixture.

Collectively, these tests provided a comprehensive evaluation of the effect of cement stabilization on the gradation, compaction characteristics, load-bearing capacity, and compressive strength of the selected RAP–aggregate mixture.

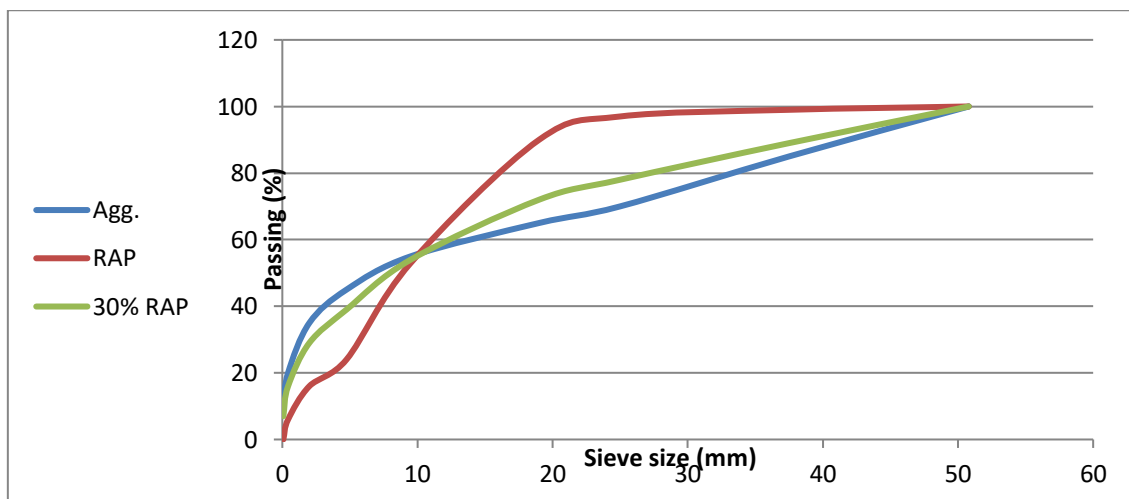
### 3. Results and Discussion

#### 3.1. Gradation Analysis of Natural Aggregate, RAP, and RAP-Aggregate Mixture

The sieve analysis results demonstrated that the natural aggregate, RAP material, and the selected blended mixture exhibited particle size distributions suitable for the investigated base course application. The natural aggregate showed a well-graded particle distribution, which is favorable for achieving adequate compaction and structural stability. The RAP material exhibited a different gradation pattern as a result of the milling process and the characteristics of the reclaimed material. When 30% RAP was blended with 70% natural aggregate, the resulting gradation remained within the specified limits for base course materials, confirming the suitability of the selected mixture for subsequent stabilization and laboratory evaluation. Table (2) presents the complete gradation results for the natural aggregate, RAP material, and the selected mixture containing 30% RAP, allowing direct comparison of their particle size distributions.

**Table (2):** Gradation of Natural Aggregate, RAP, and the blended mixture containing 30% RAP.

| Sieve Size | Agg. Pass. (%) | RAP Pass. (%) | 30% RAP Mixture Pass. (%) | Specs. Limits (%) |     |
|------------|----------------|---------------|---------------------------|-------------------|-----|
| 2"         | 100            | 100           | 100                       | 100               |     |
| 1.5"       | 85             | 99            | 89                        | 70                | 100 |
| 1"         | 70             | 97            | 78                        | 55                | 85  |
| 3/4"       | 65             | 90            | 72                        | 50                | 80  |
| 3/8"       | 55             | 53            | 54                        | 40                | 70  |
| No. 4      | 45             | 24            | 39                        | 30                | 60  |
| No.10      | 35             | 16            | 29                        | 20                | 50  |
| No.40      | 20             | 6             | 16                        | 10                | 30  |
| No. 200    | 10             | 0             | 7                         | 5                 | 15  |



**Figure (2):** Particle Size Distribution Curves for Natural Aggregate, RAP, and the blended mixture containing 30% RAP

Figure (2) illustrates the gradation curves of the natural aggregate, RAP material, and the selected mixture containing 30% RAP and 70% natural aggregate. The natural aggregate exhibits a well-graded particle distribution suitable for base course applications, while the RAP material shows a different gradation pattern resulting from the characteristics of the reclaimed and milled material. The gradation curve of the selected

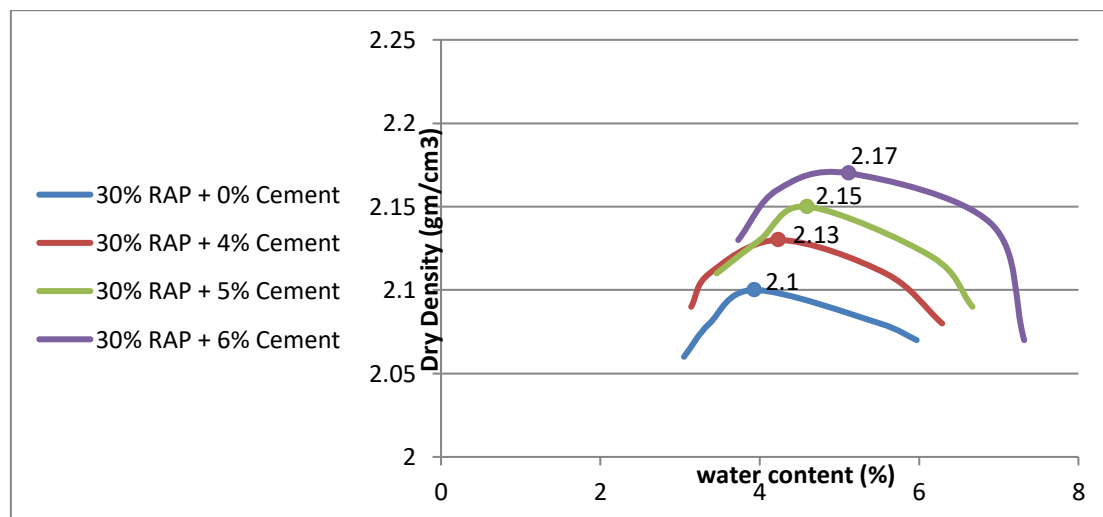
mixture lies between those of the natural aggregate and RAP, demonstrating the influence of RAP incorporation on the overall particle size distribution. Despite this variation, the gradation of the selected 30% RAP mixture remains within the specified limits for base course materials, confirming its suitability for subsequent cement stabilization and mechanical performance evaluation

### 3.2. Compaction Characteristics of RAP–Aggregate Base Mixtures

The Modified Proctor test results demonstrated that the compaction characteristics of the selected 30% RAP mixture were influenced by cement addition. The untreated mixture exhibited a maximum dry density (MDD) of 2.10 g/cm<sup>3</sup> and an optimum moisture content (OMC) of 3.94%. With the addition of 4% cement, the MDD increased to 2.13 g/cm<sup>3</sup> and the OMC to 4.24%. Further increases in cement content to 5% and 6% resulted in MDD values of 2.15 and 2.17 g/cm<sup>3</sup>, respectively, while the corresponding OMC values increased to 4.60% and 5.12%. The gradual increase in MDD indicates a modest improvement in the compacted density of the mixture, whereas the increase in OMC reflects the additional water demand associated with cement addition and hydration. Table (3) summarizes the Modified Proctor test results for the untreated and cement-stabilized mixtures.

**Table (3):** Modified Proctor Test Results for untreated and cement-stabilized RAP-Aggregate mixtures.

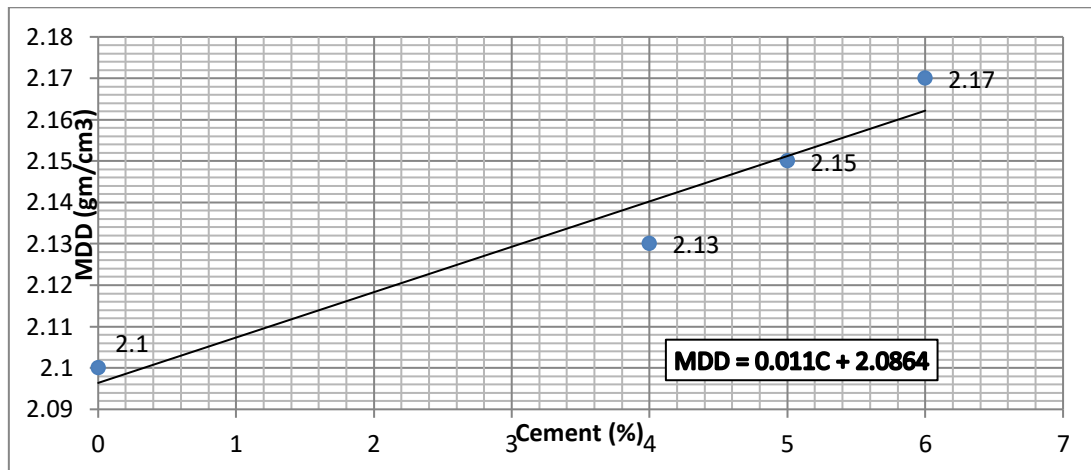
| Mixture Type<br>RAP Content (%) | MDD (gm/cm <sup>3</sup> ) | OMC (%) |
|---------------------------------|---------------------------|---------|
| 30% RAP + 0% Cement             | 2.10                      | 3.94    |
| 30% RAP + 4% Cement             | 2.13                      | 4.24    |
| 30% RAP + 5% Cement             | 2.15                      | 4.60    |
| 30% RAP + 6% Cement             | 2.17                      | 5.12    |



**Figure (3):** Modified Proctor Compaction Curves for untreated and cement-stabilized RAP-Aggregate mixtures.

Figure (3) illustrates the compaction curves representing the relationship between dry density and moisture content for the untreated and cement-stabilized mixtures. The untreated 30% RAP mixture exhibited a maximum dry density of 2.10 g/cm<sup>3</sup> at an optimum moisture content of 3.94%. With increasing cement content, the compaction curves shifted upward and to the right. At 4%, 5%, and 6% cement, the MDD increased to 2.13, 2.15, and 2.17 g/cm<sup>3</sup>, respectively, while the corresponding OMC increased to 4.24%, 4.60%, and 5.12%. The increase in MDD indicates a gradual improvement in the compacted density of the mixture with cement addition. Meanwhile, the increase in OMC can be attributed primarily to the additional water required for cement

hydration and the increased moisture demand of the cement-treated mixture. Overall, cement addition produced a modest increase in MDD together with a progressive increase in OMC.

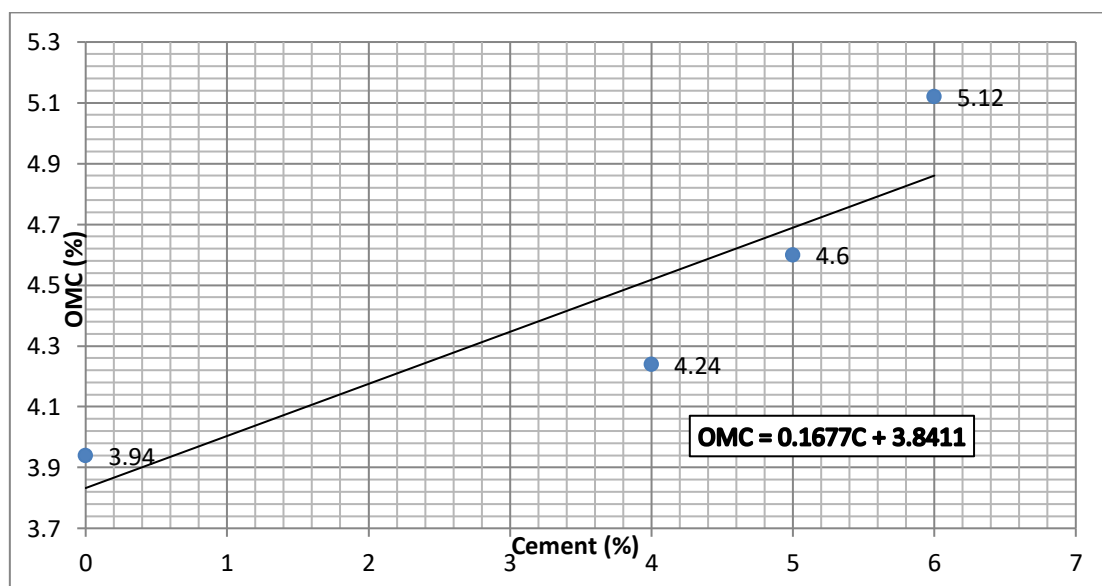


**Figure (4):** Relationship between maximum dry density and Cement%

Figure (4) illustrates the relationship between maximum dry density (MDD) and cement content, showing an increasing trend as the percentage of cement increases. The fitted regression line follows the equation ( $MDD = 0.011C + 2.0864$ ), indicating that MDD increases at an average rate of approximately 0.011 g/cm³ for every 1% increase in cement content within the investigated range.

The experimental results show that MDD increased from 2.10 g/cm³ at 0% cement to 2.13, 2.15, and 2.17 g/cm³ at 4%, 5%, and 6% cement, respectively. This represents an overall increase of approximately 3.35% between the untreated mixture and the mixture containing 6% cement. The observed increase indicates that cement addition contributes to a modest improvement in the compacted density of the selected RAP–aggregate mixture.

Although the overall trend is increasing, the improvement in MDD remains relatively small compared with the changes observed in the strength characteristics. Therefore, the main contribution of cement stabilization is expected to be reflected more strongly in the mechanical performance of the mixture, as demonstrated by the CBR and UCS results presented in the following sections.



**Figure (5):** Relationship between optimum moisture content and Cement%

Figure (5) illustrates the relationship between optimum moisture content (OMC) and cement content, showing a clear increasing trend as the percentage of cement increases. The fitted regression line follows the equation ( $OMC = 0.1677C + 3.8411$ ), indicating that OMC increases at an approximate rate of 0.1677 percentage points for every 1% increase in cement content.

The experimental results confirm this trend, with OMC increasing from 3.94% at 0% cement to 4.24%, 4.60%, and 5.12% at cement contents of 4%, 5%, and 6%, respectively. This behavior reflects the increased water demand associated with cement addition, particularly the water required for cement hydration and for achieving optimum compaction conditions.

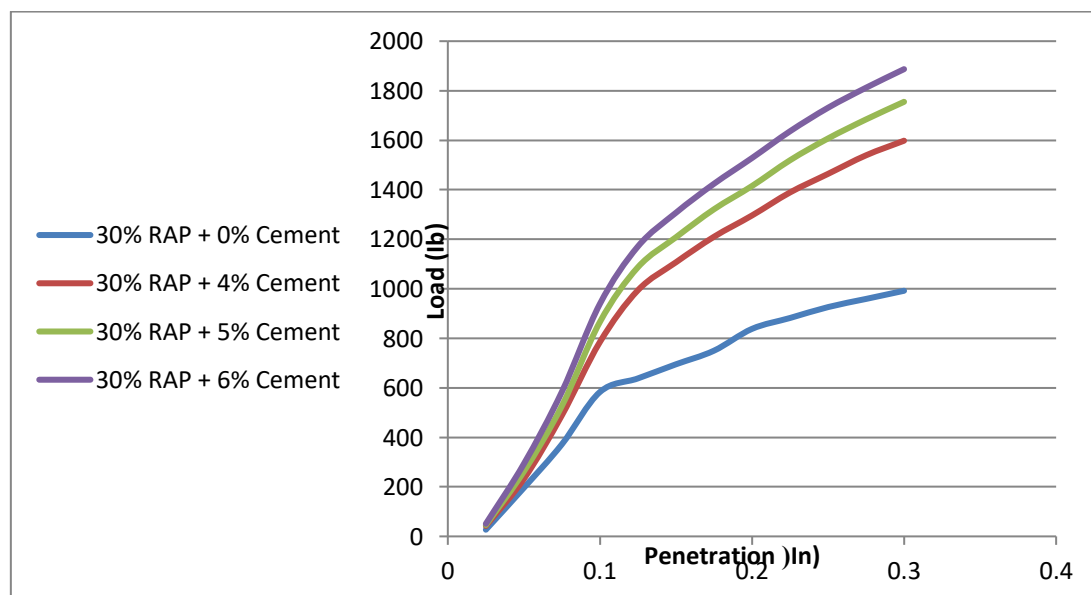
The continuous increase in OMC indicates that higher cement contents require greater moisture availability to achieve maximum dry density. Overall, the results demonstrate a clear positive relationship between cement content and OMC within the investigated range.

### 3.3. CBR Performance of RAP–Aggregate Base Mixtures

The California Bearing Ratio (CBR) test results demonstrated a significant improvement in the load-bearing capacity of the selected 30% RAP mixture with cement addition. The untreated mixture exhibited a CBR value of 58.3%, indicating relatively low load-bearing capacity. With the addition of cement, the CBR values increased markedly to 84.6%, 94.33%, and 101.9% at cement contents of 4%, 5%, and 6%, respectively. This substantial increase demonstrates the effectiveness of cement stabilization in enhancing the strength and load-bearing performance of the selected RAP–aggregate mixture. Table (4) presents the CBR results for the untreated and cement-stabilized mixtures.

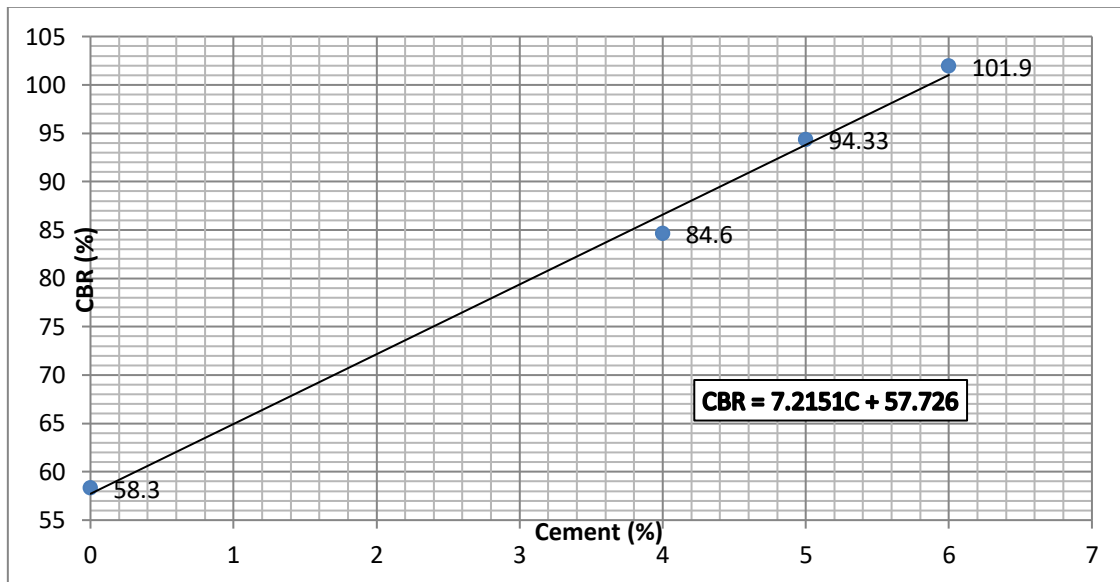
**Table (4):** CBR Test Results for untreated and cement-stabilized RAP-Aggregate mixtures.

| Mixture Type<br>RAP Content (%) | CBR (%) |
|---------------------------------|---------|
| 30% RAP + 0% Cement             | 58.3    |
| 30% RAP + 4% Cement             | 84.6    |
| 30% RAP + 5% Cement             | 94.33   |
| 30% RAP + 6% Cement             | 101.9   |



**Figure (6):** Load-Penetration Curves for untreated and cement-stabilized RAP-Aggregate mixtures

Figure (6) illustrates the load–penetration behavior of the untreated and cement-stabilized mixtures. The untreated 30% RAP mixture exhibited the lowest CBR value of 58.3%, indicating relatively low load-bearing capacity. With increasing cement content, the CBR values increased significantly, reaching 84.6%, 94.33%, and 101.9% at 4%, 5%, and 6% cement, respectively. This trend demonstrates the positive effect of cement stabilization on the load-bearing performance of the selected RAP–aggregate mixture. The improvement can be attributed to the formation of cementitious bonds between particles, resulting in increased stiffness and resistance to deformation under applied loads. Overall, the results demonstrate that increasing cement content substantially improves the load-bearing capacity of the selected mixture.



**Figure (7):** Relationship between California Bearing Ratio and Cement%

Figure (7) illustrates the relationship between California Bearing Ratio (CBR) and cement content, showing a strong increasing trend as the percentage of cement increases. The fitted regression line follows the equation ( $CBR = 7.2151C + 57.726$ ), indicating that the CBR increases at an approximate rate of 7.2151 percentage points for every 1% increase in cement content.

The experimental results support this trend, with the CBR increasing from 58.3% for the untreated mixture to 84.6%, 94.33%, and 101.9% at cement contents of 4%, 5%, and 6%, respectively. This corresponds to an overall increase of approximately 74.8% in CBR between the untreated mixture and the mixture stabilized with 6% cement, demonstrating the effectiveness of cement stabilization in improving load-bearing capacity.

The substantial improvement in CBR can be attributed to the formation of cementitious bonds between particles, which increases the stiffness and stability of the mixture and reduces deformation under applied loads. As cement content increases, the mixture develops a stronger and more rigid structure capable of resisting higher loads. Overall, the results confirm a strong positive relationship between cement content and CBR within the investigated range.

### 3.4. Unconfined Compressive Strength (UCS) Performance of Cement-Stabilized RAP–Aggregate Mixtures

The Unconfined Compressive Strength (UCS) test was conducted to evaluate the compressive strength of the selected 30% RAP mixture stabilized with different cement contents. The cement-stabilized specimens were tested after a curing period of 7 days. The results showed a progressive increase in UCS with increasing cement content. The UCS values were 386.4, 445.3, and 491.7 psi at cement contents of 4%, 5%, and 6%, respectively. This increase demonstrates the effectiveness of cement stabilization in enhancing the compressive strength of the selected RAP–aggregate mixture. Table (5) presents the 7-day UCS results for the cement-stabilized mixtures.

**Table (5):** 7-Day UCS Test Results for Cement-Stabilized 30% RAP Mixtures.

| Mixture Type<br>RAP + Cement Content (%) | UCS (Psi) |
|------------------------------------------|-----------|
| 30% RAP + 4% Cement                      | 386.4     |
| 30% RAP + 5% Cement                      | 445.3     |
| 30% RAP + 6% Cement                      | 491.7     |

The results presented in Table (5) indicate that increasing cement content leads to a significant increase in the 7-day UCS of the stabilized mixture. The UCS increased from 386.4 psi at 4% cement to 445.3 psi at 5% cement and further increased to 491.7 psi at 6% cement. This corresponds to an overall increase of approximately 28.4% as the cement content increased from 4% to 6%. The improvement in compressive strength can be attributed to cement hydration and the progressive formation of cementitious bonds between the RAP and aggregate particles, resulting in increased cohesion, stiffness, and resistance to compressive loading.

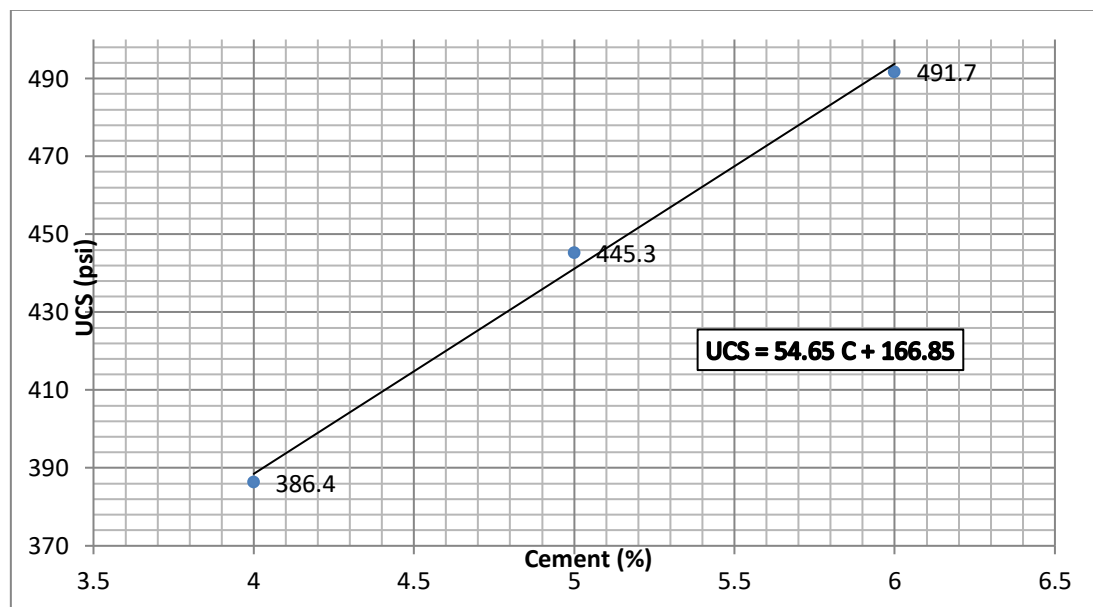
**Figure (8):** Relationship between unconfined compressive strength and Cement%.

Figure (8) illustrates the relationship between cement content and 7-day Unconfined Compressive Strength (UCS), showing a clear increasing trend as the percentage of cement increases. The fitted regression line follows the equation ( $UCS = 54.65C + 166.85$ ), indicating that the 7-day UCS increases at an approximate rate of 54.65 psi for every 1% increase in cement content.

The experimental results support this trend, with the UCS increasing from 386.4 psi at 4% cement to 445.3 psi at 5% cement and reaching 491.7 psi at 6% cement. This substantial improvement in UCS can be attributed to cement hydration and the formation of cementitious bonds between the RAP and aggregate particles, which enhance cohesion and increase the stiffness and compressive strength of the mixture. As cement content increases, the bonding between particles becomes stronger, resulting in a more rigid and stable matrix capable of resisting higher compressive loads. Overall, the results demonstrate a strong positive relationship between cement content and the 7-day UCS of the selected RAP–aggregate mixture.

#### 4. CONCLUSION & RECOMMENDATIONS

This study investigated the effectiveness of cement stabilization in improving the engineering performance of a selected RAP–aggregate mixture containing 30% RAP for base course applications. The selected mixture exhibited relatively low load-bearing capacity in its untreated condition, with a California Bearing Ratio (CBR)

of 58.3%. Therefore, cement contents of 4%, 5%, and 6% were investigated to evaluate their influence on the compaction characteristics, load-bearing capacity, and compressive strength of the mixture.

The Modified Proctor test results showed that cement addition had a moderate effect on the compaction characteristics of the mixture. The maximum dry density (MDD) increased from 2.10 g/cm<sup>3</sup> for the untreated mixture to 2.13, 2.15, and 2.17 g/cm<sup>3</sup> at cement contents of 4%, 5%, and 6%, respectively. Meanwhile, the optimum moisture content (OMC) increased from 3.94% to 4.24%, 4.60%, and 5.12%. These results indicate that increasing cement content produces a modest increase in dry density while progressively increasing the water demand of the mixture, mainly due to the additional moisture required for cement hydration.

The CBR results demonstrated a substantial improvement in load-bearing capacity with increasing cement content. The CBR increased from 58.3% for the untreated mixture to 84.6%, 94.33%, and 101.9% at cement contents of 4%, 5%, and 6%, respectively. This corresponds to an overall increase of approximately 74.8% between the untreated mixture and the mixture containing 6% cement. These findings demonstrate the effectiveness of cement stabilization in enhancing the load-bearing performance of the selected RAP–aggregate mixture.

The 7-day Unconfined Compressive Strength (UCS) results further confirmed the beneficial effect of cement stabilization on the mechanical performance of the mixture. The UCS increased from 386.4 psi at 4% cement to 445.3 psi at 5% cement and 491.7 psi at 6% cement. This represents an overall increase of approximately 28.4% as the cement content increased from 4% to 6%. The improvement in compressive strength can be attributed to cement hydration and the progressive formation of cementitious bonds between the RAP and aggregate particles, resulting in a stronger and more stable material matrix.

Overall, the results demonstrate that cement stabilization is an effective technique for improving the engineering performance of the selected 30% RAP mixture. Although the increase in MDD was relatively modest, substantial improvements were observed in both CBR and UCS, indicating significant enhancement in load-bearing capacity and compressive strength. Within the investigated range, increasing cement content consistently improved the mechanical performance of the mixture, with the 6% cement mixture exhibiting the highest CBR and 7-day UCS values. These findings support the potential use of cement-stabilized RAP mixtures in pavement base course applications while promoting the reuse of reclaimed materials and reducing the demand for virgin aggregates.

Based on the findings of this study, cement stabilization is recommended as a practical method for improving the performance of RAP–aggregate mixtures intended for pavement base applications. However, the selection of cement content should consider the required mechanical performance, economic feasibility, and field construction conditions rather than strength improvement alone. Further research is recommended to investigate additional cement contents and longer curing periods, such as 14 and 28 days, to assess the development of compressive strength over time. Additional studies involving durability, wet–dry cycles, resilient modulus, and field performance are also recommended to provide a more comprehensive assessment of the long-term behavior of cement-stabilized RAP mixtures under actual pavement conditions.

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