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EXAMINING REJUVENATORS' IMPACT IN A BALANCED MIX DESIGN USING LARGE AMOUNTS OF REUSED ASPHALT PAVEMENTS

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A B S T R A C T

This study examined the properties of asphalt mixtures incorporating high proportions of recycled asphalt pavement (RAP). Bitumen was modified with a rejuvenator at 2%, 4%, and 6% proportions, in combination with 35%, 40%, and 45% RAP. Results showed increased strength and rutting resistance with higher RAP ratios. All RAP-rejuvenator combinations exhibited higher indirect tensile strength compared to the reference mixture. Asphalt mixtures with 45% RAP and 2% rejuvenator-modified bitumen displayed the best rutting resistance. Statistical analysis confirmed the significance of the findings. The rejuvenator effectively enhanced the properties of asphalt mixtures with RAP, allowing for higher RAP utilization than specified in Highway Technical Specification. This study underscores the potential of rejuvenator-modified bitumen in improving the performance and sustainability of asphalt mixtures containing recycled materials.

Keywords: **Recycled asphalt pavement Rejuvenator agent Indirect tensile strength Rutting resistance**

1.0 Introduction

The popularity of environmentally conscious options and remedies has grown significantly in all areas of civil engineering, including materials used for asphalt pavement. The incorporation of Recycled Asphalt Pavement (RAP) in the design of new pavement mixes has experienced substantial growth in recent years, owing to the environmental and economic advantages associated with substituting virgin components with recycled resources. However, issues arise in the replacement of RAP when the amount of replacement exceeds 25% ("high" RAP). Implementing a Balanced Mix Design (BMD) technique can assist in adequate preparation of the design of pavement for high RAP mixtures. The widespread use of BMD can frequently result in uncertainty because to changes in gradation, asphalt composition, and consequent volumetrics. Presently, there is no standardized approach for integrating high RAP (reclaimed asphalt pavement) into mix design in order to achieve best performance according to state or federal criteria. This paper proposes and outlines the Consi-Grad approach for high RAP mix design. The Consi-Grad approach incorporates both Superpave and BMD techniques to provide a mixture design that allows for significant levels of RAP replacement while still satisfying volumetric criteria and achieving satisfactory performance during testing. In this study, a mixture without any recycled asphalt pavement (RAP) was created, referred to as the virgin/control mix. To maintain uniformity in the RAP-inclusive mixes, the gradation and asphalt content are carefully controlled to prevent any variations caused by these two factors. The proposed approach is a research effort that use this methodology to establish the most effective mix design parameters for asphalt mixes with varying percentages of reclaimed asphalt pavement (RAP) replacement, including 0% (control/virgin), 25%, 50%, and 70% RAP replacement. IDEAL-CT is employed to assess the resistance to cracking, while HWTT is used to evaluate the resistance to rutting. The results suggest a favorable initial stage for this approach.

Reclaimed Asphalt Pavement (RAP) refers to the residual material obtained from crushing existing asphalt pavements on road surfaces. RAP refers to a mixture of old asphalt binder and aggregate that has undergone oxidation during the lifespan of the pavement. Both materials contribute to the development of novel pavement mix designs. The Federal Highway Administration (FHWA) promotes the utilization of recycled materials in contemporary pavement mix design, provided that the design is economically viable, environmentally aware, and exhibits satisfactory performance (Asphalt Pavement Recycling with Reclaimed Asphalt Pavement (RAP) - Recycling - Sustainability - Pavements - Federal Highway Administration, 2022). According to conventional practice, blends that include less than 15% RAP replacement do not need to employ a blending chart in order to mix the stiff binder back to the desired PG grade. If the percentage of RAP replacement falls within the range of 15% to 25%, it is recommended to utilize a virgin PG binder grade that is lower than the desired grade. A RAP replacement above 25% is classified as a "high" RAP mix, requiring the utilization of a blending chart for accurate asphalt mix design [8].

Incorporating RAP material into new pavement mix design can yield significant economic and environmental advantages [9]. Expanding the utilization of recycled materials enables the conservation of raw materials and resources. According to the 2020 National Asphalt Pavement Association (NAPA) industry survey report, approximately 87 million tons of RAP material were utilized in the production of new asphalt. As a result, the use of RAP material reduced the amount of new asphalt binder and aggregate by 4.4 million mix tons, which is equivalent to approximately 24 million barrels and 82 million tons, respectively. Additionally, the incorporation of RAP material led to a decrease in greenhouse gas emissions by 2.3 million metric tons of CO_2 and saved approximately 58.4 million cubic yards of landfill space [10]. Furthermore, RAP adoption not only leads to environmental savings but also offers numerous economic benefits. By minimizing the requirement for raw materials, the overall expenses associated with mix design are reduced, enabling projects with limited budgets to do more in terms of maintenance and construction. According to the 2020 NAPA report, the utilization of less new binder and aggregate led to a projected savings of $2.9 billion in material expenses. By diverting the RAP material from landfill disposal, an estimated $5.1 billion in gate fees were saved [11].

Although there are many advantages to adopting a high RAP pavement mix design, there are also significant difficulties associated with this procedure. The process of developing a high RAP mix design is more complex and time-consuming compared to a virgin mix design. This is mostly because of the uncertainties related to sourcing, consistency, and qualities of RAP (reclaimed asphalt pavement). The availability of the RAP binder is categorized into three options: 100% availability, partial availability, or 0% availability (which functions as a complete absence in the mixture). It is important to understand that availability in this context refers to the presence of aged asphalt binder in the Recycled Asphalt Pavement (RAP) that might contribute to the total asphalt content in the mixture [12]. Many transportation authorities, both historically and currently, create mix designs that incorporate RAP (reclaimed asphalt pavement) under the assumption that the binder from RAP is fully available. However, adopting this assumption can result in excessively "dry" mixtures with asphalt content lower than the desired optimal level. As a result, older RAP asphalt mixes exhibit inferior performance in terms of flow, adhesion, and cohesion compared to virgin asphalt mixes. For instance, if we estimate 100% availability but in reality only 65% of the RAP binder is actively contributing to the overall asphalt content in the mix, then the actual asphalt content in the mix will be lower than the optimum design asphalt content percentage. This can ultimately lead to premature failure in the field [13].

Super pave is a commonly employed approach for designing asphalt mixes, which relies mostly on volumetric verification and proportioning. Nevertheless, as the industry shifts towards sustainable practices and augments the utilization of recycled materials, Superpave frequently neglects to consider the interplay of these recycled elements. In order to effectively include recycled materials, it is necessary to have enough asphalt to meet both the volumetric design standards and the performance testing criteria. Due to the inconsistent nature of RAP in terms of asphalt composition and lack of fractionation, the use of RAP in high RAP mix performance is still being assessed. Due to Superpave's focus on verifying volumetric attributes as a measure of mix performance, these particular interactions and evaluations of performance are frequently disregarded. Recently, the asphalt paving industry has shifted towards adopting Balanced Mix Design (BMD) as a more advanced alternative to the existing Superpave technique (Meroni et al., 2020; West & Taylor, 2019). The objective of employing a BMD technique is to create a mixture that exhibits optimal performance by effectively managing both rutting and cracking distresses in the mix. BMD achieves this by conducting performance testing, specifically fracture and rut resistance tests, to guarantee that the mixture is effective and well-balanced. Another objective of BMD is to employ testing criteria that are straightforward, cost-effective, and sufficiently precise to determine good performance, rather than relying on volumetric features as markers of favorable mix characteristics [14].

Augmenting the quantity of RAP material frequently results in asphalt mixes that are considerably stiffer, more fragile, and prone to cracking, raveling, and other forms of damage. This is the outcome of the deteriorated and oxidized reclaimed asphalt pavement (RAP) binder that is added to the mixture. The user's text is a reference to a specific source or citation, indicated by the number 15. Although extensive research has been undertaken on various approaches to RAP inclusive mix design, there is a requirement for a standardized method of practice. The proposed procedure aims to address the challenges associated with sustainable asphalt solutions by adopting a systematic and iterative approach. This approach takes into account factors such as material variability, the impact of different mix components, high RAP mix performance thresholds, and the overall uncertainty in this field. The goal is to develop a method that is reliable, can be continuously improved, and can be replicated. The diversity of features in reclaimed asphalt pavement (RAP), such as gradation, real grade, and accessible asphalt content, has a substantial influence on the properties of RAP replacement mixtures. This influence becomes increasingly challenging to manage as the percentage of RAP climbs to higher quantities known as 'high RAP'. The purpose of this research is to develop a straightforward approach to reduce the impact of variability in mix qualities by reducing variations in gradation and overall asphalt content in a high RAP mix design. This procedure integrates the mix design techniques of Superpave and BMD in order to reconcile the differences between these two methodologies.

The objective of this study is to provide a standardized mix design that methodically integrates the effective elements of prior research procedures in this specific field. This will offer the asphalt pavement community a reliable and uniform approach for high-RAP mix design. The Experimental Procedure section will provide a detailed description of the materials and procedures employed in the Idaho pavement project design. This will include information about the project parameters and mix design characteristics. The Results section will present graphical representations and conduct ANOVA analysis to assess the statistical significance of the performance outcomes for each mix of RAP. The Conclusion section will provide a concise summary of the research findings and important points.

1.2 DATA COLLECTION AND METHODOLOGY

The Superpave (Better Producing Asphalt Paving) combination was widely adopted as the norm in several states for a significant period of time. This method was developed with the collaboration of multiple pavement organisations with the aim of creating a more advanced approach to designing HMA pavement mixes. The goal was to enhance the service life, performance, and efficiency of the pavement. This approach was developed to replace the Marshall mix design, which was its predecessor. The Superpave process integrated the novel PG binder grading system, which takes into account traffic and environmental circumstances when grading asphalt binder. Additionally, it includes a mechanism for predicting performance and verifying volume (What Is Superpave?, n.d.). Over time, several Departments of Transportation (DOTs) observed the emergence of pavement distresses, including cracking, rutting, raveling, and moisture damage, which were linked to mix performance testing [15].This issue is worsened by the use of RAP (reclaimed asphalt pavement) in asphalt mixes.

The Balancing Mix Design (BMD) process was developed to specifically tackle these issues related to mix performance. The BMD mix design utilizes multiple performance testing methods to provide a successful mix by effectively managing rutting and cracking issues in the design of an asphalt mixture. The objective of BMD is to create a Hot Mix Asphalt (HMA) design that takes into account the effects of aging, traffic loads, and climate conditions in a particular region

[16].The process of developing a comprehensive BMD application involves initially finding the Optimum Binder Content (OBC) by using the approach outlined in AASHTO R35. This is done to ensure that the volumetric criteria specified in AASHTO M323 are met, utilizing the Superpave process. Subsequently, specimens are produced from identical mixtures containing varying amounts of asphalt (e.g., +0.5%) and subjected to performance testing in order to determine the optimal binder content (OBC) that achieves a balance between resistance to rutting and cracking [17]. In addition, as the use of recycled materials becomes more common in pavement design, implementing the BMD technique will increase the level of confidence in the performance of pavement mixes in real-world situations [18].

A study conducted by Meroni et al. (2020) examined asphalt mixes with 30% and 45% reclaimed asphalt pavement (RAP) replacement. One set of mixes was made following the usual methods specified by the Virginia Department of Transportation (DOT), while the other set was prepared using a bituminous mixture design (BMD) technique. The findings of this investigation revealed that specific BMD mixes exhibited superior performance and cost-effectiveness in comparison to Superpave mixes. However, when using various levels of gradations, AC content, and volumetric features in a mix design, the outcomes may exhibit substantial variety and an unidentified factor that affects the mix performance. By employing various combinations without any means of regulating these variables, it is quite probable that a source of uncertainty is generated. In order to achieve precise and efficient design implementation, it is imperative to establish a strategy to address this issue promptly.

This work introduces the Consi-Grad approach, which is designed for high RAP replacement in mix design. It is regarded as an intermediary stage in the mix design process, bridging the gap between Superpave and BMD. Several Departments of Transportation (DOTs), including Idaho's, employ volumetric verification for mix design and impose restrictions on the maximum quantity of Recycled Asphalt Pavement (RAP) that can be used in a mix. Figure 2.1 below displays the flowchart of this procedure. The process commences by choosing certain criteria that are applicable to the state or federal regulations for mix design. Next, the materials are collected and examined to identify the final qualities, such as the distribution of Recycled Asphalt Pavement (RAP) and virgin aggregate, the amount of asphalt contributed by the RAP and its actual quality, and the necessary quality of the virgin binder to match the specified criteria. Next, the virgin mix design is formulated to ascertain the ideal asphalt composition and gradation of the mixture in order to fulfill the specified requirements. Performance testing is carried out on this virgin mixture to guarantee optimal performance. Next, the process of designing the RAP replacement mix commences, ensuring that the combined gradation of both the virgin and RAP aggregate is in line with the virgin mix design. The main factors to consider for this procedure (Consi-Grad) are maintaining the same gradation and asphalt composition as the original mix design (0% RAP) in order to minimize any significant impact from these variables. This allows us to focus on the rejuvenation process and its effectiveness in enhancing resistance to rutting and cracking.

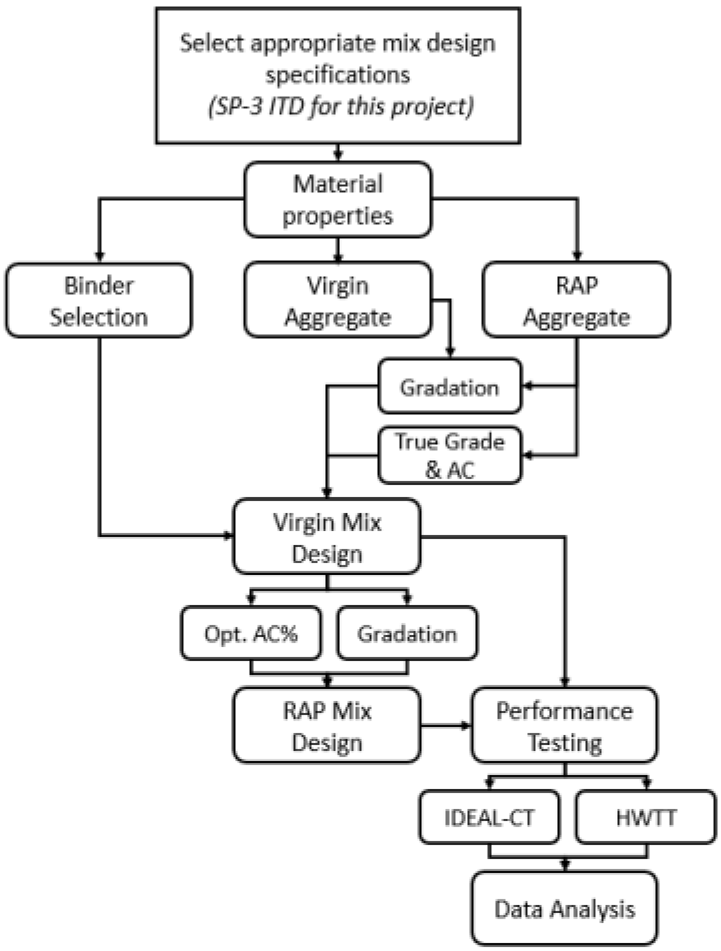

Figure 1 depicts the Consi-Grad Mixed Formulation Diagram.

This part provides a comprehensive explanation of the specific techniques and project specifications for a research project that will be using the Consi-Grad approach, which was previously described. This project was specifically tailored to adhere to the paving regulations of Idaho. The geographical climate, anticipated traffic loading, and materials were determined using

Idaho-specific data, and the pavement design requirements for Idaho highway design are used. When implementing this approach in a study or pavement building endeavor, it is important to take into account the relevant specifications and the climate conditions of the area.

1.2.1 MATERIALS & MIXTURE DESIGNING

The mix design was performed following the Idaho Transportation Department (ITD) Standard Specifications for Highway Construction for SP-3 specifications. This specification is suitable for medium-heavy traffic conditions and is commonly utilized in Idaho pavement projects (2018 Standard Specifications for Highway Construction, 2018). The chosen virgin binder was PG 70-28, which is a frequently utilized asphalt binder in highway pavement projects in Idaho. The virgin and RAP aggregate were obtained from Knife River, Inc. at a local level. Idaho Asphalt, Inc. designed and provided the asphalt binder. The virgin/control mix will be compared to the RAP replacement mixes in order to assess the impact of introducing RAP in the mix.

1.2.2 TESTING TECHNIQUES

The assessment of rutting resistance is conducted by the application of the Hamburg Wheel Tracking Test (HWTT) methodology. The HWTT process is widely adopted by several Department of Transportation (DOTs) because of its superior functionality and user-friendly nature, when compared to other rutting evaluation methods (Walubita et al., 2019). The HWTT was chosen for its applicability to Idaho's specifications for HMA asphalt pavement design. This approach involves applying repetitive wheel tracking loads using two distinct wheel attachments, with two samples per wheel. The samples are immersed in a water bath maintained at a constant temperature of 50℃ while the wheels move back and forth over the samples for 20,000 cycles under a load of 705 + 4.5 N. The depth of rutting (measured in millimeters) for each pass is recorded and displayed on a graph. Additionally, the incidence of stripping is taken into account by determining the inflection point in the curve using the rutting data.

The IDEAL-CT was employed to evaluate the fracture resistance of the mixtures. The use of IDEAL-CT has rapidly increased in popularity due to its affordability, practicality, and quick processing time (Zhou et al., 2017). The IDEAL-CT procedure examines samples of different dimensions and follows a comparable methodology to the original indirect tensile strength test. It is customary to create and examine samples with identical dimensions to the HWTT in order to simplify the process of preparing laboratory samples. The sample is being loaded at a pace of 50 millimeters per minute in terms of displacement. There are other measurable results, such as fracture energy, peak load, CTindex, and a graphical representation of the load vs displacement.

The preparation of all HWTT and IDEAL-CT samples followed the guidelines specified in section 6.2.4 of AASHTO T 324. Additionally, the samples were conditioned as per the technique indicated in section 7.3.2.1 of AASHTO R 30. The samples were compressed using the guidelines outlined in section 8.1.7 of the AASHTO T312 standard. The samples were compressed to a thickness of 62 mm and a diameter of 150 mm. The air void content was determined to be 7% + 0.5% using the methods specified in AASHTO T269 and AASHTO T209.

1.3 RESULTS

The RAP (Reclaimed Asphalt Pavement), virgin the aggregate, which and virgin binders are chosen and subjected to testing. The assessment of the grading and amount of asphalt binder in the RAP material was conducted following the guidelines of AASHTO T 308, using an ignition oven.

1.3.1 MIX DESIGN RESULTS

The resulting gradation and available RAP binder were determined by calculating the average of 8 randomly collected specimens corresponding to the RAP substance used. The authentic RAP grade asphalt was ascertained by examining the RAP binder that was retrieved using the approach specified in AASHTO T164 (method A - centrifuge extraction). Table 2.1 provides a comprehensive overview of the ultimate material qualities and project specifications.

Table 1 Material Properties and Parameters

Property/Parameter	In Project Use:
Design Specifications	ITD SP-3 (medium-heavy traffic flow)
RAP Percentages:	0 % (Control/Virgin mix) 25 % 50 % 70 %
True RAP Grade:	PG 82-16
Available Asphalt Content (RAP):	5.3%
Target Binder Grade (virgin) :	PG 70-28
Optimum Asphalt Content in Mix:	5.3%

The necessary volumetric and material specifications for the choosing of HMA pavement design, known as SP-3, may be found in Table 2.2 below. When utilizing this approach for research or business applications, it is important to take into account the particular needs that are relevant to the area of interest.

Table 3.2 Design Specifications for ITD SP-3.

Mix Property	Job Mix Formula	Spec.
Percent Asphalt by Weight of Total Mix	**5.3**	-
Percent Asphalt by Weight of Aggregate	5.3	-
Percent Air Voids (Pa)	4.1	4.0
Voids in Mineral Aggregate (VMA)	14.7	14 min
Compacted Unit Weight Gmb, pcf	2.307	-
Theoretical Maximum Density Gmm, pcf	2.406	-
Percent Effective Asphalt Content (Pbe)	4.7	-
Percent Absorbed Asphalt (Pba)	0.54	-
Specific Gravity of Binder (Gb)	1.0331	-
Percent Gmm @ N Initial (7 gyrations)	86.7	≤ 89.0
Percent Gmm @ N Design (75 gyrations)	95.9	96.0
Percent Gmm @ N Maximum (115 gyrations)	96.8	≤ 98.0
Dust to Asphalt Ratio (DP)	1.1	0.8-1.2
Percent Passing #200 Sieve	5.0	3.0-6.0
Voids Filled with Asphalt (VFA)	72.1	-
Laboratory Mixing Temperature for Design (°F)	336	327-337
Laboratory Compaction Temperature for Design (°F)	314	306-316
Laboratory Sample Weight for Volumetric Testing (g)	4741	-
Ignition Oven (NCAT) Correction Factor @ 538 °F	0.37	-
Los Angeles Abrasion (LAR) (%)	29	40 max
Sand Equivalent	64	45 min
Fracture Face Count (%)	98	75 min (2 Face)
Fine Aggregate Angularity (%)	46.1	45.0 min
Flat and Elongated Particles in Coarse Aggregates (%)	0	20 max (3:1)
Coarse Clay Lumps and Friable Particles	0	0.3 max
Fine Clay Lumps and Friable Particles	0	0.3 max
Percent Natural Sand	0	15 max
Coarse Sodium Sulfate Soundness	1.1	12 max

An important factor to consider in this mix design approach is the need to maintain a consistent gradation that aligns with the virgin/control mix. Figure 2.2 displays both the initial RAP gradation and the ultimate total mix gradation. The ultimate choice of mix gradation fell within the top and lower limits of the ITD and outside of the prohibited zone. It is important to mention that in order to maintain a consistent transition across the different mixes with 0%, 25%, 50%, and 70% RAP supplementation, only the gradation of the virgin aggregate was modified to provide a combined gradation that matches the virgin mix

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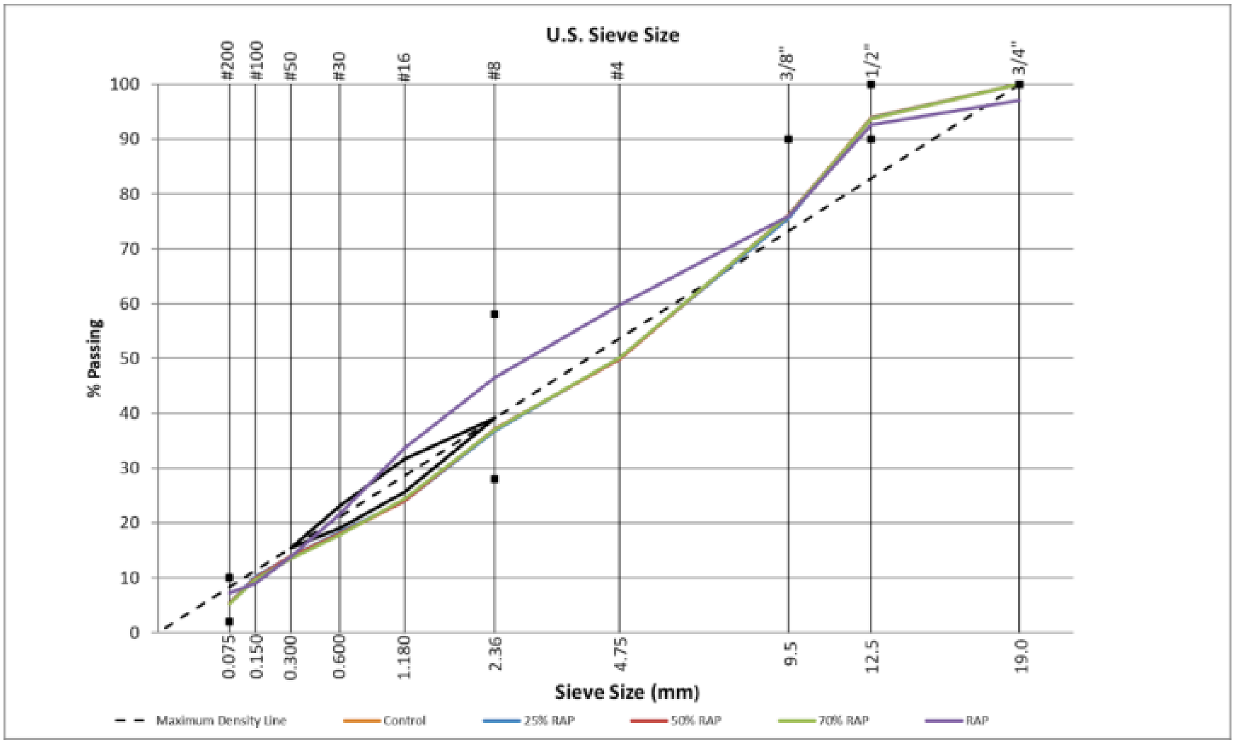

Figure 2 illustrates the gradation of Recycled Asphalt Pavement (RAP) and Hot Mix Asphalt (HMA) mixes.

The level of grade and asphalt content of each mix are consistent throughout to align with the control/virgin mix. The selection of gradation and AC content is based on the appropriate combination to fulfill all the standards outlined in the ITD Standardized requirements for Motorway Building for SP-3.

1.3.2 OUTCOME OF EFFICIENCY TESTING

The following figure displays the outcomes for the resistance to rutting as measured by the HWTT rut width. The rut depth naturally reduces as the amount of RAP replacement increases. This is because the oxidized RAP enhances the stiffness of the mixes, resulting in an overall stiffer mixture. According to the current guidelines for Idaho SP-3 pavement design, the maximum allowable rut depth is less than 10 mm after 15,000 passes out of a total of 20,000. If the rut depth exceeds 10 mm before reaching this threshold, the pavement design is considered to be unsuccessful. This information is based on the 2021 Supplement Specification for the 2018 Standard Specifications for Highway Construction. There was no occurrence of stripping in any of the mixes examined in this study. This absence of stripping is a hallmark of a mix that contains the correct quantity of asphalt in its design. It is worth noting that dry mixes have a tendency to strip and ravel. Although the virgin/control (0% RAP) mix had the maximum rut depth, it still demonstrated excellent performance with a rut depth of less than 4 mm, suggesting it is a commendable control mix.

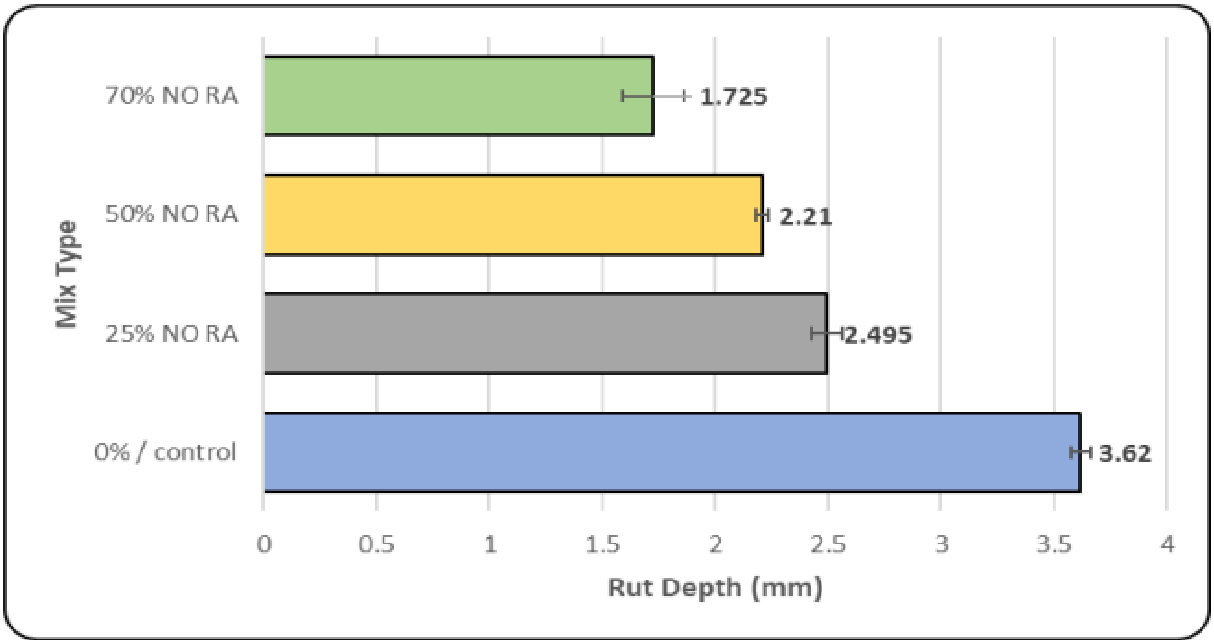

Figure 3 Rut Depth (mm)

An analysis of variance (ANOVA) was conducted on the HWTT and IDEAL-CT findings to assess the performance of each RAP percentage and ascertain whether there is a significant difference. The ANOVA table indicates that the p-value for the proportion of RAP is less than 0.05, which is the chosen alpha confidence level. This suggests that the HWTT is responsive to this variable. When employing numerous comparisons to further discern the importance of each one, it is evident that the 0%, 25%, and 70% RAP replacement blends exhibit substantial differences. Nevertheless, there is no substantial distinction between 50% and 70%, as well as between the 25% and 50% RAP replacement blends.

Table 3 presents the results of the ANOVA analysis conducted for the rut depth (measured in millimeters) of the HWTT.

Source	Degrees of Freedom	Sum of Squares	Mean Squared Err.	F-stat	p-value
% RAP	3	3.8770	1.29235	49.47	0.001
Residual	4	0.1045	0.02612	-	-
Total	7	3.9815	-	-	-

The CTindex is a measure of the resistance to cracking, as demonstrated by the IDEAL-CT values shown in Figure 2.4. The CTindex decreased as the RAP replacement increased, as anticipated. This can be attributed to the increased stiffness of the mix caused by the oxidized and aged binder. The current requirement for Idaho HMA mixes is a CT index of 80 or greater, as stated in the 2021 Supplemental Specifications for the 2018 Standard Specifications for Highway Construction. Based on the data, the virgin blend successfully met this requirement. However, it is also observed that the mixes containing RAP (Recycled Asphalt Pavement) do not meet this barrier.

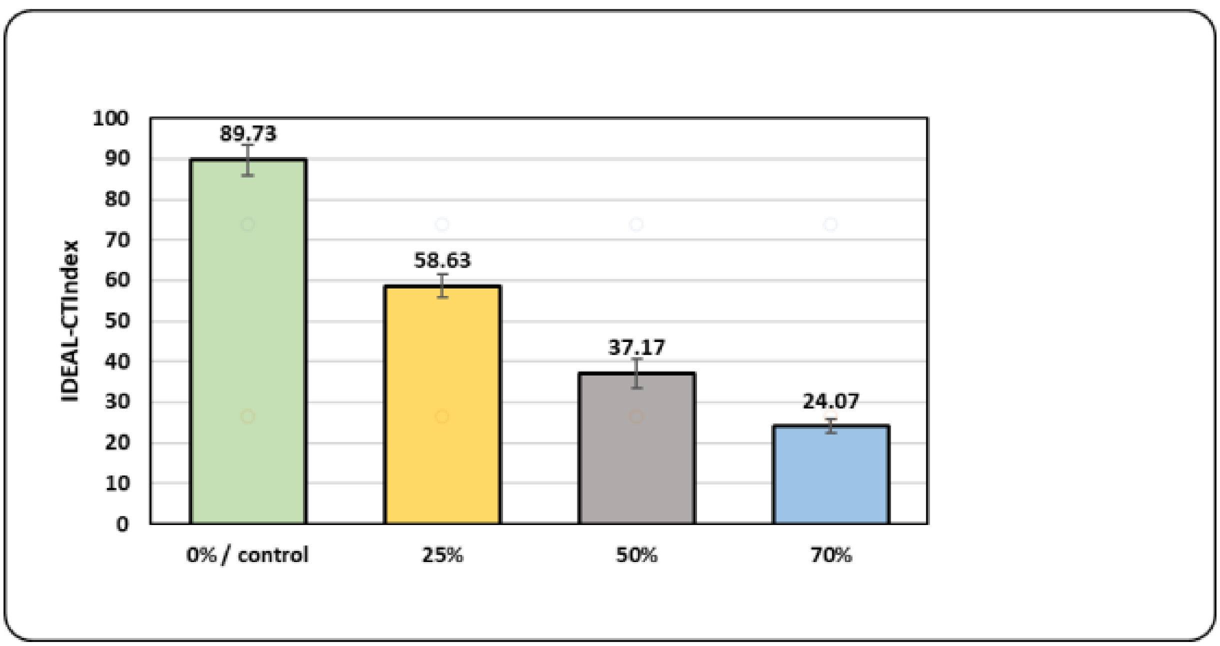

Figure 4 IDEAL-CT Results (CTindex)

The results of the IDEAL-CT CTindex indicate that the mixes with 0%, 25%, and 70% RAP replacement are statistically distinct from each other. However, the mixes with 50% and 70% RAP replacement are not significantly different according to the one-way ANOVA analysis. The findings obtained from the initial implementation and testing of the suggested Consi-Grad approach exhibit good outcomes, minimal fluctuation, and adhere to anticipated patterns. The findings of the one-way layout ANOVA analysis for the CT index are presented in the table below. The p-value, which is less than 0.05 (the alpha value chosen by Tukey), indicates that there is statistical significance in the differences between the various levels of RAP replacement. During the multiple comparison analysis, the significance of each individual RAP replacement percentage is determined. Statistical significance is observed for all levels of RAP, except for 50% and 70% RAP, which do not show any statistically significant difference.

Table 4 presents the results of the ANOVA analysis conducted for the CT index.

Source	**Degrees of Freedom**	**Sum of Squares**	**Mean Squared Err.**	**F-stat**	**p-value**
% RAP	3	7402.3933	2467.4644	56.09042288	0.0001
Residual	8	351.926667	43.9908333	-	-
Total	11	7754.32	-	-	-

1.5 SUMMARY

The purpose of this research was to develop a technique for integrating a high percentage of reclaimed asphalt pavement (RAP) into the mix design used in the pavement business. Although there are established protocols for BMD and recycled material, they frequently overlook the unpredictability related to RAP and the entire mix's gradation, asphalt concentration, and volumetric qualities. Performance testing is employed to examine and validate the features of a mixture. This paper proposes the Consi-Grad approach to remove variation from controllable mix factors.

The Consi-Grad proposal can be succinctly stated by following the steps outlined following.

- Choose the precise mix design criteria that are required for the particular design.
- Investigation of material characteristics
  - Choose and authenticate unused asphalt binder
  - Choose and authenticate unused asphalt binder

- ➢ The RAP aggregate refers to the combination of gradation, available asphalt content, and real grade.
- ➢ Create a virgin mix design (without any reclaimed asphalt pavement) that fulfills the specified requirements.
  - ▪ Optimal asphalt content (percentage)
  - ▪ Optimal gradation
- ➢ Conducting performance testing to evaluate the rutting and cracking of a virgin mix design control mix.
- ➢ Utilize the most efficient asphalt content and gradation to create mixtures that include reclaimed asphalt pavement (RAP).
- ➢ Modify the virgin mix gradation just to match the overall mix gradation.
- ➢ Conducting performance tests on RAP inclusive mixtures to evaluate their resistance to r utting and cracking.

The suggested approach serves as an intermediary solution to connect Superpave with BMD for RAP inclusive mixtures. The objective is to remove any known differences in the mix variables in order to provide the most effective considerations regarding the binders mix components. This provides a solid foundation for the pavement industry to develop and apply a high RAP mix design methodology. To enhance the effectiveness of the RAP-inclusive mixtures, the next phase involves integrating rejuvenators and recycling agents (RAs) and creating a blending chart. The main objective of this contribution is to establish a systematic approach to address and minimize the impact of certain mixed contribution.

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