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The Suitability of Bailey Method for Design of Local Asphalt Concrete Mixture

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Abstract

The study investigated the behaviour of asphalt concrete mixes for aggregate gradations, according to the Iraqi specification using the Bailey method designed by an Excel spreadsheet. In mixing aggregates with varying gradations (coarse and fine aggregate), The Bailey method is a systematic methodology that offers aggregate interlocking as the backbone of the framework and a controlled gradation to complete the blends. Six types of gradation are used according to the bailey method considered in this study. Two-course prepared Asphalt Concrete Wearing and Asphalt Concrete binder, the Nominal Maximum Aggregate Sizes (NMAS) of the mixtures are 19 and 12.5 mm, respectively. The total number of specimens was 240 for both layers (15 samples) for each Chosen Unit Weight (CUW). The Marshall Test results show the increase in stability and decrease in flow and bulk density when the rise in CUW for both courses. In volumetric properties, VMA increases when the increase in CUW. When an increase in CUW air void increases gradually. The permanent deformation for the coarse aggregate (95, 100, 105% CUW) has more resistances than the fine aggregate (80, 85, 90%) wearing and binder coarse. The CUW (105%) blend of wearing, and binder course has a high value of stability and resistance to permanent deformation (11.9, 11.1 kN). The CUW above mentioned is considered a good design aggregate structure and produces improvement to the Marshall properties, leading to better performance for pavement roads and higher resistance to distresses.

Keywords: Bailey Method; Volumetric Properties; Marshall Test; CUW.

1. Introduction

Asphalt mixtures are consisting of parts of fractured rock adhesive together by asphalt content. It’s a very simple material. Hot mix asphalt, as a structure material, is much more complex than it looks. Highway engineers also refer to asphalt mixture’s skeleton when they consider the function of aggregate. Compressive strength and movement resistance under truckloads come from the aggregate. The packing properties of aggregates are considered by the Bailey Method for gradation selection. The aggregate gradation considers one of the mixture’s key features, which affects the volumetric properties of the asphalt mix [1]. Robert Bailey Originally developed the Bailey method of the Transportation Department of Illinois (IDOT). The system recommends a solid aggregate skeleton for rutting resistance and sufficient mineral aggregate voids for good durability. District 5 of the IDOT has used the method since the early 1980s, and IDOT encouraged using the method throughout the 1990s [2].

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Many experiments on the Bailey graduation method have been conducted. A mixture design procedure based on and adapted to the Bailey Method for designing mastic asphalt (SMA) in stone has led to excellent rutting properties [3]. Results of a Bailey Method study in Oregon for the design and testing of dense-graded HMA suggested that an evaluation of the adapted Bailey Method should be additional zed in the development and selection of dense-graded mixture tests for design [4]. Many studies were designed to relate HMA aggregate gradation to permanent deformation resistance. Laboratory research shows that mixtures that are larger and with the same air void content 4% are typically more resistant to permanent deformation than mixes prepared for smaller aggregate particles, based on the influence of variable maximum size on rutting potentials and other properties of aggregate asphalt mixtures [5]. Fine gradations or mixtures with sanded products have been more susceptible to permanent deformation [6].

1.1. Coarse and Fine Aggregate

The conventional concept of coarse aggregate that any particle retained on the sieve 4.75 mm. Any aggregate passing the Sieve 4.75 mm (clay material, silt, and sand) is known as a fine aggregate. For (9.5 and 25-mm) blends, the same sieve size is used. In the Bailey process, the terms coarse and fine are more applicable to the estimation of packing. The aggregate interlock is given by the combination of aggregates in different measurement mixtures. The definitions of the Bailey Method are:

- Coarse Aggregate: Large aggregates of particles that produce voids if placed in a unit volume.
- Fine Aggregate: The aggregate particle fills the voids produced by the coarse aggregate in the mixes, as shown in Figure 1.

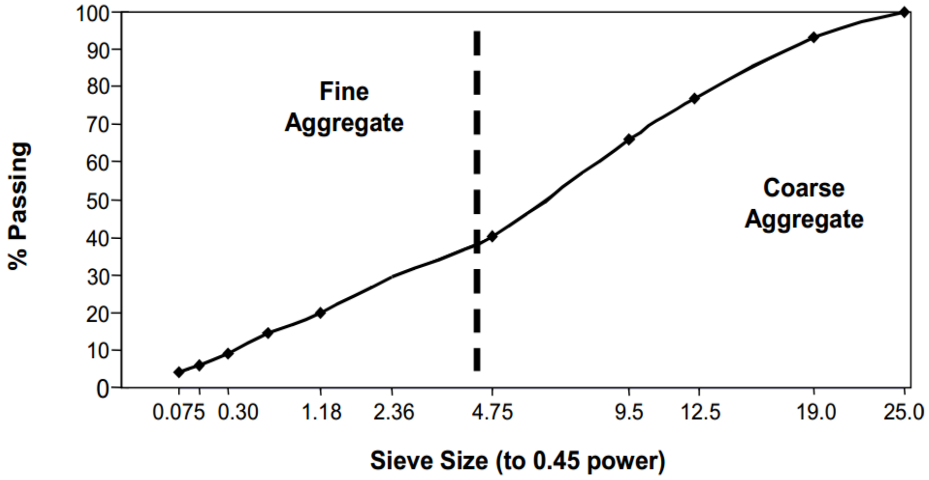

Figure 1. Sieve analysis of course and fine aggregate [2]

A mixture with a small CA ratio typically requires a stronger fine aggregate to satisfy the necessary volumetric properties. Furthermore, a CA ratio below the basic range in Table 1 might suggest a mixture that might separate. In general, that agreed to gap-grade mix, with CA ratio rise to reach the 1.0 Void in Mineral Aggregate (VMA) will rise. However, the aggregate portion is “unbalanced” when the value comes from 1.0 because the aggregate size’s interceptor tries to manage the coarse aggregate backbone. This combination will not be as vulnerable to segregation.

The coarse portion of the fine aggregate (FAc) produces voids filled with the fine portion of fine aggregate (FAf). The ratio is commonly accepted to be below 0.50, as high values normally show a too significant (FAf) blend volume. If the FAc proportion was smaller than the set of principles values recommended in Table 3, gradation must be avoided if the FAc ratio exceeds 0.50. Aggregate gradation plays an important role in mixture performance against large distresses like rutting, durability, and fatigue. Cracking also influences the working properties of the mixture [7-9].

Table 1. Recommended ratio for aggregate mixes [10]

NMPS	37.5 mm	25.0 mm	19.0 mm	12.5 mm	9.5 mm	4.75 mm
CA Ratio	0.80 - 0.95	0.70 - 0.85	0.60 - 0.75	0.50 - 0.65	0.40 - 0.55	0.30 - 0.45
FA_e Ratio	0.35 - 0.50					
FA_f Ratio	0.35 - 0.50					

Note: NMPS=Nominal Maximum Particle Sizes; CA=Course Aggregate; FA= Fine Aggregate; FA_e Ratio: ratio of the fine part of the fine fraction to the total fine part of the fine fraction.

1.2. Bailey Method

Coarse aggregate and fine aggregate are typically separated using the standard sieve size that is usually among (4.75-2 mm). In Bailey, a separate definition of "course" and "fine" is used concerning their volumetric properties inside the aggregate mixture. Large particles create a void when packed together in the mixture, while fine particles fill the void. So, the definition relates to the overall category of the maximum total size of the mixture (NMAS). The limited Sieve between coarse and fine, called Primary Control Sieve (PCS), is present in the following equation :

$$PCS = 0.22 \times NMAS \tag{1}$$

In that relation, (NMAS) is used to describe the scales of the coarse aggregate particles, while PCS is used to describe the scales of the intergranular voids that are proportionate to coarse particles.

Many researchers, e.g. (Kim et al., 2006) [11], who used packing theories, suggested a value of 0.22. This value is suggested by the Bailey method as a mean of particle diameter ratios ranging from 0.15 (round particles) to 0.29 (flat particles), as seen in Figure 2 [12].

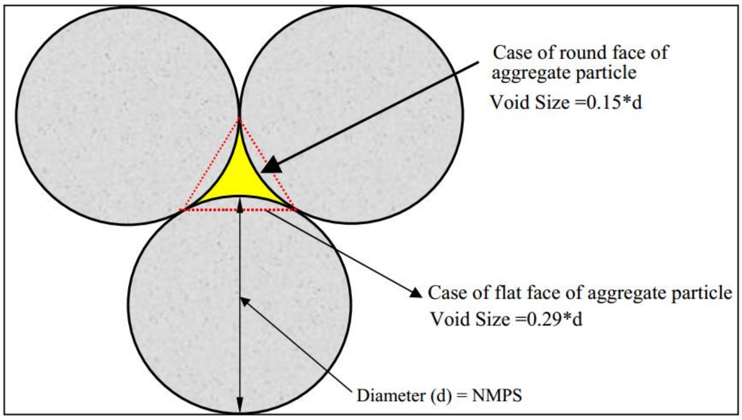

Figure 2. Two-Dimensional Aggregate Packing by bailey [12]

The average conditions of asphalt concrete mixtures consisting of particles of various shapes, strength, and textures were found in Equation 1. Single sizes are defined as "coarse" or "fine" if the PCS pass is below 50% or above. Half NMAS(HS) can evaluate the packing properties of the coarse portion of the aggregate mixture. The HS classifies particles in the PCS as "pluggers" (larger HS-retained particles) or "interceptors" (smaller particles passing on the HS). The coarse aggregate ratios regulate these two fractions' equilibriums, Equation 2:

$$CA = \frac{\boldsymbol{PHS - PPCS}}{\boldsymbol{100 - PHS}} \tag{2}$$

P represents the percentage to the defined Sieve; raising the CA ratio means raising the interceptors, which typically increases the void in mineral aggregate (VMA) because the interceptors are too large to meet in the void created by a large portion. The packing properties of the fine portion of the aggregate mixture can be analyzed considering that the PCS passing itself is a "new" mixture of fine and coarse portions. The secondary control sieve (SCS) is generally considered the NMAS of the new mix and, therefore, a new break and is equally 0.22 times the value of a PCS. The fine portion of a fine aggregate can be divided into a coarse and a fine portion. The Tertiary Control Sieve (TCS) is also the closest to 0.22 times SCS values. The balance between the various factions of the fine aggregate is defined as the ratio of Fine Aggregate Coarse (FAc) and Fine Aggregate Fine (FAf) that defined as the Equations 3 and 4:

$$\mathrm{FA}c = \frac{\boldsymbol{Pscs}}{\boldsymbol{Ppcs}} \tag{3}$$

$$\mathrm{FAf} = \frac{\boldsymbol{Ptcs}}{\boldsymbol{Pscs}} \tag{4}$$

P represents the percentage to the defined Sieve; increased FA ratios typically minimize VMA and air void (AV) because the small portion increases the packaging potential. For the determination of the fine-graded mixes (CUW < 90 per cent), just the passing to the PCS is determined because only the fine aggregate carry the load and control void in mineral aggregate, only the, Therefore, the characteristic sieves and the ratios must be redefined, provided that the original PCS is the new NMAS [2]. The primary purpose of this study has been to evaluate the laboratory efficiency of asphalt concrete blends of aggregate structures that have been constructed and evaluated using aggregate blending and analysis methods. In all of the aggregate structures in this study, the Bailey method of aggregate gradation analysis was used.

2. Materials and Methods

The flowchart methodology of this research is available in the Figure 3. The crushed coarse aggregate was from Badra in Waist governorate in Iraq. Specification (SCRB R/9, 2003) [13], The coarse aggregate sizes varied from 3/4 in (19 mm) to No.4 sieve (4.75 mm) for carrying, and the fine aggregate ranged from No.4 (4.75 mm) to No.200 (0.075 mm) Sieve retained. Tables 2 and 3 show the coarse and fine aggregate relative gravity and absorption tests performed by ASTM C-127 and 128. While Figures 4 and 5 exhibited the selected gradation for wearing and binder course, respectively. Penetration grade (40-50) of asphalt cement is used, prepared from Dhi Qar governorate in Iraq.

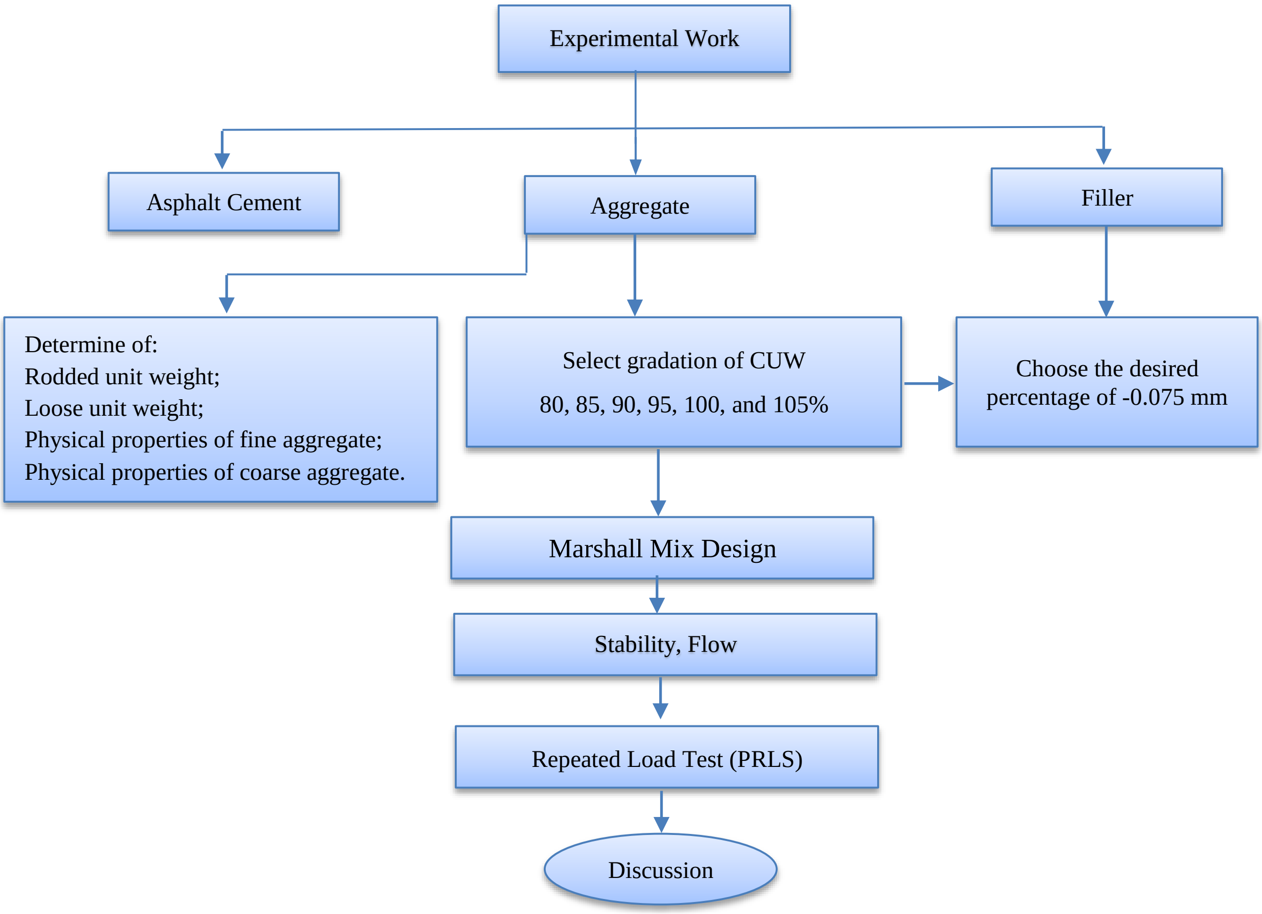

Figure 3. Flowchart of the Work Program

2.1. Design Mix of Bailey Method

The LUW and RUW are used to determine the Chosen Unit Weight (CUW), which determines the volume of coarse aggregate in a mixture. The volume of fine aggregate in a fine-graded mixture exceeds the volume of voids in the coarse aggregate structure. Since the fine aggregate primarily carries the load, the strength of the fine aggregate becomes much more important. For fine-graded mixes, we suggest (80, 85, 90) per cent LUW. A coarse-graded mix uses the coarse aggregate skeleton to carry more of the load and uses some of the strength from the fine aggregate, for coarse-graded mixes suggest a CUW in the range of (95, 100, 105) per cent LUW.

Table 2. Physical Properties of Coarse Aggregate.

Type of CA	Property	Coarse Aggregate
CA1	Bulk Specific Gravity	2.621
	Apparent Specific Gravity	2.669
	Percent of Water Absorption %	0.7
CA2	Bulk Specific Gravity	2.674
	Apparent Specific Gravity	2.754
	Percent of Water Absorption %	1.1
CA3	Bulk Specific Gravity	2.738
	Apparent Specific Gravity	2.806
	Percent of Water Absorption %	0.9

Table 3. Physical Properties of Fine Aggregate

Type of coarse aggregate	Property	Fine Aggregate
FA1	Bulk Specific Gravity	2.634
	Apparent Specific Gravity	2.735
	Percent of Water Absorption %	1.4
FA2	Bulk Specific Gravity	2.640
	Apparent Specific Gravity	2.751
	Percent of Water Absorption %	1.5

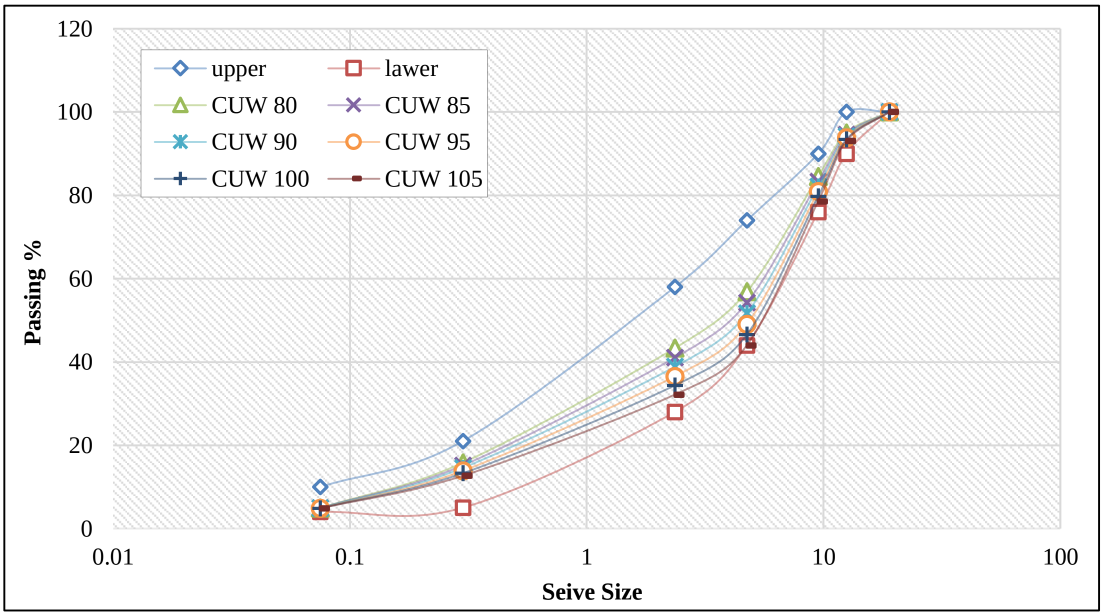

Figure 4. Selected gradation for bailey method wearing course

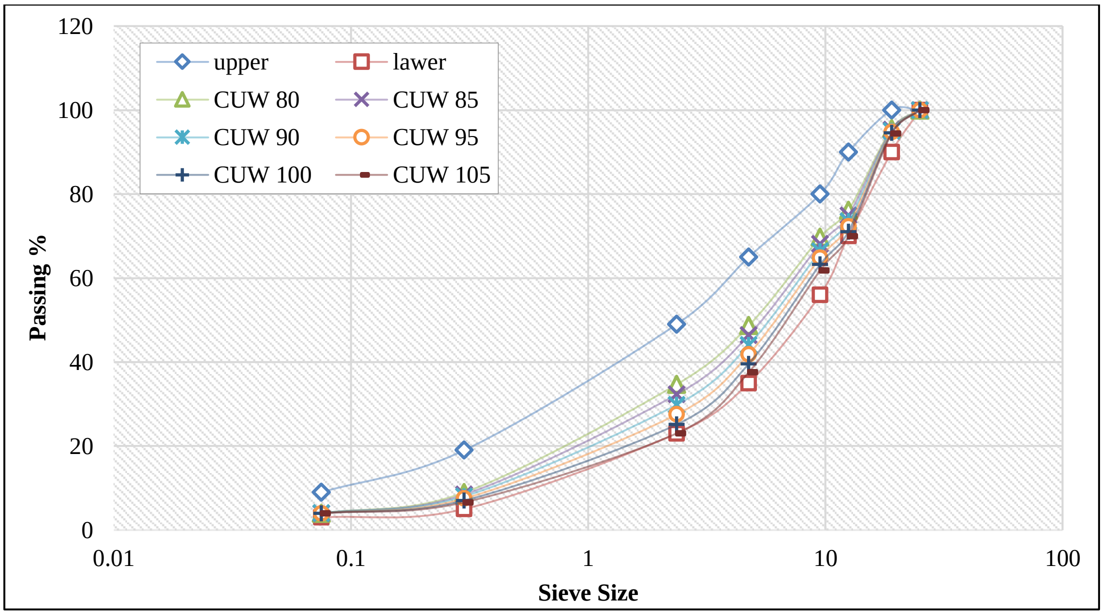

Figure 5. Selected Gradation for bailey method binder Course

2.2. Aggregate Ratios Coarse Graded

A blend with a small CA ratio generally needs a stronger fine aggregate to meet the required volumetric properties, with CA ratio rise to reach the 1.0 void in mineral aggregate (VMA) will rise. However, the aggregate portion is "unbalanced" when the value comes from 1.0 because the aggregate size's interceptor tries to manage the coarse aggregate backbone. This combination will not be as vulnerable to segregation. Tables 4 to 7 show the Aggregate ratios for wearing and binder course. The coarse portion of the fine aggregate (FAc) produces voids filled with the fine portion of fine aggregate (FAf). The ratio is commonly accepted to be below 0.50, as high values normally show a too significant (FAf) blend volume. If the FAc proportion was smaller than the set of principles values recommended in Table 1, gradation must be avoided if the FAc ratio exceeds 0.50.

Table 4. Aggregate ratios for wearing course (coarse graded)

Type	Aggregate ratios		
	CA	FAc	FAf
CUW80%	0.684	0.465	0.435
CUW85%	0.611	0.469	0.443
CUW90%	0.527	0.482	0.471
CUW95%	0.522	0.477	0.46
CUW100%	0.527	0.482	0.471
CUW105%	0.504	0.488	0.484

Table 5. Aggregate ratios for binder course (coarse graded)

Type	Aggregate ratios		
	CA	FAc	FAf
CUW80%	0.66	0.498	0.378
CUW85%	0.647	0.475	0.393
CUW90%	0.611	0.391	0.464
CUW95%	0.622	0.422	0.435
CUW100%	0.611	0.391	0.464
CUW105%	0.603	0.359	0.498

Table 6. New control sieve for wearing course (fine graded)

Type	Aggregate ratios	
	CA	FAc
CUW80%	0.561	0.435
CUW85%	0.559	0.443
CUW90%	0.551	0.471
CUW95%	0.555	0.46
CUW100%	0.551	0.471
CUW105%	0.55	0.484

Table 7. New control sieve for binder course (fine graded)

Type	Aggregate ratios		
	CA	FAc	FAf
CUW80%	0.774	0.378	0.433
CUW85%	0.755	0.393	0.457
CUW90%	0.698	0.464	0.553
CUW95%	0.718	0.435	0.518
CUW100%	0.698	0.464	0.553
CUW105%	0.684	0.498	0.589

2.3. Preparation of Marshall Specimens

A cylindrical specimen was used for the Marshall specimens (Figure 6). With a height 63.5 mm (2.5 ± 0.05 inch) and diameter 102 mm (4 inch). The hotplates were heated to the middle of (120-150 °C) Marshall mould, hammer for compaction, and spatula. Before conducting the mixture, the bottom of the mould held a sheet of non-absorbent paper cut into size. Afterwards, the mould was heated, and the asphalt mixture was placed in the preheated mould and then heated with a spatula ten times round and 15 times around the inner surface. The non-absorbent piece of paper in size was then placed on the mixture top. The mixture temperature was (150 °C) just before compaction. Put the mould on the seat pedestal, and (75) blows were applied on top and bottom of the sample with a 4.535 kg weight slipper and a 457.2 mm (18 inch) free drop. Let the moulded specimen cooled one day at room temperature and automatically jacked out of the mould. The total number of specimens was 240 for both layers (15 specimens) for each chosen unit weight (CUW) (90 total specimens of CUW) for Marshall test, Theoretical Maximum Specific Gravity (30 specimens).

Figure 6. A group of Prepared Specimens

2.4. Stability and Flow

This method involves determining the resistance to plastic flow of cylindrical specimens of the asphalt mixture on the lateral surface formed by the Marshall device (Figure 7). The overall load carried by a compact sample measured at 60 °C was typically the marshal stability at the load rate of 2 inches per minute. In addition to Marshall's stability, the flow was measured. The flow was proportional to the vertical deformation of the specimen. High values of flow normally mean that the plastic blend has been permanently deformed throughout traffic. In contrast, lower flow values may show a mixture of higher void and insufficient durability of asphalt and one which may experience premature cracking due to fragility during pavement life. The stability and flow are calculated according to ASTM D-1559 [14].

Figure 7. Marshall Test Apparatus

2.5. Repeated Load Test

Axial load tests on samples were performed using (PRLS). The device utilized for this reason is illustrated in detail by Al-Bayati (2006) [15]. The tests were accomplished on the cylindrical samples, height (4 inches) and (4 inches) diameter, arranged for every mixture one sample (Figure 8). The repeated compressive stress was subjected to the sample, and the permanent deformation was determined under the various load repeats. The repeated load test protocols used for this research are described as follows: Place the sample in a test chamber at the appropriate temperature for two hours to be tested and distribute the temperature to allow inside the chamber.

After completing the test sample "set up" of the test apparatus, the dial indicator was fixed to zero reading. The pressure was calibrated to the stress level specified. The timer (port and port of repository) is also set to the loading and rest periods needed. A recording video is in the right place to show the view of the dial indicator ready to be recording . The experiment starts by repeated axial stress and recording the reading of permanent deformation.

When the test is completed after 10000 load repetitions (or any number when the sample failed early for load repetitions), the recording is terminated. The specimen is removed from the test chamber.

The data analyses of deformation include:

1. Determining the following load repetitions of the permanent deformation: (1, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 2000, 3000, 4000, 5000, 6000…) or until the sample failed.
2. The permanent strain (εp), calculated based on Equation 5:

$$\varepsilon p = \frac{Pd \times 10}{\mathrm{h}} \tag{5}$$

Where; εp= axial permanent microstrain; pd= axial permanent deformation, h=height of sample.

3. Resilient deformation is calculated as the load is replicated from 50 to 100.

4. The resilient strain (εr) and resilient modulus (Mr) are calculated as Equation 6:

$$\varepsilon r = \frac{rd \times 10}{\mathrm{h}} \tag{6}$$

Where εr = axial resilient microstrain; rd= axial resilient deformation.

Resilient modulus:

$$Mr = \frac{\sigma}{\varepsilon \mathrm{r}} \tag{7}$$

Where; Mr= Resilient modulus (psi); σ = repeated axial stress (psi); εr= axial resilient strain (in/in).

Figure 8. Apparatus for the PRLS and test samples

3. Results and Discussions

3.1. Optimum Asphalt Content

Five percentages are used (4, 4.5, 5, 5.5, and 6%) to obtain the (OAC) for Marshall Mix design wearing and binder course of bailey method. The highest OAC founded in CUW, 80% (5.2%) wearing course, and (5%) in the same CUW of binder course because the aggregate gradation is immediately relating to (OAC). The finer the mixing gradation has a large surface area. The larger the binder volume used to cover the particles (Asphalt Institute, 2014) [16] Tables 8 and 9 show the Optimum Asphalt Content for wearing and binder coarse.

3.2. 4.2 Marshall Stability

All the gradations were found to have more than adequate stability. CUW (80%) has low stability (9.2 kN). This value increases the CUW rises to the up to reach (11.9 kN) in CUW (105%). While, the stability of course binder record (8 kN) in CUW (80%), this value arises to (9.5 kN) in CUW (90%) and then values decreases gradually to reach (11.1kN) in CUW (105%) with the coarse gradations providing the high-value stability and the low producing with fine gradations. Figure 9 presents Marshall stability for wearing and binder coarse for bailey method Mixtures in different CUW.

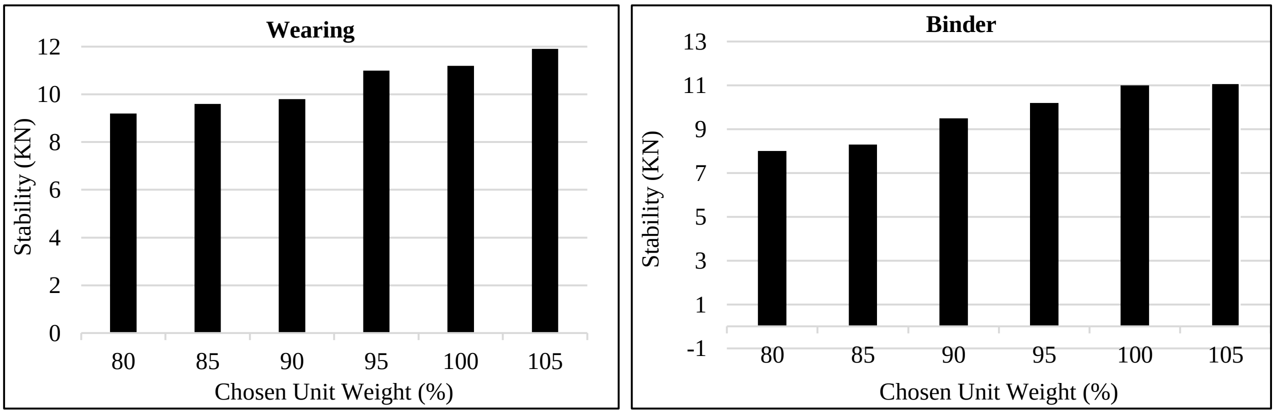

Figure 9. Marshall Stability for bailey method Mixtures for wearing and binder course

3.3. Marshall Flow

Marshall flow is also affected by gradation; The Bailey method raised the flow number of a finer to more than the number of coarser blends. The figure presents the Marshall flow for bailey method Mixtures for both wearing and binder course. The CUW (80%) that considers a fine grade, therefore. The value was a maximum of 4.3 mm, and this value decreases when an increase in CUW reaching 3.3 mm in CUW (105%). The analysis for all the data showed the flow for the binder course has the same behaviour; the flow decreases when CUW increases, as shown in the Figure 10.

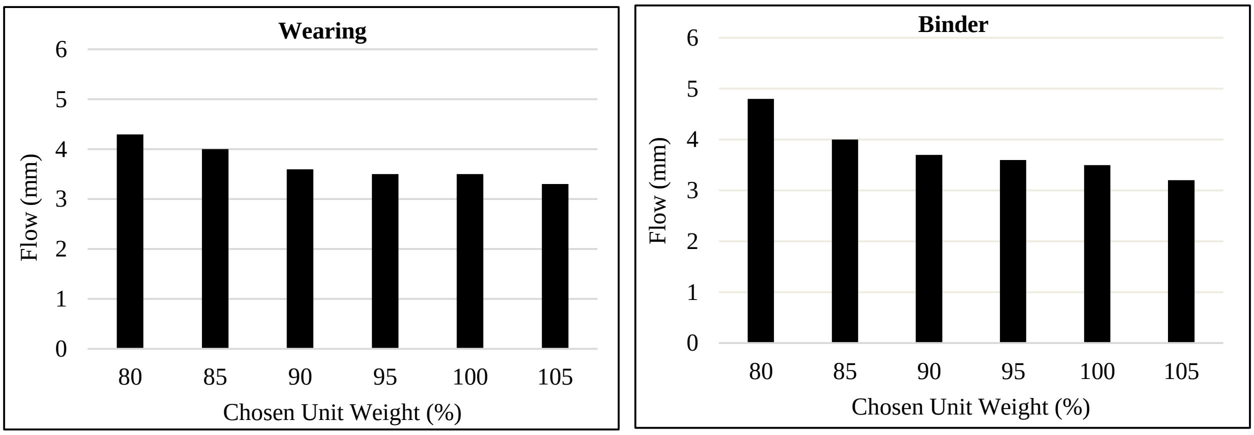

Figure 10. Marshall Flow for bailey method Mixtures for wearing and binder course

3.4. Bulk Density

The relationship between the Bailey Method's ratios and the dry bulk densities generally supports the arguments provided in the Bailey Method regarding changes in VMA ratios and the Bailey Method. Reducing the CA ratio can usually reduce VMA (increasing Bulk density) [4]. Figure 11 exhibits the relationship between Bulk density and CUW for wearing and binder course. The Bulk density in CUW (80%) was (2.326), corresponding (16.2%) of VMA. This value increase in conjunction with a decrease in the VMA value (fine grade); on the other hand, for binder course also have the same behaviour, in CUW (80%) was (2.318) corresponding (16.2%) of VMA, the Bulk density opposite VMA for coarse and fine gradation.

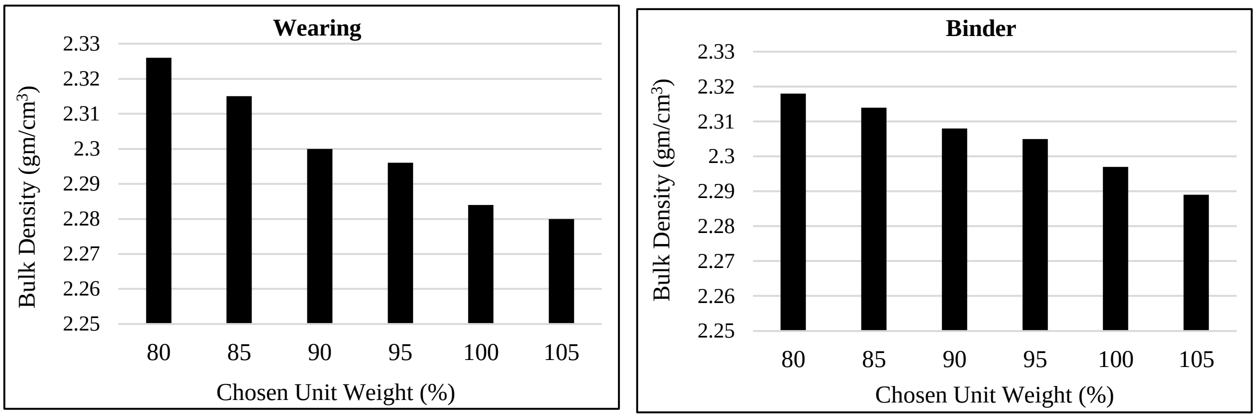

Figure 11. Bulk Density for bailey method Mixtures for wearing and binder course

3.5. Air Voids

The Bailey method of gradation selection takes into consideration the packing properties of aggregates. The process parameters are directly related to the mineral aggregate (VMA) voids, air voids, and compaction properties [17]. Figure 12 illustrate Air void for both wearing and binder course for bailey method Mixtures. For wearing coarse CUW (80%) it considers a fine grade recorded a percent (2.6%), this ratio is increasing in CUW (85%) (3.6%), and increasing slightly to become (4%) in CUW (90%) and increase gradually to reach (5.8%) in CUW (105%). For coarse binder CUW (80%) have (3.6%), this value increases slightly to reach (4%) in CUW (85%) and increase gradually to reach (6%) in CUW (105%).

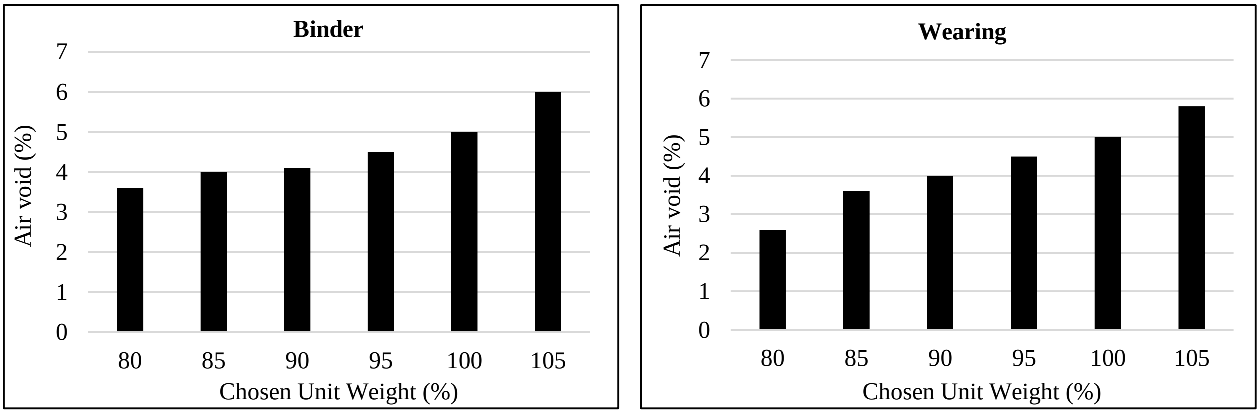

Figure 12. Air Voids for bailey method mixtures for wearing and binder course

3.6. Voids in the Mineral Aggregate

Voids in the mineral aggregates (VMA) of a compacted asphaltic mixture include the air voids and the voids filled with the effective asphaltic binder. Specifications require a minimum VMA to ensure that the aggregate particles are coated with the binder at a thickness that ensures the mixture durability [18]. The low void in the mineral aggregate did not lead to finely graded mixtures to durability or crushing problems [19]. For wearing coarse CUW (80%), it considers a fine gradation has a percent (16.2%), this ratio increases gradually in CUW (105%) (coarse gradation) to reach (17.7%). For coarse binder CUW (80%) have (16.2%), this value increases slightly to reach (16.7%) in CUW (85%) and increase gradually to reach (17.1%) in CUW (105%). VMA void mineral aggregate (VMA) increases when CUW increases for fine and coarse for wearing and binder course (Tables 8, 9). Similar findings were reported by Jebur and Alhaddad [20]. Figure 13 shows lower and high values for void mineral aggregate.

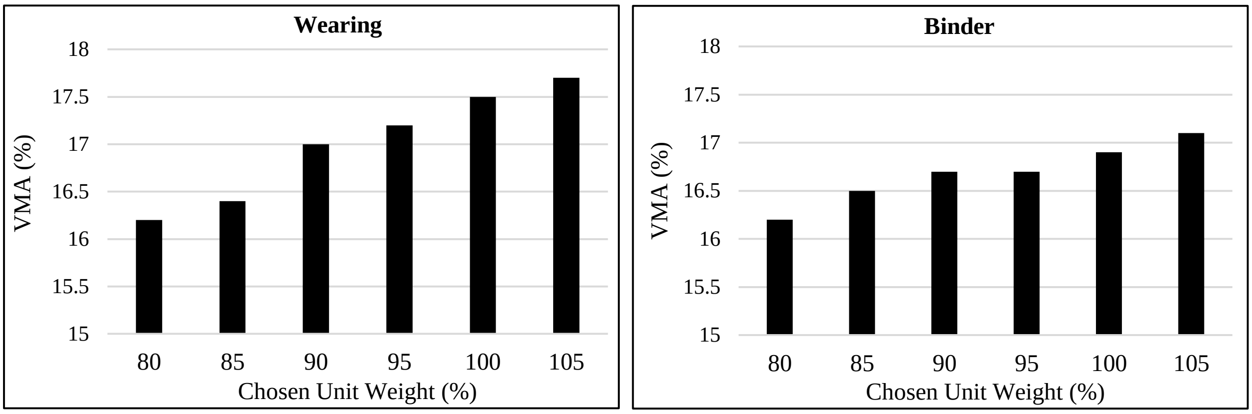

Figure 13. Void in mineral aggregate for bailey method Mixtures for wearing and binder course

Table 8. Optimum asphalt content mixture type for wearing coarse

Chosen unit weight for bailey method	O.A.C (%) by Wt. of Total Mix	Bulk Density (gm/cm^3)	Stability (kN)	Flow (mm)	Air Voids (%)	VMA (%)	VFA (%)
CUW (80%)	5.2	2.326	9.2	4.3	2.6	16.2	84.4
CUW (85%)	5.1	2.315	9.6	4	3.6	16.4	75
CUW (90%)	5	2.3	9.8	3.6	4	17	74
CUW (95%)	5	2.296	11	3.5	4.5	17.2	70
CUW (100%)	4.9	2.284	11.2	3.5	5	17.5	68
CUW (105%)	4.8	2.28	11.9	3.3	5.8	17.7	65

Table 9. Optimum asphalt content mixture type for binder coarse

Chosen unit weight for bailey method	O.A.C (%) by Wt. of Total Mix	Bulk Density (gm/cm^3)	Stability (kN)	Flow (mm)	Air Voids (%)	VMA (%)	VFA (%)
CUW (80%)	5	2.318	8	4.8	3.6	16.2	78
CUW (85%)	5	2.314	8.3	4	4	16.5	75
CUW (90%)	4.9	2.308	9.5	3.7	4.1	16.7	73
CUW (95%)	4.9	2.305	10.2	3.6	4.5	16.7	70
CUW (100%)	4.8	2.297	11	3.5	5	16.9	66
CUW (105%)	4.8	2.289	11.1	3.2	6	17.1	63

3.7. Repeated Load Test

The PRLS is characterized as the study of permanent deformation after certain stress and frequency in the sample. Initially, the test was performed under standard stress conditions of 100 kPa and 1800 cycles. The results showed no variation in deformation, which makes it impossible to determine. Axial stress and the number of cycles were increased to 300 kPa and 500 cycles, respectively. The axial stress and number of cycles were raised to 300 kPa and 500 cycles to treat these small differences and better simulate high pressures in the field. Each cycle consisted of a 1-second load period and 1-second rest at a temperature of 40 °C. The standard test outcome is based on three steps: primary, secondary and tertiary, which are the relation between the total permanent strain accumulated and the cycle number as presents in Figure 14. The permanent strain accumulates quickly during the primary stage. A permanent strain growth rate per cycle starts slowing until a constant value is achieved, indicating the beginning of the second stage. Then the specimen begins again to grow, and the rate of stress accumulation begins to grow rapidly, where the tertiary stage begins [21].

Some specimens were highly resistant to permanent deformation and did not reach the tertiary stage. Figure 15 presents the results of permanent deformation for asphalt mixture selection. The results show the fine aggregate mixes less effective and resistant to permanent deformation and the coarse aggregate mixes show the high value of permanent deformation. Such behaviour of materials comply with the findings of Yaghoubi and Mansourkhaki (2010) study [22].

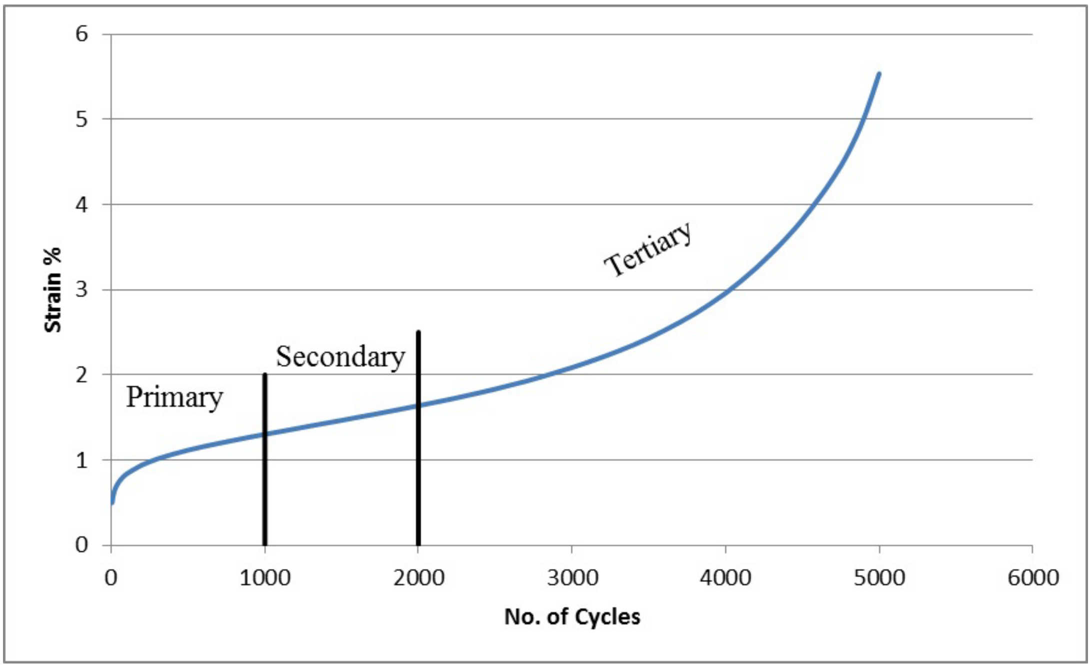

Figure 14. The three Stages of PRLS

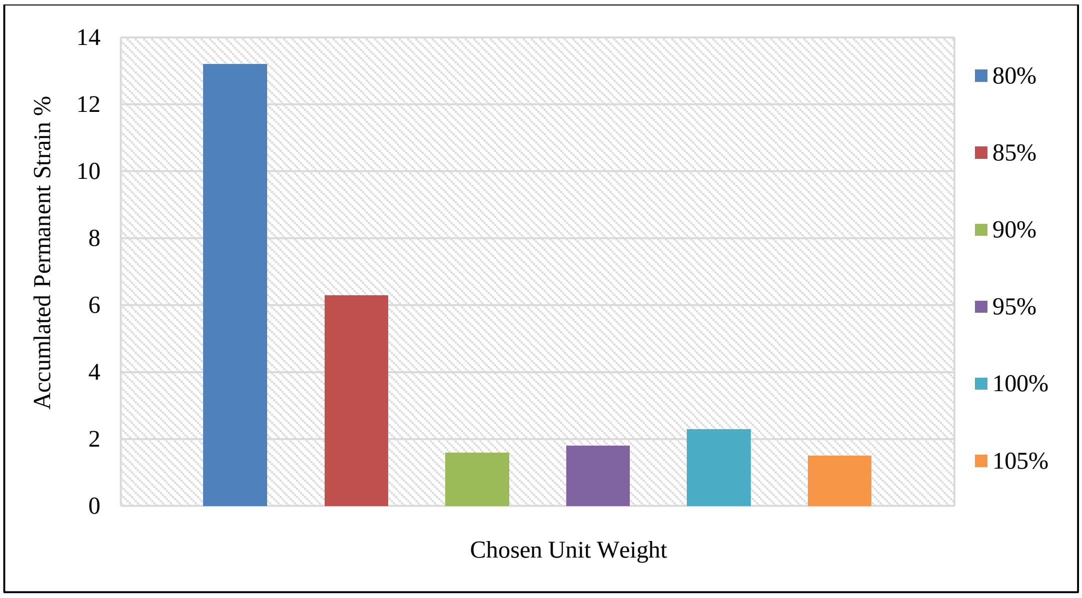

Figure 11. Accumulated Permanent Strain resulted from PRLS

4. Conclusion

The bailey method is a practical approach to help the designer control and understand the volumetric properties and HMA compatibility. Providing a good starting point for mixture design and have more gradation depending on aggregate ratios that may be suitable for different conditions and compaction. Void Mineral Aggregate (VMA) decreases when CUW increase for fine gradation (80, 85, 90%). void mineral aggregate (VMA) increases when CUW increase for coarse gradation (95,100, 105%). Marshall stability decrease when the increase in CUW for both courses. Marshall flow increases when increasing in CUW for both courses. The coarse aggregate (95, 100, 105 CUW) more resistances to permanent deformation than fine aggregate for wearing and binder coarse. The CUW (80%) blend of the wearing course and CUW (90%) of the binder course have a high value of stability (9.2, 8.6 kN), respectively. So, the CUW considers a good design structure.

5. Declarations

5.1. Author Contributions

Conceptualization, A.B.; data collection, A.F.; writing—original draft preparation, A.F.; writing—review and editing, A.B. All authors have read and agreed to the published version of the manuscript.

5.2. Data Availability Statement

The data presented in this study are available in article.

5.3. Funding

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5.5. Conflicts of Interest

The authors declare no conflict of interest.

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