Creep Performance of Various Bituminous Mixtures

by

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Dissertation submitted in partial fulfillment of
the requirements for the
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CERTIFICATION OF APPROVAL

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Approved by,

(A.P. Dr. Madzlan b. Napiah)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

JUNE 2007

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(Liyana bt. Nikmatlah)

ABSTRACT

Creep is a failure mode, used to describe the tendency of a material to move or to deform permanently to relieve stresses. An example of permanent deformations is rutting, which is caused by repetitive traffic loading that exceeds the ability of the pavement structure to maintain its original profile. Aggregate's particle size distribution, or gradation, is one of the most influential characteristics in the creep performance analysis. Aggregate gradation plays vital role in the rutting behavior; different gradation yield different strength and durability of pavement structures. This report presents mix design and creep performance data of four gradations; gap graded, continuous graded, open graded and dense graded. The aggregates used are crushed granite (coarse aggregate), river sand (fine aggregate) and ordinary Portland cement (OPC) as filler, while the bitumen used is 80 penetration bitumen. The evaluation of creep performance is done using the Dynamic Creep Test, and the result shows that dense graded mixture yields the best creep resistance.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Creep is the term used to describe the tendency of a material to move or to deform permanently to relieve stresses. Material deformation occurs as a result of long term exposure to level of stress that are below the yield or ultimate strength of the materials. The rate of this damage is a function of the material properties and the exposure time, exposure temperature, and the applied load (stress). Creep does not happen upon sudden loading, but the accumulation of creep strain in longer times causes failure of the material. An example of a permanent deformation is rutting, which is caused by repetitive traffic loading that exceeds the ability of the pavement structure to maintain its original profile.

Aggregate's gradation is one of the most influential characteristics in the creep performance analysis. Rutting resistance under traffic loads depends on the stability of aggregate structure in bituminous mixture. Aggregate gradation and shape have been recognized among the top factors that influence the stability of aggregate structure.

A bituminous mixture consists of aggregates, sand, binder (bitumen) and filler. As bitumen is a viscoelastic binding material, then, viscoelastic properties can also be found in the bituminous mixtures. One of the reason there is permanent deformation on pavement surface is due to pavement structures with viscoelastic properties. A way to describe viscoelastic properties in bituminous mixtures is creep analysis. Creep involves time dependent deformation under constant compressive stress and temperature level (Tjan and Adrian, 2003).

1.2 PROBLEM STATEMENT

"Rutting is one of the main modes of failure in road pavement. Various bituminous mixtures will result in different creep characteristics."

Rutting problem often requires complete removal and replacement of the rutted layer, which is an expensive undertaking. Rutting is also a serious safety issue for road users. When water accumulates in the ruts, there is a potential for aquaplaning. This phenomenon results in the tire losing contact with the surface with the consequence loss of steering control.

Resistance to permanent deformation such as rutting is an important consideration in the design of bituminous mixtures. It depends on the following factors.

- Magnitude, frequency, pressure, and speed of loading,
- Temperature,
- Aggregate gradation, shape, and texture,
- Binder type, and amount, and
- Construction variables such as compaction, quality control, and segregation.

Aggregate gradation plays vital role in the stability and strength of bituminous structures. Different aggregates gradations will result in different creep characteristics.

1.3 OBJECTIVES AND SCOPE OF STUDY

The objectives of this project are:

- To perform the sieve analyses tests and determine the aggregates proportion for each gradation.
- To assess creep performances of various bituminous mixtures,
    - By preparing various bituminous mixtures with different aggregates gradation; gap graded, continuous graded, open graded, and dense graded mixtures.
    - By performing the dynamic creep test for these different bituminous mixtures.
- To determine the best mixture for creep resistance,
    - By evaluating the result from the dynamic creep test.

CHAPTER 2

LITERATURE REVIEW AND THEORY

Rutting resistance under traffic loads depends on the stability of aggregate structure in bituminous mixture. Lee (1970) has discussed the variation of the aggregate gradation on properties of mixes, while Huang (1970) combines gradation effects and shape effects in his study by using a gradation index and a particle index. He found a large influence of gradation and shape of the aggregate on the properties of the mixes. Huang also suggest that gradation should be further studied in order to get high stability mixes with sufficient voids in the mineral aggregate to allow sufficient asphalt binder. Pan et al. (2006) discussed that fine or coarse graded asphalt mixtures, having either more fine aggregate or more coarse aggregate in the mix respectively often result in different rutting performances under traffic loads.

Pan et al. (2006) also suggested that, in certain asphalt mixes, coarse aggregate are more likely to establish physical contact due to their large sizes, commonly referred as interlock and has been shown to be significant for increased rutting resistances. Previous research studies that realized the important role the coarse aggregate plays in the rutting behavior of Hot Mix Asphalt related stability of aggregate structure to coarse aggregate morphologies.

Lee and Al-Dhalaan (1989) discuss the successful elimination of rutting in Saudi Arabia using coarse graded aggregates. Sahu and Rao (1978) suggested that asphaltic pavements constructed using gap graded aggregates perform well and have better Marshall Design properties than those constructed using continuous graded aggregates. Krutz and Sebaaly (1993) developed the Mohr failure envelope for four mixes with aggregate gradations ranging from fine to coarse and several binder contents. They found that the coarser the aggregate gradation, the less is the impact of the binder on the Mohr failure properties. Stephens and Sinha (1978) presented data on the effect of shape of the aggregate particles, and recommended blends of regular particles, flat particles, and rod-like particles to achieve optimum strength.

2.1 TESTS

The analysis of the work of Pilat et al. (2000) concerning the influence of mastics on the properties of bituminous mixtures, and specifically its resistance to rutting indicates that the assessment of bituminous mixtures resistance to rutting can be conducted on the basis of tests on creep under static or dynamic pressure.

Triggered by traffic loading, rutting is then a manifestation of two mechanisms: densification and shear deformation or plastic flow. Dawley et al. (1989) stated that rutting is characterized primarily by shear deformation and secondarily by post construction densification. According to Perl et al. (1983), asphalt-concrete creep deformation consists of recoverable and incoverable elements, some of which are time-dependent and some are time-independent. Sousa et al. (1991) had done an extensive review prediction of the rut depth as a function of wheel load, time, and temperature.

2.2 AGGREGATE GRADATION

Read and Whiteoak (2003) discussed that a continuously graded mixture was one that contained fractions of various (but not necessarily all) sizes throughout the range, while a gap graded mixture is one where sizes are discontinuous. The traditional British Standards that specify asphalts emerged from the description of asphalt as being gap graded or continuously graded. BS 594 deals with asphalts (gap graded materials) whilst BS 4987 applies to coated macadam (continuously graded materials).

Hunter (2007) discussed that the wearing course of a road pavement may also be bituminous macadam. Dense bituminous macadam provide a surface texture as a result of the stone content of the material, and when compacted they can have a low permeability. Coated stone is an open-graded material resulting from a limited mass proportion of fine aggregate. Continuously graded materials include dense bitumen macadam commonly used for roadbases and basecourses and for wearing courses on minor roads. Gap graded materials include hot-rolled asphalt wearing course. Table 1 shows typical composition of bituminous mixtures while Table 2 shows typical grading ranges.

Table 1: Typical compositions of bituminous mixtures

Sieve size (mm)	Percentage by weight passing each sieve			
	Bitumen macadam		Asphalt	
	20 mm open-graded crushed rock basecourse	20 mm dense crushed rock basecourse	Column 2/2 roadbase, basecourse & regulating course	Column 3/2, 30/14 type F wearing course
28.0	100	100	100	100
20.0	95-100	95-100	100	100
14.0	50-80	65-85	90-100	85-100
10.0	-	52-72	65-100	60-90
6.30	15-35	39-55	-	-
3.35	10-25	32-46	-	-
2.36	-	-	35-55	60-72
0.600	-	-	15-55	45-72
0.300	-	7-21	-	-
0.212	-	-	5-30	15-50
0.075	0-9	2-9	2-9	8-12

Table 2: Grading ranges for common mixtures

	Coated Stone	Continuously-graded	Gap-graded	Mastic
Coarse aggregate %wt	86.0	52.0	30.0	30.0
Fine aggregate %wt	7.0	38.0	53.0	26.0
Filler %wt	3.0	5.0	9.0	32.0
Bitumen %wt	4.0	5.0	8.0	12.0
Coarse aggregate %wt	64.5	44.1	25.7	27.5
Fine aggregate %wt	5.1	32.2	46.0	18.9
Filler %wt	2.1	4.2	7.8	27.0
Bitumen %wt	8.3	11.5	17.5	26.6
Void content %vol	20.0	8.0	3.0	<1.0
Grade of bitumen pen	100-300	100-200	35-100	15-25

Open graded friction course (OGFC) is a type of asphalt wearing course with a higher amount of air voids than regular asphalt dense graded surface course (DGSC). OGFC can be placed on either asphalt or concrete pavements, and it consists of roughly 93 % crushed stone, 7 % modified asphalt binder, and a small amount of stabilizing fibers.

DGSC is a layer of hot mix asphalt (HMA) that is the standard wearing course for most asphalt pavements. Although there are several different types of layers in asphalt pavements, what most people associate with the term "asphalt" is actually DGSC because it is so frequently used as the top layer of asphalt pavements. DGSC is composed of approximately 95 % aggregate (rocks and sand) and about 5 % asphalt cement binder.

The most common type of flexible pavement surfacing in the U.S. is HMA. HMA is known by many different name such as hot mix, asphaltic concrete (AC or ACP), asphalt, blacktop or bitumen.

2.3 AGGREGATE PROPERTIES

Atkins (2003) mentioned that relative density (specific gravity) for Portland cement is usually 3.15.

Mannan and Ganapathy (2005) discussed the properties of crushed granite and river sand. The physical and mechanical properties of crushed granite aggregate and oil palm shell (OPS) are shown in Table 3. Physical properties such as specific gravity, water absorption and fineness modulus of sand are noted as 2.6, 0.95 % and 2.56, respectively. The maximum bulking of sand due to moisture content has been found to be 13 % increase of volume at the moisture content of 10 %.

Table 3: Physical and mechanical properties of crushed granite and OPS aggregates

Physical and mechanical properties	Granite	OPS
Maximum size (mm)	12.50	12.5
Specific gravity (saturated surface dry)	2.61	1.17
Water absorption for 24 h (%)	0.76	23.30
Aggregate abrasion value (%)	24.00	4.80
Bulk density (compacted), kg/m³	1470	590
Fineness modulus (FM)	6.33	6.24
Flakiness index (%)	24.94	65.17
Elongation index (%)	33.38	12.36
Aggregate impact value (%)	17.29	7.86

CHAPTER 3

METHODOLOGY

This chapter provides an overview of the works involved in completing the project. There are basically two steps involved which are the literature review and laboratory works. As mentioned in Chapter 2, literature review is done to strengthen the knowledge on this topic. Various journals are referred to study the effect of gradation and creep characteristics in various bituminous mixtures. Also, the journals provide the knowledge on aggregates properties and helped in conducting the laboratory works.

The laboratory works were conducted in Universiti Teknologi PETRONAS Highway Lab. Four tests were conducted which are the Sieve Analysis, Marshall Mix, Marshall Stability Test and Dynamic Creep Test. The procedures and parameters involved in conducting these tests are discussed below.

3.1 LABORATORY WORKS

3.1.1 Sieve Analysis Test

References

1. UTP Highway Engineering Laboratory Manual
2. BS 594: Part 1 (gap graded, refer Table 4)
3. JKR Standard Specification for Road Works (continuous graded, refer Table 5 and dense graded, refer Table 7)
4. Federal Highway Administration (Open graded, refer Table 6)

Objective

1. To determine the gradation of the aggregates.

Tools/Equipment

1. Aggregates (coarse and fine)
2. Set of sieve
3. Mechanical sieve shaker

Procedures

1. 2 kg of coarse aggregate is weight to nearest gram. 500 g of sand is weight to the nearest 0.1 g.
2. Sieve sizes varying from 28 mm to 2.36 mm (depending on types of gradation) are used for coarse aggregate, while sieve sizes of 6.3 mm to 75μm (depending on types of gradation) are used for fine aggregates.
3. The aggregates are sieved for 5-10 minutes on the mechanical sieve shaker.
4. Aggregates retained on each sieve are weight and percentage passing each sieve is computed.
5. Aggregates proportions are then calculated.

Figure 1: Set of sieve and mechanical sieve shaker

Table 4: Gradation limit for gap graded mixture

Sieve size (mm)	Percentage by weight passing each sieve
20.0	100
14.0	85-100
10.0	60-90
2.36	60-72
0.600	45-72
0.212	15-50
0.075	8-12

Coarse aggregate : Retained on 2.36 mm sieve

Fine aggregate : Passing 2.36 mm sieve and retained on 0.075 mm sieve

Filler : Passing 0.075 mm sieve

Target binder content: 6.5 %

Table 5: Gradation limit for continuous graded mixture

Sieve size (mm)	Percentage by weight passing each sieve
28	100
20.0	95-100
14.0	65-85
10.0	52-72
6.3	39-55
3.35	32-46
0.300	7-21
0.075	2-8

Coarse aggregate : Retained on 6.30 mm sieve

Fine aggregate : Passing 6.30 mm sieve and retained on 0.075 mm sieve

Filler : Passing 0.075 mm sieve

Target binder content: 4.9 % ± 0.5 %

Table 6: Gradation limit for open graded mixture

Sieve size (mm)	Percentage by weight passing each sieve
12.5	100
9.5	95-100
4.75	30-50
2.36	5-15
0.075	2-2.5

Coarse aggregate : Retained on 2.36 mm sieve

Fine aggregate : Passing 2.36 mm sieve and retained on 0.075 mm sieve

Filler : Passing 0.075 mm sieve

Target binder content: 4.0 % ± 0.5 %

Table 7: Gradation limit for dense graded mixture

Sieve size (mm)	Percentage by weight passing each sieve
28	100
20.0	76-100
14.0	64-89
10.0	56-81
5.0	46-71
3.35	32-58
1.18	20-42
0.425	12-28
0.150	6-16
0.075	4-8

Coarse aggregate : Retained on 5.00 mm sieve

Fine aggregate : Passing 5.00 mm sieve and retained on 0.075 mm sieve

Filler : Passing 0.075 mm sieve

Target binder content: 4.5 % - 6.5 %

3.1.2 Marshall Mix

Reference

1. UTP Highway Engineering Laboratory Manual.

Objective

1. To prepare the bituminous mixture samples.

Tools/Equipment

1. Aggregates (based on specified grading)
2. Bitumen
3. Marshall Compactor
4. 100 mm moulds
5. Mixer

Procedures:

1. Mixer is heated to 150 °C. Bitumen and moulds are kept at 150 – 160 °C.
2. Aggregates (which had been oven dried previously) and filler are placed in the mixer and mixed dry about 1 minute. Then, appropriate amount of bitumen (3.0 – 7.5 % with 0.5 % incremental) is added to the aggregate until all particles are coated with bitumen.
3. The material is then placed in the mould. The material is distributed evenly by tamping the material (using steel rod) 15 times around the edges and 5 times in the centre.
4. Material is then compacted using Marshall Compactor with 76 blows on both sides.
5. When specimen is cooled down to room temperature it is extruded from the moulds using extruder.
6. 3 samples are prepared for each bitumen contents.

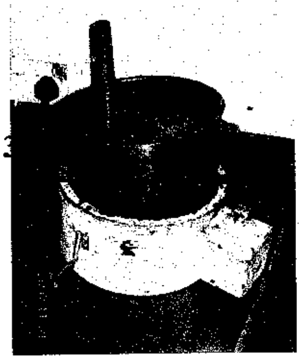

Figure 2: Mixer

Figure 3: Marshall Compactor

3.1.3 Marshall Stability Test

Reference

1. UTP Highway Engineering Laboratory Manual.

Objective

1. To determine the optimum binder content that should be used in the bituminous mixture.

Tools/Equipment

1. Bituminous mixture samples (prepared earlier)
2. Buoyancy Balance Test equipment
3. Bath water
4. Marshall Stability equipment

Procedures:

1. Sample is weighed in air and in water using the Buoyancy Balance Test equipment.
2. Sample is immersed in a bath water at a temperature of 60 °C ± 1 °C for a period of 30 to 40 minutes.
3. Then, sample is placed in the Marshall Stability testing machine and loaded at a constant rate of deformation of 2 inch per minute until failure occurs.
4. The total load (kN) that causes failure of the specimen at 60 °C is noted as the Marshall stability value of the specimen. The total amount of deformation (mm) is recorded as flow value.
5. Results are then analysed to determine the optimum binder content.

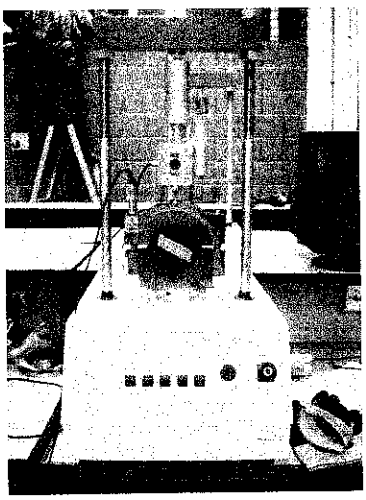

Figure 4: Marshall Stability Test equipment

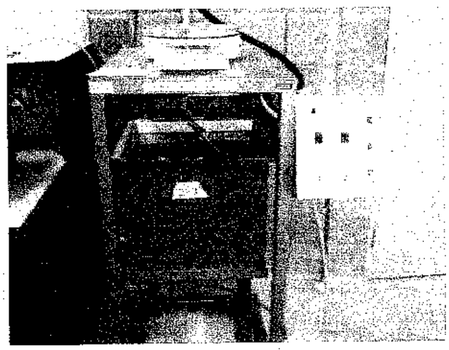

Figure 5: Buoyancy Balance equipment

3.1.4 Dynamic Creep Test

Reference

1. Universal Testing Machine manual.
2. British DD226 test setup.

Objective

1. To determine the creep performance of bituminous mixture samples.

Tools/Equipment

1. Bituminous mixture samples (prepared earlier)
2. Universal Testing Machine (UTM)

Procedures

1. The circulating-air environmental chamber is set to 40 °C.
2. The British DD226 standard testing is set up.
3. Setup parameters (pre-load):
   - stress 12 kPa
   - hold time 120 s
4. Setup parameters (loading):
   - Deviator stress 100 kPa
   - Contact stress 2 kPa
   - Rest period 1000 ms
   - Pulse width 1000 ms
   - Wave shape square pulse
   - Test duration 1800 cycles or until fail
5. Test data is stored automatically and graphs are shown in the next chapter.

CHAPTER 4

RESULTS & DISCUSSIONS

4.1 SIEVE ANALYSIS

4.1.1 Gap Graded

Table 8: Sieve analysis result for gap graded mixture

Passing sieve	Average % by weight passing		
	Coarse (A)	Fine (B)	Filler (C)
20	99.73	100.00	100.00
14	63.92	100.00	100.00
10	25.77	100.00	100.00
2.36	0.12	91.53	100.00
0.6	0.00	55.80	100.00
0.212	0.00	5.40	100.00
0.075	0.00	0.40	80.00

From calculation (sample calculation is attached in Appendix 1-a), the proportion of aggregates required to achieve the gap graded mixture is:

25 % coarse aggregate

63 % fine aggregate

12 % filler

The grading envelope for the gap graded mixture is shown in Figure 6. The "minimum" and "maximum" refer to the minimum and maximum percentage passing each sieve, based on the gradation limit specified by each standard. The grading envelope for the mixture (based on the calculated aggregates proportion) must lie within the minimum and maximum range.

4.1.2 Continuous Graded

Table 9: Sieve analysis result for continuous graded mixture

Sieve size (mm)	Average % by weight passing		
	Coarse (A)	Fine (B)	Filler (C)
28	100.00	100.00	100.00
20	99.52	100.00	100.00
14	69.80	100.00	100.00
10	33.38	100.00	100.00
6.3	7.67	99.87	100.00
3.35	0.00	97.07	100.00
0.3	0.00	7.07	100.00
0.075	0.00	0.40	80.00

From calculation (attached in Appendix 1-b), the proportion of aggregates required to achieve the continuous graded mixture is:

54 % coarse aggregate

38 % fine aggregate

8 % filler

The grading envelope for the mixture is shown in Figure 7.

4.1.3 Open Graded

Table 10: Sieve analysis result for open graded mixture

Sieve size (mm)	Average % by weight passing		
	Coarse (A)	Fine (B)	Filler (C)
12.5	99.55	100.00	100.00
9.5	98.97	100.00	100.00
4.75	33.45	100.00	100.00
2.36	0.15	90.40	100.00
0.075	0.00	0.40	80.00

From calculation (attached in Appendix 1-c), the proportion of aggregates required to achieve the open graded mixture is:

90 % coarse aggregate

7.5 % fine aggregate

2.5 % filler

The grading envelope for the mixture is shown in Figure 8.

4.1.4 Dense Graded

Table 11: Sieve analysis result for dense graded mixture

Sieve size (mm)	Average % by weight passing		
	Coarse (A)	Fine (B)	Filler (C)
28	100.00	100.00	100.00
20	98.05	100.00	100.00
14	58.65	100.00	100.00
10	15.32	100.00	100.00
5	2.30	100.00	100.00
3.35	0.00	92.60	100.00
1.18	0.00	66.20	100.00
0.425	0.00	30.70	100.00
0.15	0.00	4.50	100.00
0.075	0.00	0.60	80.00

From calculation (attached in Appendix 1-d), the proportion of aggregates required to achieve the dense graded mixture is:

51 % coarse aggregate

42 % fine aggregate

7 % filler

The grading envelope for the mixture is shown in Figure 9.

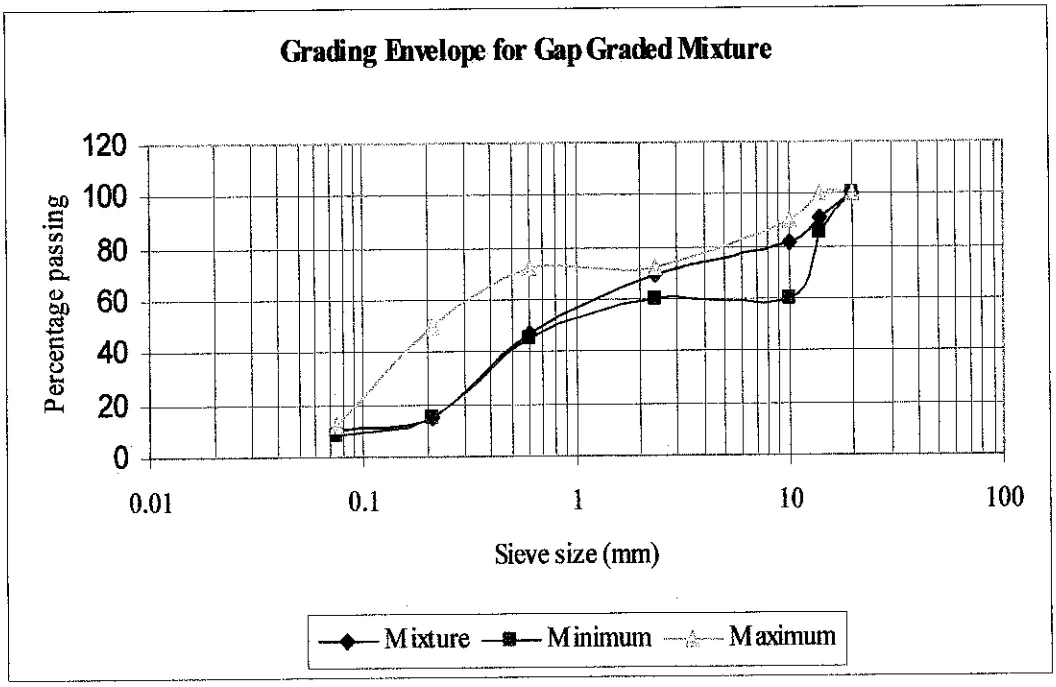

Figure 6: Grading envelope for gap graded mixture

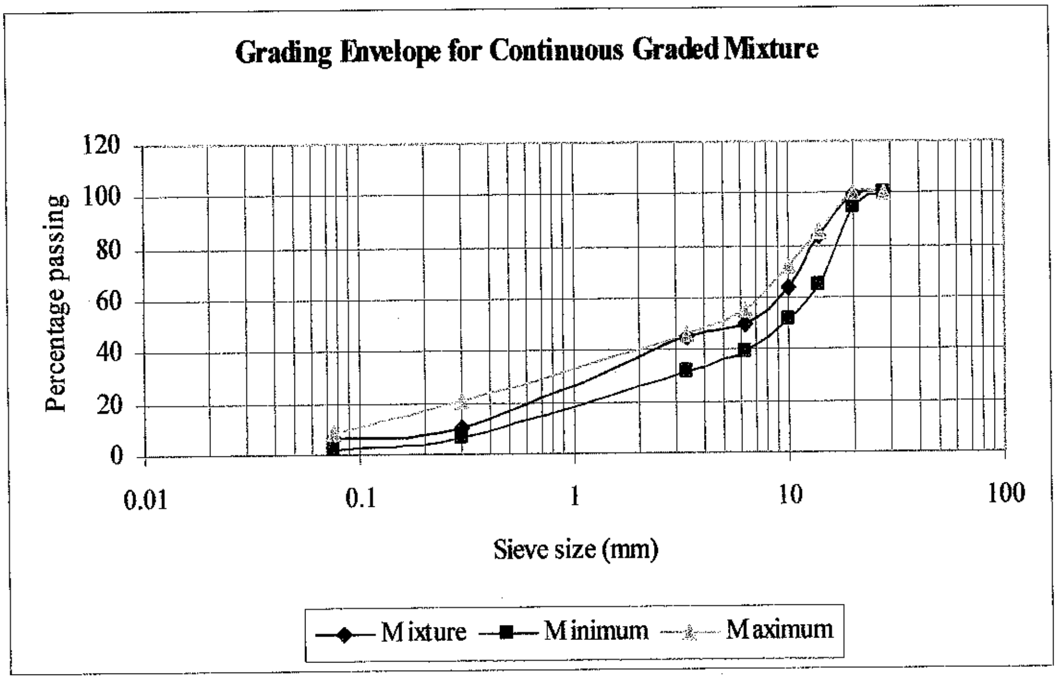

Figure 7: Grading envelope for continuous graded mixture

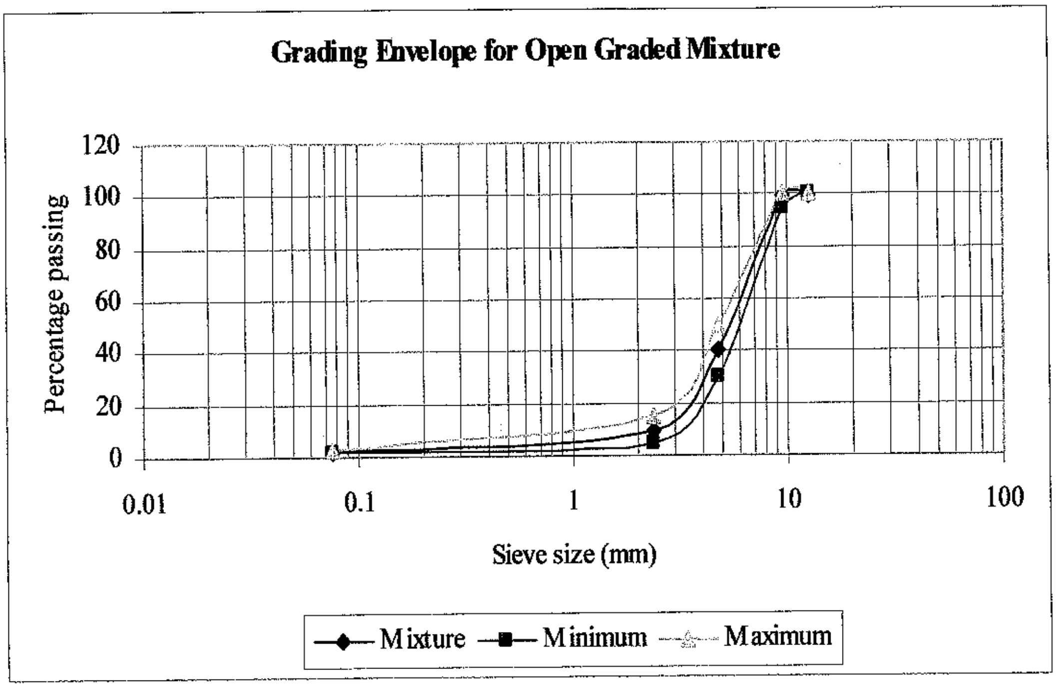

Figure 8: Grading envelope for open graded mixture

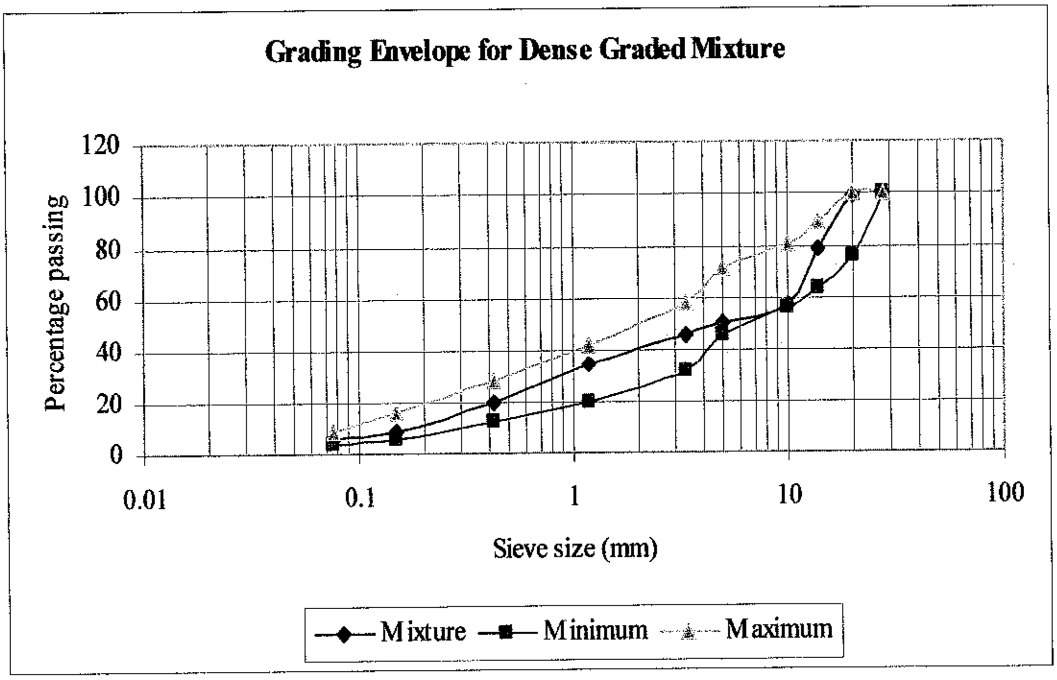

Figure 9: Grading envelope for dense graded mixture

4.2 MARSHALL STABILITY TEST

In Marshall Mix, three samples were prepared for each bitumen contents. The optimum binder content (OBC) for each gradation is determined through the Marshall Stability Test. The weight of the samples in air and in water, diameter, height and Marshall Stability value for each samples are presented in Appendix 2. The following are the summary of the results. Also, the steps in determining the OBC are discussed below. From literature review, the following specific gravity is used for the OBC calculation.

Table 12: Specific gravity for aggregates and filler

Type		Bulk specific gravity
Coarse	Crushed granite	2.61
Fine	River sand	2.60
Filler	OPC	3.15

4.2.1 Gap Graded

For gap graded mixture, 15 samples were prepared, ranging from 5.5 % to 7.5 %. The voids in mineral aggregates (VMA) and voids in total mix values are obtained from calculation. Refer Appendix 3 for sample calculation.

Table 13: Summary of Marshall Stability result for gap graded mixture

Bitumen content (%)	Weight (g)		Diameter (mm)	Height (mm)	Marshall Test	
	in air	in water			Load (kN)	Flow (mm)
5.5	1239.2	688.7	102.85	68.22	10.66	3.22
6.0	1257.8	694.2	102.72	69.92	9.76	3.37
6.5	1256.7	692.3	102.42	69.83	6.23	3.19
7.0	1266.3	707.2	102.52	68.97	6.88	4.99
7.5	1284.8	726.3	103.64	67.97	5.37	5.37

Table 14: Values for OBC calculation

Bitumen content (%)	Bulk density	Stability	Flow	VMA	Voids in total mix
5.5	2.25	10.66	3.22	20.07	7.79
6.0	2.23	9.76	3.37	19.99	7.85
6.5	2.23	6.23	3.19	20.42	7.08
7.0	2.26	6.88	4.99	19.78	5.44
7.5	2.30	5.37	5.37	19.72	2.95

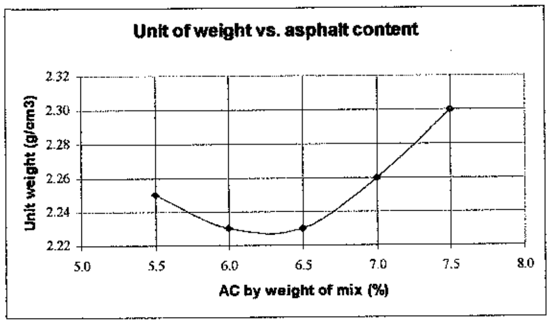

Figure 10: Unit weight vs. asphalt content

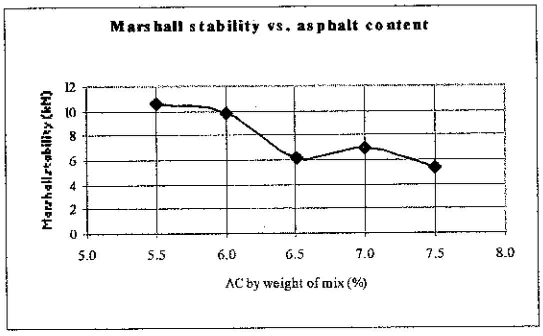

Figure 11: Stability vs. asphalt content

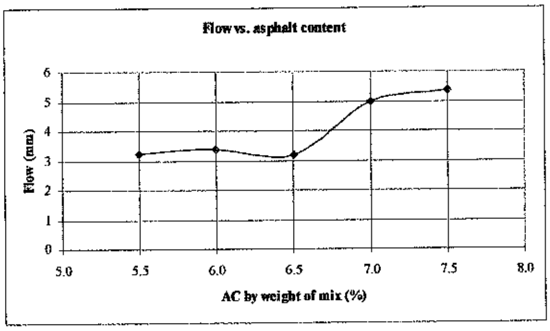

Figure 12: Flow vs. asphalt content

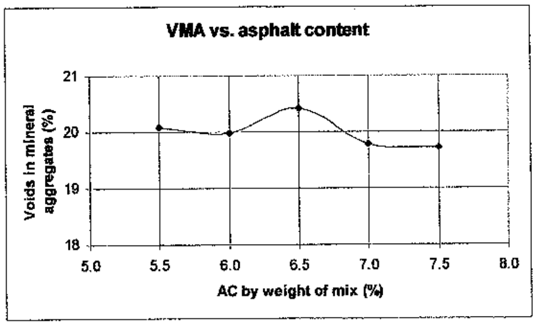

Figure 13: VMA vs. asphalt content

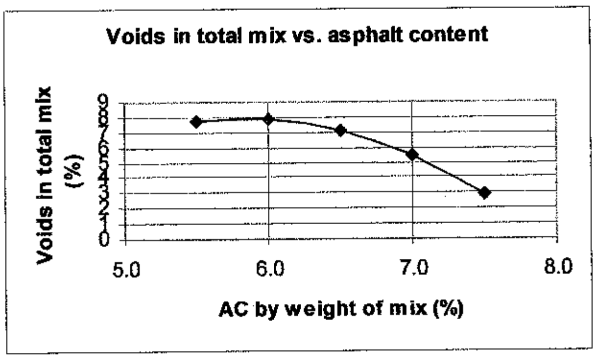

Figure 14: Voids in total mix vs. asphalt content

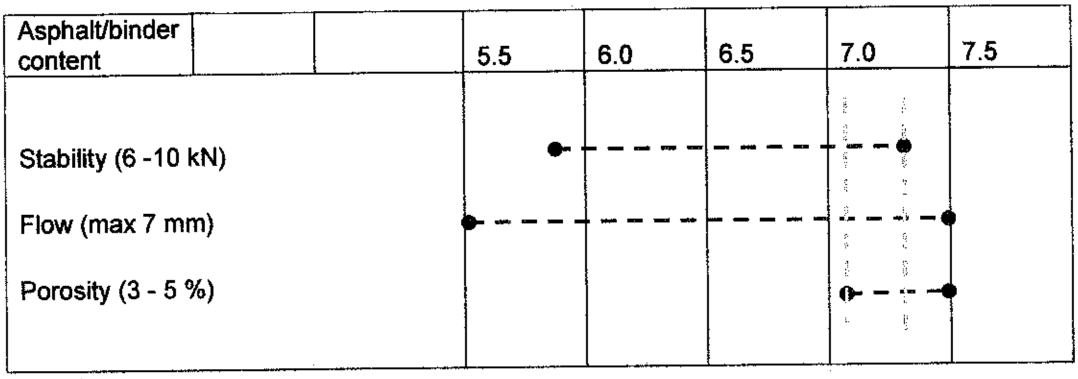

Figure 15: Determining OBC for gap graded mixture

The stability, flow and porosity lines intersect between binder content 7.1 % to 7.3 %. Thus, taking the mean of these values, the OBC for gap graded mixture is 7.2 %.

4.2.2 Continuous Graded

For continuous graded mixture, 12 samples were prepared, ranging from 4.0 % to 5.5 %.

Table 15: Summary of Marshall Stability result for continuous graded mixture

Bitumen content (%)	Weight (g)		Diameter (mm)	Height (mm)	Marshall Test	
	in air	in water			Load (kN)	Flow (mm)
4.0	1218.8	703.5	103.87	65.27	17.98	4.62
4.5	1236.0	711.0	103.61	65.14	12.49	4.86
5.0	1228.2	709.0	102.51	65.55	14.21	4.49
5.5	1229.7	706.3	104.57	63.80	9.85	3.93

Table 16: Values for OBC calculation

Bitumen content (%)	Bulk density	Stability	Flow	VMA	Voids in total mix
4.0	2.35	17.98	4.62	14.55	5.66
4.5	2.36	12.49	4.86	14.99	4.68
5.0	2.37	14.21	4.49	14.72	3.84
5.5	2.35	9.85	3.93	15.88	3.70

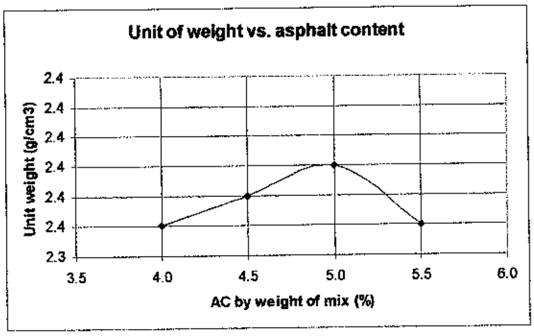

Figure 16: Unit weight vs. asphalt content

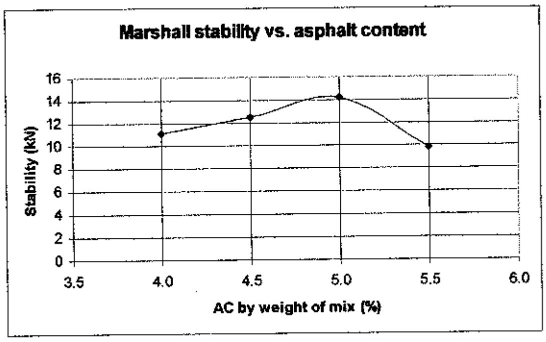

Figure 17: Stability vs. asphalt content

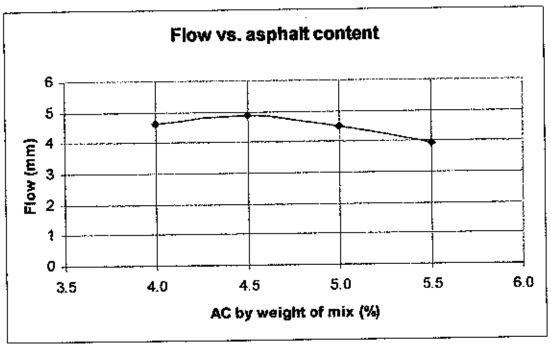

Figure 18: Flow vs. asphalt content

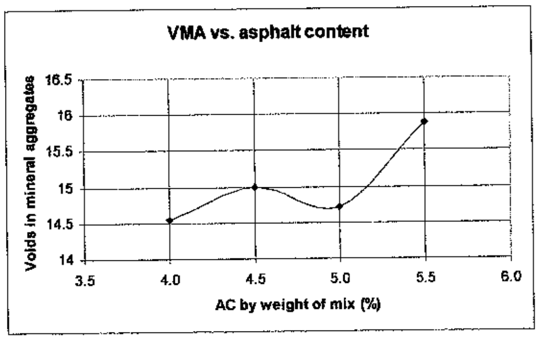

Figure 19: VMA vs. asphalt content

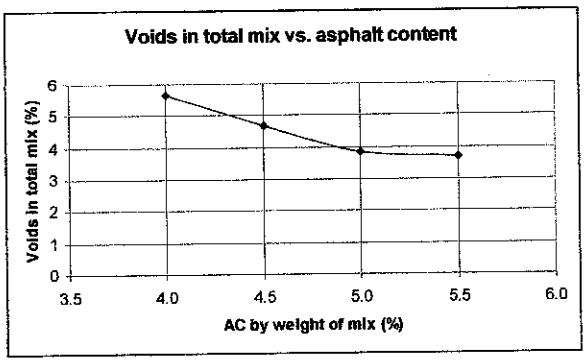

Figure 20: Voids in total mix vs. asphalt content

The asphalt content having the maximum value of unit weight and stability is selected from each of the respective plots.

Max unit weight = 5.0 %

Max stability = 4.9 %

Percent air voids in compacted mixture using mean of limits given in the JKR Standard Specification for Road Works [that is, (3 + 5)/2 = 4] = 4.90 %

Therefore, the optimum asphalt content or OBC for continuous graded mixture is;

$$\frac{5.0 + 4.90 + 4.90}{3} = \mathbf{4.93\ \%}$$

4.2.3 Open Graded

For open graded mixture, 15 samples were prepared, ranging from 3.0 % to 5.0 %.

Table 17: Summary of Marshall Stability result for open graded mixture

Bitumen content (%)	Weight (g)		Diameter (mm)	Height (mm)	Marshall Test	
	in air	in water			Load (kN)	Flow (mm)
3.0	1225.8	708.5	103.32	80.98	4.56	5.45
3.5	1224.5	714.0	102.71	81.53	5.37	3.04
4.0	1231.0	714.2	102.68	82.81	1.71	4.59
4.5	1235.2	710.0	101.48	82.83	3.77	2.52
5.0	1251.7	713.5	103.70	81.89	2.16	4.97

Table 18: Values for OBC calculation

Bitumen content (%)	Bulk density	Stability	Flow	VMA	Voids in total mix
3.0	2.37	4.56	5.45	15.79	6.32
3.5	2.40	5.37	3.04	15.16	4.38
4.0	2.38	1.71	4.59	16.31	4.42
4.5	2.35	3.77	2.52	17.79	4.86
5.0	2.33	2.16	4.97	18.92	5.28

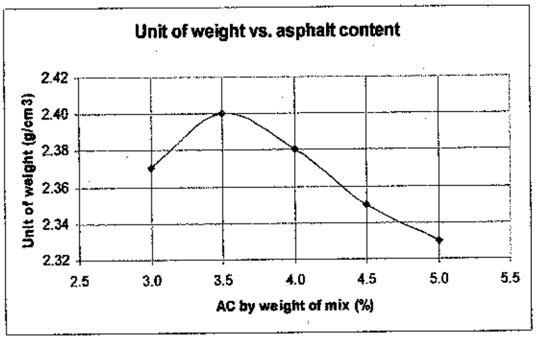

Figure 21: Unit weight vs. asphalt content

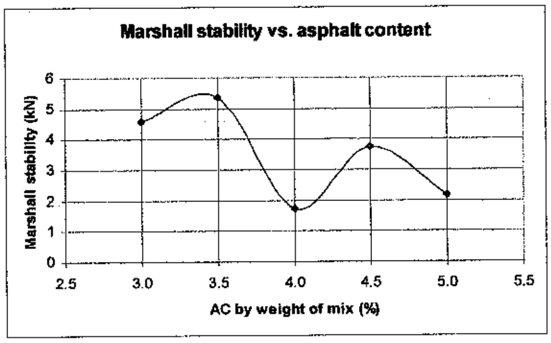

Figure 22: Stability vs. asphalt content

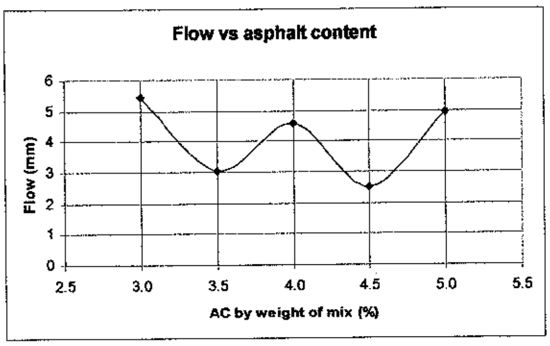

Figure 23: Flow vs. asphalt content

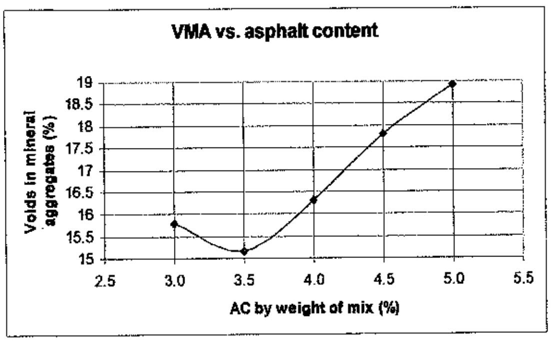

Figure 24: VMA vs. asphalt content

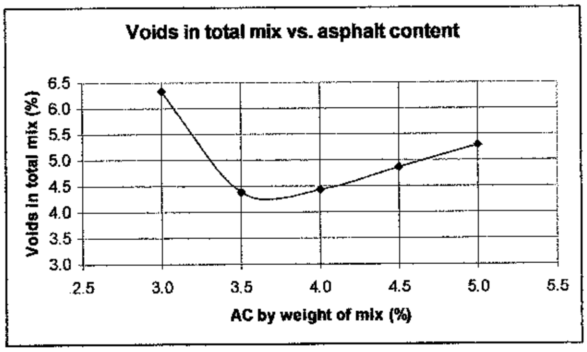

Figure 25: Voids in total mix vs. asphalt content

The asphalt content having the maximum value of unit weight and stability is selected from each of the respective plots.

Max unit weight = 3.5 %

Max stability = 3.4 %

Percent air voids in compacted mixture using maximum limits of 5 % = 3.3 %

Therefore, the optimum asphalt content or OBC for continuous graded mixture is;

$$\frac{3.5+3.4+3.3}{3} = \mathbf{3.40\%}$$

4.2.4 Dense Graded

For dense graded mixture, 24 samples were prepared, ranging from 3.0 % to 6.5 %.

Table 19: Summary of Marshall Stability result for dense graded mixture

Bitumen content (%)	Weight (g)		Diameter (mm)	Height (mm)	Marshall Test	
	in air	in water			Load (kN)	Flow (mm)
3.0	1229.2	690.3	101.68	69.00	10.36	2.61
3.5	1232.8	712.2	103.81	65.66	12.45	3.51
4.0	1225.7	709.7	103.87	64.77	14.13	0.29
4.5	1224.5	710.5	101.58	66.89	21.00	1.62
5.0	1210.7	702.3	102.77	64.20	14.45	2.79
5.5	1248.2	728.5	103.67	63.37	12.83	4.07
6.0	1241.0	725.3	103.73	63.01	10.36	4.98
6.5	1221.2	710.2	103.92	62.93	9.56	5.56

Table 20: Values for OBC calculation

Bitumen content (%)	Bulk density	Stability	Flow	VMA	Voids in total mix
3.0	2.28	10.36	2.61	16.23	9.88
3.5	2.37	12.45	3.51	13.37	5.58
4.0	2.38	14.13	0.29	13.45	4.42
4.5	2.38	21.00	1.62	13.91	3.64
5.0	2.38	14.45	2.79	14.36	3.25
5.5	2.40	12.83	4.07	14.09	1.64
6.0	2.41	10.36	4.98	14.19	0.41
6.5	2.39	9.56	5.56	15.35	0.42

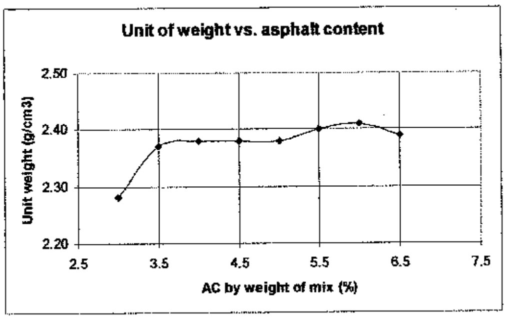

Figure 26: Unit weight vs. asphalt content

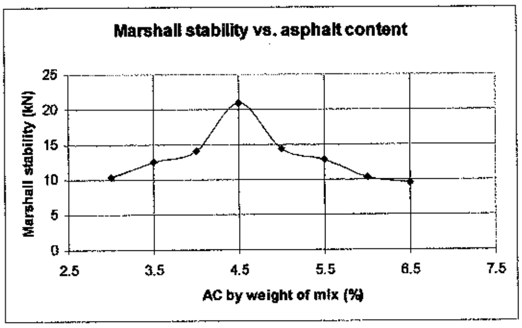

Figure 27: Stability vs. asphalt content

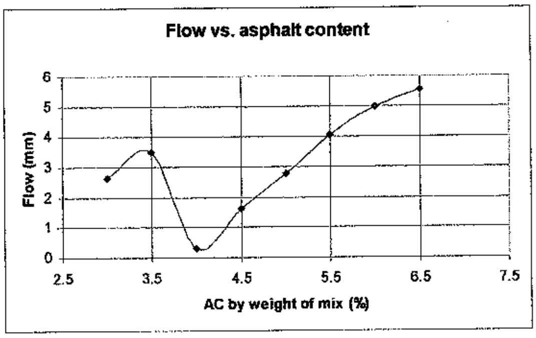

Figure 28: Flow vs. asphalt content

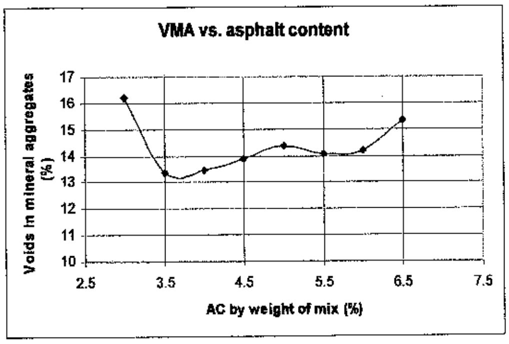

Figure 29: VMA vs. asphalt content

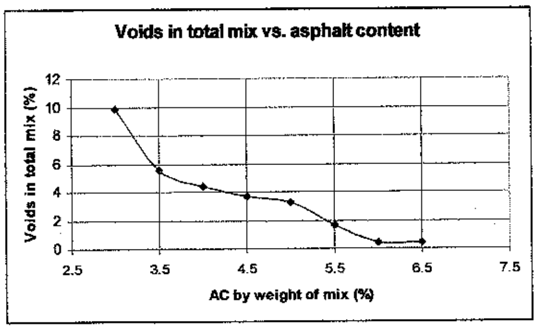

Figure 30: Voids in total mix vs. asphalt content

The asphalt content having the maximum value of unit weight and stability is selected from each of the respective plots.

Max unit weight = 6.0 %

Max stability = 4.5 %

Percent air voids in compacted mixture using mean of limits given in the JKR Standard Specification for Road Works [that is, (3 + 5)/2 = 4] = 3.42 %

Therefore, the optimum asphalt content or OBC for dense graded mixture is;

$$\frac{6.0 + 4.5 + 3.42}{3} = \mathbf{4.64\ \%}$$

4.3 DYNAMIC CREEP TEST

From the Dynamic Creep Test conducted, the creep stiffness for each samples are recorded (refer Appendix 4). The following table discussed the summary of the results.

The S_{mix} average refers to the average creep stiffness of mixture based on the Dynamic Creep Test results. Referring to "*Nomograph for stiffness modulus of bitumen*" in Appendix 5, the stiffness modulus of bitumen, S_{bit} are as follow:

Table 21: Summary of results from Dynamic Creep Test (S_{mix}) and S_{bit}

Cycles	Time of loading (s)	S_{mix} average (MPa)				S_{bit} (MPa)
		Gap	Continuous	Open	Dense	
10	20	19.562	44.531	29.904	150.433	1.50E-03
20	40	15.275	35.38	19.761	117.495	1.00E-03
30	60	13.365	30.989	17.479	103.902	7.50E-04
60	120	10.873	25.259	14.338	82.997	5.00E-04
180	360	8.126	18.848	10.63	56.016	1.00E-04
420	840	6.618	15.273	7.947	40.488	8.00E-05
600	1200	6.115	14.028	6.761	34.908	7.00E-05
1200	2400	5.356	11.831	5.327	25.576	1.05E-05
1800	3600	5.066	10.551	4.605	20.786	1.00E-05

Graph S_{mix} average vs. S_{bit} for all gradations are plotted (refer Figure 31). From the graph, linear equations for the new S_{mix} are obtained (equations are displayed on Figure 31). To find the rut depth, the first step is to calculate the viscous component of the stiffness modulus of the bitumen, $(S_{bit})v$. Refer Appendix 7 for sample calculation.

$$(Sbit)v = \frac{3\eta}{NT_w}$$

$(S_{bit})v$ = the viscous component of the stiffness modulus of the bitumen

η = the viscosity of the bitumen as a function of PI and ring and ball temperature from Appendix 6.

N = the number of wheel passes in standard axles

T_w = the time loading for one wheel pass, taken as 0.02s

The rut depth is then calculated using the stiffness linear relationship obtained from Figure 31. The equation below is used to calculate the rut depth:

$$R_d = C_m \times H \times \left(\frac{\sigma_{av}}{S_{mix}} \right)$$

R_d = calculated rut depth of the pavement in mm

C_m = correlation factor for dynamic effect, varying from 1.0 to 2.0, taken as 1.5

H = pavement layer thickness, assumed 65mm

σ_{av} = average stress in the pavement, related to wheel loading and stress, taken as 2.5 MPa

S_{mix} = stiffness of the design mixture derived from creep test at a certain value of stiffness which is related to the viscous part of the bitumen

From the calculations using the above equation, a relationship between rut depths and cycles to standard axial loading can be established as in Figure 32. The following table shows the summary of calculated new S_{mix}, $(S_{bit})v$ and rut depth.

Table 22: Calculated results for S_{mix}, $(S_{bit})v$, and rut depth

N	*Smix (MPa)				Sbit vis (MPa)	Rut depth (mm)			
	Gap	Continuous	Open	Dense		Gap	Continuous	Open	Dense
1.E+00	75.996	193.678	178.673	1319.953	7.50E-01	3.207	1.259	1.364	0.185
1.E+01	42.736	105.579	83.899	565.534	7.50E-02	5.704	2.309	2.905	0.431
1.E+02	24.032	57.555	39.397	242.303	7.50E-03	10.143	4.235	6.187	1.006
1.E+03	13.514	31.375	18.499	103.815	7.50E-04	18.037	7.769	13.176	2.348
1.E+04	7.600	17.103	8.687	44.479	7.50E-05	32.074	14.252	28.060	5.480
1.E+05	4.274	9.324	4.079	19.057	7.50E-06	57.037	26.144	59.757	12.790
1.E+06	2.403	5.083	1.915	8.165	7.50E-07	101.427	47.958	127.259	29.853

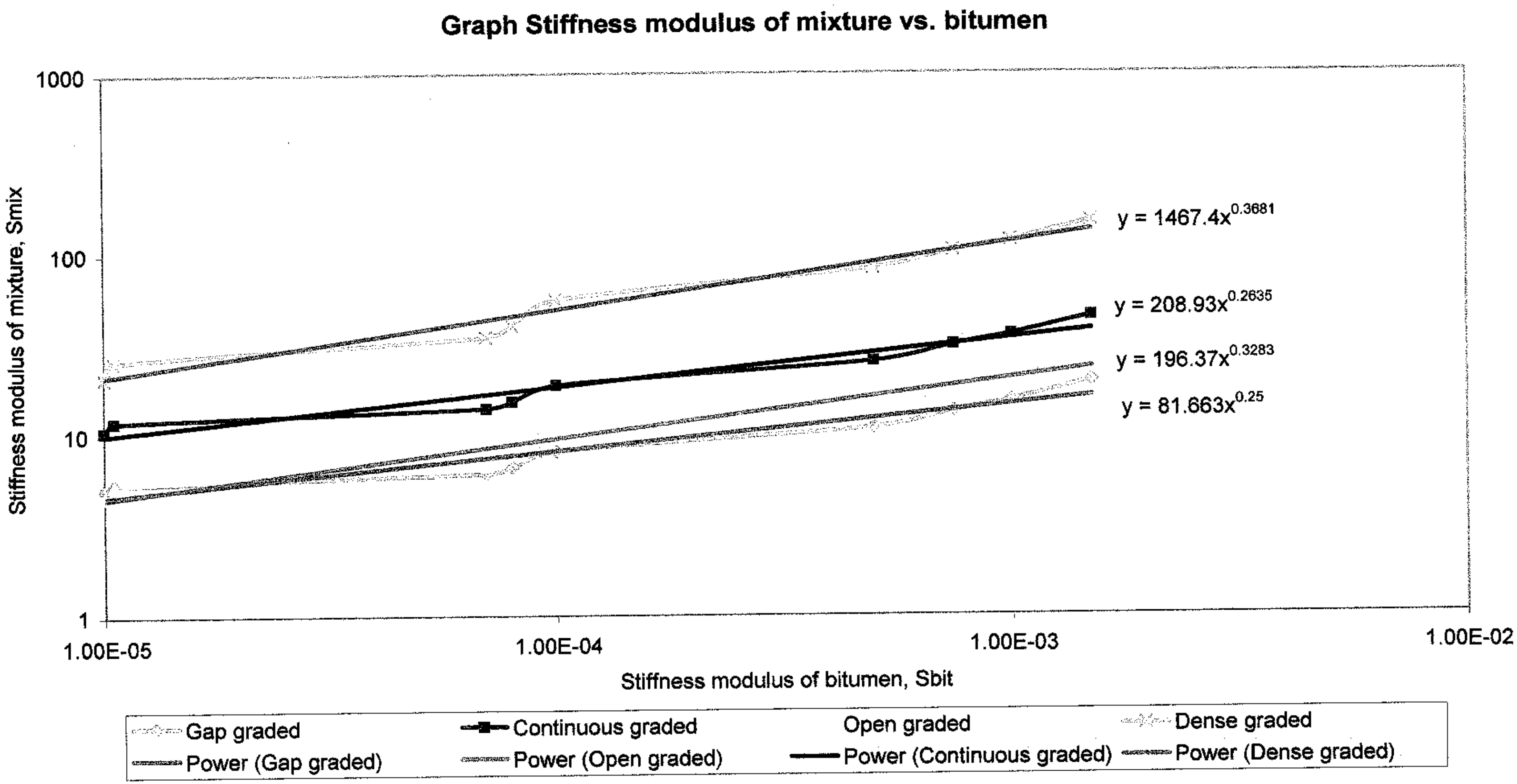

Figure 31: Graph stiffness modulus of mixture vs. bitumen

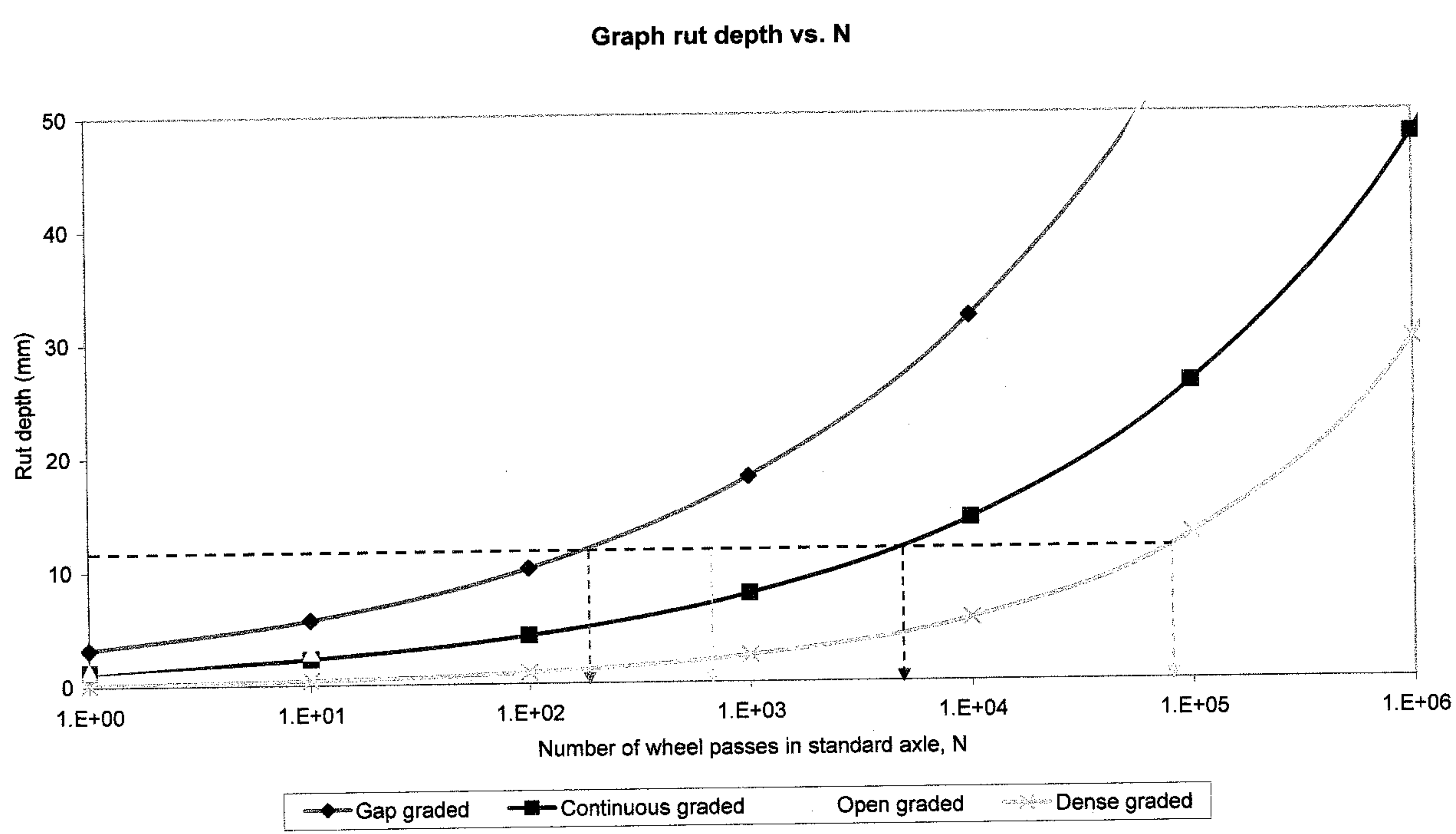

Figure 32: Graph rut depth vs. number of wheel pass in standard axle, N

As shown in Figure 32, the gradation with the highest rut depth is gap graded mixture, followed by open graded and continuous graded mixture. Dense graded mixture shows the lowest rut depth, thus indicating the highest resistance to creep. As discussed by Uzan (2004), 12 mm rut depth is taken as the maximum allowable rut depth for maintenance purposes. Referring to Figure 32, at 12 mm rut depth the N (numbers of wheels pass at standard axle) values are as follow:

Gap graded	1.9×10^2
Continuous graded	6.8×10^2
Open graded	5.0×10^3
Dense graded	8.0×10^4

The values indicate that the expected maintenance to be carried out for each gradation is at the specified N. Dense graded mixture shows the highest value of N thus indicates the most stable mixture.

For gap graded mixture, the coarse aggregate used is only 25 %, while the fine aggregate used is 63 %. From previous study by Huber and Heiman (1987), the mix that cause rutting problem was oversand mix. Since the amount of coarse aggregate is small, the stone-on-stone contact is minimal. Stone-on-stone contact is very important as bituminous mixture develop their strength from both aggregate interlock and viscosity of the binder. Coarse aggregate are more likely to establish physical contact or interlock due to their larger sizes. Interlock properties has shown to be significant for increased rutting resistance of the surface courses in high volume roads (Pan et al., 2006).

Comparing gap graded mixture with open graded mixture; the coarse aggregate used in open graded mixture is much higher (90 %) that those used in gap graded mixture (25 %). This proves that the interlock property is significant in rutting resistance. Thus, this shows that rutting resistance of bituminous mixture depends on the stability of aggregate structure in the mixture. While conducting the Dynamic Creep Test, two samples from open graded mixtures failed. Though the average rut depth shows that open graded mixture is the third best mixture in term of creep resistance, other aspects such as durability and strength must also be considered.

For dense graded mixture, the coarse aggregate used is 51 %, the fine aggregate used is 42 % while the filler used is 7 %. As compared to gap graded and open graded mixture, the coarse aggregate and fine aggregate used is "optimum"; not too much coarse aggregate, not too much fine aggregate. The optimum content of coarse aggregate gives good interlocks property, while optimum amount of fine aggregate helps to fill the air voids. From Abdullah et al. (1998), air voids play important role in the durability and stability of pavement. High permeability to air causes embrittlement of bituminous binder due to oxidation, causing the pavement to crack. High permeability to water encourages stripping of the bitumen from aggregate particles, and endangering the subgraded layer and the base course as well. Low voids contents, is one of the main factors in causing rutting of pavement.

While for continuous graded mixture, the coarse aggregate used is 54 %, the fine aggregate used is 38 %, and the filler used is 8 %. The aggregate proportions are similar to dense graded, but continuous graded mixture shows lower rut resistance compared to dense graded mixture. The rut resistance is higher compared to open graded and gap graded mixtures.

The dense graded mixture shows the highest rut resistance, thus highest creep resistance. Apart from good rut resistance, the dense graded mixture also has other advantages. From previous studies, it is shown that using the dense graded mixture can increase the crack resistance, and increase pavement lifespan.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This project investigated the relationship between aggregate gradation and creep performance. There were four gradations studied, which are the gap graded, continuous graded, open graded, and dense graded mixture. The following are the summary of all experimental results.

Table 23: Summary of all experimental results

Properties		Gap Graded	Continuous Graded	Open Graded	Dense Graded
Mixture	Coarse	25 %	54 %	90 %	51 %
	Fine	63 %	38 %	7.50 %	42 %
	Filler	12 %	8 %	2.50 %	7 %
	OBC	7.20 %	4.93 %	3.40 %	4.64 %
Ranking on rut resistance		4	2	3	1

From the rut depth result, it can be concluded that dense graded mixture has the highest creep resistance, followed by continuous graded mixture, open graded mixture and gap graded mixture. Thus, it can be said that, based on the experimental result, the best mix for creep resistance is the dense graded mixture. The objectives of the project are achieved.

5.2 RECOMMENDATION

There are several aspects that can be improved for this project. For the Marshall Mix sample preparation, the used of Gyratory Compactor will enhance the quality of sample, thus improving the overall result. In Gyratory compaction, the test involves placing sample of hot mould and applying a static pressure of a controlled magnitude. The mould is then gyrated to allow aggregate particles to reorientate themselves under loading.

Tests for aggregate must also be conducted to get more accurate results. In this experiment, the specific gravities of aggregates are taken from literature review. Hence, the actual value may differ from the one used in calculation. Also, other tests such as flakiness and elongation index, and Los Angeles abrasion test should be conducted to study the affect of aggregates shape on the rutting behavior. Different types of aggregates may affect the creep performance of bituminous mixtures. Different aggregates have different properties, thus may affect its creep performance. Further study should be conducted to study this relationship.

In future, the creep performance can be studied by varying the aggregates types. Example of coarse aggregate that can be used is crushed limestone, while fine aggregate that can be used is mining sand. Apart from studying the aggregate properties and its effects on creep performance, other tests such as fatigue test and wheel tracking test can be conducted to measure the strength and durability of the mixture. The environmental and cost analyses should also be conducted.

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APPENDIX

ENDIX 1-a

ulation for determining aggregates proportion for Gap Graded Mixture:

Analysis Result: Coarse Aggregate

Size	Sieve weight (kg)	Weight Retained (kg)						Average weight retained	% by weight retained
		Trial 1		Trial 2		Trial 3			
		Agg + sieve	Agg	Agg + sieve	Agg	Agg + sieve	Agg		
.00	1.384	1.384	0.000	1.393	0.009	1.391	0.007	0.005	0.27
.00	1.135	1.861	0.726	1.867	0.732	1.826	0.691	0.716	35.82
.00	1.106	1.858	0.752	1.845	0.739	1.904	0.798	0.763	38.15
36	1.138	1.659	0.521	1.654	0.516	1.640	0.502	0.513	25.65
00	0.985	0.986	0.001	0.989	0.004	0.987	0.002	0.002	0.12
								Total	100.00

Size	Sieve weight (kg)	Weight (kg) and Percentage (%) Passing						Average Weight Passing	Average % Passing
		Trial 1		Trial 2		Trial 3			
		Weight (kg)	%	Weight (kg)	%	Weight (kg)	%		
).00	0.610	2.000	100.00	1.991	99.55	1.993	99.65	1.995	99.73
.00	0.507	1.274	63.70	1.259	62.95	1.302	65.10	1.278	63.92
).00	0.500	0.522	26.10	0.520	26.00	0.504	25.20	0.515	25.77
.36	0.390	0.001	0.05	0.004	0.20	0.002	0.10	0.002	0.12
.00	0.393	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00

e Analysis Result: Fine Aggregate

e Size	Sieve weight (kg)	Weight Retained (kg)						Average weight retained	% by weight retained
		Trial 1		Trial 2		Trial 3			
		Agg + sieve	Agg	Agg + sieve	Agg	Agg + sieve	Agg		
360	0.389	0.429	0.040	0.436	0.047	0.429	0.040	0.042	8.47
600	0.340	0.512	0.172	0.519	0.179	0.525	0.185	0.179	35.73
212	0.276	0.530	0.254	0.524	0.248	0.530	0.254	0.252	50.40
.075	0.255	0.287	0.032	0.279	0.024	0.274	0.019	0.025	5.00
.000	0.393	0.395	0.002	0.395	0.002	0.395	0.002	0.002	0.40
								Total	100.00

e Size	Sieve weight (kg)	Weight (kg) and Percentage (%) Passing						Average Weight Passing	Average % Passing
		Trial 1		Trial 2		Trial 3			
		Weight (kg)	%	Weight (kg)	%	Weight (kg)	%		
.360	0.389	0.460	92.00	0.453	90.60	0.460	92.00	0.458	91.53
.600	0.340	0.288	57.60	0.274	54.80	0.275	55.00	0.279	55.80
.212	0.276	0.034	6.80	0.026	5.20	0.021	4.20	0.027	5.40
.075	0.255	0.002	0.40	0.002	0.40	0.002	0.40	0.002	0.40
.000	0.393	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00

culation for determining proportions of aggregates to obtain required gradation

ssing sieve	Average % by weight passing			JKR Standard	
	Coarse (A)	Fine (B)	Filler (C)	Minimum	Maximum
20	99.73	100.00	100.00	100	100
14	63.92	100.00	100.00	85	100
10	25.77	100.00	100.00	60	90
2.36	0.12	91.53	100.00	60	72

.6	0.00	55.80	100.00	45	72
212	0.00	5.40	100.00	15	50
)75	0.00	0.40	80.00	8	12

bB + cC = P

mix:	1	2
se (%	35	25
(%)	55	63
(%)	10	12

L 1 (a=35%, b=55%, c=10%)

ssing	Average % by weight passing			
eve	Coarse (A)	Fine (B)	Filler (C)	Total
20	34.91	55.00	10.00	100
14	35.16	55.00	10.00	100
10	14.17	55.00	10.00	79
.36	0.07	50.34	10.00	60
).6	0.00	30.69	10.00	[redacted]
212	0.00	2.97	10.00	
075	0.00	0.22	8.00	8

[redacted] total aggregate not in the limit specified by BS 594

L 2 (a=25%, b=63%, c=12%)

ssing	Average % by weight passing			
eve	Coarse (A)	Fine (B)	Filler (C)	Total
20	24.93	63.00	12.00	100
14	15.98	63.00	12.00	91
10	6.44	63.00	12.00	81
.36	0.03	57.66	12.00	70
0.6	0.00	35.15	12.00	47
.212	0.00	3.40	12.00	15
.075	0.00	0.25	9.60	10

om calculation, Trial 2 meets the gradation limit specified by BS 594.
s, the proportions of aggregate requires to obtain the Gap Graded mix are:

coarse aggregate, 63% fine aggregate, and 12% filler

ENDIX 1-b

ulation for determining aggregates proportion for Continuous Graded Mixture:

Analysis Result: Coarse Aggregate

e Size	Sieve weight (kg)	Weight Retained (kg)						Average weight retained	% by weight retained
		Trial 1		Trial 2		Trial 3			
		Agg + sieve	Agg	Agg + sieve	Agg	Agg + sieve	Agg		
.00	1.495	1.495	0.000	1.495	0.000	1.495	0.000	0.000	0.00
.00	1.406	1.432	0.026	1.409	0.003	1.406	0.000	0.010	0.48
.00	1.119	1.809	0.690	1.718	0.599	1.613	0.494	0.594	29.72
.00	1.105	1.892	0.787	1.790	0.685	1.818	0.713	0.728	36.42
.30	1.290	1.734	0.444	1.850	0.560	1.829	0.539	0.514	25.72
.00	0.767	0.820	0.053	0.920	0.153	1.021	0.254	0.153	7.67
								Total	100.00

e Size	Sieve weight (kg)	Weight (kg) and Percentage (%) Passing						Average Weight Passing	Average % Passing
		Trial 1		Trial 2		Trial 3			
		Weight (kg)	%	Weight (kg)	%	Weight (kg)	%		
3.00	1.495	2.000	100.00	2.000	100.00	2.000	100.00	2.000	100.00
.00	1.406	1.974	98.70	1.997	99.85	2.000	100.00	1.990	99.52
4.00	1.119	1.284	64.20	1.398	69.90	1.506	75.30	1.396	69.80
.00	1.105	0.497	24.85	0.713	35.65	0.793	39.65	0.668	33.38
.30	1.290	0.053	2.65	0.153	7.65	0.254	12.70	0.153	7.67
.00	0.767	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00

e Analysis Result: Fine Aggregate

e Size	Sieve weight (kg)	Weight Retained (kg)						Average weight retained	% by weight retained
		Trial 1		Trial 2		Trial 3			
		Agg + sieve	Agg	Agg + sieve	Agg	Agg + sieve	Agg		
.300	0.512	0.513	0.001	0.512	0.000	0.513	0.001	0.001	0.13
.350	0.484	0.498	0.014	0.498	0.014	0.498	0.014	0.014	2.80
.300	0.280	0.728	0.448	0.734	0.454	0.728	0.448	0.450	90.00
.075	0.255	0.290	0.035	0.285	0.030	0.290	0.035	0.033	6.67
.000	0.393	0.395	0.002	0.395	0.002	0.395	0.002	0.002	0.40
								Total	100.00

e Size	Sieve weight (kg)	Weight (kg) and Percentage (%) Passing						Average Weight Passing	Average % Passing
		Trial 1		Trial 2		Trial 3			
		Weight (kg)	%	Weight (kg)	%	Weight (kg)	%		
.300	0.512	0.499	99.80	0.500	100.00	0.499	99.80	0.499	99.87
.350	0.484	0.485	97.00	0.486	97.20	0.485	97.00	0.485	97.07
.300	0.280	0.037	7.40	0.032	6.40	0.037	7.40	0.035	7.07
.075	0.255	0.002	0.40	0.002	0.40	0.002	0.40	0.002	0.40
.000	0.393	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00

ılation for determining proportions of aggregates to obtain required gradation

ısing ɘve	Average % by weight passing			JKR Standard	
	Coarse (A)	Fine (B)	Filler (C)	Minimum	Maximum
:8	100.00	100.00	100.00	100	100
:0	99.52	100.00	100.00	95	100
4	69.80	100.00	100.00	65	85
0	33.38	100.00	100.00	52	72
.3	7.67	99.87	100.00	39	55
35	0.00	97.07	100.00	32	46
ı.3	0.00	7.07	100.00	7	21
ͻ75	0.00	0.40	80.00	2	8

bB + cC = P

mix:	1	2	3
se (%	50	52	54
(%)	42	40	38
(%)	8	8	8

ΑL 1

ssing eve	Average % by weight passing			
	Coarse (A)	Fine (B)	Filler (C)	Total
28	50.00	42.00	8.00	100.00
20	49.76	42.00	8.00	99.76
14	34.90	42.00	8.00	84.90
10	16.69	42.00	8.00	66.69
3.3	3.39	41.95	8.00	53.34
ı.35	0.00	40.77	8.00	[redacted]
ͻ.3	0.00	2.97	8.00	10.97
.075	0.00	0.17	6.40	6.57

[redacted] total aggregate not in the limit specified by JKR Standard

ΑL 2

ssing ieve	Average % by weight passing			
	Coarse (A)	Fine (B)	Filler (C)	Total
28	52.00	40.00	8.00	100.00
20	51.75	40.00	8.00	99.75
14	36.30	40.00	8.00	84.30
10	17.36	40.00	8.00	65.36
6.3	3.99	39.95	8.00	51.94
3.35	0.00	38.83	8.00	[redacted]
0.3	0.00	2.83	8.00	10.83
ı.075	0.00	0.16	6.40	6.56

AL 3

ıssing ıieve	Average % by weight passing			
	Coarse (A)	Fine (B)	Filler (C)	Total
28	54.00	38.00	8.00	100.00
20	53.74	38.00	8.00	99.74
14	37.69	38.00	8.00	83.69
10	18.03	38.00	8.00	64.03
6.3	4.14	37.95	8.00	50.09

35	0.00	36.89	8.00	44.89
.3	0.00	2.69	8.00	10.69
)75	0.00	0.15	6.40	6.55

ım calculation, Trial 3 meets the gradation limit specified by JKR.
, the proportions of aggregate requires to obtain the Continuous Graded mix are:

coarse aggregate, 38% fine aggregate, and 8% filler

ENDIX 1-c

ulation for determining aggregates proportion for Open Graded Mixture:

e Analysis Result: Coarse Aggregate

e Size	Sieve weight (kg)	Weight Retained (kg)						Average weight retained	% by weight retained
		Trial 1		Trial 2		Trial 3			
		Agg + sieve	Agg	Agg + sieve	Agg	Agg + sieve	Agg		
.50	1.375	1.380	0.005	1.382	0.007	1.390	0.015	0.009	0.45
50	1.358	1.363	0.005	1.381	0.023	1.365	0.007	0.012	0.58
75	1.223	2.590	1.367	2.540	1.317	2.470	1.247	1.310	65.52
36	1.138	1.757	0.619	1.788	0.650	1.867	0.729	0.666	33.30
0	0.985	0.989	0.004	0.988	0.003	0.987	0.002	0.003	0.15
								Total	100.00

e Size	Sieve weight (kg)	Weight (kg) and Percentage (%) Passing						Average Weight Passing	Average % Passing
		Trial 1		Trial 2		Trial 3			
		Weight (kg)	%	Weight (kg)	%	Weight (kg)	%		
2.50	1.375	1.995	99.75	1.993	99.65	1.985	99.25	1.991	99.55
.50	1.358	1.990	99.50	1.970	98.50	1.978	98.90	1.979	98.97
.75	1.223	0.623	31.15	0.653	32.65	0.731	36.55	0.669	33.45
.36	1.138	0.004	0.20	0.003	0.15	0.002	0.10	0.003	0.15
0	0.985	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00

e Analysis Result: Fine Aggregate

e Size	Sieve weight (kg)	Weight Retained (kg)						Average weight retained	% by weight retained
		Trial 1		Trial 2		Trial 3			
		Agg + sieve	Agg	Agg + sieve	Agg	Agg + sieve	Agg		
.360	0.389	0.432	0.043	0.440	0.051	0.439	0.050	0.048	9.60
.075	0.255	0.710	0.455	0.702	0.447	0.703	0.448	0.450	90.00
.000	0.393	0.395	0.002	0.395	0.002	0.395	0.002	0.002	0.40
								Total	100.00

e Size	Sieve weight (kg)	Weight (kg) and Percentage (%) Passing						Average Weight Passing	Average % Passing
		Trial 1		Trial 2		Trial 3			
		Weight (kg)	%	Weight (kg)	%	Weight (kg)	%		
.360	0.389	0.457	91.40	0.449	89.80	0.450	90.00	0.452	90.40
.075	0.255	0.002	0.40	0.002	0.40	0.002	0.40	0.002	0.40

culation for determining proportions of aggregates to obtain required gradation

ssing sieve	Average % by weight passing			JKR Standard	
	Coarse (A)	Fine (B)	Filler (C)	Minimum	Maximum
12.5	99.55	100.00	100.00	100	100
9.5	98.97	100.00	100.00	95	100
4.75	33.45	100.00	100.00	30	50
2.36	0.15	90.40	100.00	5	15
).075	0.00	0.40	80.00	2	2.5

+ bB + cC = P

mix:	1	3
se (%	70	90
(%)	28	7.5
(%)	2	2.5

.L 1 (a=70%, b=28%, c=2%)

ising	Average % by weight passing			
eve	Coarse (A)	Fine (B)	Filler (C)	Total
2.5	69.69	28.00	2.00	100
.5	69.28	28.00	2.00	99
.75	23.42	28.00	2.00	[redacted]
.36	0.11	25.31	2.00	[redacted]
075	0.00	0.11	1.60	2

[redacted] total aggregate not in the limit specified by FHWA

L 2 (a=90%, b=7.5%, c=2.5%)

ssing	Average % by weight passing			
eve	Coarse (A)	Fine (B)	Filler (C)	Total
2.5	89.60	7.50	2.50	100
.5	89.07	7.50	2.50	99
.75	30.11	7.50	2.50	40
.36	0.14	6.78	2.50	9
075	0.00	0.03	2.00	2

om calculation, Trial 2 meets the gradation limit specified by FHWA.
s, the proportions of aggregate requires to obtain the Open Graded mix are:

coarse aggregate, 7.5% fine aggregate, and 2% filler

ENDIX 1-d

ulation for determining aggregates proportion for Dense Graded Mixture:

e Analysis Result: Coarse Aggregates

e Size (m)	Sieve weight (kg)	Weight (kg) and Percentage (%) Passing						Average weight passing	Average % by weight
		Sample 1		Sample 2		Sample 3			
		Weight (kg)	%	Weight (kg)	%	Weight (kg)	%		
.00	1.708	2.000	100.00	2.000	100.00	2.000	100.00	2.000	100.00
).00	1.600	1.971	98.55	1.979	98.95	1.933	96.65	1.961	98.05
.00	1.281	1.165	58.25	1.176	58.80	1.178	58.90	1.173	58.65
).00	1.311	0.330	16.50	0.320	16.00	0.269	13.45	0.306	15.32
.00	1.322	0.039	1.95	0.057	2.85	0.042	2.10	0.046	2.30
0	0.779	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00

e Analysis Result: Fine Aggregates

e Size	Sieve weight (kg)	Weight (kg) and Percentage (%) Passing						Average weight passing	Average % by weight
		Sample 1		Sample 2		Sample 3			
		Weight (kg)	%	Weight (kg)	%	Weight (kg)	%		
350	0.501	0.458	91.60	0.468	93.60	0.474	94.80	0.463	92.60
180	0.433	0.333	66.60	0.329	65.80	0.097	19.40	0.331	66.20
425	0.371	0.143	28.60	0.164	32.80	0.003	0.60	0.154	30.70
150	0.336	0.019	3.80	0.026	5.20	0.000	0.00	0.023	4.50
075	0.327	0.002	0.40	0.004	0.80	0.000	0.00	0.003	0.60
000	0.246	0.000	0.00	0.000	0.00	0.000	0.00	0.000	0.00

ulation for determining proportions of aggregates to obtain required gradation

ssing ieve	Average % by weight passing			JKR Standard	
	Coarse (A)	Fine (B)	Filler (C)	Minimum	Maximum
28	100.00	100.00	100.00	100	100
20	98.05	100.00	100.00	76	100
14	58.65	100.00	100.00	64	89
10	15.32	100.00	100.00	56	81
5	2.30	100.00	100.00	46	71
3.35	0.00	92.60	100.00	32	58
1.18	0.00	66.20	100.00	20	42
.425	0.00	30.70	100.00	12	28
0.15	0.00	4.50	100.00	6	16
.075	0.00	0.60	80.00	4	8

+ bB + cC = P
ere a + b + c = 1 --> eqn 1

ve size (mm):	Equation:
).425	30.7b + 100c = 20
1.18	66.2b + 100c = 31
3.35	92.6b + 100c = 45
0.15	4.50b + 100c = 11
).075	0.60b + 80c = 6

lculation for determining trial mix

Mix 1

sieve size 0.425 mm & 1.18 mm

) + 100c = 20
) + 100c = 31

ng these 2 equations, get;
).31
).10

; into eqn 1, get;
).59

, in %: a = 59%, b = 31% and c = 10%

Trial Mix 2

Take sieve size 0.425 mm & 3.35 mm

30.7b + 100c = 20
92.6b + 100c = 45

Solving these 2 equations, get;
b = 0.40
c = 0.08

b & c into eqn 1, get;
a = 0.52

Thus, in %: a = 52%, b = 40% and c = 8%

Mix 3

sieve size 0.425 mm & 0.15 mm

b + 100c = 20
b + 100c = 11

ing these 2 equations, get;
0.34
0.09

c into eqn 1, get;
0.57

s, in %: a = 57%, b = 34% and c = 9%

Trial Mix 4

Take sieve size 0.425 mm & 0.075 mm

30.7b + 100c = 20
0.60b + 80c = 6

Solving these 2 equations, get;
b = 0.42
c = 0.07

b & c into eqn 1, get;
a = 0.51

Thus, in %: a = 51%, b = 42% and c = 7%

l Mix 5

e sieve size1.18 mm & 3.35 mm

2b + 100c = 31
5b + 100c = 45

ving these 2 equations, get;
0.53
-0.04

ce the c value is -ve, eliminate this mix

Trial Mix 6

Take sieve size 1.18 mm & 0.15 mm

66.2b + 100c = 31
4.50b + 100c = 11

Solving these 2 equations, get;
b = 0.32
c = 0.10

b & c into eqn 1, get;
a = 0.58

Thus, in %: a = 58%, b = 32% and c = 10%

al Mix 7

ke sieve size 1.18 mm & 0.075 mm

2b + 100c = 31
0b + 80c = 6

Trial Mix 8

Take sieve size 3.35 mm & 0.15 mm

92.6b + 100c = 45
4.50b + 100c = 11

ng these 2 equations, get;
).36
).07

: into eqn 1, get;
).57

;, in %: a = 57%, b = 36% and c = 7%

Solving these 2 equations, get;
b = 0.39
c = 0.09

b & c into eqn 1, get;
a = 0.52

Thus, in %: a = 52%, b = 39% and c = 9%

Mix 9

; sieve size3.35 mm & 0.075 mm

b + 100c = 45
b + 80c = 6

ing these 2 equations, get;
).41
).07

c into eqn 1, get;
).52

s, in %: a = 52%, b = 41% and c = 7%

Trial Mix 10

Take sieve size 0.15 mm & 0.075 mm

4.50b + 100c = 11
0.60b + 80c = 6

Solving these 2 equations, get;
b = 0.94
c = 0.07

b & c into eqn 1, get;
a = -0.01

Since the a value is -ve, eliminate this mix

---

trial mix can be summarized as follow:

l mix:	1	2	3	4	6	7	8	9
ırse (%	59	52	57	51	58	57	52	52
; (%)	31	40	34	42	32	36	39	41
ır (%)	10	8	9	7	10	7	9	7

AL 1

ıssing	Average % by weight passing			
;ieve	Coarse (A)	Fine (B)	Filler (C)	Total
37.5				
28	59.00	31.00	10.00	100.00
20	57.85	31.00	10.00	98.85
14	34.60	31.00	10.00	75.60
10	9.04	31.00	10.00	[redacted]
5	1.36	31.00	10.00	[redacted]
3.35	0.00	28.71	10.00	38.71
1.18	0.00	20.52	10.00	30.52
).425	0.00	9.52	10.00	19.52
0.15	0.00	1.40	10.00	11.40
).075	0.00	0.19	8.00	8.19

[redacted] total aggregate not in the limit specified by JKR Standard

IAL 2

assing	Average % by weight passing			
sieve	Coarse (A)	Fine (B)	Filler (C)	Total
37.5				
28	52.00	40.00	8.00	100.00
20	50.99	40.00	8.00	98.99

4	30.50	40.00	8.00	78.50
0	7.96	40.00	8.00	[redacted]
5	1.20	40.00	8.00	49.20
35	0.00	37.04	8.00	45.04
18	0.00	26.48	8.00	34.48
425	0.00	12.28	8.00	20.28
15	0.00	1.80	8.00	9.80
075	0.00	0.24	6.40	6.64

AL 3

ssing	Average % by weight passing			
eve	Coarse (A)	Fine (B)	Filler (C)	Total
7.5				
28	57.00	34.00	9.00	100.00
20	55.89	34.00	9.00	98.89
14	33.43	34.00	9.00	76.43
10	8.73	34.00	9.00	[redacted]
5	1.31	34.00	9.00	
.35	0.00	31.48	9.00	40.48
.18	0.00	22.51	9.00	31.51
425	0.00	10.44	9.00	19.44
.15	0.00	1.53	9.00	10.53
.075	0.00	0.20	7.20	7.40

AL 4

ssing	Average % by weight passing			
ieve	Coarse (A)	Fine (B)	Filler (C)	Total
37.5				
28	51.00	42.00	7.00	100.00
20	50.01	42.00	7.00	99.01
14	29.91	42.00	7.00	78.91
10	7.81	42.00	7.00	56.81
5	1.17	42.00	7.00	50.17
3.35	0.00	38.89	7.00	45.89
1.18	0.00	27.80	7.00	34.80
.425	0.00	12.89	7.00	19.89
0.15	0.00	1.89	7.00	8.89
.075	0.00	0.25	5.60	5.85

IAL 6

assing	Average % by weight passing			
sieve	Coarse (A)	Fine (B)	Filler (C)	Total
37.5				
28	58.00	32.00	10.00	100.00
20	56.87	32.00	10.00	98.87
14	34.02	32.00	10.00	76.02
10	8.88	32.00	10.00	[redacted]
5	1.33	32.00	10.00	
3.35	0.00	29.63	10.00	39.63
1.18	0.00	21.18	10.00	31.18
0.425	0.00	9.82	10.00	19.82
0.15	0.00	1.44	10.00	11.44
0.075	0.00	0.19	8.00	[redacted]

L 7

;sing ;ve	Average % by weight passing			
	Coarse (A)	Fine (B)	Filler (C)	Total
'.5				
'8	57.00	36.00	7.00	100.00
'0	55.89	36.00	7.00	98.89
l4	33.43	36.00	7.00	76.43
l0	8.73	36.00	7.00	[redacted]
5	1.31	36.00	7.00	[redacted]
.35	0.00	33.34	7.00	40.34
.18	0.00	23.83	7.00	30.83
425	0.00	11.05	7.00	18.05
.15	0.00	1.62	7.00	8.62
075	0.00	0.22	5.60	5.82

\L 8

ssing eve	Average % by weight passing			
	Coarse (A)	Fine (B)	Filler (C)	Total
7.5				
28	52.00	39.00	9.00	100.00
20	50.99	39.00	9.00	98.99
14	30.50	39.00	9.00	78.50
10	7.96	39.00	9.00	[redacted]
5	1.20	39.00	9.00	49.20
.35	0.00	36.11	9.00	45.11
.18	0.00	25.82	9.00	34.82
.425	0.00	11.97	9.00	20.97
).15	0.00	1.76	9.00	10.76
.075	0.00	0.23	7.20	7.43

AL 9

ıssing ieve	Average % by weight passing			
	Coarse (A)	Fine (B)	Filler (C)	Total
37.5				
28	52.00	41.00	7.00	100.00
20	50.99	41.00	7.00	98.99
14	30.50	41.00	7.00	78.50
10	7.96	41.00	7.00	[redacted]
5	1.20	41.00	7.00	49.20
3.35	0.00	37.97	7.00	44.97
1.18	0.00	27.14	7.00	34.14
).425	0.00	12.59	7.00	19.59
0.15	0.00	1.85	7.00	8.85
).075	0.00	0.25	5.60	5.85

'rom calculation, Trial 4 meets the gradation limit specified by JKR.
ıs, the proportions of aggregate requires to obtain the Asphaltic Concrete are:

% coarse aggregate, 42% fine aggregate, and 7% filler

ENDIX 2

lts from Bouyancy Balance Test and Marshall Stability Test

ıp Graded

men tent	Sample	Weight (g)		Diameter (mm)	Height (mm)			Average height	Marshall Test	
		in air	in water		1	2	3		Load (kN)	Flow (mm)
	1	1254.5	699.0	104.98	66.75	66.43	66.30	66.49	6.07	1.82
.5	2	1236.0	692.5	101.96	68.65	68.02	68.54	68.40	11.43	3.88
	3	1227.0	674.5	101.62	69.57	69.67	70.04	69.76	14.47	3.95
	1	1276.5	707.5	104.62	68.72	69.01	69.57	69.10	6.93	5.68
ı.0	2	1235.0	688.0	101.87	68.36	68.23	68.37	68.32	10.48	2.78
	3	1262.0	687.0	101.66	72.21	72.49	72.36	72.35	11.86	1.64
	1	1254.5	705.5	104.15	65.62	67.04	66.13	66.26	4.03	3.64
;.5	2	1263.0	692.5	101.60	71.48	71.35	71.36	71.40	7.08	1.44
	3	1252.5	679.0	101.50	71.93	71.55	71.98	71.82	7.57	4.49
	1	1283.0	708.0	101.54	71.69	72.12	71.84	71.88	7.98	5.16
'.0	2	1248.0	695.0	104.41	66.66	65.54	66.61	66.27	4.51	3.88
	3	1268.0	718.5	101.62	68.56	68.57	69.12	68.75	8.14	5.93
	1	1279.5	727.5	101.54	69.53	69.59	68.99	69.37	7.15	6.41
'.5	2	1256.5	710.5	104.62	65.63	65.66	65.46	65.58	3.91	5.09
	3	1318.5	741.0	104.77	69.03	68.60	69.21	68.95	5.04	4.61

ımary values obtained from the above table

ımen ntent	Weight (g)		Diameter (mm)	Height (mm)	Marshall Test	
	in air	in water			Load (kN)	Flow (mm)
5.5	1239.2	688.7	102.85	68.22	10.66	3.22
5.0	1257.8	694.2	102.72	69.92	9.76	3.37
5.5	1256.7	692.3	102.42	69.83	6.23	3.19
7.0	1266.3	707.2	102.52	68.97	6.88	4.99
7.5	1284.8	726.3	103.64	67.97	5.37	5.37

:ulated VMA and voids in total mix

umen ntent	Gbcm	Bulk density	Stability	Flow	VMA	Gmp	Voids in total mix
5.5	2.25	2.25	10.66	3.22	20.07	2.44	7.79
6.0	2.23	2.23	9.76	3.37	19.99	2.42	7.85
6.5	2.23	2.23	6.23	3.19	20.42	2.40	7.08
7.0	2.26	2.26	6.88	4.99	19.78	2.39	5.44
7.5	2.30	2.30	5.37	5.37	19.72	2.37	2.95

ɔntinuous Graded

ımen ıtent	Sample	Weight (g)		Diameter (mm)	Height (mm)			Average height	Marshall Test	
		in air	in water		1	2	3		Load (kN)	Flow (mm)
·.0	1	1214.5	703.5	104.80	64.02	62.87	64.24	63.71	13.04	5.76
	2	1229.5	709.5	105.07	65.36	65.57	65.48	65.47	15.92	5.34
	3	1212.5	697.5	101.75	66.36	67.19	66.35	66.63	24.97	2.75
·.5	1	1211.5	697.0	104.61	64.64	63.29	64.30	64.08	10.88	4.91
	2	1243.0	714.0	101.44	64.65	64.93	65.24	64.94	15.77	4.37
	3	1253.5	722.0	104.78	66.60	66.13	66.46	66.40	10.82	5.29
;.0	1	1223.5	708.5	101.41	65.45	65.78	66.65	65.96	15.91	3.78
	2	1225.0	705.5	104.69	65.00	64.81	63.47	64.43	9.66	5.81
	3	1236.0	713.0	101.44	66.06	66.82	65.88	66.25	17.06	3.89
;.5	1	1233.0	707.0	104.58	64.85	63.95	64.12	64.31	11.16	5.41
	2	1240.0	713.5	104.51	63.94	63.94	64.16	64.01	11.03	4.32
	3	1216.0	698.5	104.61	62.94	63.21	63.12	63.09	7.36	2.07

ımary values obtained from the above table

ımen ntent	Weight (g)		Diameter (mm)	Height (mm)	Marshall Test	
	in air	in water			Load (kN)	Flow (mm)
4.0	1218.8	703.5	103.87	65.27	17.98	4.62
4.5	1236.0	711.0	103.61	65.14	12.49	4.86
5.0	1228.2	709.0	102.51	65.55	14.21	4.49
5.5	1229.7	706.3	104.57	63.80	9.85	3.93

;ulated VMA and voids in total mix

umen ntent	Gbcm	Bulk density	Stability	Flow	VMA	Gmp	Voids in total mix
4.0	2.35	2.35	17.98	4.62	14.55	2.49	5.66
4.5	2.36	2.36	12.49	4.86	14.99	2.47	4.45
5.0	2.37	2.37	14.21	4.49	14.72	2.46	3.84
5.5	2.35	2.35	9.85	3.93	15.88	2.44	3.70

›en Graded

men tent	Sample	Weight (g)		Diameter (mm)	Height (mm)			Average height	Marshall Test	
		in air	in water		1	2	3		Load (kN)	Flow (mm)
	1	1207.5	687.0	104.10	79.55	79.68	79.73	79.65	2.75	4.81
.0	2	1247.0	716.5	104.27	80.07	81.03	80.57	80.56	4.18	5.27
	3	1223.0	722.0	101.60	82.70	82.71	82.80	82.74	6.75	6.27
	1	1221.5	713.0	101.71	83.12	82.88	83.41	83.14	5.13	2.72
.5	2	1233.5	719.5	101.65	82.36	83.25	82.80	82.80	8.42	2.24
	3	1218.5	709.5	104.78	78.10	79.21	78.64	78.65	2.55	4.16
	1	1227.5	711.5	104.76	80.37	80.11	80.33	80.27	1.71	4.59
.0	2	1239.5	721.0	101.61	84.44	84.65	84.83	84.64		
	3	1226.0	710.0	101.68	83.68	83.20	83.68	83.52		
	1	1247.5	716.0	101.74	82.52	82.34	82.16	82.34	4.34	2.30
.5	2	1229.5	706.5	101.64	81.84	82.21	82.10	82.05	3.83	3.02
	3	1228.5	707.5	101.05	84.07	84.31	83.88	84.09	3.13	2.24
	1	1269.0	722.5	104.81	81.42	80.52	80.68	80.87	2.23	4.67
ı.0	2	1240.0	704.5	104.81	80.09	80.36	79.71	80.05	1.52	5.75
	3	1246.0	713.5	101.49	85.02	84.66	84.59	84.76	2.74	4.48

mary values obtained from the above table

ımen ıtent	Weight (g)		Diameter (mm)	Height (mm)	Marshall Test	
	in air	in water			Load (kN)	Flow (mm)
3.0	1225.8	708.5	103.32	80.98	4.56	5.45
3.5	1224.5	714.0	102.71	81.53	5.37	3.04
4.0	1231.0	714.2	102.68	82.81	1.71	4.59
4.5	1235.2	710.0	101.48	82.83	3.77	2.52
5.0	1251.7	713.5	103.70	81.89	2.16	4.97

:ulated VMA and voids in total mix

umen ntent	Gbcm	Bulk density	Stability	Flow	VMA	Gmp	Voids in total mix
3.0	2.37	2.37	4.56	5.45	15.79	2.53	6.32
3.5	2.40	2.40	5.37	3.04	15.16	2.51	4.38
4.0	2.38	2.38	1.71	4.59	16.31	2.49	4.42
4.5	2.35	2.35	3.77	2.52	17.79	2.47	4.86
5.0	2.33	2.33	2.16	4.97	18.92	2.46	5.28

nse Graded

men tent	Sample	Weight (g) in air	Weight (g) in water	Diameter (mm)	Height (mm) 1	Height (mm) 2	Height (mm) 3	Average height	Marshall Test Load (kN)	Marshall Test Flow (mm)
	1	1251.0	706.0							
.0	2	1235.5	700.0	101.68	69.71	68.61	68.67	69.00	10.36	2.61
	3	1201.0	665.0							
	1	1242.5	717.0	104.93	64.86	66.29	65.33	65.49	10.63	5.39
.5	2	1230.0	710.0	101.58	67.57	68.01	67.96	67.85	17.63	
	3	1226.0	709.5	104.91	62.97	63.10	64.85	63.64	9.09	1.62
	1	1218.0	703.5	104.85	63.18	64.86	63.39	63.81	10.45	0.42
.0	2	1225.0	710.0	101.60	65.39	66.16	66.60	66.05	20.77	0.07
	3	1234.0	715.5	105.17	64.32	64.70	64.30	64.44	11.18	0.39
	1	1237.5	717.5	101.57	67.11	67.02	66.76	66.96	17.05	1.04
.5	2	1237.0	720.5	101.53	66.05	65.25	65.64	65.65	20.97	
	3	1199.0	693.5	101.64	67.68	68.45	68.07	68.07	24.99	2.20
	1	1218.0	709.0	101.58	65.34	64.19	65.65	65.06	16.44	1.81
.0	2	1210.0	703.0	105.16	62.31	61.49	63.19	62.33	10.93	4.68
	3	1204.0	695.0	101.57	65.19	65.20	65.27	65.22	15.97	1.88
	1	1267.5	741.5	104.67	63.09	62.94	63.77	63.27	9.66	4.44
.5	2	1252.5	729.0	101.51	65.94	65.69	65.69	65.77	18.64	3.63
	3	1224.5	715.0	104.82	61.23	60.95	61.02	61.07	10.18	4.13
	1	1234.0	719.5	104.71	61.28	62.08	63.20	62.19	8.52	6.00
.0	2	1248.5	730.5	101.64	65.92	65.05	65.43	65.47	13.11	4.10
	3	1240.5	726.0	104.83	61.76	61.02	61.33	61.37	9.46	4.85
	1	1199.0	694.0	104.66	62.40	62.21	60.87	61.83	8.18	6.30
.5	2	1221.0	711.0	105.15	60.78	61.04	60.90	60.91	9.87	6.12
	3	1243.5	725.5	101.95	65.64	65.86	66.65	66.05	10.63	4.26

mary values obtained from the above table

umen ntent	Weight (g) in air	Weight (g) in water	Diameter (mm)	Height (mm)	Marshall Test Load (kN)	Marshall Test Flow (mm)
3.0	1229.2	690.3	101.68	69.00	10.36	2.61
3.5	1232.8	712.2	103.81	65.66	12.45	3.51
4.0	1225.7	709.7	103.87	64.77	14.13	0.29
4.5	1224.5	710.5	101.58	66.89	21.00	1.62
5.0	1210.7	702.3	102.77	64.20	14.45	2.79
5.5	1248.2	728.5	103.67	63.37	12.83	4.07
6.0	1241.0	725.3	103.73	63.01	10.36	4.98
6.5	1221.2	710.2	103.92	62.93	9.56	5.56

culated VMA and voids in total mix

tumen ontent	Gbcm	Bulk density	Stability	Flow	VMA	Gmp	Voids in total mix
3.0	2.28	2.28	10.36	2.61	16.23	2.53	9.88
3.5	2.37	2.37	12.45	3.51	13.37	2.51	5.58
4.0	2.38	2.38	14.13	0.29	13.45	2.49	4.42
4.5	2.38	2.38	21.00	1.62	13.91	2.47	3.64
5.0	2.38	2.38	14.45	2.79	14.36	2.46	3.25
5.5	2.40	2.40	12.83	4.07	14.09	2.44	1.64
6.0	2.41	2.41	10.36	4.98	14.19	2.42	0.41
6.5	2.39	2.39	9.56	5.56	15.35	2.40	0.42

APPENDIX 3

Calculation for determining VMA and voids in total mix:

E.g.: For 5.5 % bitumen content Gap graded mixture

→ Bulk specific gravity of compacted mixture, G_{bcm}

$$G_{bcm} = \frac{Wa}{Wa - Ww}$$

Where W_a = weight in air

W_w = weight in water

$$G_{bcm} = \frac{1239.2}{1239.2 - 688.7} = 2.25$$

→ Therefore, the bulk density is 2.25 x 1.0 g/cm³ = 2.25 g/cm³

Where 1.0 g/cm³ is the density of water

→ Percent voids in the mineral aggregate, VMA

$$VMA = 100 - \frac{Gbcm * Pta}{Gbam}$$

$$G_{bam} = \frac{Pca + Pfa + Pmf}{\frac{Pca}{Gbca} + \frac{Pfa}{Gbfa} + \frac{Pmf}{Gbmf}}$$

Where G_{bam} = bulk specific gravity of aggregates in the paving mixture (asphalt concrete)

P_{ta} = aggregate percent by weight of total paving mixture (asphalt concrete)

P_{ca} = percent by weight of coarse aggregate

P_{fa} = percent by weight of fine aggregate

P_{mf} = percent by weight of mineral filler

G_{bca} = bulk specific gravity of coarse aggregate

G_{bfa} = bulk specific gravity of fine aggregate

G_{bmf} = bulk specific gravity of mineral filler

Determine Pca, Pfa and Pmf in terms of total aggregates:

$P_{ca} = 0.25 \times 94.5 = 23.63$

$P_{fa} = 0.63 \times 94.5 = 59.54$

$P_{mf} = 0.12 \times 94.5 = 11.34$

$$\text{Therefore, } G_{bam} = \frac{23.63 + 59.54 + 11.34}{\frac{23.63}{2.61} + \frac{59.54}{2.60} + \frac{11.34}{3.15}} = 2.66$$

$$\text{and} \qquad VMA = 100 - \frac{2.25 * 94.5}{2.66} = 20.07\ \%$$

→ Percent air voids in total mix, P_{av}

$$P_{av} = 100 \frac{Gmp - Gbcm}{Gmp}$$

Where G_{mp} = maximum specific gravity of the compacted paving mixture

$$G_{mp} = \frac{100}{\frac{Pta}{Gea} + \frac{Pac}{Gac}}$$

Where G_{ea} = effective specific gravity of aggregates (assumed to be constant for different asphalt cement contents) = 2.65

G_{ac} = specific gravity of asphalt = 1.03

Therefore, $G_{mp} = \dfrac{100}{\dfrac{94.5}{2.65} + \dfrac{5.5}{1.03}} = 2.44$

and $P_{av} = 100\dfrac{2.44 - 2.25}{2.44} = 7.79\ \%$

Result from Dynamic Creep Test:

Cycle	Creep Stiffnes (Smix) Gap Graded 1	Gap Graded 2	Gap Graded 3	Gap Graded Average	Continuous Graded 1	Continuous Graded 2	Continuous Graded 3	Continuous Graded Average	Open Graded 1	Open Graded 2	Open Graded 3	Open Graded Average	Dense Graded 1	Dense Graded 2	Dense Graded 3	Dense Graded Average
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	41.123	21.600	54.514	39.079	17.161	208.949	21.261	82.457	55.501	43.460	42.601	47.187	511.148	288.718	63.176	287.681
4	30.260	17.088	37.735	28.361	14.770	157.778	15.810	62.786	40.224	32.879	31.913	35.005	392.276	208.245	51.084	217.202
6	25.574	15.056	30.983	23.871	13.641	138.056	13.015	54.904	33.924	28.550	27.529	30.001	337.358	168.068	45.795	183.740
8	22.772	14.002	27.044	21.273	12.950	119.862	11.536	48.116	30.028	25.744	24.810	26.861	311.236	146.146	42.027	166.470
10	**20.980**	**13.203**	**24.504**	**19.562**	**12.619**	**110.360**	**10.614**	**44.631**	**27.701**	**23.993**	**23.019**	**24.904**	**278.526**	**132.902**	**39.871**	**150.433**
12	19.775	12.509	22.619	18.301	12.165	103.363	9.911	41.813	25.658	22.662	21.378	23.233	270.091	120.472	38.284	142.949
14	18.652	11.977	20.977	17.202	11.867	99.117	9.325	40.103	24.198	21.565	20.452	22.072	254.648	109.767	37.019	133.811
16	17.855	11.691	19.904	16.483	11.588	93.909	8.866	38.121	23.182	20.781	19.655	21.206	242.691	106.087	35.935	128.238
18	17.335	11.262	18.913	15.837	11.437	90.595	8.413	36.815	22.312	20.160	18.793	20.422	229.392	100.877	35.087	121.785
20	**16.644**	**11.017**	**18.164**	**15.275**	**11.306**	**86.866**	**7.967**	**35.380**	**21.681**	**19.474**	**18.127**	**19.761**	**221.946**	**96.239**	**34.300**	**117.495**
22	16.157	10.745	17.442	14.781	11.092	85.427	7.647	34.722	20.977	18.833	17.741	19.184	221.946	93.551	33.546	116.348
24	15.854	10.533	16.752	14.380	11.009	81.811	7.352	33.391	20.265	18.664	17.248	18.726	211.970	90.359	33.204	111.844
26	15.415	10.336	16.340	14.030	10.800	79.702	7.083	32.528	19.644	18.084	16.789	18.172	208.245	87.398	32.453	109.365
28	15.042	10.193	15.935	13.723	10.708	78.007	6.891	31.869	19.227	17.712	16.562	17.834	196.138	85.314	31.947	104.466
30	**14.642**	**10.008**	**15.446**	**13.365**	**10.570**	**75.496**	**6.900**	**30.989**	**18.902**	**17.412**	**16.123**	**17.479**	**197.727**	**82.386**	**31.592**	**103.902**
32	14.353	9.874	15.175	13.134	10.477	74.697	6.882	30.685	18.518	17.153	15.856	17.176	192.479	80.415	31.010	101.301
34	14.160	9.782	14.700	12.881	10.453	72.593	6.836	29.961	18.169	16.892	15.525	16.862	186.063	78.251	30.838	98.384
36	13.917	9.616	14.443	12.659	10.274	70.928	6.872	29.358	17.834	16.590	15.339	16.588	182.018	77.022	30.725	96.588
38	13.671	9.527	14.099	12.432	10.199	69.374	6.860	28.811	17.551	16.392	15.085	16.343	182.682	75.706	30.172	96.187
40	13.516	9.417	13.781	12.238	10.079	69.028	6.845	28.651	17.296	16.204	14.869	16.123	176.913	73.769	30.068	93.583
42	13.277	9.326	13.593	12.065	10.099	68.146	6.833	28.359	16.999	15.908	14.744	15.884	176.913	73.392	29.694	93.333
44	13.148	9.231	13.412	11.930	10.014	66.099	6.845	27.653	16.759	15.714	14.380	15.618	173.896	72.085	29.382	91.788
46	12.961	9.155	13.144	11.753	9.917	64.984	6.779	27.227	16.543	15.540	14.281	15.455	169.765	70.360	28.972	89.699
48	12.904	9.033	12.936	11.624	10.029	64.440	6.740	27.070	16.397	15.294	14.069	15.253	165.798	69.197	29.027	88.007
50	12.614	9.071	12.745	11.477	9.824	63.893	6.755	26.824	16.255	15.309	13.892	15.152	164.772	68.350	28.933	87.352
52	12.610	8.897	12.648	11.385	9.741	62.612	6.740	26.364	16.040	15.130	13.636	14.935	162.191	66.983	28.534	85.903
54	12.380	8.856	12.418	11.218	9.725	61.358	6.734	25.939	15.873	14.880	13.665	14.806	160.064	66.693	28.287	85.015
56	12.262	8.800	12.185	11.082	9.682	61.358	6.725	25.922	15.666	14.811	13.457	14.645	156.501	66.129	28.302	83.644
58	12.156	8.696	12.109	10.987	9.590	60.396	6.740	25.575	15.478	14.640	13.353	14.490	158.554	65.634	28.011	84.066
60	**12.089**	**8.672**	**11.858**	**10.873**	**9.574**	**59.470**	**6.734**	**25.259**	**15.279**	**14.532**	**13.204**	**14.338**	**157.073**	**64.148**	**27.771**	**82.997**
62	11.986	8.619	11.769	10.791	9.576	58.550	6.670	24.932	15.129	14.437	13.059	14.208	152.233	63.413	27.743	81.130
64	11.876	8.595	11.628	10.700	9.449	58.327	6.687	24.821	15.055	14.273	12.961	14.096	151.412	62.706	27.452	80.523
66	11.841	8.568	11.507	10.639	9.500	57.453	6.705	24.553	15.027	14.238	12.976	14.080	152.789	62.243	27.417	80.816
68	11.659	8.463	11.372	10.498	9.394	57.253	6.646	24.431	14.883	14.121	12.737	13.914	146.677	61.790	27.383	78.617
70	11.608	8.370	11.168	10.382	9.377	56.414	6.664	24.152	14.712	13.988	12.602	13.767	144.886	60.674	27.151	77.570
72	11.585	8.362	11.084	10.344	9.331	56.004	6.679	24.005	14.645	14.010	12.590	13.748	143.648	60.239	27.261	77.049
74	11.482	8.322	10.974	10.259	9.298	55.600	6.644	23.847	14.519	13.880	12.429	13.609	142.430	59.165	26.774	76.123
76	11.397	8.240	10.932	10.190	9.301	55.420	6.638	23.786	14.357	13.726	12.330	13.471	142.430	59.186	26.538	76.051

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
78	11.286	8.229	10.818	**10.111**	9.142	54.614	6.659	**23.472**	14.181	13.708	12.204	**13.364**	140.566	58.757	26.551	**75.291**
80	11.293	8.263	10.755	**10.104**	9.146	54.253	6.618	**23.339**	14.147	13.557	12.137	**13.280**	137.137	57.943	26.522	**73.867**
82	11.140	8.127	10.640	**9.969**	9.160	53.875	6.618	**23.218**	14.087	13.540	12.052	**13.226**	137.760	57.755	26.397	**73.971**
84	11.032	8.117	10.504	**9.884**	9.117	53.291	6.613	**23.007**	13.968	13.416	11.920	**13.101**	137.137	57.166	26.179	**73.494**
86	11.041	8.051	10.419	**9.837**	9.054	53.135	6.599	**22.929**	13.788	13.452	11.876	**13.039**	135.538	56.619	26.057	**72.738**
88	11.002	8.036	10.384	**9.807**	9.099	52.385	6.599	**22.694**	13.744	13.307	11.766	**12.939**	132.337	56.226	25.936	**71.500**
90	10.975	8.012	10.294	**9.760**	9.032	51.856	6.593	**22.494**	13.725	13.261	11.760	**12.915**	131.780	56.039	25.802	**71.207**
92	10.778	7.978	10.213	**9.656**	9.000	51.682	6.611	**22.431**	13.557	13.141	11.606	**12.768**	133.387	55.305	25.792	**71.495**
94	10.753	7.954	10.179	**9.629**	8.984	51.713	6.608	**22.435**	13.516	13.096	11.519	**12.710**	128.813	54.369	25.752	**69.645**
96	10.700	7.890	10.054	**9.548**	8.902	51.030	6.599	**22.177**	13.381	13.048	11.530	**12.653**	129.283	54.391	25.542	**69.739**
98	10.621	7.893	9.937	**9.484**	8.968	50.662	6.568	**22.066**	13.288	12.983	11.445	**12.572**	127.363	54.610	25.611	**69.195**
100	10.612	7.822	9.919	**9.451**	8.851	50.495	6.591	**21.979**	13.348	12.939	11.353	**12.547**	128.296	53.868	25.480	**69.215**
102	10.576	7.856	9.856	**9.429**	8.861	49.842	6.528	**21.744**	13.141	12.845	11.242	**12.409**	127.286	53.355	25.273	**68.638**
104	10.449	7.793	9.763	**9.335**	8.801	49.842	6.580	**21.741**	13.074	12.853	11.265	**12.397**	126.367	53.355	25.214	**68.312**
106	10.530	7.762	9.708	**9.333**	8.786	49.010	6.574	**21.457**	13.048	12.707	11.172	**12.309**	125.880	53.549	25.381	**68.270**
108	10.391	7.743	9.660	**9.265**	8.790	49.086	6.597	**21.491**	12.983	12.705	11.120	**12.269**	123.130	52.686	25.101	**66.972**
110	10.404	7.716	9.562	**9.227**	8.736	48.738	6.540	**21.338**	12.907	12.703	11.088	**12.233**	122.677	52.195	25.010	**66.627**
112	10.315	7.666	9.535	**9.172**	8.741	48.816	6.534	**21.364**	12.792	12.612	10.966	**12.123**	120.472	51.713	24.862	**65.682**
114	10.260	7.677	9.408	**9.115**	8.775	48.128	6.555	**21.153**	12.718	12.600	10.869	**12.062**	121.788	51.210	24.662	**65.887**
116	10.220	7.643	9.382	**9.082**	8.687	48.510	6.555	**21.251**	12.686	12.520	10.800	**12.002**	120.048	51.084	24.680	**65.271**
118	10.193	7.583	9.368	**9.048**	8.672	47.492	6.520	**20.895**	12.684	12.390	10.790	**11.955**	120.048	51.115	24.786	**65.316**
120	10.139	7.684	9.270	**9.031**	8.657	47.430	6.538	**20.875**	12.641	12.380	10.745	**11.922**	118.357	50.623	24.842	**64.607**
122	10.106	7.542	9.215	**8.954**	8.599	47.871	6.538	**21.003**	12.540	12.282	10.636	**11.819**	118.357	50.287	24.500	**64.381**
124	10.067	7.513	9.176	**8.919**	8.575	46.714	6.535	**20.608**	12.480	12.301	10.627	**11.803**	117.927	50.020	24.517	**64.155**
126	10.067	7.521	9.148	**8.912**	8.590	46.812	6.478	**20.627**	12.360	12.272	10.576	**11.736**	116.714	49.872	24.304	**63.630**
128	10.054	7.473	9.146	**8.891**	8.537	46.529	6.501	**20.522**	12.330	12.213	10.560	**11.701**	117.138	49.611	24.411	**63.720**
130	9.970	7.451	9.011	**8.811**	8.557	46.389	6.521	**20.489**	12.350	12.213	10.476	**11.680**	115.909	49.252	24.429	**63.197**
132	9.944	7.470	9.009	**8.808**	8.538	46.111	6.519	**20.389**	12.233	12.118	10.426	**11.592**	112.797	48.999	24.182	**61.993**
134	9.828	7.441	8.927	**8.732**	8.481	46.156	6.487	**20.375**	12.252	12.128	10.356	**11.579**	113.559	48.715	24.148	**62.141**
136	9.856	7.452	8.942	**8.750**	8.500	45.973	6.510	**20.328**	12.165	11.985	10.247	**11.466**	112.797	48.434	24.044	**61.758**
138	9.760	7.409	8.876	**8.682**	8.448	45.882	6.505	**20.278**	12.089	11.986	10.233	**11.436**	110.494	48.434	23.907	**60.945**
140	9.729	7.410	8.761	**8.633**	8.454	45.431	6.476	**20.120**	12.014	11.949	10.233	**11.399**	112.860	48.471	23.994	**61.775**
142	9.737	7.334	8.760	**8.610**	8.431	44.641	6.471	**19.848**	11.948	11.903	10.159	**11.337**	110.248	47.746	23.806	**60.600**
144	9.739	7.349	8.741	**8.610**	8.388	44.901	6.468	**19.919**	12.006	11.960	10.179	**11.382**	107.736	47.438	23.960	**59.711**
146	9.702	7.299	8.785	**8.595**	8.375	44.641	6.489	**19.835**	11.912	11.839	10.033	**11.261**	110.973	47.343	23.825	**60.714**
148	9.716	7.282	8.711	**8.570**	8.343	44.384	6.435	**19.721**	11.820	11.785	10.166	**11.257**	110.248	47.553	23.758	**60.520**
150	9.604	7.272	8.566	**8.481**	8.372	44.129	6.480	**19.660**	11.821	11.732	10.008	**11.187**	110.248	46.946	23.671	**60.288**
152	9.574	7.276	8.562	**8.471**	8.377	44.100	6.455	**19.644**	11.758	11.723	9.989	**11.157**	108.036	46.815	23.724	**59.525**
154	9.594	7.256	8.553	**8.468**	8.265	43.927	6.449	**19.547**	11.769	11.661	9.905	**11.112**	109.135	46.556	23.658	**59.783**
156	9.521	7.214	8.486	**8.407**	8.280	44.100	6.447	**19.609**	11.716	11.588	9.913	**11.072**	106.372	46.725	23.558	**58.885**
158	9.449	7.314	8.454	**8.406**	8.243	43.679	6.498	**19.473**	11.580	11.591	9.842	**11.004**	106.087	46.046	23.493	**58.542**
160	9.494	7.215	8.455	**8.388**	8.249	43.506	6.439	**19.398**	11.536	11.556	9.760	**10.951**	105.985	46.046	23.408	**58.480**
162	9.440	7.195	8.361	**8.332**	8.269	43.556	6.436	**19.420**	11.519	11.505	9.762	**10.929**	105.424	45.753	23.408	**58.195**
164	9.411	7.178	8.386	**8.325**	8.223	43.191	6.459	**19.291**	11.451	11.442	9.788	**10.894**	103.484	45.671	23.310	**57.488**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
166	9.357	7.133	8.355	**8.282**	8.247	43.070	6.431	**19.249**	11.408	11.453	9.720	**10.860**	105.149	45.504	23.330	**57.994**
168	9.295	7.124	8.286	**8.235**	8.192	43.191	6.456	**19.280**	11.437	11.428	9.678	**10.848**	105.806	45.137	23.182	**58.042**
170	9.331	7.160	8.255	**8.249**	8.207	42.376	6.397	**18.993**	11.423	11.394	9.604	**10.807**	103.484	45.344	23.150	**57.326**
172	9.357	7.144	8.257	**8.253**	8.153	42.764	6.445	**19.121**	11.353	11.406	9.562	**10.774**	102.230	45.222	23.286	**56.913**
174	9.250	7.081	8.194	**8.175**	8.149	42.427	6.417	**18.998**	11.356	11.266	9.559	**10.727**	100.404	45.101	23.107	**56.204**
176	9.253	7.118	8.164	**8.178**	8.132	41.913	6.417	**18.821**	11.262	11.278	9.449	**10.663**	101.246	44.699	22.991	**56.312**
178	9.195	7.039	8.198	**8.144**	8.151	42.080	6.386	**18.872**	11.257	11.298	9.414	**10.656**	100.877	44.301	23.012	**56.063**
180	9.229	7.036	8.112	**8.126**	8.170	41.965	6.409	**18.848**	11.196	11.245	9.448	**10.630**	100.768	44.184	23.095	**56.016**
182	9.218	7.103	8.047	**8.123**	8.089	42.017	6.406	**18.837**	11.120	11.152	9.414	**10.562**	100.172	44.273	22.960	**55.802**
184	9.160	7.035	8.017	**8.071**	8.108	41.737	6.378	**18.741**	11.176	11.172	9.320	**10.556**	99.942	43.952	22.835	**55.576**
186	9.128	7.019	8.115	**8.087**	8.091	41.565	6.398	**18.685**	11.180	11.132	9.340	**10.551**	99.223	43.882	22.712	**55.272**
188	9.106	6.985	7.995	**8.029**	8.115	41.290	6.421	**18.609**	11.088	11.116	9.275	**10.493**	100.172	43.383	22.629	**55.395**
190	9.121	6.993	7.989	**8.034**	8.030	41.343	6.419	**18.597**	10.977	11.076	9.237	**10.430**	98.863	43.882	22.877	**55.207**
192	9.063	7.011	7.950	**8.008**	8.005	41.070	6.416	**18.497**	10.989	11.052	9.204	**10.415**	97.149	43.474	22.960	**54.528**
194	9.042	6.968	7.925	**7.978**	8.068	40.960	6.416	**18.481**	10.958	11.029	9.207	**10.398**	95.107	43.316	22.651	**53.691**
196	9.026	6.928	7.924	**7.959**	7.992	41.123	6.416	**18.510**	10.971	10.997	9.216	**10.395**	96.796	43.316	22.620	**54.244**
198	9.036	6.937	7.857	**7.943**	7.984	40.636	6.411	**18.344**	10.866	10.958	9.148	**10.324**	96.737	43.140	22.559	**54.145**
200	8.949	6.961	7.814	**7.908**	8.003	40.905	6.383	**18.430**	10.886	10.892	9.110	**10.296**	96.942	43.094	22.754	**54.263**
202	8.928	6.918	7.844	**7.897**	7.943	40.423	6.377	**18.248**	10.762	10.869	9.042	**10.224**	94.575	42.502	22.439	**53.172**
204	8.943	6.912	7.816	**7.890**	7.974	40.371	6.375	**18.240**	10.740	10.853	9.117	**10.237**	97.855	42.703	22.379	**54.312**
206	8.952	6.897	7.835	**7.895**	7.926	40.266	6.375	**18.189**	10.753	10.838	8.984	**10.192**	94.953	42.441	22.521	**53.306**
208	8.897	6.918	7.777	**7.864**	7.950	40.317	6.395	**18.221**	10.800	10.878	9.019	**10.232**	95.107	42.334	22.298	**53.246**
210	8.841	6.902	7.720	**7.821**	7.942	39.851	6.372	**18.055**	10.678	10.778	8.927	**10.128**	93.893	42.180	22.209	**52.761**
212	8.856	6.857	7.731	**7.815**	7.925	39.851	6.344	**18.040**	10.642	10.775	8.897	**10.105**	94.798	42.122	22.320	**53.080**
214	8.876	6.881	7.704	**7.820**	7.944	39.592	6.389	**17.975**	10.556	10.768	8.861	**10.062**	94.763	41.711	22.342	**52.939**
216	8.825	6.809	7.673	**7.769**	7.932	39.490	6.379	**17.934**	10.632	10.695	8.796	**10.041**	92.345	41.760	22.224	**52.110**
218	8.805	6.863	7.688	**7.785**	7.881	39.545	6.384	**17.937**	10.526	10.688	8.800	**10.005**	93.016	41.450	22.202	**52.223**
220	8.751	6.848	7.579	**7.726**	7.850	39.490	6.354	**17.898**	10.477	10.735	8.770	**9.994**	93.016	41.498	22.085	**52.200**
222	8.736	6.835	7.613	**7.728**	7.877	39.189	6.381	**17.816**	10.504	10.706	8.741	**9.984**	92.508	41.245	22.005	**51.919**
224	8.716	6.767	7.538	**7.674**	7.857	39.244	6.328	**17.810**	10.462	10.600	8.731	**9.931**	91.838	41.294	22.050	**51.727**
226	8.736	6.817	7.576	**7.710**	7.818	38.948	6.376	**17.714**	10.482	10.627	8.682	**9.930**	90.688	41.092	22.056	**51.279**
228	8.746	6.779	7.550	**7.692**	7.864	38.892	6.348	**17.701**	10.453	10.605	8.609	**9.889**	91.508	41.141	21.970	**51.540**
230	8.716	6.770	7.484	**7.657**	7.829	39.046	6.321	**17.732**	10.329	10.583	8.633	**9.848**	89.876	41.343	21.970	**51.063**
232	8.682	6.728	7.484	**7.631**	7.840	38.948	6.393	**17.727**	10.343	10.562	8.638	**9.848**	89.876	40.892	22.021	**50.930**
234	8.662	6.743	7.503	**7.636**	7.767	38.446	6.338	**17.517**	10.322	10.574	8.576	**9.824**	90.373	40.351	21.963	**50.896**
236	8.599	6.764	7.467	**7.610**	7.782	38.656	6.366	**17.601**	10.261	10.511	8.600	**9.791**	88.778	40.448	21.776	**50.334**
238	8.624	6.734	7.489	**7.616**	7.739	38.615	6.366	**17.573**	10.308	10.504	8.543	**9.785**	89.571	40.254	21.799	**50.541**
240	8.614	6.720	7.372	**7.569**	7.778	38.407	6.363	**17.516**	10.226	10.510	8.477	**9.738**	88.633	40.403	21.770	**50.269**
242	8.600	6.738	7.326	**7.555**	7.731	38.463	6.360	**17.518**	10.206	10.406	8.463	**9.692**	87.854	40.304	21.850	**50.003**
244	8.624	6.702	7.359	**7.562**	7.777	38.368	6.335	**17.493**	10.193	10.426	8.440	**9.686**	87.715	40.403	21.719	**49.946**
246	8.600	6.697	7.382	**7.560**	7.739	37.841	6.358	**17.313**	10.146	10.371	8.413	**9.643**	86.633	40.257	21.686	**49.525**
248	8.547	6.708	7.332	**7.529**	7.727	38.027	6.305	**17.353**	10.173	10.432	8.385	**9.663**	88.032	40.016	21.765	**49.938**
250	8.538	6.647	7.336	**7.507**	7.685	37.783	6.327	**17.265**	10.133	10.363	8.329	**9.608**	86.633	39.826	21.630	**49.363**
252	8.476	6.644	7.290	**7.470**	7.700	37.898	6.297	**17.298**	10.073	10.356	8.300	**9.576**	86.948	39.639	21.469	**49.352**

Cycle	Gap Graded				Continuous Graded				Open Graded				[illegible]			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
254	8.486	6.685	7.273	**7.481**	7.689	37.805	6.347	**17.280**	10.093	10.329	8.267	**9.563**	87.442	39.402	21.653	**49.499**
256	8.520	6.645	7.278	**7.481**	7.693	37.748	6.317	**17.253**	10.054	10.267	8.245	**9.522**	86.372	39.402	21.630	**49.135**
258	8.472	6.613	7.264	**7.450**	7.677	37.472	6.322	**17.157**	9.989	10.328	8.270	**9.529**	85.191	39.360	21.465	**48.672**
260	8.463	6.660	7.212	**7.445**	7.670	37.564	6.342	**17.192**	9.963	10.220	8.229	**9.471**	86.684	39.360	21.625	**49.223**
262	8.449	6.622	7.227	**7.433**	7.605	37.656	6.367	**17.209**	9.898	10.253	8.194	**9.448**	84.645	39.137	21.543	**48.442**
264	8.431	6.613	7.172	**7.405**	7.658	37.439	6.315	**17.137**	9.873	10.274	8.140	**9.429**	85.070	39.228	21.281	**48.526**
266	8.384	6.602	7.162	**7.383**	7.609	36.964	6.337	**16.970**	9.886	10.172	8.114	**9.391**	83.920	39.085	21.543	**48.183**
268	8.413	6.591	7.152	**7.385**	7.632	37.316	6.337	**17.095**	9.828	10.233	8.157	**9.406**	83.616	39.137	21.383	**48.045**
270	8.385	6.585	7.129	**7.366**	7.598	37.406	6.309	**17.104**	9.791	10.159	8.108	**9.353**	83.920	38.444	21.278	**47.881**
272	8.372	6.556	7.078	**7.335**	7.583	37.080	6.307	**16.990**	9.882	10.152	8.030	**9.355**	84.339	38.599	21.406	**48.115**
274	8.358	6.545	7.086	**7.330**	7.636	37.137	6.284	**17.019**	9.825	10.106	8.049	**9.327**	82.792	38.725	21.379	**47.632**
276	8.307	6.563	7.067	**7.312**	7.591	36.845	6.329	**16.922**	9.749	10.119	8.032	**9.300**	82.282	38.267	21.429	**47.326**
278	8.355	6.555	7.057	**7.322**	7.561	36.815	6.302	**16.893**	9.698	10.093	8.003	**9.265**	82.386	38.372	21.221	**47.326**
280	8.317	6.552	7.007	**7.292**	7.542	36.727	6.302	**16.857**	9.706	10.093	7.978	**9.259**	81.192	38.145	21.117	**46.818**
282	8.313	6.538	7.050	**7.300**	7.557	36.640	6.324	**16.840**	9.644	10.067	7.966	**9.226**	81.783	38.197	21.194	**47.058**
284	8.286	6.558	7.006	**7.283**	7.554	36.640	6.324	**16.839**	9.658	10.093	7.973	**9.241**	81.487	38.197	21.217	**46.967**
286	8.310	6.496	6.978	**7.261**	7.520	36.382	6.296	**16.733**	9.646	10.080	7.909	**9.212**	80.897	38.024	21.318	**46.746**
288	8.227	6.501	6.941	**7.223**	7.535	36.382	6.346	**16.754**	9.666	9.968	7.951	**9.195**	80.508	38.163	21.088	**46.586**
290	8.218	6.510	6.977	**7.235**	7.532	36.468	6.321	**16.774**	9.598	9.995	7.900	**9.164**	80.323	37.715	21.138	**46.392**
292	8.205	6.476	6.903	**7.195**	7.521	36.153	6.294	**16.656**	9.568	9.969	7.845	**9.127**	80.032	37.715	21.217	**46.321**
294	8.238	6.494	6.942	**7.225**	7.517	36.068	6.316	**16.634**	9.519	9.969	7.852	**9.113**	80.032	37.599	21.135	**46.255**
296	8.248	6.491	6.869	**7.203**	7.473	36.068	6.291	**16.611**	9.565	9.917	7.801	**9.094**	79.653	37.515	21.111	**46.093**
298	8.166	6.486	6.881	**7.178**	7.425	36.042	6.311	**16.593**	9.509	9.976	7.812	**9.099**	78.905	37.484	21.108	**45.832**
300	8.190	6.470	6.836	**7.165**	7.455	35.959	6.261	**16.558**	9.480	9.885	7.781	**9.049**	78.905	37.432	20.880	**45.739**
302	8.136	6.464	6.845	**7.148**	7.444	35.959	6.309	**16.571**	9.474	9.879	7.762	**9.038**	79.192	37.401	20.980	**45.858**
304	8.164	6.459	6.860	**7.161**	7.466	35.651	6.286	**16.468**	9.483	9.866	7.742	**9.030**	79.479	37.183	20.878	**45.847**
306	8.155	6.425	6.818	**7.133**	7.459	35.509	6.306	**16.425**	9.368	9.886	7.693	**8.982**	78.171	37.183	20.876	**45.410**
308	8.174	6.471	6.806	**7.150**	7.448	35.509	6.256	**16.404**	9.405	9.867	7.692	**8.988**	78.171	37.154	20.978	**45.434**
310	8.125	6.443	6.788	**7.119**	7.441	35.486	6.303	**16.410**	9.340	9.842	7.643	**8.942**	78.375	36.885	20.799	**45.353**
312	8.085	6.457	6.746	**7.096**	7.437	35.627	6.276	**16.447**	9.323	9.830	7.617	**8.923**	77.887	37.072	20.852	**45.270**
314	8.072	6.449	6.767	**7.096**	7.397	35.405	6.301	**16.368**	9.368	9.778	7.591	**8.912**	77.376	36.857	20.775	**45.003**
316	8.127	6.388	6.770	**7.095**	7.387	35.464	6.301	**16.384**	9.309	9.819	7.512	**8.880**	76.049	37.289	20.826	**44.721**
318	8.083	6.403	6.705	**7.064**	7.376	35.243	6.271	**16.297**	9.267	9.774	7.610	**8.884**	77.095	36.991	20.547	**44.878**
320	8.062	6.405	6.720	**7.062**	7.372	35.243	6.273	**16.296**	9.270	9.755	7.532	**8.852**	77.376	36.616	20.773	**44.922**
322	8.021	6.420	6.676	**7.039**	7.358	35.162	6.248	**16.256**	9.259	9.808	7.513	**8.860**	76.950	36.696	20.748	**44.798**
324	8.017	6.440	6.691	**7.049**	7.355	35.141	6.296	**16.264**	9.257	9.757	7.521	**8.845**	76.325	36.616	20.748	**44.563**
326	8.072	6.384	6.653	**7.036**	7.351	35.003	6.293	**16.216**	9.209	9.656	7.470	**8.778**	76.325	36.536	20.671	**44.511**
328	8.028	6.376	6.673	**7.026**	7.337	34.923	6.293	**16.184**	9.176	9.650	7.500	**8.775**	75.706	36.511	20.646	**44.288**
330	8.016	6.343	6.656	**7.005**	7.334	35.062	6.261	**16.219**	9.124	9.676	7.430	**8.743**	75.093	36.300	20.745	**44.046**
332	8.003	6.363	6.616	**6.994**	7.320	35.200	6.263	**16.261**	9.086	9.620	7.402	**8.703**	75.706	36.144	20.621	**44.157**
334	7.963	6.333	6.628	**6.975**	7.320	34.747	6.293	**16.120**	9.070	9.634	7.432	**8.712**	74.697	36.197	20.696	**43.863**
336	8.006	6.350	6.590	**6.982**	7.274	34.884	6.285	**16.148**	9.054	9.648	7.330	**8.677**	74.697	36.197	20.571	**43.822**
338	8.006	6.390	6.605	**7.000**	7.332	34.747	6.233	**16.104**	9.099	9.622	7.339	**8.687**	74.039	35.835	20.521	**43.465**
340	7.993	6.365	6.565	**6.974**	7.296	34.747	6.283	**16.109**	9.058	9.586	7.318	**8.654**	74.907	35.835	20.645	**43.796**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
342	7.950	6.327	6.580	**6.952**	7.289	34.514	6.283	**16.029**	9.032	9.530	7.268	**8.610**	74.308	36.042	20.546	**43.632**
344	7.958	6.329	6.563	**6.950**	7.250	34.377	6.231	**15.953**	9.005	9.513	7.269	**8.596**	74.096	35.966	20.421	**43.494**
346	7.894	6.344	6.557	**6.932**	7.300	34.360	6.228	**15.963**	8.984	9.501	7.274	**8.586**	73.714	35.835	20.496	**43.348**
348	7.948	6.314	6.543	**6.935**	7.261	34.377	6.253	**15.964**	8.979	9.527	7.232	**8.579**	74.637	35.813	20.495	**43.648**
350	7.882	6.309	6.561	**6.917**	7.254	34.437	6.250	**15.980**	8.943	9.498	7.240	**8.560**	73.392	35.943	20.495	**43.277**
352	7.932	6.323	6.490	**6.915**	7.309	34.225	6.250	**15.928**	8.917	9.561	7.188	**8.555**	73.659	35.661	20.570	**43.297**
354	7.889	6.321	6.508	**6.906**	7.269	34.208	6.250	**15.909**	8.967	9.494	7.193	**8.551**	73.073	35.511	20.470	**43.018**
356	7.916	6.315	6.522	**6.918**	7.288	34.073	6.273	**15.878**	8.871	9.489	7.173	**8.511**	72.757	35.328	20.372	**42.819**
358	7.904	6.280	6.455	**6.880**	7.227	34.149	6.223	**15.866**	8.871	9.471	7.132	**8.491**	72.492	35.457	20.274	**42.741**
360	7.834	6.303	6.498	**6.878**	7.256	34.073	6.245	**15.858**	8.861	9.417	7.109	**8.462**	72.706	35.234	20.298	**42.746**
362	7.853	6.273	6.487	**6.871**	7.239	33.923	6.270	**15.811**	8.865	9.368	7.086	**8.440**	72.706	35.362	20.347	**42.805**
364	7.822	6.240	6.484	**6.849**	7.204	33.567	6.268	**15.680**	8.810	9.394	7.032	**8.412**	72.394	35.087	20.323	**42.601**
366	7.806	6.250	6.437	**6.831**	7.225	33.700	6.240	**15.722**	8.751	9.340	7.013	**8.368**	71.563	35.141	20.250	**42.318**
368	7.790	6.252	6.424	**6.822**	7.197	33.700	6.240	**15.712**	8.770	9.414	6.994	**8.393**	71.518	35.288	20.225	**42.344**
370	7.817	6.225	6.444	**6.829**	7.187	33.687	6.240	**15.705**	8.711	9.360	7.003	**8.358**	71.215	35.014	20.274	**42.168**
372	7.809	6.220	6.411	**6.813**	7.205	33.834	6.243	**15.761**	8.736	9.343	6.963	**8.347**	71.474	34.887	20.250	**42.204**
374	7.763	6.210	6.369	**6.781**	7.170	33.687	6.268	**15.708**	8.716	9.315	6.941	**8.324**	71.518	34.797	20.153	**42.156**
376	7.797	6.230	6.359	**6.795**	7.167	33.481	6.263	**15.637**	8.706	9.303	6.956	**8.322**	70.283	34.923	20.421	**41.876**
378	7.812	6.252	6.379	**6.814**	7.157	33.687	6.263	**15.702**	8.643	9.323	6.949	**8.305**	70.657	34.977	20.057	**41.897**
380	7.816	6.220	6.341	**6.792**	7.122	33.336	6.260	**15.573**	8.662	9.275	6.882	**8.273**	70.873	34.923	20.105	**41.967**
382	7.735	6.261	6.330	**6.775**	7.147	33.541	6.211	**15.633**	8.614	9.222	6.881	**8.239**	70.321	34.779	20.081	**41.727**
384	7.724	6.210	6.312	**6.749**	7.137	33.528	6.257	**15.641**	8.653	9.253	6.884	**8.263**	69.774	34.977	19.961	**41.571**
386	7.747	6.224	6.332	**6.768**	7.158	33.264	6.230	**15.551**	8.604	9.231	6.842	**8.226**	70.577	34.440	20.081	**41.699**
388	7.800	6.192	6.296	**6.763**	7.155	33.050	6.255	**15.487**	8.581	9.226	6.803	**8.203**	69.738	34.245	20.082	**41.355**
390	7.689	6.192	6.309	**6.730**	7.117	33.384	6.230	**15.577**	8.571	9.204	6.832	**8.202**	69.131	34.456	20.082	**41.223**
392	7.720	6.187	6.306	**6.738**	7.132	33.324	6.230	**15.562**	8.586	9.193	6.752	**8.177**	69.955	34.370	20.009	**41.445**
394	7.712	6.204	6.293	**6.736**	7.129	33.468	6.203	**15.600**	8.500	9.207	6.740	**8.149**	69.415	34.495	19.890	**41.267**
396	7.735	6.175	6.253	**6.721**	7.125	33.252	6.230	**15.536**	8.510	9.171	6.749	**8.143**	69.955	34.160	19.866	**41.327**
398	7.696	6.146	6.268	**6.703**	7.119	32.918	6.228	**15.422**	8.491	9.155	6.729	**8.125**	69.738	34.160	19.915	**41.271**
400	7.655	6.146	6.238	**6.680**	7.087	32.908	6.247	**15.414**	8.477	9.097	6.685	**8.086**	69.131	34.215	19.915	**41.087**
402	7.708	6.165	6.250	**6.708**	7.112	32.908	6.223	**15.414**	8.459	9.169	6.691	**8.106**	68.880	34.146	19.868	**40.965**
404	7.700	6.129	6.240	**6.690**	7.074	32.838	6.247	**15.386**	8.416	9.148	6.753	**8.106**	68.848	34.008	19.796	**40.884**
406	7.636	6.150	6.282	**6.689**	7.068	32.768	6.245	**15.360**	8.398	9.065	6.709	**8.057**	68.569	33.967	19.891	**40.809**
408	7.655	6.116	6.220	**6.664**	7.090	32.699	6.193	**15.327**	8.379	9.090	6.607	**8.025**	67.769	33.939	19.916	**40.541**
410	7.670	6.138	6.215	**6.674**	7.058	32.898	6.242	**15.399**	8.390	9.085	6.640	**8.038**	67.988	33.994	19.821	**40.601**
412	7.666	6.116	6.180	**6.654**	7.045	33.028	6.242	**15.438**	8.367	9.033	6.628	**8.009**	68.262	33.994	19.845	**40.700**
414	7.632	6.104	6.168	**6.635**	7.067	32.629	6.242	**15.313**	8.353	9.053	6.585	**7.997**	68.016	33.871	19.775	**40.554**
416	7.621	6.148	6.177	**6.649**	7.064	32.690	6.213	**15.322**	8.340	9.042	6.566	**7.983**	67.988	33.871	19.703	**40.521**
418	7.583	6.121	6.221	**6.642**	7.057	32.759	6.262	**15.359**	8.355	9.037	6.580	**7.991**	67.227	33.994	19.729	**40.317**
420	**7.579**	**6.114**	**6.160**	**6.618**	**7.048**	**32.560**	**6.210**	**15.273**	**8.300**	**8.985**	**6.555**	**7.947**	**67.988**	**33.723**	**19.754**	**40.488**
422	7.606	6.109	6.153	**6.623**	7.013	32.492	6.210	**15.238**	8.332	9.011	6.493	**7.945**	68.479	33.358	19.634	**40.490**
424	7.587	6.080	6.119	**6.595**	6.982	32.612	6.213	**15.269**	8.306	8.975	6.522	**7.934**	67.203	33.668	19.611	**40.161**
426	7.557	6.095	6.155	**6.602**	7.007	32.423	6.235	**15.222**	8.255	8.990	6.480	**7.908**	66.913	33.790	19.731	**40.145**
428	7.542	6.092	6.126	**6.587**	6.997	32.423	6.232	**15.217**	8.270	8.939	6.467	**7.892**	66.959	33.281	19.588	**39.943**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
430	7.565	6.061	6.116	**6.581**	6.991	32.220	6.232	**15.148**	8.220	8.928	6.448	**7.865**	66.890	33.347	19.543	**39.927**
432	7.531	6.104	6.087	**6.574**	6.988	32.025	6.205	**15.073**	8.211	8.928	6.427	**7.855**	66.890	33.468	19.662	**40.007**
434	7.546	6.073	6.145	**6.588**	7.003	32.476	6.230	**15.236**	8.162	8.913	6.439	**7.838**	67.131	33.457	19.591	**40.060**
436	7.516	6.076	6.061	**6.551**	7.009	32.086	6.274	**15.123**	8.177	8.933	6.400	**7.837**	67.421	33.160	19.520	**40.034**
438	7.505	6.040	6.083	**6.543**	6.941	32.280	6.203	**15.141**	8.127	8.917	6.409	**7.818**	66.650	33.149	19.546	**39.782**
440	7.465	6.061	6.068	**6.531**	7.000	32.146	6.227	**15.124**	8.106	8.877	6.363	**7.782**	66.129	32.964	19.478	**39.524**
442	7.494	6.064	6.056	**6.538**	6.963	32.019	6.227	**15.070**	8.097	8.942	6.353	**7.797**	66.650	32.835	19.500	**39.662**
444	7.349	6.054	6.033	**6.479**	6.950	31.826	6.176	**14.984**	8.080	8.871	6.307	**7.753**	65.872	33.204	19.571	**39.549**
446	7.038	6.052	6.109	**6.400**	6.919	32.146	6.200	**15.088**	8.068	8.846	6.316	**7.743**	66.628	32.899	19.503	**39.677**
448	6.536	6.018	6.031	**6.195**	6.910	32.153	6.225	**15.096**	8.083	8.861	6.291	**7.745**	65.379	33.064	19.363	**39.269**
450	6.474	6.018	6.000	**6.164**	6.928	31.820	6.247	**14.998**	8.070	8.831	6.283	**7.728**	64.862	33.194	19.407	**39.154**
452	7.183	6.038	6.019	**6.413**	6.956	31.755	6.217	**14.976**	8.053	8.916	6.275	**7.748**	65.835	32.826	19.596	**39.419**
454	7.350	6.031	6.074	**6.485**	7.004	31.947	6.171	**15.041**	8.041	8.836	6.225	**7.701**	65.112	32.762	19.363	**39.079**
456	7.403	6.007	5.986	**6.465**	6.891	31.881	6.195	**14.989**	8.024	8.820	6.235	**7.693**	65.599	32.698	19.459	**39.252**
458	7.447	6.026	5.982	**6.485**	6.940	31.820	6.217	**14.992**	8.043	8.870	6.217	**7.710**	64.876	32.817	19.411	**39.035**
460	7.421	6.019	5.953	**6.464**	6.906	31.750	6.195	**14.950**	7.999	8.795	6.200	**7.665**	64.876	32.690	19.411	**38.992**
462	7.444	5.993	5.946	**6.461**	6.897	31.560	6.190	**14.882**	7.978	8.785	6.182	**7.648**	64.614	32.698	19.296	**38.869**
464	7.437	5.986	5.977	**6.467**	6.867	31.875	6.166	**14.969**	7.974	8.706	6.170	**7.617**	64.614	32.508	19.392	**38.838**
466	7.459	6.005	5.973	**6.479**	6.912	31.690	6.217	**14.940**	7.958	8.765	6.126	**7.616**	63.662	32.383	19.347	**38.464**
468	7.422	6.026	5.964	**6.471**	6.912	31.745	6.215	**14.957**	7.942	8.716	6.165	**7.608**	64.136	32.501	19.300	**38.646**
470	7.452	6.000	5.957	**6.470**	6.851	31.431	6.188	**14.823**	7.921	8.721	6.119	**7.587**	63.643	32.438	19.347	**38.476**
472	7.474	5.946	5.922	**6.447**	6.930	31.560	6.185	**14.892**	7.917	8.741	6.104	**7.587**	63.404	32.314	19.186	**38.301**
474	7.493	5.991	5.943	**6.476**	6.894	31.556	6.215	**14.888**	7.932	8.731	6.068	**7.577**	63.652	32.129	19.186	**38.322**
476	7.419	6.003	5.911	**6.444**	6.884	31.300	6.212	**14.799**	7.846	8.716	6.095	**7.552**	64.136	32.259	19.094	**38.496**
478	7.423	5.970	5.895	**6.429**	6.854	31.240	6.158	**14.751**	7.869	8.692	6.054	**7.538**	63.422	32.431	19.168	**38.340**
480	7.412	5.953	5.888	**6.418**	6.821	31.240	6.185	**14.749**	7.830	8.682	6.014	**7.509**	62.940	32.501	19.142	**38.194**
482	7.464	5.970	5.879	**6.438**	6.869	31.300	6.210	**14.793**	7.833	8.633	6.000	**7.489**	63.396	32.369	19.259	**38.341**
484	7.424	5.965	5.870	**6.420**	6.866	31.364	6.232	**14.821**	7.856	8.657	6.031	**7.515**	62.940	32.307	19.216	**38.154**
486	7.398	5.984	5.889	**6.424**	6.860	31.113	6.183	**14.719**	7.786	8.726	6.010	**7.507**	63.168	32.129	19.194	**38.164**
488	7.362	5.942	5.878	**6.394**	6.857	31.364	6.183	**14.801**	7.797	8.638	5.998	**7.478**	62.474	31.952	19.034	**37.820**
490	7.384	5.930	5.890	**6.401**	6.821	31.174	6.183	**14.726**	7.812	8.619	5.952	**7.461**	62.700	31.780	18.986	**37.822**
492	7.341	5.949	5.839	**6.376**	6.848	30.926	6.180	**14.651**	7.705	8.585	5.940	**7.410**	63.168	32.123	19.012	**38.101**
494	7.337	5.952	5.824	**6.371**	6.845	30.988	6.205	**14.679**	7.735	8.624	5.915	**7.425**	61.787	31.947	19.289	**37.674**
496	7.370	5.961	5.824	**6.385**	6.782	30.864	6.202	**14.616**	7.750	8.595	5.925	**7.423**	62.469	31.771	18.995	**37.745**
498	7.356	5.938	5.792	**6.362**	6.797	30.986	6.254	**14.679**	7.731	8.610	5.863	**7.401**	62.014	31.831	19.038	**37.628**
500	7.404	5.938	5.800	**6.381**	6.854	31.049	6.173	**14.692**	7.727	8.576	5.870	**7.391**	62.239	31.826	19.017	**37.694**
502	7.339	5.903	5.821	**6.354**	6.794	30.864	6.197	**14.618**	7.704	8.562	5.855	**7.374**	61.562	31.771	19.107	**37.480**
504	7.339	5.905	5.766	**6.337**	6.758	30.863	6.178	**14.600**	7.658	8.620	5.814	**7.364**	61.562	31.886	18.905	**37.451**
506	7.335	5.901	5.803	**6.346**	6.785	30.924	6.175	**14.628**	7.685	8.500	5.865	**7.350**	61.560	31.651	19.017	**37.409**
508	7.303	5.913	5.778	**6.331**	6.800	30.679	6.173	**14.551**	7.636	8.529	5.804	**7.323**	61.337	31.596	18.842	**37.258**
510	7.325	5.913	5.788	**6.342**	6.764	30.924	6.197	**14.628**	7.681	8.490	5.810	**7.327**	61.782	31.592	19.064	**37.479**
512	7.343	5.936	5.782	**6.354**	6.785	30.986	6.197	**14.656**	7.639	8.471	5.794	**7.301**	62.011	31.473	18.910	**37.465**
514	7.314	5.881	5.750	**6.315**	6.758	30.497	6.170	**14.475**	7.624	8.510	5.752	**7.295**	60.676	31.359	19.069	**37.035**
516	7.307	5.902	5.762	**6.324**	6.779	30.619	6.195	**14.531**	7.639	8.486	5.758	**7.294**	60.895	31.584	18.979	**37.153**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
518	7.300	5.876	5.778	**6.318**	6.743	30.619	6.170	**14.511**	7.598	8.453	5.718	**7.256**	60.674	31.525	18.868	**37.022**
520	7.290	5.890	5.727	**6.302**	6.770	30.679	6.165	**14.538**	7.591	8.539	5.704	**7.278**	60.676	31.184	18.800	**36.887**
522	7.302	5.863	5.720	**6.295**	6.767	30.618	6.168	**14.518**	7.576	8.497	5.693	**7.255**	60.458	31.239	18.894	**36.864**
524	7.251	5.881	5.687	**6.273**	6.734	30.497	6.143	**14.458**	7.598	8.507	5.654	**7.253**	60.024	31.184	18.868	**36.692**
526	7.276	5.856	5.683	**6.272**	6.722	30.739	6.190	**14.550**	7.520	8.411	5.656	**7.196**	60.458	31.295	18.805	**36.853**
528	7.244	5.875	5.740	**6.286**	6.717	30.618	6.190	**14.508**	7.572	8.431	5.643	**7.215**	60.242	31.353	18.784	**36.793**
530	7.259	5.891	5.687	**6.279**	6.717	30.139	6.165	**14.340**	7.502	8.388	5.631	**7.174**	60.463	30.953	18.695	**36.704**
532	7.263	5.868	5.656	**6.262**	6.743	30.317	6.187	**14.416**	7.510	8.413	5.608	**7.177**	60.246	30.896	18.716	**36.619**
534	7.246	5.840	5.674	**6.253**	6.699	30.198	6.165	**14.354**	7.528	8.399	5.574	**7.167**	60.032	31.009	18.784	**36.608**
536	7.220	5.864	5.668	**6.251**	6.726	30.558	6.160	**14.481**	7.455	8.394	5.580	**7.143**	59.820	30.838	18.810	**36.489**
538	7.217	5.859	5.633	**6.236**	6.720	30.198	6.185	**14.368**	7.503	8.381	5.536	**7.140**	58.979	31.237	18.721	**36.312**
540	7.207	5.878	5.651	**6.245**	6.687	30.438	6.160	**14.428**	7.466	8.385	5.552	**7.134**	59.394	30.838	18.653	**36.295**
542	7.235	5.827	5.641	**6.234**	6.708	30.198	6.136	**14.347**	7.448	8.396	5.554	**7.133**	59.400	30.950	18.695	**36.348**
544	7.197	5.867	5.661	**6.242**	6.708	30.318	6.212	**14.413**	7.430	8.320	5.496	**7.082**	59.400	30.952	18.680	**36.344**
546	7.222	5.869	5.647	**6.246**	6.699	30.319	6.158	**14.392**	7.390	8.340	5.501	**7.077**	59.400	30.782	18.680	**36.287**
548	7.212	5.835	5.663	**6.237**	6.699	29.963	6.158	**14.273**	7.409	8.359	5.485	**7.084**	60.246	30.837	18.680	**36.588**
550	7.240	5.853	5.616	**6.236**	6.638	29.961	6.180	**14.260**	7.362	8.392	5.450	**7.068**	58.986	30.837	18.748	**36.190**
552	7.202	5.833	5.612	**6.216**	6.685	30.141	6.134	**14.320**	7.403	8.317	5.460	**7.060**	58.773	30.669	18.639	**36.027**
554	7.163	5.849	5.582	**6.198**	6.644	30.201	6.182	**14.342**	7.337	8.313	5.458	**7.036**	59.192	30.836	18.639	**36.222**
556	7.224	5.824	5.616	**6.221**	6.676	29.847	6.156	**14.226**	7.316	8.300	5.427	**7.014**	58.560	30.725	18.753	**36.013**
558	7.157	5.824	5.588	**6.190**	6.668	29.671	6.153	**14.164**	7.320	8.262	5.435	**7.006**	58.773	30.558	18.530	**35.954**
560	7.178	5.817	5.608	**6.201**	6.638	30.084	6.177	**14.300**	7.361	8.245	5.416	**7.007**	57.954	30.558	18.510	**35.674**
562	7.178	5.790	5.580	**6.183**	6.656	29.963	6.177	**14.265**	7.321	8.273	5.424	**7.006**	58.376	30.447	18.469	**35.764**
564	7.137	5.790	5.544	**6.157**	6.656	29.966	6.175	**14.266**	7.311	8.231	5.346	**6.963**	58.366	30.447	18.536	**35.783**
566	7.137	5.806	5.536	**6.160**	6.650	29.966	6.175	**14.264**	7.258	8.288	5.348	**6.965**	58.578	30.447	18.583	**35.869**
568	7.158	5.793	5.550	**6.167**	6.650	29.847	6.175	**14.224**	7.302	8.270	5.357	**6.976**	58.385	30.558	18.624	**35.856**
570	7.158	5.800	5.570	**6.176**	6.616	29.905	6.175	**14.232**	7.263	8.168	5.340	**6.924**	57.987	30.503	18.516	**35.669**
572	7.155	5.795	5.562	**6.171**	6.636	29.968	6.148	**14.251**	7.281	8.229	5.325	**6.945**	57.374	30.337	18.516	**35.409**
574	7.089	5.770	5.560	**6.140**	6.607	29.621	6.148	**14.125**	7.246	8.225	5.295	**6.922**	57.570	30.447	18.301	**35.439**
576	7.167	5.787	5.526	**6.160**	6.622	29.735	6.146	**14.168**	7.235	8.179	5.284	**6.899**	57.767	30.120	18.402	**35.430**
578	7.173	5.782	5.496	**6.150**	6.619	29.561	6.173	**14.118**	7.244	8.194	5.244	**6.894**	57.179	30.175	18.321	**35.225**
580	7.125	5.799	5.512	**6.145**	6.613	29.443	6.151	**14.069**	7.170	8.190	5.268	**6.876**	56.972	30.174	18.522	**35.223**
582	7.094	5.753	5.528	**6.125**	6.613	29.504	6.173	**14.097**	7.163	8.144	5.233	**6.847**	57.789	30.339	18.522	**35.550**
584	7.097	5.753	5.520	**6.123**	6.602	29.500	6.146	**14.083**	7.168	8.144	5.196	**6.836**	56.573	30.121	18.388	**35.027**
586	7.087	5.790	5.515	**6.131**	6.634	29.621	6.192	**14.149**	7.190	8.132	5.203	**6.842**	57.193	30.284	18.548	**35.342**
588	7.109	5.745	5.481	**6.112**	6.591	29.561	6.185	**14.112**	7.152	8.140	5.189	**6.827**	56.604	30.284	18.375	**35.088**
590	7.078	5.784	5.454	**6.105**	6.568	29.561	6.165	**14.098**	7.145	8.151	5.156	**6.817**	57.000	29.797	18.315	**35.037**
592	7.071	5.736	5.497	**6.101**	6.533	29.391	6.141	**14.022**	7.132	8.138	5.159	**6.810**	57.000	30.014	18.381	**35.132**
594	7.099	5.759	5.469	**6.109**	6.559	29.391	6.165	**14.038**	7.112	8.157	5.169	**6.813**	56.604	29.959	18.288	**34.950**
596	7.099	5.752	5.458	**6.103**	6.580	29.396	6.163	**14.046**	7.134	8.089	5.105	**6.776**	55.836	30.069	18.401	**34.769**
598	7.061	5.723	5.454	**6.079**	6.582	29.280	6.114	**13.992**	7.065	8.076	5.117	**6.753**	56.006	29.961	18.401	**34.789**
600	**7.127**	**5.746**	**5.472**	**6.115**	**6.545**	**29.396**	**6.143**	**14.028**	**7.049**	**8.132**	**5.101**	**6.761**	**56.210**	**30.179**	**18.335**	**34.908**
602	7.052	5.737	5.421	**6.070**	6.568	29.229	6.165	**13.987**	7.073	8.091	5.086	**6.750**	56.243	29.855	18.275	**34.791**
604	7.080	5.735	5.437	**6.084**	6.537	29.340	6.136	**14.004**	7.026	8.091	5.078	**6.732**	56.039	30.124	18.361	**34.841**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
606	7.070	5.733	5.474	**6.092**	6.531	29.108	6.114	**13.918**	7.075	8.074	5.031	**6.727**	56.023	29.910	18.474	**34.802**
608	7.045	5.756	5.445	**6.082**	6.580	29.285	6.141	**14.002**	7.007	8.034	5.023	**6.688**	56.226	29.910	18.368	**34.835**
610	7.057	5.729	5.482	**6.089**	6.518	29.229	6.136	**13.961**	6.994	8.057	5.027	**6.693**	55.285	29.855	18.361	**34.500**
612	7.057	5.706	5.389	**6.051**	6.518	29.059	6.160	**13.912**	7.012	8.066	5.030	**6.703**	55.871	29.805	18.150	**34.609**
614	7.020	5.766	5.403	**6.063**	6.532	29.053	6.158	**13.914**	7.024	8.013	4.978	**6.672**	55.104	29.857	18.262	**34.408**
616	7.048	5.698	5.395	**6.047**	6.535	29.119	6.109	**13.921**	7.015	8.036	4.985	**6.679**	55.505	29.589	18.242	**34.445**
618	7.013	5.716	5.372	**6.034**	6.527	29.004	6.185	**13.905**	6.984	8.060	4.969	**6.671**	54.904	29.593	18.091	**34.196**
620	7.038	5.737	5.426	**6.067**	6.498	29.114	6.133	**13.915**	6.928	8.052	4.951	**6.644**	56.259	29.645	18.130	**34.678**
622	7.031	5.687	5.357	**6.025**	6.547	28.955	6.131	**13.878**	6.925	8.035	4.943	**6.634**	55.486	29.755	18.289	**34.510**
624	7.028	5.699	5.355	**6.027**	6.542	29.004	6.158	**13.901**	6.937	8.031	4.926	**6.631**	55.889	29.280	18.335	**34.501**
626	7.077	5.726	5.367	**6.057**	6.487	29.010	6.155	**13.884**	6.955	7.991	4.891	**6.612**	55.124	29.280	18.184	**34.196**
628	7.019	5.675	5.340	**6.011**	6.482	29.064	6.129	**13.892**	6.915	8.014	4.902	**6.610**	55.124	29.280	18.099	**34.168**
630	7.012	5.718	5.360	**6.030**	6.471	28.841	6.131	**13.814**	6.879	7.978	4.902	**6.586**	54.745	29.438	18.145	**34.109**
632	7.009	5.711	5.352	**6.024**	6.468	28.841	6.129	**13.813**	6.927	7.943	4.888	**6.586**	55.143	29.493	18.060	**34.232**
634	6.978	5.691	5.380	**6.016**	6.463	28.787	6.153	**13.801**	6.857	7.970	4.852	**6.560**	54.924	29.335	17.929	**34.063**
636	7.055	5.689	5.358	**6.034**	6.460	28.847	6.129	**13.812**	6.863	7.918	4.878	**6.553**	54.589	29.234	17.994	**33.939**
638	6.996	5.709	5.353	**6.019**	6.457	28.794	6.153	**13.801**	6.860	7.950	4.846	**6.552**	54.589	29.391	18.041	**34.007**
640	6.990	5.656	5.328	**5.991**	6.478	28.787	6.129	**13.798**	6.848	7.910	4.809	**6.522**	54.589	29.083	18.184	**33.952**
642	6.987	5.699	5.321	**6.002**	6.470	28.901	6.102	**13.824**	6.869	7.894	4.813	**6.525**	54.413	29.072	18.094	**33.860**
644	6.953	5.650	5.291	**5.965**	6.498	28.733	6.102	**13.778**	6.800	7.917	4.759	**6.492**	54.434	29.083	18.021	**33.846**
646	6.953	5.670	5.331	**5.985**	6.467	28.955	6.150	**13.857**	6.779	7.936	4.782	**6.499**	54.041	29.133	18.067	**33.747**
648	6.978	5.690	5.304	**5.991**	6.402	28.687	6.119	**13.736**	6.803	7.897	4.769	**6.490**	54.064	29.083	18.048	**33.732**
650	6.968	5.646	5.318	**5.977**	6.513	28.513	6.146	**13.724**	6.764	7.866	4.760	**6.463**	53.500	28.977	18.010	**33.496**
652	6.962	5.646	5.311	**5.973**	6.420	28.619	6.097	**13.712**	6.779	7.858	4.737	**6.458**	53.696	29.138	18.029	**33.621**
654	6.989	5.684	5.269	**5.981**	6.448	28.407	6.121	**13.659**	6.800	7.877	4.752	**6.476**	53.719	29.193	17.990	**33.634**
656	6.931	5.660	5.255	**5.949**	6.471	28.521	6.165	**13.719**	6.725	7.900	4.731	**6.452**	53.914	29.138	17.861	**33.638**
658	6.922	5.651	5.277	**5.950**	6.420	28.407	6.170	**13.666**	6.743	7.865	4.727	**6.445**	53.573	28.730	17.925	**33.409**
660	6.922	5.676	5.282	**5.960**	6.409	28.581	6.167	**13.719**	6.723	7.849	4.741	**6.438**	53.719	28.933	17.861	**33.504**
662	6.940	5.645	5.278	**5.954**	6.406	28.528	6.119	**13.684**	6.726	7.853	4.703	**6.427**	53.937	28.730	17.823	**33.497**
664	6.971	5.643	5.257	**5.957**	6.398	28.634	6.146	**13.726**	6.685	7.837	4.701	**6.408**	53.549	28.674	17.998	**33.407**
666	6.909	5.643	5.252	**5.935**	6.424	28.641	6.167	**13.744**	6.697	7.821	4.716	**6.411**	52.712	28.736	17.850	**33.099**
668	6.903	5.619	5.273	**5.932**	6.416	28.311	6.119	**13.615**	6.670	7.813	4.711	**6.398**	53.719	28.576	17.876	**33.390**
670	6.928	5.651	5.260	**5.946**	6.408	28.588	6.141	**13.712**	6.703	7.852	4.708	**6.421**	52.851	28.993	17.831	**33.225**
672	6.924	5.653	5.233	**5.937**	6.385	28.147	6.116	**13.549**	6.662	7.801	4.705	**6.389**	53.404	28.680	18.082	**33.389**
674	6.918	5.607	5.251	**5.925**	6.411	28.311	6.116	**13.613**	6.627	7.797	4.721	**6.382**	53.044	28.840	17.850	**33.245**
676	6.921	5.625	5.225	**5.924**	6.403	28.371	6.090	**13.621**	6.642	7.812	4.678	**6.377**	53.261	28.431	17.941	**33.211**
678	6.882	5.625	5.241	**5.916**	6.369	28.267	6.138	**13.591**	6.630	7.770	4.697	**6.366**	52.877	28.638	17.747	**33.087**
680	6.885	5.641	5.234	**5.920**	6.344	28.595	6.138	**13.692**	6.651	7.774	4.691	**6.372**	52.903	28.534	17.793	**33.077**
682	6.872	5.616	5.210	**5.899**	6.361	28.156	6.114	**13.544**	6.582	7.762	4.687	**6.344**	53.261	28.590	17.884	**33.245**
684	6.866	5.614	5.203	**5.894**	6.381	28.267	6.136	**13.595**	6.599	7.754	4.683	**6.345**	52.548	28.748	17.820	**33.039**
686	6.897	5.590	5.199	**5.895**	6.374	28.267	6.112	**13.584**	6.559	7.773	4.661	**6.331**	53.428	28.590	17.764	**33.261**
688	6.915	5.614	5.170	**5.900**	6.376	28.371	6.112	**13.620**	6.568	7.693	4.714	**6.325**	52.738	28.486	17.737	**32.987**
690	6.887	5.606	5.185	**5.893**	6.371	28.216	6.112	**13.566**	6.560	7.720	4.691	**6.324**	52.764	28.390	17.764	**32.973**
692	6.878	5.602	5.182	**5.887**	6.346	28.104	6.133	**13.528**	6.497	7.746	4.669	**6.304**	52.575	28.239	17.764	**32.859**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
694	6.899	5.600	5.197	**5.899**	6.313	28.224	6.109	**13.549**	6.538	7.708	4.647	**6.298**	52.250	28.645	17.737	**32.877**
696	6.872	5.572	5.171	**5.872**	6.360	28.216	6.131	**13.569**	6.530	7.696	4.663	**6.296**	53.144	28.349	17.737	**33.077**
698	6.845	5.596	5.144	**5.862**	6.333	28.002	6.109	**13.481**	6.524	7.696	4.677	**6.299**	52.439	28.349	17.700	**32.829**
700	6.836	5.612	5.181	**5.876**	6.353	28.062	6.109	**13.508**	6.482	7.693	4.653	**6.276**	51.929	28.397	17.764	**32.697**
702	6.890	5.564	5.174	**5.876**	6.320	27.951	6.131	**13.467**	6.497	7.708	4.649	**6.285**	52.465	28.247	17.745	**32.819**
704	6.824	5.610	5.171	**5.868**	6.347	27.951	6.080	**13.459**	6.491	7.636	4.664	**6.264**	51.901	28.397	17.607	**32.635**
706	6.845	5.584	5.168	**5.866**	6.340	27.850	6.153	**13.448**	6.472	7.624	4.643	**6.246**	51.901	28.105	17.663	**32.556**
708	6.851	5.582	5.137	**5.857**	6.284	28.011	6.131	**13.475**	6.492	7.628	4.636	**6.252**	51.584	28.207	17.571	**32.454**
710	6.836	5.604	5.154	**5.865**	6.307	27.850	6.104	**13.420**	6.448	7.677	4.634	**6.253**	51.771	28.105	17.607	**32.494**
712	6.890	5.604	5.128	**5.874**	6.324	27.790	6.129	**13.414**	6.465	7.639	4.649	**6.251**	52.117	28.011	17.690	**32.606**
714	6.812	5.602	5.145	**5.853**	6.299	27.910	6.126	**13.445**	6.432	7.598	4.627	**6.219**	51.456	28.207	17.525	**32.396**
716	6.803	5.578	5.140	**5.840**	6.319	27.910	6.102	**13.444**	6.419	7.624	4.621	**6.221**	52.144	27.918	17.634	**32.565**
718	6.857	5.556	5.155	**5.856**	6.294	27.910	6.124	**13.443**	6.408	7.617	4.637	**6.221**	51.456	28.113	17.534	**32.368**
720	6.797	5.600	5.110	**5.836**	6.341	27.860	6.075	**13.425**	6.405	7.609	4.616	**6.210**	51.799	27.918	17.598	**32.438**
722	6.821	5.578	5.106	**5.835**	6.281	27.860	6.078	**13.406**	6.417	7.602	4.593	**6.204**	51.485	27.918	17.598	**32.334**
724	6.818	5.576	5.078	**5.824**	6.301	27.910	6.124	**13.445**	6.384	7.587	4.607	**6.193**	50.776	28.020	17.643	**32.146**
726	6.785	5.554	5.095	**5.811**	6.303	27.810	6.102	**13.405**	6.346	7.580	4.606	**6.177**	51.145	27.927	17.389	**32.154**
728	6.815	5.574	5.093	**5.827**	6.318	27.860	6.099	**13.426**	6.355	7.542	4.602	**6.166**	50.960	28.168	17.416	**32.181**
730	6.776	5.574	5.064	**5.805**	6.293	27.700	6.097	**13.363**	6.345	7.572	4.617	**6.178**	50.534	28.028	17.335	**31.966**
732	6.853	5.572	5.081	**5.835**	6.261	27.650	6.145	**13.352**	6.334	7.561	4.596	**6.164**	51.330	27.881	17.453	**32.221**
734	6.794	5.618	5.111	**5.841**	6.288	27.810	6.124	**13.407**	6.302	7.557	4.610	**6.156**	50.686	27.597	17.462	**31.915**
736	6.764	5.572	5.070	**5.802**	6.308	27.442	6.095	**13.282**	6.314	7.524	4.588	**6.142**	50.869	27.881	17.525	**32.092**
738	6.791	5.548	5.061	**5.800**	6.275	27.770	6.119	**13.388**	6.356	7.543	4.604	**6.168**	50.202	27.835	17.462	**31.833**
740	6.764	5.592	5.081	**5.812**	6.221	27.453	6.119	**13.264**	6.268	7.572	4.583	**6.141**	50.686	27.698	17.471	**31.952**
742	6.808	5.568	5.056	**5.811**	6.270	27.491	6.143	**13.301**	6.250	7.498	4.577	**6.108**	50.352	27.643	17.534	**31.843**
744	6.805	5.568	5.051	**5.808**	6.240	27.661	6.095	**13.332**	6.297	7.513	4.594	**6.135**	50.202	27.789	17.471	**31.821**
746	6.746	5.564	5.026	**5.779**	6.260	27.671	6.097	**13.343**	6.268	7.510	4.590	**6.123**	49.611	27.643	17.327	**31.527**
748	6.767	5.568	5.020	**5.785**	6.235	27.502	6.092	**13.276**	6.255	7.443	4.604	**6.101**	50.234	27.597	17.498	**31.776**
750	6.743	5.542	5.078	**5.788**	6.247	27.562	6.090	**13.300**	6.240	7.491	4.583	**6.105**	49.905	27.652	17.309	**31.622**
752	6.764	5.564	5.015	**5.781**	6.247	27.611	6.116	**13.325**	6.235	7.488	4.562	**6.095**	50.447	27.562	17.354	**31.788**
754	6.788	5.564	5.047	**5.800**	6.277	27.404	6.092	**13.258**	6.244	7.506	4.576	**6.109**	49.905	27.652	17.300	**31.619**
756	6.728	5.564	5.020	**5.771**	6.215	27.562	6.114	**13.297**	6.210	7.447	4.554	**6.070**	50.118	27.517	17.291	**31.642**
758	6.728	5.542	5.015	**5.762**	6.240	27.355	6.114	**13.236**	6.197	7.470	4.536	**6.068**	49.791	27.362	17.399	**31.517**
760	6.773	5.540	4.992	**5.768**	6.225	27.355	6.090	**13.223**	6.185	7.437	4.549	**6.057**	49.611	27.517	17.336	**31.488**
762	6.749	5.584	4.987	**5.773**	6.205	27.307	6.116	**13.209**	6.148	7.452	4.546	**6.049**	49.611	27.373	17.399	**31.461**
764	6.711	5.560	4.979	**5.750**	6.198	27.415	6.087	**13.233**	6.187	7.500	4.541	**6.076**	49.466	27.662	17.300	**31.476**
766	6.734	5.562	4.994	**5.763**	6.220	27.210	6.087	**13.172**	6.131	7.467	4.519	**6.039**	49.466	27.472	17.318	**31.419**
768	6.708	5.582	4.970	**5.753**	6.195	27.534	6.109	**13.279**	6.170	7.460	4.554	**6.061**	49.321	27.527	17.354	**31.401**
770	6.758	5.560	5.003	**5.774**	6.185	27.210	6.112	**13.169**	6.129	7.423	4.514	**6.022**	49.287	27.482	17.230	**31.333**
772	6.755	5.534	4.959	**5.749**	6.185	27.259	6.109	**13.184**	6.124	7.416	4.528	**6.023**	49.390	27.383	17.230	**31.334**
774	6.746	5.556	4.977	**5.760**	6.205	27.318	6.085	**13.203**	6.167	7.405	4.524	**6.032**	49.035	27.472	17.265	**31.257**
776	6.740	5.580	4.988	**5.769**	6.202	27.222	6.083	**13.169**	6.099	7.369	4.538	**6.002**	49.679	27.349	17.167	**31.398**
778	6.687	5.578	4.982	**5.749**	6.197	27.318	6.083	**13.199**	6.116	7.417	4.516	**6.016**	49.500	27.053	17.355	**31.303**
780	6.676	5.598	4.957	**5.744**	6.165	27.318	6.085	**13.189**	6.104	7.391	4.493	**5.996**	49.212	27.250	17.310	**31.257**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
782	6.682	5.554	4.954	**5.730**	6.244	26.818	6.083	**13.048**	6.076	7.348	4.509	**5.978**	48.787	27.162	17.204	**31.051**
784	6.708	5.576	4.949	**5.744**	6.187	27.174	6.083	**13.148**	6.064	7.403	4.490	**5.986**	48.928	27.108	17.150	**31.062**
786	6.676	5.554	4.927	**5.719**	6.158	27.115	6.107	**13.127**	6.028	7.363	4.485	**5.959**	48.751	27.359	17.239	**31.116**
788	6.697	5.552	4.934	**5.728**	6.170	27.019	6.058	**13.082**	6.016	7.359	4.517	**5.964**	48.647	27.206	17.150	**31.001**
790	6.667	5.550	4.935	**5.717**	6.124	27.127	6.080	**13.110**	6.011	7.313	4.478	**5.934**	48.574	27.119	17.097	**30.930**
792	6.694	5.528	4.929	**5.717**	6.119	27.127	6.080	**13.109**	6.000	7.352	4.473	**5.942**	48.963	27.119	17.160	**31.081**
794	6.661	5.550	4.945	**5.719**	6.143	26.938	6.080	**13.054**	5.986	7.332	4.487	**5.935**	48.647	27.130	17.063	**30.947**
796	6.708	5.524	4.944	**5.725**	6.114	26.912	6.104	**13.043**	6.000	7.321	4.465	**5.929**	48.332	26.922	17.204	**30.819**
798	6.679	5.570	4.916	**5.722**	6.133	27.019	6.104	**13.085**	5.991	7.263	4.479	**5.911**	48.332	26.934	17.204	**30.823**
800	6.679	5.590	4.912	**5.727**	6.131	27.032	6.102	**13.088**	5.984	7.278	4.475	**5.912**	48.332	27.086	17.160	**30.859**
802	6.671	5.566	4.928	**5.722**	6.129	27.127	6.102	**13.119**	5.972	7.275	4.470	**5.906**	48.647	26.793	17.125	**30.855**
804	6.671	5.546	4.923	**5.713**	6.121	27.032	6.078	**13.077**	5.937	7.290	4.504	**5.910**	48.057	26.945	17.152	**30.718**
806	6.671	5.592	4.902	**5.722**	6.097	26.725	6.078	**12.967**	5.954	7.265	4.465	**5.895**	48.267	26.945	17.090	**30.767**
808	6.659	5.522	4.914	**5.698**	6.112	26.725	6.099	**12.979**	5.945	7.290	4.475	**5.903**	47.920	26.708	17.152	**30.593**
810	6.662	5.544	4.869	**5.692**	6.131	26.891	6.078	**13.033**	5.952	7.305	4.451	**5.903**	48.194	26.805	16.994	**30.664**
812	6.682	5.542	4.905	**5.710**	6.133	26.785	6.124	**13.014**	5.920	7.273	4.451	**5.881**	48.231	26.860	17.100	**30.730**
814	6.680	5.542	4.879	**5.700**	6.131	26.692	6.078	**12.967**	5.908	7.295	4.463	**5.889**	47.746	26.957	17.083	**30.595**
816	6.648	5.522	4.872	**5.681**	6.129	26.891	6.099	**13.040**	5.902	7.224	4.441	**5.856**	47.883	26.720	16.977	**30.527**
818	6.648	5.562	4.872	**5.694**	6.124	26.798	6.102	**13.008**	5.867	7.246	4.456	**5.856**	47.822	26.774	17.083	**30.560**
820	6.627	5.540	4.886	**5.684**	6.114	26.798	6.099	**13.004**	5.881	7.242	4.450	**5.858**	47.611	26.871	16.925	**30.469**
822	6.616	5.540	4.862	**5.673**	6.109	26.646	6.073	**12.943**	5.868	7.232	4.464	**5.855**	47.995	26.817	16.908	**30.573**
824	6.639	5.518	4.872	**5.676**	6.109	26.738	6.102	**12.983**	5.885	7.225	4.407	**5.839**	47.934	26.871	16.908	**30.571**
826	6.630	5.538	4.871	**5.680**	6.099	26.798	6.049	**12.982**	5.897	7.247	4.422	**5.855**	47.995	26.593	16.970	**30.519**
828	6.610	5.538	4.823	**5.657**	6.078	26.751	6.071	**12.967**	5.835	7.215	4.417	**5.822**	47.515	26.483	16.891	**30.296**
830	6.599	5.520	4.843	**5.654**	6.044	26.751	6.049	**12.948**	5.837	7.240	4.431	**5.836**	47.382	26.744	16.980	**30.369**
832	6.619	5.534	4.820	**5.658**	6.090	26.659	6.121	**12.957**	5.796	7.202	4.393	**5.797**	46.907	26.635	16.997	**30.180**
834	6.645	5.536	4.853	**5.678**	6.068	26.494	6.097	**12.886**	5.842	7.160	4.424	**5.809**	47.249	26.605	17.014	**30.289**
836	6.616	5.554	4.827	**5.666**	6.061	26.659	6.047	**12.922**	5.804	7.192	4.421	**5.806**	47.249	26.714	16.902	**30.288**
838	6.587	5.578	4.823	**5.663**	6.083	26.417	6.095	**12.865**	5.839	7.182	4.399	**5.807**	46.986	26.660	16.885	**30.177**
840	6.637	5.556	4.818	**5.670**	6.059	26.613	6.092	**12.921**	5.762	7.172	4.413	**5.782**	47.326	26.756	16.885	**30.322**
842	6.579	5.510	4.828	**5.639**	6.080	26.522	6.042	**12.881**	5.774	7.165	4.425	**5.788**	47.288	26.576	16.790	**30.218**
844	6.602	5.506	4.825	**5.644**	6.073	26.613	6.095	**12.927**	5.784	7.130	4.389	**5.768**	46.855	26.480	16.868	**30.068**
846	6.605	5.510	4.803	**5.639**	6.044	26.627	6.044	**12.905**	5.732	7.127	4.367	**5.742**	47.195	26.576	16.851	**30.207**
848	6.597	5.530	4.781	**5.636**	6.068	26.476	6.092	**12.879**	5.766	7.142	4.398	**5.769**	46.946	26.384	16.973	**30.101**
850	6.602	5.532	4.815	**5.650**	6.066	26.417	6.087	**12.857**	5.762	7.167	4.393	**5.774**	46.895	26.534	16.834	**30.088**
852	6.565	5.528	4.787	**5.627**	6.083	26.417	6.066	**12.855**	5.745	7.160	4.354	**5.753**	46.725	26.630	16.834	**30.063**
854	6.597	5.508	4.767	**5.624**	6.083	26.811	6.068	**12.987**	5.737	7.125	4.354	**5.739**	46.765	26.547	16.784	**30.032**
856	6.582	5.506	4.765	**5.618**	6.006	26.431	6.039	**12.825**	5.728	7.091	Fail	**6.410**	46.934	26.356	16.878	**30.056**
858	6.580	5.522	4.775	**5.626**	6.049	26.581	6.063	**12.898**	5.699	7.116	Fail	**6.408**	46.765	26.601	16.956	**30.107**
860	6.597	5.528	4.755	**5.627**	6.045	26.627	6.063	**12.912**	5.687	7.131	Fail	**6.409**	46.131	26.452	16.767	**29.783**
862	6.577	5.548	4.793	**5.639**	5.992	26.237	6.112	**12.780**	5.678	7.127	Fail	**6.403**	46.340	26.220	16.767	**29.776**
864	6.574	5.524	4.766	**5.621**	6.040	26.237	6.063	**12.780**	5.666	7.114	Fail	**6.390**	46.676	26.477	16.662	**29.938**
866	6.597	5.524	4.798	**5.640**	6.014	26.237	6.087	**12.779**	5.658	7.090	Fail	**6.374**	46.213	26.328	16.811	**29.784**
868	6.563	5.502	4.755	**5.607**	6.031	26.536	6.039	**12.869**	5.690	7.077	Fail	**6.384**	46.381	26.356	16.811	**29.849**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
870	6.568	5.526	4.752	**5.615**	6.028	26.522	6.035	**12.862**	5.659	7.064	Fail	**6.362**	45.962	26.328	16.855	**29.715**
872	6.534	5.544	4.747	**5.608**	5.978	26.341	6.059	**12.793**	5.633	7.008	Fail	**6.321**	46.381	26.192	16.717	**29.763**
874	6.555	5.520	4.744	**5.606**	6.019	26.192	6.059	**12.757**	5.602	7.060	Fail	**6.331**	45.671	26.192	16.882	**29.582**
876	6.555	5.516	4.734	**5.602**	6.007	26.252	6.061	**12.773**	5.633	7.048	Fail	**6.341**	45.712	26.017	16.778	**29.502**
878	6.578	5.520	4.731	**5.610**	6.016	26.400	6.087	**12.834**	5.624	7.016	Fail	**6.320**	45.962	26.017	16.712	**29.564**
880	6.526	5.498	4.770	**5.598**	6.012	26.163	6.059	**12.745**	5.590	7.035	Fail	**6.313**	45.628	26.111	16.778	**29.506**
882	6.569	5.495	4.726	**5.597**	5.983	26.296	6.083	**12.787**	5.580	7.028	Fail	**6.304**	45.671	26.165	16.849	**29.562**
884	6.541	5.518	4.723	**5.594**	5.957	26.104	6.056	**12.706**	5.548	7.019	Fail	**6.284**	45.424	26.098	16.805	**29.442**
886	6.564	5.516	4.701	**5.594**	5.976	26.104	6.059	**12.713**	5.558	7.016	Fail	**6.287**	45.631	26.273	16.591	**29.498**
888	6.538	5.538	4.714	**5.597**	5.993	26.104	6.032	**12.710**	5.552	7.037	Fail	**6.295**	45.712	26.045	16.745	**29.501**
890	6.535	5.538	4.730	**5.601**	5.969	26.163	6.080	**12.737**	5.514	7.000	Fail	**6.257**	45.424	26.045	16.723	**29.397**
892	6.558	5.514	4.710	**5.594**	5.982	26.163	6.059	**12.735**	5.512	6.993	Fail	**6.253**	45.712	25.951	16.712	**29.458**
894	6.532	5.514	4.684	**5.577**	6.010	25.956	6.056	**12.674**	5.548	6.990	Fail	**6.269**	45.466	25.911	16.575	**29.317**
896	6.501	5.514	4.697	**5.571**	5.958	26.015	6.054	**12.676**	5.514	7.008	Fail	**6.261**	45.466	25.763	16.662	**29.297**
898	6.527	5.491	4.674	**5.564**	5.970	25.972	6.032	**12.658**	5.526	6.981	Fail	**6.254**	44.774	25.857	16.602	**29.078**
900	6.498	5.534	4.688	**5.573**	5.951	26.178	6.078	**12.736**	5.536	6.941	Fail	**6.239**	45.058	26.005	16.646	**29.236**
902	6.493	5.534	4.667	**5.565**	5.927	25.928	6.078	**12.644**	5.465	6.928	Fail	**6.197**	45.466	26.058	16.646	**29.390**
904	6.570	5.489	4.681	**5.580**	5.994	26.090	6.078	**12.721**	5.452	6.928	Fail	**6.190**	45.265	26.005	16.690	**29.320**
906	6.485	5.530	4.693	**5.569**	5.961	26.075	6.054	**12.697**	5.440	6.949	Fail	**6.195**	45.508	25.792	16.570	**29.290**
908	6.508	5.489	4.653	**5.550**	5.937	26.075	6.052	**12.688**	5.436	6.946	Fail	**6.191**	44.938	25.885	16.553	**29.125**
910	6.505	5.508	4.666	**5.560**	5.937	25.781	6.078	**12.599**	5.450	6.937	Fail	**6.194**	44.774	26.139	16.521	**29.145**
912	6.502	5.510	4.663	**5.558**	5.935	25.987	6.073	**12.665**	5.435	6.903	Fail	**6.169**	44.818	25.620	16.581	**29.006**
914	6.497	5.508	4.660	**5.555**	5.926	25.900	6.052	**12.626**	5.406	6.924	Fail	**6.165**	44.861	25.713	16.445	**29.006**
916	6.474	5.506	4.654	**5.545**	5.947	25.797	6.052	**12.599**	5.394	6.946	Fail	**6.170**	44.861	25.620	16.461	**28.981**
918	6.514	5.485	4.650	**5.550**	5.940	25.943	6.049	**12.644**	5.385	6.921	Fail	**6.153**	45.024	25.713	16.641	**29.126**
920	6.468	5.506	4.666	**5.547**	5.919	26.090	6.049	**12.686**	5.403	6.900	Fail	**6.152**	45.024	25.596	16.548	**29.056**
922	6.463	5.506	4.660	**5.543**	5.938	25.900	6.076	**12.638**	5.368	6.900	Fail	**6.134**	44.981	25.542	16.548	**29.024**
924	6.460	5.505	4.638	**5.534**	5.889	25.797	6.073	**12.586**	5.380	6.894	Fail	**6.137**	44.742	25.542	16.456	**28.913**
926	6.455	5.505	4.634	**5.531**	5.901	25.813	6.068	**12.594**	5.349	6.887	Fail	**6.118**	44.462	25.713	16.624	**28.933**
928	6.483	5.526	4.631	**5.547**	5.950	25.754	6.073	**12.592**	5.352	6.905	Fail	**6.129**	44.345	25.728	16.592	**28.888**
930	6.478	5.505	4.624	**5.536**	5.929	25.813	6.025	**12.589**	5.352	6.878	Fail	**6.115**	44.433	25.665	16.516	**28.871**
932	6.506	5.524	4.604	**5.545**	5.922	25.711	6.097	**12.577**	5.364	6.860	Fail	**6.112**	44.872	25.650	16.468	**28.997**
934	6.472	5.501	4.616	**5.530**	5.871	25.857	6.044	**12.591**	5.311	6.860	Fail	**6.086**	44.668	25.743	16.408	**28.940**
936	6.447	5.501	4.628	**5.525**	5.913	25.669	6.047	**12.543**	5.321	6.863	Fail	**6.092**	44.786	25.572	16.408	**28.922**
938	6.441	5.522	4.627	**5.530**	5.934	25.711	6.044	**12.563**	5.287	6.824	Fail	**6.056**	44.112	25.426	16.468	**28.669**
940	6.439	5.501	4.621	**5.520**	5.885	25.770	6.044	**12.566**	5.327	6.869	Fail	**6.098**	44.317	25.388	16.420	**28.708**
942	6.444	5.479	4.584	**5.502**	5.927	25.915	6.044	**12.629**	5.297	6.836	Fail	**6.067**	44.593	25.334	16.452	**28.793**
944	6.459	5.477	4.616	**5.517**	5.869	25.685	6.068	**12.541**	5.265	6.833	Fail	**6.049**	44.273	25.519	16.420	**28.737**
946	6.459	5.518	4.594	**5.524**	5.897	25.600	6.116	**12.538**	5.277	6.791	Fail	**6.034**	44.317	25.327	16.479	**28.708**
948	6.482	5.516	4.573	**5.524**	5.897	25.642	6.068	**12.536**	5.270	6.818	Fail	**6.044**	44.317	25.403	16.420	**28.713**
950	6.464	5.518	4.567	**5.516**	5.865	25.727	6.042	**12.545**	5.257	6.815	Fail	**6.036**	44.086	25.457	16.392	**28.645**
952	6.422	5.495	4.604	**5.507**	5.837	25.685	6.020	**12.514**	5.250	6.829	Fail	**6.040**	44.245	25.419	16.372	**28.679**
954	6.443	5.495	4.577	**5.505**	5.858	25.701	6.042	**12.534**	5.234	6.823	Fail	**6.029**	43.971	25.419	16.404	**28.598**
956	6.422	5.493	4.609	**5.508**	5.877	25.583	6.040	**12.500**	5.233	6.773	Fail	**6.003**	43.857	25.327	16.329	**28.504**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
958	6.443	5.471	4.564	**5.493**	5.851	25.583	6.044	**12.493**	5.201	6.785	Fail	**5.993**	44.086	25.198	16.372	**28.552**
960	6.414	5.516	4.583	**5.504**	5.847	25.642	6.040	**12.510**	5.213	6.817	Fail	**6.015**	43.971	25.289	16.313	**28.524**
962	6.463	5.515	4.560	**5.513**	5.898	25.642	6.064	**12.535**	5.203	6.773	Fail	**5.988**	43.676	25.289	16.357	**28.441**
964	6.483	5.493	4.538	**5.505**	5.840	25.456	6.013	**12.436**	5.175	6.770	Fail	**5.973**	44.130	25.214	16.313	**28.552**
966	6.412	5.518	4.552	**5.494**	5.815	25.473	6.064	**12.451**	5.189	6.767	Fail	**5.978**	43.631	25.176	16.266	**28.358**
968	6.435	5.491	4.546	**5.491**	5.836	25.473	6.035	**12.448**	5.177	6.737	Fail	**5.957**	44.060	25.214	16.325	**28.533**
970	6.457	5.469	4.564	**5.497**	5.832	25.372	6.037	**12.414**	5.170	6.755	Fail	**5.963**	43.676	25.122	16.309	**28.369**
972	6.424	5.465	4.578	**5.489**	5.802	25.456	6.013	**12.424**	5.163	6.728	Fail	**5.946**	43.519	25.027	16.325	**28.290**
974	6.421	5.489	4.542	**5.484**	5.823	25.473	6.013	**12.436**	5.151	6.740	Fail	**5.946**	43.631	25.010	16.278	**28.306**
976	6.393	5.489	4.523	**5.468**	5.821	25.331	6.009	**12.387**	5.168	6.764	Fail	**5.966**	43.408	24.973	16.176	**28.186**
978	6.436	5.465	4.538	**5.480**	5.823	25.473	6.059	**12.452**	5.135	6.731	Fail	**5.933**	43.453	25.101	16.204	**28.253**
980	6.439	5.489	4.537	**5.488**	5.862	25.289	6.059	**12.403**	5.125	6.726	Fail	**5.926**	43.297	25.192	16.262	**28.250**
982	6.388	5.465	4.518	**5.457**	5.833	25.431	6.035	**12.433**	5.142	6.743	Fail	**5.943**	43.297	24.789	16.188	**28.091**
984	6.413	5.463	4.534	**5.470**	5.830	25.431	6.035	**12.432**	5.111	6.720	Fail	**5.916**	43.030	25.101	16.278	**28.136**
986	6.431	5.487	4.551	**5.490**	5.807	25.431	6.059	**12.432**	5.100	6.758	Fail	**5.929**	42.812	25.027	16.098	**27.979**
988	6.405	5.485	4.550	**5.480**	5.847	25.289	6.056	**12.397**	5.090	6.673	Fail	**5.882**	43.076	24.916	16.083	**28.025**
990	6.405	5.483	4.547	**5.478**	5.796	25.532	6.033	**12.454**	5.085	6.670	Fail	**5.878**	43.076	25.171	16.274	**28.174**
992	6.375	5.461	4.544	**5.460**	5.817	25.448	6.011	**12.425**	5.095	6.691	Fail	**5.893**	43.030	24.862	16.185	**28.026**
994	6.400	5.463	4.509	**5.457**	5.813	25.390	6.009	**12.404**	5.068	6.708	Fail	**5.888**	43.076	25.133	16.200	**28.136**
996	6.392	5.524	4.525	**5.480**	5.794	25.490	6.009	**12.431**	5.035	6.656	Fail	**5.846**	42.967	25.027	16.212	**28.069**
998	6.415	5.479	4.522	**5.472**	5.783	25.224	6.056	**12.354**	5.028	6.697	Fail	**5.863**	42.858	25.027	16.216	**28.034**
1000	6.367	5.481	4.521	**5.456**	5.779	25.206	6.033	**12.339**	5.060	6.641	Fail	**5.851**	42.858	24.969	16.126	**27.984**
1002	6.361	5.458	4.520	**5.446**	5.798	25.024	6.006	**12.276**	5.048	6.691	Fail	**5.870**	42.904	24.789	16.154	**27.949**
1004	6.387	5.479	4.538	**5.468**	5.798	25.206	6.054	**12.353**	5.022	6.659	Fail	**5.841**	42.703	24.789	16.196	**27.896**
1006	6.412	5.461	4.518	**5.464**	5.752	25.165	6.033	**12.317**	5.027	6.680	Fail	**5.854**	43.059	24.842	16.138	**28.013**
1008	6.381	5.479	4.532	**5.464**	5.791	25.224	6.078	**12.364**	4.999	6.618	Fail	**5.809**	42.950	24.859	16.065	**27.958**
1010	6.407	5.477	4.532	**5.472**	5.741	24.984	6.030	**12.252**	4.994	6.616	Fail	**5.805**	42.322	24.985	15.991	**27.766**
1012	6.368	5.501	4.531	**5.467**	5.782	25.083	6.054	**12.306**	5.022	6.665	Fail	**5.844**	42.535	24.859	16.049	**27.814**
1014	6.343	5.499	4.494	**5.445**	5.776	25.124	6.028	**12.309**	4.957	6.628	Fail	**5.793**	42.750	24.806	16.034	**27.863**
1016	6.348	5.456	4.511	**5.438**	5.778	25.101	6.030	**12.303**	5.008	6.654	Fail	**5.831**	42.582	24.697	16.108	**27.796**
1018	6.368	5.475	4.527	**5.457**	5.774	25.183	6.030	**12.329**	4.977	6.616	Fail	**5.797**	42.642	24.590	16.224	**27.819**
1020	6.358	5.475	4.509	**5.447**	5.749	25.183	6.030	**12.321**	4.967	6.648	Fail	**5.808**	42.170	24.607	15.961	**27.579**
1022	6.366	5.452	4.509	**5.442**	5.765	25.124	6.025	**12.305**	4.942	6.605	Fail	**5.774**	42.217	24.697	16.004	**27.639**
1024	6.338	5.473	4.524	**5.445**	5.742	25.183	6.028	**12.318**	4.913	6.576	Fail	**5.745**	42.217	24.823	16.077	**27.706**
1026	6.335	5.471	4.524	**5.443**	5.711	25.142	6.049	**12.301**	4.903	6.591	Fail	**5.747**	41.856	24.589	15.946	**27.464**
1028	6.335	5.475	4.523	**5.444**	5.711	24.961	6.049	**12.240**	4.934	6.643	Fail	**5.789**	42.112	24.750	16.046	**27.636**
1030	6.333	5.452	4.486	**5.424**	5.752	25.101	6.025	**12.293**	4.906	6.582	Fail	**5.744**	41.856	24.678	15.973	**27.502**
1032	6.380	5.475	4.504	**5.453**	5.748	24.921	6.025	**12.231**	4.898	6.603	Fail	**5.751**	42.369	24.500	16.016	**27.628**
1034	6.358	5.471	4.518	**5.449**	5.694	24.961	6.047	**12.234**	4.871	6.582	Fail	**5.727**	41.856	24.535	15.989	**27.460**
1036	6.378	5.471	4.518	**5.456**	5.723	24.840	6.025	**12.196**	4.902	6.568	Fail	**5.735**	41.856	24.606	15.885	**27.449**
1038	6.353	5.491	4.500	**5.448**	5.694	25.020	6.025	**12.246**	4.870	6.534	Fail	**5.702**	42.055	24.464	15.958	**27.492**
1040	6.370	5.469	4.499	**5.446**	5.710	24.979	6.049	**12.246**	4.864	6.552	Fail	**5.708**	41.601	24.589	16.001	**27.397**
1042	6.317	5.448	4.481	**5.415**	5.737	24.921	6.021	**12.226**	4.837	6.575	Fail	**5.706**	41.396	24.714	15.971	**27.360**
1044	6.337	5.446	4.496	**5.426**	5.710	25.020	6.023	**12.251**	4.828	6.543	Fail	**5.686**	41.697	24.535	15.941	**27.391**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1046	6.309	5.446	4.477	**5.411**	5.706	24.979	6.071	**12.252**	4.836	6.535	Fail	**5.686**	41.697	24.446	15.956	**27.366**
1048	6.334	5.489	4.495	**5.439**	5.700	25.020	6.021	**12.247**	4.848	6.532	Fail	**5.690**	41.848	24.358	15.898	**27.368**
1050	6.309	5.466	4.511	**5.429**	5.702	24.702	5.997	**12.134**	4.801	6.524	Fail	**5.663**	41.951	24.304	15.898	**27.384**
1052	6.329	5.444	4.492	**5.422**	5.673	24.702	6.021	**12.132**	4.811	6.544	Fail	**5.678**	41.642	24.322	15.811	**27.258**
1054	6.304	5.468	4.507	**5.426**	5.725	24.899	6.021	**12.215**	4.821	6.539	Fail	**5.680**	41.041	24.322	15.926	**27.096**
1056	6.327	5.466	4.491	**5.428**	5.710	24.899	5.997	**12.202**	4.813	6.519	Fail	**5.666**	41.092	24.376	15.838	**27.102**
1058	6.319	5.487	4.490	**5.432**	5.685	25.060	6.045	**12.263**	4.804	6.505	Fail	**5.655**	41.141	24.499	15.838	**27.159**
1060	6.296	5.442	4.487	**5.408**	5.708	24.859	6.045	**12.204**	4.774	6.497	Fail	**5.636**	41.541	24.429	15.838	**27.269**
1062	6.319	5.468	4.488	**5.425**	5.681	24.721	5.995	**12.132**	4.765	6.520	Fail	**5.643**	41.391	24.252	15.911	**27.185**
1064	6.291	5.444	4.486	**5.407**	5.679	24.899	6.016	**12.198**	4.758	6.480	Fail	**5.619**	41.391	24.305	15.824	**27.173**
1066	6.291	5.440	4.487	**5.406**	5.699	24.761	6.016	**12.159**	4.768	6.478	Fail	**5.623**	41.141	24.340	15.881	**27.121**
1068	6.311	5.462	4.486	**5.420**	5.675	24.899	6.018	**12.197**	4.723	6.498	Fail	**5.611**	41.290	24.340	15.809	**27.146**
1070	6.346	5.440	4.484	**5.423**	5.675	24.642	6.018	**12.112**	4.733	6.495	Fail	**5.614**	40.793	24.376	15.866	**27.012**
1072	6.314	5.440	4.483	**5.412**	5.668	24.544	6.018	**12.077**	4.707	6.492	Fail	**5.600**	40.645	24.270	15.737	**26.884**
1074	6.311	5.483	4.482	**5.425**	5.664	24.642	5.992	**12.099**	4.734	6.456	Fail	**5.595**	40.793	24.182	15.836	**26.937**
1076	6.281	5.438	4.464	**5.394**	5.683	24.837	6.016	**12.179**	4.727	6.405	Fail	**5.566**	40.891	24.323	15.764	**26.993**
1078	6.278	5.458	4.481	**5.406**	5.680	24.740	6.016	**12.145**	4.698	6.473	Fail	**5.586**	40.744	24.376	15.764	**26.961**
1080	6.278	5.458	4.479	**5.405**	5.656	24.740	6.038	**12.145**	4.708	6.443	Fail	**5.576**	41.090	24.254	15.836	**27.060**
1082	6.273	5.438	4.479	**5.397**	5.650	24.700	6.014	**12.121**	4.697	6.465	Fail	**5.581**	40.695	24.078	15.693	**26.822**
1084	6.323	5.479	4.496	**5.433**	5.670	24.642	5.992	**12.101**	4.674	6.435	Fail	**5.555**	40.498	23.888	15.693	**26.693**
1086	6.268	5.456	4.496	**5.407**	5.668	24.740	6.040	**12.149**	4.684	6.432	Fail	**5.558**	40.351	24.010	15.720	**26.694**
1088	6.268	5.434	4.477	**5.393**	5.668	24.602	5.990	**12.087**	4.639	6.419	Fail	**5.529**	40.645	24.063	15.663	**26.790**
1090	6.288	5.458	4.459	**5.402**	5.664	24.602	6.016	**12.094**	4.631	6.455	Fail	**5.543**	40.645	24.306	15.691	**26.881**
1092	6.263	5.456	4.477	**5.399**	5.637	24.602	6.038	**12.092**	4.624	6.411	Fail	**5.518**	40.793	24.063	15.792	**26.883**
1094	6.261	5.434	4.475	**5.390**	5.635	24.563	6.040	**12.079**	4.621	6.405	Fail	**5.513**	40.793	23.907	15.691	**26.797**
1096	6.283	5.454	4.474	**5.404**	5.653	24.524	6.038	**12.072**	4.653	6.400	Fail	**5.527**	40.646	23.994	15.620	**26.753**
1098	6.305	5.432	4.474	**5.404**	5.633	24.349	6.014	**11.999**	4.615	6.397	Fail	**5.506**	40.208	24.150	15.748	**26.702**
1100	6.305	5.476	4.473	**5.418**	5.656	24.621	6.033	**12.103**	4.635	6.415	Fail	**5.525**	40.498	23.922	15.676	**26.699**
1102	6.273	5.454	4.490	**5.406**	5.629	24.758	6.035	**12.141**	4.612	6.407	Fail	**5.510**	40.401	23.907	15.662	**26.657**
1104	6.250	5.432	4.470	**5.384**	5.643	24.543	6.014	**12.067**	4.628	6.376	Fail	**5.502**	40.891	23.941	15.690	**26.841**
1106	6.248	5.452	4.452	**5.384**	5.641	24.543	6.011	**12.065**	4.625	6.376	Fail	**5.501**	40.401	23.960	15.662	**26.674**
1108	6.278	5.452	4.470	**5.400**	5.641	24.582	6.011	**12.078**	4.621	6.374	Fail	**5.498**	40.403	24.081	15.633	**26.706**
1110	6.268	5.452	4.452	**5.391**	5.592	24.543	6.035	**12.057**	4.639	6.399	Fail	**5.519**	40.453	24.099	15.618	**26.723**
1112	6.270	5.450	4.468	**5.396**	5.653	24.466	6.035	**12.051**	4.617	6.360	Fail	**5.489**	40.357	24.013	15.604	**26.658**
1114	6.235	5.429	4.468	**5.377**	5.611	24.272	6.011	**11.965**	4.597	6.360	Fail	**5.479**	40.307	24.013	15.590	**26.637**
1116	6.260	5.448	4.468	**5.392**	5.627	24.427	6.033	**12.029**	4.613	6.350	Fail	**5.482**	39.971	24.013	15.660	**26.548**
1118	6.260	5.429	4.484	**5.391**	5.600	24.292	6.033	**11.975**	4.628	6.342	Fail	**5.485**	39.971	24.134	15.590	**26.565**
1120	6.275	5.448	4.466	**5.396**	5.627	24.369	6.031	**12.009**	4.607	6.312	Fail	**5.460**	39.971	24.013	15.632	**26.539**
1122	6.257	5.470	4.449	**5.392**	5.598	24.523	6.033	**12.051**	4.605	6.332	Fail	**5.469**	40.116	23.945	15.519	**26.527**
1124	6.280	5.468	4.465	**5.404**	5.596	24.292	6.007	**11.965**	4.605	6.324	Fail	**5.465**	39.739	23.858	15.561	**26.386**
1126	6.299	5.425	4.481	**5.402**	5.616	24.330	5.988	**11.978**	4.599	6.294	Fail	**5.447**	39.877	23.997	15.504	**26.459**
1128	6.272	5.427	4.462	**5.387**	5.604	24.388	6.035	**12.009**	4.596	6.339	Fail	**5.468**	39.833	23.671	15.546	**26.350**
1130	6.242	5.444	4.461	**5.382**	5.592	24.446	6.035	**12.024**	4.592	6.311	Fail	**5.452**	39.545	23.791	15.321	**26.219**
1132	6.245	5.446	4.460	**5.384**	5.608	24.157	6.028	**11.931**	4.588	6.303	Fail	**5.446**	39.402	23.691	15.546	**26.213**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1134	6.237	5.423	4.459	**5.373**	5.604	24.446	6.007	**12.019**	4.587	6.298	Fail	**5.443**	39.360	23.777	15.518	**26.218**
1136	6.213	5.419	4.460	**5.364**	5.606	24.485	6.028	**12.040**	4.584	6.318	Fail	**5.451**	39.402	23.724	15.532	**26.219**
1138	6.215	5.423	4.459	**5.366**	5.554	24.254	6.033	**11.947**	4.598	6.263	Fail	**5.431**	39.411	23.638	15.531	**26.193**
1140	6.237	5.444	4.459	**5.380**	5.598	24.254	6.007	**11.953**	4.579	6.253	Fail	**5.416**	39.503	23.896	15.504	**26.301**
1142	6.232	5.419	4.459	**5.370**	5.568	24.274	6.028	**11.957**	4.593	6.245	Fail	**5.419**	39.839	23.829	15.462	**26.377**
1144	6.257	5.443	4.475	**5.392**	5.594	24.157	6.004	**11.918**	4.590	6.270	Fail	**5.430**	39.739	23.743	15.629	**26.370**
1146	6.232	5.441	4.437	**5.370**	5.590	24.216	6.052	**11.953**	4.586	6.312	Fail	**5.449**	39.554	23.863	15.545	**26.321**
1148	6.249	5.419	4.436	**5.368**	5.586	24.178	6.028	**11.931**	4.565	6.260	Fail	**5.413**	39.177	23.658	15.587	**26.141**
1150	6.200	5.443	4.436	**5.360**	5.588	24.140	6.004	**11.911**	4.562	6.250	Fail	**5.406**	39.228	23.691	15.503	**26.141**
1152	6.205	5.419	4.472	**5.365**	5.540	24.198	6.028	**11.922**	4.576	6.223	Fail	**5.400**	38.956	23.558	15.419	**25.978**
1154	6.249	5.441	4.453	**5.381**	5.586	24.485	6.026	**12.032**	4.556	6.250	Fail	**5.403**	39.470	23.591	15.503	**26.188**
1156	6.190	5.439	4.471	**5.367**	5.584	24.235	5.983	**11.934**	4.557	6.264	Fail	**5.411**	38.905	23.611	15.516	**26.011**
1158	6.188	5.462	4.451	**5.367**	5.598	24.312	6.026	**11.979**	4.532	6.257	Fail	**5.395**	39.462	23.729	15.489	**26.227**
1160	6.212	5.437	4.485	**5.378**	5.532	24.160	6.023	**11.905**	4.548	6.227	Fail	**5.388**	38.995	23.710	15.600	**26.102**
1162	6.210	5.437	4.448	**5.365**	5.570	24.102	6.028	**11.900**	4.562	6.195	Fail	**5.379**	38.956	23.762	15.460	**26.059**
1164	6.180	5.437	4.448	**5.355**	5.570	24.122	6.023	**11.905**	4.558	6.222	Fail	**5.390**	38.995	23.729	15.474	**26.066**
1166	6.188	5.458	4.431	**5.359**	5.594	24.160	5.976	**11.910**	4.556	6.259	Fail	**5.408**	38.815	23.493	15.362	**25.890**
1168	6.207	5.439	4.447	**5.364**	5.544	24.064	6.004	**11.871**	4.532	6.185	Fail	**5.359**	38.956	23.460	15.432	**25.949**
1170	6.207	5.476	4.429	**5.371**	5.538	24.160	5.997	**11.898**	4.530	6.175	Fail	**5.353**	39.007	23.545	15.362	**25.971**
1172	6.205	5.415	4.462	**5.361**	5.560	23.989	5.976	**11.842**	4.562	6.170	Fail	**5.366**	38.866	23.480	15.390	**25.912**
1174	6.200	5.456	4.426	**5.361**	5.556	24.027	6.023	**11.869**	4.506	6.165	Fail	**5.336**	38.777	23.460	15.348	**25.862**
1176	6.246	5.456	4.426	**5.376**	5.516	24.102	6.021	**11.880**	4.503	6.185	Fail	**5.344**	38.917	23.480	15.334	**25.910**
1178	6.202	5.433	4.442	**5.359**	5.554	24.122	5.976	**11.884**	4.517	6.153	Fail	**5.335**	38.636	23.460	15.334	**25.810**
1180	6.170	5.456	4.441	**5.356**	5.570	24.122	5.997	**11.896**	4.498	6.221	Fail	**5.360**	38.548	23.447	15.404	**25.800**
1182	6.192	5.454	4.442	**5.363**	5.526	24.160	5.997	**11.894**	4.511	6.170	Fail	**5.341**	38.599	23.363	15.376	**25.779**
1184	6.214	5.435	4.439	**5.363**	5.548	24.084	6.021	**11.884**	4.511	6.168	Fail	**5.340**	38.651	23.363	15.348	**25.787**
1186	6.185	5.454	4.421	**5.353**	5.522	24.027	6.002	**11.850**	4.524	6.180	Fail	**5.352**	38.548	23.363	15.348	**25.753**
1188	6.217	5.431	4.421	**5.356**	5.518	24.047	6.021	**11.862**	4.503	6.153	Fail	**5.328**	38.651	23.499	15.390	**25.847**
1190	6.212	5.454	4.456	**5.374**	5.538	23.915	6.021	**11.825**	4.500	6.167	Fail	**5.334**	38.301	23.383	15.307	**25.664**
1192	6.153	5.431	4.453	**5.346**	5.494	24.047	6.023	**11.855**	4.499	6.167	Fail	**5.333**	38.790	23.415	15.279	**25.828**
1194	6.156	5.453	4.437	**5.349**	5.536	23.783	5.995	**11.771**	4.477	6.133	Fail	**5.305**	38.511	23.363	15.307	**25.727**
1196	6.204	5.431	4.452	**5.362**	5.512	23.952	5.995	**11.820**	4.492	6.126	Fail	**5.309**	38.423	23.318	15.334	**25.692**
1198	6.175	5.429	4.434	**5.346**	5.508	24.047	6.021	**11.859**	4.471	6.148	Fail	**5.310**	38.475	23.383	15.265	**25.708**
1200	**6.170**	**5.429**	**4.469**	**5.366**	**5.526**	**23.972**	**5.995**	**11.831**	**4.486**	**6.167**	Fail	**5.327**	**38.197**	**23.266**	**15.265**	**25.576**
1202	6.177	5.429	4.433	**5.346**	5.502	24.237	5.995	**11.911**	4.501	6.119	Fail	**5.310**	38.336	23.182	15.279	**25.599**
1204	6.148	5.472	4.432	**5.351**	5.522	23.935	6.043	**11.833**	4.479	6.107	Fail	**5.293**	38.475	23.170	15.279	**25.641**
1206	6.148	5.406	4.465	**5.340**	5.518	23.783	6.019	**11.773**	4.475	6.155	Fail	**5.315**	38.388	23.402	15.182	**25.657**
1208	6.168	5.425	4.447	**5.347**	5.469	23.841	5.995	**11.768**	4.473	6.095	Fail	**5.284**	38.475	23.234	15.265	**25.658**
1210	6.187	5.425	4.430	**5.347**	5.516	23.935	6.019	**11.823**	4.454	6.092	Fail	**5.273**	38.388	23.286	15.265	**25.646**
1212	6.163	5.470	4.410	**5.348**	5.491	23.709	6.019	**11.740**	4.449	6.059	Fail	**5.254**	38.214	23.234	15.210	**25.553**
1214	6.158	5.427	4.427	**5.337**	5.510	23.804	5.993	**11.769**	4.465	6.080	Fail	**5.273**	37.820	22.991	15.183	**25.331**
1216	6.141	5.427	4.443	**5.337**	5.505	23.804	6.014	**11.774**	4.443	6.128	Fail	**5.286**	38.214	23.190	15.087	**25.497**
1218	6.158	5.425	4.428	**5.337**	5.465	23.861	5.990	**11.772**	4.440	6.044	Fail	**5.242**	38.180	23.023	15.238	**25.480**
1220	6.160	5.425	4.408	**5.331**	5.501	23.993	5.967	**11.820**	4.436	6.071	Fail	**5.254**	38.266	22.960	15.224	**25.483**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1222	6.170	5.423	4.405	**5.333**	5.522	23.861	6.019	**11.801**	4.452	6.059	Fail	**5.256**	38.094	23.138	15.210	**25.481**
1224	6.177	5.423	4.422	**5.341**	5.455	23.731	5.993	**11.726**	4.450	6.052	Fail	**5.251**	37.957	23.190	15.210	**25.452**
1226	6.150	5.445	4.438	**5.344**	5.477	23.804	5.988	**11.756**	4.446	6.049	Fail	**5.248**	38.094	23.159	15.128	**25.460**
1228	6.126	5.400	4.420	**5.315**	5.495	23.767	5.993	**11.752**	4.458	6.066	Fail	**5.262**	37.652	23.044	15.087	**25.261**
1230	6.143	5.443	4.419	**5.335**	5.515	23.679	5.990	**11.728**	4.459	6.014	Fail	**5.237**	37.736	23.044	15.183	**25.321**
1232	6.119	5.398	4.417	**5.311**	5.465	23.731	5.990	**11.729**	4.418	6.028	Fail	**5.223**	37.872	23.044	15.142	**25.353**
1234	6.146	5.422	4.434	**5.334**	5.444	23.825	5.993	**11.754**	4.415	6.026	Fail	**5.221**	37.924	22.981	15.156	**25.354**
1236	6.116	5.443	4.417	**5.325**	5.505	23.825	5.990	**11.773**	4.447	6.000	Fail	**5.224**	37.976	23.064	15.156	**25.399**
1238	6.114	5.422	4.415	**5.317**	5.438	23.673	5.964	**11.692**	4.427	6.014	Fail	**5.221**	37.924	22.783	15.088	**25.265**
1240	6.133	5.420	4.415	**5.323**	5.481	23.788	6.014	**11.761**	4.405	6.009	Fail	**5.207**	37.840	22.949	15.088	**25.292**
1242	6.109	5.422	4.413	**5.315**	5.436	23.751	5.990	**11.726**	4.402	6.026	Fail	**5.214**	37.892	23.033	15.129	**25.351**
1244	6.133	5.441	4.430	**5.335**	5.452	23.788	5.986	**11.742**	4.399	5.969	Fail	**5.184**	37.454	22.918	15.101	**25.158**
1246	6.131	5.418	4.413	**5.321**	5.466	23.643	5.988	**11.699**	4.397	5.967	Fail	**5.182**	37.568	22.908	15.115	**25.197**
1248	6.099	5.441	4.409	**5.316**	5.469	23.600	5.990	**11.686**	4.393	5.986	Fail	**5.190**	37.537	22.866	15.034	**25.146**
1250	6.126	5.418	4.411	**5.318**	5.446	23.549	5.988	**11.661**	4.425	5.979	Fail	**5.202**	37.568	22.773	15.265	**25.202**
1252	6.104	5.416	4.428	**5.316**	5.440	23.679	6.009	**11.709**	4.403	5.951	Fail	**5.177**	37.454	22.856	15.102	**25.137**
1254	6.177	5.394	4.409	**5.327**	5.485	23.751	5.986	**11.741**	4.399	5.946	Fail	**5.173**	37.371	22.908	15.116	**25.132**
1256	6.121	5.416	4.424	**5.320**	5.460	23.658	5.986	**11.701**	4.395	5.961	Fail	**5.178**	37.318	22.939	15.088	**25.115**
1258	6.095	5.418	4.443	**5.319**	5.415	23.528	5.988	**11.644**	4.410	5.937	Fail	**5.174**	37.236	22.877	14.994	**25.036**
1260	6.095	5.396	4.423	**5.305**	5.432	23.643	5.960	**11.678**	4.372	5.924	Fail	**5.148**	37.289	22.877	15.075	**25.080**
1262	6.090	5.393	4.405	**5.296**	5.448	23.606	5.962	**11.672**	4.404	5.968	Fail	**5.186**	36.829	22.877	14.980	**24.895**
1264	6.138	5.414	4.387	**5.313**	5.427	23.679	6.033	**11.713**	4.381	5.940	Fail	**5.161**	37.423	22.681	15.048	**25.051**
1266	6.170	5.416	4.404	**5.330**	5.415	23.420	6.007	**11.614**	4.378	5.912	Fail	**5.145**	37.289	22.846	14.980	**25.038**
1268	6.087	5.435	4.403	**5.308**	5.421	23.585	6.009	**11.672**	4.357	5.936	Fail	**5.147**	37.423	22.846	15.021	**25.097**
1270	6.107	5.414	4.400	**5.307**	5.443	23.606	5.960	**11.670**	4.354	5.899	Fail	**5.127**	37.177	22.620	15.062	**24.953**
1272	6.131	5.435	4.382	**5.316**	5.437	23.477	6.036	**11.650**	4.368	5.887	Fail	**5.128**	37.125	22.681	15.076	**24.961**
1274	6.083	5.412	4.399	**5.298**	5.419	23.679	5.983	**11.694**	4.364	5.883	Fail	**5.124**	37.177	22.702	14.941	**24.940**
1276	6.083	5.433	4.415	**5.310**	5.435	23.442	6.036	**11.638**	4.360	5.904	Fail	**5.132**	36.910	22.733	15.035	**24.893**
1278	6.126	5.410	4.415	**5.317**	5.429	23.349	5.983	**11.587**	4.340	5.897	Fail	**5.119**	36.963	22.754	14.927	**24.881**
1280	6.102	5.391	4.414	**5.302**	5.429	23.513	5.960	**11.634**	4.353	5.893	Fail	**5.123**	36.749	22.620	14.968	**24.779**
1282	6.087	5.432	4.395	**5.305**	5.425	23.499	5.986	**11.637**	4.349	5.886	Fail	**5.118**	37.015	22.836	14.914	**24.922**
1284	6.073	5.412	4.395	**5.293**	5.396	23.442	6.007	**11.615**	4.347	5.875	Fail	**5.111**	37.096	22.775	15.050	**24.974**
1286	6.073	5.389	4.395	**5.286**	5.377	23.442	5.955	**11.591**	4.376	5.854	Fail	**5.115**	36.696	22.663	14.955	**24.771**
1288	6.116	5.412	4.411	**5.313**	5.416	23.535	5.979	**11.643**	4.320	5.868	Fail	**5.094**	36.935	22.581	14.901	**24.806**
1290	6.114	5.432	4.427	**5.324**	5.414	23.406	5.981	**11.600**	4.316	5.838	Fail	**5.077**	36.802	22.723	14.942	**24.822**
1292	6.071	5.385	4.373	**5.276**	5.410	23.592	5.981	**11.661**	4.330	5.857	Fail	**5.094**	36.511	22.611	14.848	**24.657**
1294	6.087	5.408	4.409	**5.301**	5.408	23.520	6.009	**11.646**	4.326	5.827	Fail	**5.077**	36.669	22.551	14.902	**24.707**
1296	6.066	5.408	4.410	**5.295**	5.385	23.499	6.005	**11.630**	4.306	5.848	Fail	**5.077**	36.511	22.581	14.862	**24.651**
1298	6.085	5.430	4.422	**5.312**	5.406	23.428	5.955	**11.596**	4.320	5.841	Fail	**5.081**	36.511	22.439	14.902	**24.617**
1300	6.056	5.406	4.390	**5.284**	5.383	23.428	5.955	**11.589**	4.314	5.860	Fail	**5.087**	36.802	22.521	14.956	**24.760**
1302	6.102	5.404	4.405	**5.304**	5.399	23.392	5.981	**11.591**	4.312	5.807	Fail	**5.060**	36.882	22.521	14.848	**24.750**
1304	6.080	5.426	4.389	**5.298**	5.376	23.428	5.955	**11.586**	4.308	5.778	Fail	**5.043**	36.775	22.521	14.795	**24.697**
1306	6.080	5.385	4.385	**5.283**	5.393	23.463	6.002	**11.619**	4.323	5.865	Fail	**5.094**	36.617	22.409	14.796	**24.607**
1308	6.078	5.385	4.384	**5.282**	5.393	23.300	5.979	**11.557**	4.283	5.806	Fail	**5.045**	36.696	22.461	14.809	**24.655**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1310	6.073	5.404	4.385	5.287	5.368	23.335	6.002	11.568	4.312	5.827	Fail	5.070	36.432	22.349	14.850	24.544
1312	6.100	5.403	4.401	5.301	5.388	23.392	6.005	11.595	4.276	5.804	Fail	5.040	36.564	22.401	14.796	24.587
1314	6.121	5.403	4.383	5.302	5.382	23.335	5.974	11.564	4.272	5.768	Fail	5.020	36.485	22.202	14.663	24.450
1316	6.064	5.403	4.381	5.283	5.382	23.182	6.000	11.521	4.300	5.810	Fail	5.055	36.328	22.371	14.850	24.516
1318	6.044	5.403	4.398	5.282	5.378	23.322	5.976	11.559	4.281	5.782	Fail	5.032	36.275	22.431	14.689	24.465
1320	6.073	5.381	4.380	5.278	5.357	23.392	6.000	11.583	4.260	5.732	Fail	4.996	36.197	22.401	14.850	24.483
1322	6.088	5.422	4.379	5.296	5.376	23.265	5.976	11.539	4.270	5.742	Fail	5.006	36.120	22.431	14.770	24.440
1324	6.088	5.401	4.378	5.289	5.357	23.286	5.953	11.532	4.300	5.763	Fail	5.032	36.381	22.371	14.704	24.485
1326	6.085	5.399	4.396	5.293	5.349	23.102	5.974	11.475	4.229	5.738	Fail	4.984	35.889	22.290	14.785	24.321
1328	6.080	5.401	4.377	5.286	5.367	23.286	5.998	11.550	4.260	5.759	Fail	5.010	35.835	22.342	14.745	24.307
1330	6.078	5.399	4.377	5.285	5.346	23.286	5.998	11.543	4.255	5.730	Fail	4.993	36.304	22.231	14.785	24.440
1332	6.054	5.399	4.394	5.282	5.383	23.090	6.026	11.500	4.250	5.748	Fail	4.999	36.096	22.393	14.732	24.407
1334	6.078	5.420	4.391	5.296	5.338	23.194	6.024	11.519	4.231	5.746	Fail	4.989	35.737	22.143	14.798	24.226
1336	6.056	5.401	4.373	5.277	5.356	23.286	5.998	11.547	4.224	5.733	Fail	4.979	36.149	22.355	14.706	24.403
1338	6.052	5.374	4.389	5.272	5.375	23.056	5.974	11.468	4.239	5.727	Fail	4.983	35.759	22.063	14.693	24.172
1340	6.025	5.376	4.354	5.252	5.331	23.068	6.000	11.466	4.252	5.747	Fail	5.000	35.813	22.283	14.759	24.285
1342	6.049	5.418	4.370	5.279	5.347	23.068	6.024	11.480	4.230	5.716	Fail	4.973	35.867	22.143	14.772	24.261
1344	6.069	5.397	4.388	5.285	5.345	23.251	5.972	11.523	4.210	5.689	Fail	4.950	35.813	22.173	14.680	24.222
1346	6.016	5.397	4.386	5.266	5.343	23.343	5.974	11.553	4.222	5.685	Fail	4.954	35.661	22.143	14.693	24.166
1348	6.018	5.372	4.365	5.252	5.320	23.182	5.972	11.491	4.202	5.699	Fail	4.951	35.867	21.947	14.642	24.152
1350	6.045	5.395	4.385	5.275	5.316	23.147	5.972	11.478	4.214	5.695	Fail	4.955	35.867	22.114	14.630	24.204
1352	6.016	5.397	4.384	5.266	5.313	22.998	5.972	11.428	4.213	5.713	Fail	4.963	35.661	22.165	14.695	24.174
1354	6.040	5.395	4.401	5.279	5.293	23.090	5.972	11.452	4.210	5.683	Fail	4.947	35.791	22.217	14.577	24.195
1356	6.016	5.372	4.383	5.257	5.330	22.998	5.969	11.432	4.206	5.680	Fail	4.943	35.511	22.187	14.642	24.113
1358	6.011	5.414	4.363	5.263	5.284	23.125	5.995	11.468	4.202	5.672	Fail	4.937	35.457	22.217	14.644	24.106
1360	6.038	5.393	4.363	5.265	5.305	23.182	5.998	11.495	4.215	5.666	Fail	4.941	35.437	22.268	14.551	24.085
1362	6.035	5.374	4.362	5.257	5.321	23.147	5.969	11.479	4.196	5.660	Fail	4.928	35.640	21.998	14.697	24.112
1364	6.009	5.374	4.346	5.243	5.321	23.135	5.969	11.475	4.193	5.678	Fail	4.936	35.491	22.078	14.604	24.058
1366	6.031	5.434	4.360	5.275	5.319	23.078	5.991	11.463	4.188	5.649	Fail	4.919	35.511	22.101	14.697	24.103
1368	6.028	5.372	4.376	5.259	5.338	22.930	5.995	11.421	4.202	5.647	Fail	4.925	35.491	21.970	14.644	24.035
1370	6.023	5.391	4.378	5.264	5.291	22.987	5.969	11.416	4.166	5.665	Fail	4.916	35.416	22.021	14.632	24.023
1372	6.026	5.413	4.358	5.266	5.291	22.952	5.993	11.412	4.197	5.637	Fail	4.917	35.288	22.129	14.473	23.963
1374	6.019	5.370	4.374	5.254	5.310	22.952	5.967	11.410	4.193	5.631	Fail	4.912	35.491	22.072	14.607	24.057
1376	6.000	5.368	4.356	5.241	5.283	22.896	6.014	11.398	4.173	5.625	Fail	4.899	35.342	22.043	14.566	23.984
1378	6.043	5.413	4.356	5.271	5.280	23.100	5.993	11.458	4.170	5.621	Fail	4.896	34.960	21.992	14.541	23.831
1380	5.997	5.388	4.373	5.253	5.280	23.044	5.993	11.439	4.167	5.633	Fail	4.900	35.342	22.043	14.556	23.980
1382	6.016	5.366	4.370	5.251	5.276	22.975	5.991	11.414	4.163	5.614	Fail	4.889	35.141	22.043	14.581	23.922
1384	6.014	5.368	4.353	5.245	5.278	23.044	5.941	11.421	4.145	5.584	Fail	4.865	34.996	22.101	14.504	23.867
1386	6.014	5.409	4.351	5.258	5.293	22.884	6.012	11.396	4.159	5.600	Fail	4.880	35.396	21.986	14.569	23.984
1388	5.988	5.409	4.369	5.255	5.273	22.918	5.967	11.386	4.158	5.616	Fail	4.887	35.141	21.935	14.569	23.882
1390	6.012	5.386	4.368	5.255	5.250	23.009	5.967	11.409	4.153	5.612	Fail	4.883	35.068	22.014	14.504	23.862
1392	6.012	5.430	4.348	5.263	5.246	23.032	5.941	11.406	4.152	5.582	Fail	4.867	35.249	22.008	14.479	23.912
1394	6.007	5.409	4.347	5.254	5.262	23.044	5.988	11.431	4.166	5.606	Fail	4.886	35.269	22.065	14.479	23.938
1396	5.986	5.409	4.348	5.248	5.284	22.760	5.988	11.344	4.163	5.558	Fail	4.861	34.851	21.878	14.519	23.749

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1398	6.005	5.407	4.347	**5.253**	5.260	22.850	5.988	**11.366**	4.127	5.572	Fail	**4.850**	34.725	21.850	14.519	**23.698**
1400	5.981	5.407	4.363	**5.250**	5.256	22.952	5.988	**11.399**	4.141	5.566	Fail	**4.854**	35.068	21.929	14.414	**23.804**
1402	5.998	5.363	4.346	**5.236**	5.275	22.850	5.965	**11.363**	4.136	5.586	Fail	**4.861**	34.869	22.008	14.506	**23.794**
1404	5.998	5.386	4.360	**5.248**	5.251	22.884	5.988	**11.374**	4.118	5.552	Fail	**4.835**	34.923	21.929	14.559	**23.804**
1406	5.995	5.380	4.342	**5.239**	5.230	22.884	5.962	**11.359**	4.130	5.524	Fail	**4.827**	34.653	21.793	14.534	**23.660**
1408	5.976	5.386	4.359	**5.240**	5.247	22.884	5.965	**11.365**	4.145	5.582	Fail	**4.864**	34.653	21.872	14.534	**23.686**
1410	6.002	5.384	4.340	**5.242**	5.238	22.749	5.960	**11.316**	4.156	5.538	Fail	**4.847**	34.977	21.765	14.417	**23.720**
1412	6.021	5.382	4.323	**5.242**	5.265	22.783	5.988	**11.345**	4.121	5.532	Fail	**4.827**	34.708	21.872	14.521	**23.700**
1414	5.995	5.386	4.321	**5.234**	5.240	22.806	5.937	**11.328**	4.132	5.534	Fail	**4.833**	34.636	21.894	14.534	**23.688**
1416	5.993	5.403	4.338	**5.245**	5.235	22.806	5.965	**11.335**	4.112	5.522	Fail	**4.817**	34.636	21.872	14.484	**23.664**
1418	5.998	5.355	4.320	**5.224**	5.233	22.659	5.988	**11.293**	4.108	5.496	Fail	**4.802**	34.636	21.923	14.445	**23.668**
1420	5.967	5.359	4.336	**5.221**	5.254	22.749	5.939	**11.314**	4.088	5.538	Fail	**4.813**	34.565	21.844	14.497	**23.635**
1422	5.962	5.401	4.336	**5.233**	5.247	22.772	6.007	**11.342**	4.099	5.532	Fail	**4.816**	34.620	21.788	14.420	**23.609**
1424	6.033	5.359	4.351	**5.248**	5.231	22.749	5.962	**11.314**	4.095	5.524	Fail	**4.810**	34.495	21.603	14.420	**23.506**
1426	5.984	5.401	4.351	**5.245**	5.205	22.839	5.958	**11.334**	4.073	5.495	Fail	**4.784**	34.409	21.760	14.383	**23.517**
1428	6.003	5.380	4.334	**5.239**	5.222	22.749	5.986	**11.319**	4.071	5.483	Fail	**4.777**	34.300	21.603	14.472	**23.458**
1430	5.958	5.376	4.331	**5.222**	5.264	22.682	5.984	**11.310**	4.081	5.483	Fail	**4.782**	34.440	21.676	14.512	**23.543**
1432	5.993	5.398	4.351	**5.247**	5.217	22.649	5.986	**11.284**	4.061	5.503	Fail	**4.782**	34.284	21.810	14.435	**23.510**
1434	5.956	5.399	4.331	**5.229**	5.236	22.559	5.960	**11.252**	4.072	5.471	Fail	**4.772**	34.160	21.704	14.343	**23.402**
1436	6.001	5.357	4.347	**5.236**	5.238	22.772	5.986	**11.332**	4.069	5.468	Fail	**4.769**	34.160	21.810	14.383	**23.451**
1438	6.003	5.399	4.328	**5.243**	5.234	22.749	5.984	**11.322**	4.068	5.444	Fail	**4.756**	34.077	21.810	14.319	**23.402**
1440	5.956	5.355	4.361	**5.224**	5.208	22.705	5.982	**11.298**	Fail	5.464	Fail	**5.464**	34.339	21.625	14.420	**23.461**
1442	5.972	5.376	4.326	**5.225**	5.210	22.739	5.958	**11.302**	Fail	5.456	Fail	**5.456**	34.409	21.625	14.359	**23.464**
1444	5.998	5.396	4.325	**5.240**	5.181	22.649	5.960	**11.263**	Fail	5.491	Fail	**5.491**	34.549	21.520	14.423	**23.497**
1446	5.994	5.374	4.325	**5.231**	5.224	22.649	5.934	**11.269**	Fail	5.446	Fail	**5.446**	33.885	21.777	14.347	**23.336**
1448	5.949	5.353	4.323	**5.208**	5.243	22.582	5.979	**11.268**	Fail	5.415	Fail	**5.415**	34.409	21.492	14.271	**23.391**
1450	5.963	5.399	4.323	**5.228**	5.220	22.672	5.979	**11.290**	Fail	5.435	Fail	**5.435**	34.146	21.543	14.426	**23.372**
1452	5.944	5.374	4.321	**5.213**	5.217	22.615	5.982	**11.271**	Fail	5.474	Fail	**5.474**	34.215	21.754	14.362	**23.444**
1454	5.970	5.392	4.339	**5.234**	5.215	22.672	5.937	**11.275**	Fail	5.398	Fail	**5.398**	33.803	21.593	14.362	**23.253**
1456	5.935	5.396	4.319	**5.217**	5.189	22.549	5.937	**11.225**	Fail	5.418	Fail	**5.418**	34.447	21.566	14.322	**23.445**
1458	5.937	5.373	4.302	**5.204**	5.187	22.516	5.958	**11.220**	Fail	5.412	Fail	**5.412**	34.131	21.676	14.195	**23.334**
1460	5.961	5.394	4.353	**5.236**	5.210	22.549	5.956	**11.238**	Fail	5.408	Fail	**5.408**	34.308	21.570	14.286	**23.388**
1462	5.961	5.373	4.334	**5.223**	5.187	22.672	5.956	**11.272**	Fail	5.401	Fail	**5.401**	34.200	21.515	14.222	**23.312**
1464	5.956	5.373	4.317	**5.215**	5.197	22.705	5.956	**11.286**	Fail	5.395	Fail	**5.395**	34.062	21.566	14.274	**23.301**
1466	5.928	5.371	4.317	**5.205**	5.203	22.639	5.956	**11.266**	Fail	5.372	Fail	**5.372**	33.803	21.383	14.274	**23.153**
1468	5.933	5.392	4.331	**5.219**	5.221	22.639	5.979	**11.280**	Fail	5.411	Fail	**5.411**	34.062	21.483	14.274	**23.273**
1470	5.933	5.348	4.297	**5.193**	5.175	22.573	5.977	**11.242**	Fail	5.380	Fail	**5.380**	34.254	21.298	14.238	**23.263**
1472	5.933	5.369	4.330	**5.211**	5.190	22.639	5.977	**11.269**	Fail	5.378	Fail	**5.378**	34.117	21.483	14.289	**23.296**
1474	5.977	5.371	4.313	**5.220**	5.192	22.418	5.934	**11.181**	Fail	5.423	Fail	**5.423**	33.614	21.483	14.277	**23.125**
1476	5.952	5.390	4.295	**5.212**	5.190	22.540	5.932	**11.221**	Fail	5.369	Fail	**5.369**	34.308	21.406	14.238	**23.317**
1478	5.971	5.348	4.328	**5.216**	5.185	22.540	5.953	**11.226**	Fail	5.342	Fail	**5.342**	33.994	21.352	14.289	**23.212**
1480	5.921	5.388	4.309	**5.206**	5.165	22.540	5.956	**11.220**	Fail	5.360	Fail	**5.360**	33.967	21.479	14.111	**23.186**
1482	5.926	5.367	4.309	**5.201**	5.163	22.549	5.932	**11.215**	Fail	5.358	Fail	**5.358**	33.723	21.456	14.048	**23.076**
1484	5.954	5.388	4.291	**5.211**	5.177	22.296	5.975	**11.149**	Fail	5.348	Fail	**5.348**	33.845	21.452	14.190	**23.162**

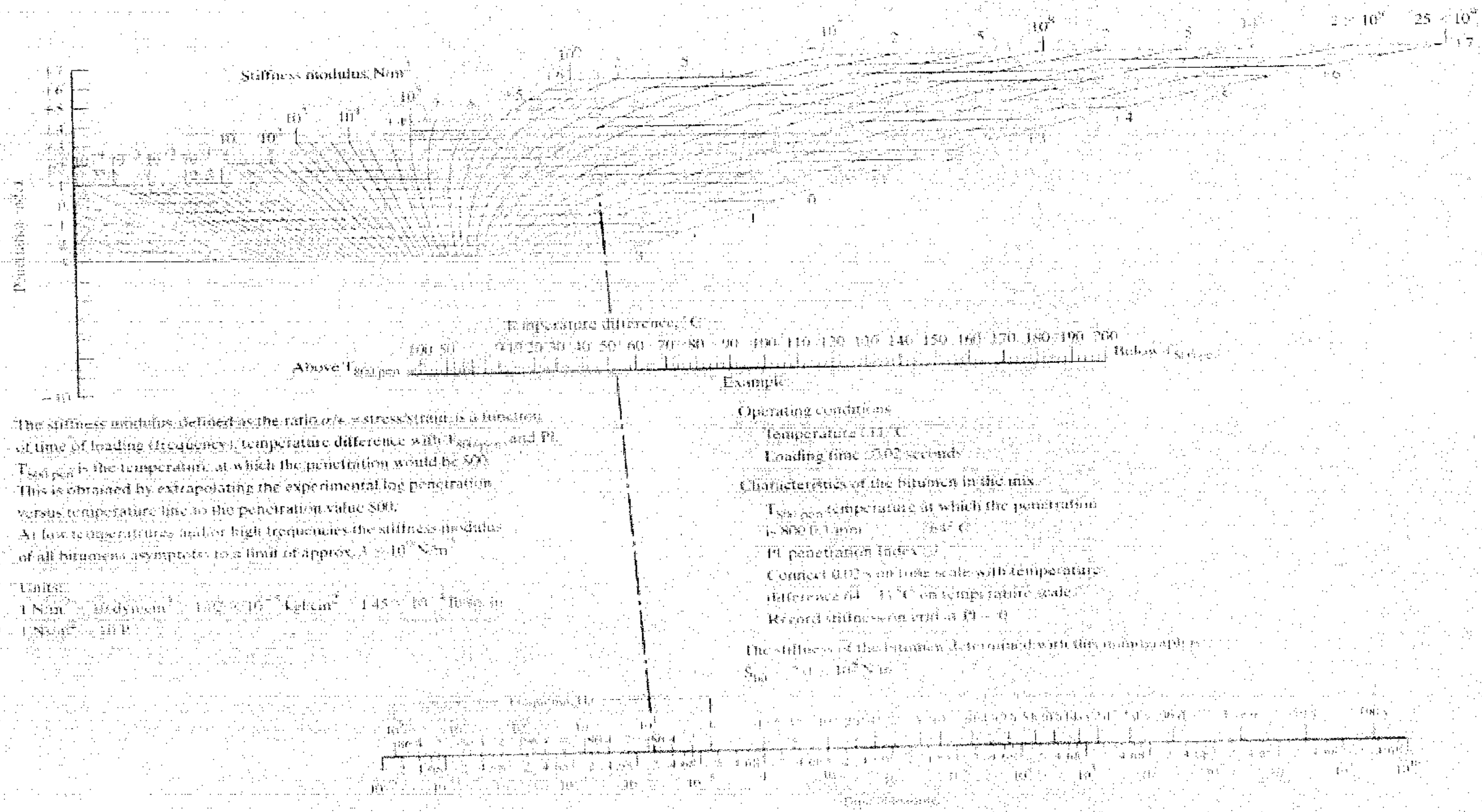
Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1486	5.945	5.369	4.307	**5.207**	5.156	22.385	5.998	**11.180**	Fail	5.324	Fail	**5.324**	33.790	21.429	14.127	**23.115**
1488	5.966	5.348	4.289	**5.201**	5.171	22.264	5.956	**11.130**	Fail	5.383	Fail	**5.383**	33.790	21.221	14.151	**23.054**
1490	5.938	5.344	4.324	**5.202**	5.170	22.563	5.975	**11.236**	Fail	5.311	Fail	**5.311**	33.601	21.325	14.127	**23.018**
1492	5.966	5.365	4.305	**5.212**	5.168	22.409	5.977	**11.185**	Fail	5.347	Fail	**5.347**	33.402	21.429	14.230	**23.020**
1494	5.938	5.363	4.288	**5.196**	5.168	22.474	5.977	**11.206**	Fail	5.321	Fail	**5.321**	33.711	21.244	14.218	**23.058**
1496	5.985	5.342	4.303	**5.210**	5.124	22.385	5.975	**11.161**	Fail	5.296	Fail	**5.296**	33.523	21.217	14.115	**22.952**
1498	5.959	5.363	4.301	**5.208**	5.183	22.442	5.927	**11.184**	Fail	5.296	Fail	**5.296**	33.468	21.529	14.104	**23.034**
1500	5.912	5.363	4.317	**5.197**	5.159	22.377	5.951	**11.162**	Fail	5.289	Fail	**5.289**	33.644	21.475	14.080	**23.066**
1502	5.938	5.363	4.301	**5.201**	5.178	22.442	5.951	**11.190**	Fail	5.304	Fail	**5.304**	33.468	21.294	14.131	**22.964**
1504	5.933	5.363	4.351	**5.216**	5.115	22.329	5.927	**11.124**	Fail	5.292	Fail	**5.292**	33.511	21.217	14.052	**22.927**
1506	5.908	5.360	4.300	**5.189**	5.151	22.288	5.949	**11.129**	Fail	5.293	Fail	**5.293**	33.523	21.064	14.158	**22.915**
1508	5.931	5.363	4.280	**5.191**	5.112	22.385	5.951	**11.149**	Fail	5.269	Fail	**5.269**	33.457	21.217	14.182	**22.952**
1510	5.903	5.361	4.299	**5.188**	5.152	22.409	5.975	**11.179**	Fail	5.307	Fail	**5.307**	33.523	21.061	14.096	**22.893**
1512	5.926	5.361	4.297	**5.195**	5.125	22.320	5.951	**11.132**	Fail	5.256	Fail	**5.256**	33.391	21.318	14.045	**22.918**
1514	5.901	5.361	4.295	**5.186**	5.164	22.288	5.949	**11.134**	Fail	5.275	Fail	**5.275**	33.511	21.138	14.158	**22.936**
1516	5.926	5.360	4.295	**5.194**	5.139	22.320	5.951	**11.137**	Fail	5.270	Fail	**5.270**	33.019	21.344	14.045	**22.803**
1518	5.976	5.360	4.294	**5.210**	5.159	22.353	5.972	**11.161**	Fail	5.223	Fail	**5.223**	33.445	21.088	14.123	**22.885**
1520	5.922	5.360	4.293	**5.192**	5.139	22.224	5.951	**11.105**	Fail	5.284	Fail	**5.284**	33.379	21.085	14.084	**22.849**
1522	5.901	5.360	4.293	**5.185**	5.115	22.368	5.972	**11.152**	Fail	5.256	Fail	**5.256**	32.881	21.008	14.072	**22.654**
1524	5.899	5.336	4.275	**5.170**	5.091	22.168	5.951	**11.070**	Fail	5.250	Fail	**5.250**	33.194	20.904	13.948	**22.682**
1526	5.920	5.358	4.290	**5.189**	5.112	22.280	5.927	**11.106**	Fail	5.219	Fail	**5.219**	32.945	21.008	14.037	**22.663**
1528	5.894	5.379	4.291	**5.188**	5.108	22.136	5.925	**11.056**	Fail	5.262	Fail	**5.262**	33.074	21.161	13.987	**22.741**
1530	5.913	5.360	4.273	**5.182**	5.125	22.160	5.925	**11.070**	Fail	5.257	Fail	**5.257**	33.488	21.108	13.975	**22.857**
1532	5.917	5.354	4.306	**5.192**	5.127	22.280	5.944	**11.117**	Fail	5.246	Fail	**5.246**	33.129	21.188	14.037	**22.785**
1534	5.913	5.335	4.288	**5.179**	5.142	22.192	5.972	**11.102**	Fail	5.243	Fail	**5.243**	33.174	20.982	13.924	**22.693**
1536	5.913	5.356	4.304	**5.191**	5.118	22.424	5.946	**11.163**	Fail	5.218	Fail	**5.218**	33.119	21.008	14.065	**22.731**
1538	5.957	5.358	4.284	**5.200**	5.098	22.216	5.970	**11.095**	Fail	5.213	Fail	**5.213**	33.119	21.056	13.952	**22.709**
1540	5.890	5.356	4.286	**5.177**	5.113	22.160	5.944	**11.072**	Fail	5.189	Fail	**5.189**	33.119	20.852	13.890	**22.620**
1542	5.913	5.356	4.301	**5.190**	5.091	22.248	5.970	**11.103**	Fail	5.180	Fail	**5.180**	33.000	20.985	13.979	**22.655**
1544	5.904	5.354	4.284	**5.181**	5.110	22.248	5.965	**11.108**	Fail	5.177	Fail	**5.177**	32.936	20.904	13.968	**22.603**
1546	5.904	5.354	4.283	**5.180**	5.088	22.272	5.991	**11.117**	Fail	5.214	Fail	**5.214**	33.055	21.080	13.906	**22.680**
1548	5.902	5.333	4.265	**5.167**	5.086	22.184	5.920	**11.063**	Fail	5.189	Fail	**5.189**	32.817	20.930	13.917	**22.555**
1550	5.906	5.358	4.298	**5.187**	5.083	22.065	5.968	**11.039**	Fail	5.183	Fail	**5.183**	32.626	20.954	13.917	**22.499**
1552	5.906	5.331	4.263	**5.167**	5.078	22.184	5.968	**11.077**	Fail	5.180	Fail	**5.180**	32.390	20.928	13.968	**22.429**
1554	5.902	5.354	4.281	**5.179**	5.078	22.033	5.944	**11.018**	Fail	5.192	Fail	**5.192**	32.872	20.749	13.833	**22.485**
1556	5.899	5.354	4.297	**5.183**	5.096	22.096	5.994	**11.062**	Fail	5.144	Fail	**5.144**	32.745	20.850	13.984	**22.526**
1558	5.897	5.331	4.278	**5.169**	5.056	22.033	5.968	**11.019**	Fail	5.181	Fail	**5.181**	32.154	20.928	14.007	**22.363**
1560	5.920	5.331	4.277	**5.176**	5.074	22.120	5.939	**11.044**	Fail	5.152	Fail	**5.152**	32.618	20.978	13.945	**22.514**
1562	5.872	5.331	4.276	**5.160**	5.091	22.089	5.991	**11.057**	Fail	5.152	Fail	**5.152**	32.690	21.027	13.849	**22.522**
1564	5.895	5.331	4.278	**5.168**	5.088	21.946	5.944	**10.993**	Fail	5.129	Fail	**5.129**	32.626	20.876	13.910	**22.471**
1566	5.867	5.329	4.292	**5.163**	5.046	22.002	5.944	**10.997**	Fail	5.161	Fail	**5.161**	32.376	20.952	13.872	**22.400**
1568	5.893	5.350	4.275	**5.173**	5.061	22.113	5.965	**11.046**	Fail	5.156	Fail	**5.156**	32.438	20.800	13.799	**22.346**
1570	5.918	5.348	4.257	**5.174**	5.041	22.208	5.965	**11.071**	Fail	5.130	Fail	**5.130**	32.673	20.749	13.815	**22.412**
1572	5.863	5.327	4.273	**5.154**	5.081	21.883	5.963	**10.976**	Fail	5.125	Fail	**5.125**	32.673	20.825	13.815	**22.438**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1574	5.881	5.350	4.305	**5.179**	5.076	22.033	5.916	**11.008**	Fail	5.138	Fail	**5.138**	32.611	20.850	13.815	**22.425**
1576	5.884	5.352	4.271	**5.169**	5.053	21.939	5.939	**10.977**	Fail	5.113	Fail	**5.113**	32.493	20.900	13.815	**22.403**
1578	5.884	5.350	4.270	**5.168**	5.050	22.050	5.965	**11.022**	Fail	5.106	Fail	**5.106**	32.431	20.724	13.904	**22.353**
1580	5.881	5.348	4.269	**5.166**	5.048	22.145	5.942	**11.045**	Fail	5.123	Fail	**5.123**	32.197	20.773	13.765	**22.245**
1582	5.879	5.348	4.251	**5.159**	5.070	21.877	5.963	**10.970**	Fail	5.138	Fail	**5.138**	32.252	20.699	13.792	**22.248**
1584	5.905	5.371	4.251	**5.176**	5.043	21.995	5.963	**11.000**	Fail	5.095	Fail	**5.095**	32.486	20.724	13.770	**22.327**
1586	5.877	5.325	4.250	**5.151**	5.065	21.995	5.942	**11.001**	Fail	5.110	Fail	**5.110**	32.307	20.572	13.770	**22.216**
1588	5.886	5.347	4.267	**5.167**	5.043	21.846	5.918	**10.936**	Fail	5.083	Fail	**5.083**	32.246	20.647	13.808	**22.234**
1590	5.875	5.325	4.247	**5.149**	5.061	21.846	5.916	**10.941**	Fail	5.076	Fail	**5.076**	32.246	20.748	13.770	**22.255**
1592	5.875	5.347	4.247	**5.156**	5.033	21.932	5.939	**10.968**	Fail	5.073	Fail	**5.073**	32.246	20.647	13.797	**22.230**
1594	5.847	5.345	4.246	**5.146**	5.030	21.901	5.961	**10.964**	Fail	5.068	Fail	**5.068**	32.246	20.797	13.758	**22.267**
1596	5.872	5.348	4.262	**5.161**	5.031	21.932	5.939	**10.967**	Fail	5.060	Fail	**5.060**	32.246	20.671	13.725	**22.214**
1598	5.872	5.345	4.261	**5.159**	5.028	21.901	5.961	**10.963**	Fail	5.036	Fail	**5.036**	31.891	20.522	13.725	**22.046**
1600	5.891	5.345	4.261	**5.166**	5.026	21.870	5.911	**10.936**	Fail	5.035	Fail	**5.035**	32.007	20.697	13.847	**22.184**
1602	5.872	5.325	4.261	**5.153**	5.026	21.901	5.961	**10.963**	Fail	5.045	Fail	**5.045**	32.007	20.521	13.824	**22.117**
1604	5.891	5.345	4.260	**5.165**	5.025	21.870	5.961	**10.952**	Fail	5.041	Fail	**5.041**	32.117	20.497	13.714	**22.109**
1606	5.866	5.341	4.258	**5.155**	5.048	21.839	5.937	**10.941**	Fail	5.037	Fail	**5.037**	32.002	20.497	13.752	**22.084**
1608	5.864	5.364	4.274	**5.167**	4.995	21.808	5.937	**10.913**	Fail	5.012	Fail	**5.012**	31.836	20.546	13.714	**22.032**
1610	5.868	5.318	4.240	**5.142**	4.997	21.784	5.914	**10.898**	Fail	5.008	Fail	**5.008**	32.239	20.621	13.703	**22.188**
1612	5.832	5.343	4.256	**5.144**	5.015	21.722	5.937	**10.891**	Fail	5.022	Fail	**5.022**	31.711	20.521	13.741	**21.991**
1614	5.861	5.324	4.237	**5.141**	5.033	21.753	5.914	**10.900**	Fail	5.019	Fail	**5.019**	31.711	20.670	13.752	**22.044**
1616	5.852	5.341	4.255	**5.149**	5.008	21.722	5.937	**10.889**	Fail	5.009	Fail	**5.009**	31.941	20.422	13.818	**22.060**
1618	5.834	5.343	4.254	**5.144**	5.010	21.895	5.937	**10.947**	Fail	5.007	Fail	**5.007**	31.826	20.571	13.719	**22.039**
1620	5.880	5.343	4.254	**5.159**	5.019	21.778	5.911	**10.903**	Fail	4.979	Fail	**4.979**	31.821	20.471	13.658	**21.983**
1622	5.867	5.364	4.253	**5.161**	5.004	21.747	5.958	**10.903**	Fail	4.956	Fail	**4.956**	31.941	20.471	13.697	**22.036**
1624	5.827	5.320	4.268	**5.138**	5.002	21.545	5.984	**10.844**	Fail	4.994	Fail	**4.994**	31.821	20.645	13.587	**22.018**
1626	5.852	5.360	4.250	**5.154**	4.997	21.631	5.935	**10.854**	Fail	5.004	Fail	**5.004**	31.996	20.595	13.719	**22.103**
1628	5.852	5.362	4.249	**5.154**	5.015	21.600	5.958	**10.858**	Fail	4.981	Fail	**4.981**	31.881	20.545	13.686	**22.037**
1630	5.827	5.362	4.249	**5.146**	4.995	21.747	5.956	**10.899**	Fail	4.995	Fail	**4.995**	31.762	20.521	13.686	**21.990**
1632	5.850	5.341	4.265	**5.152**	5.014	21.600	5.980	**10.865**	Fail	4.969	Fail	**4.969**	31.529	20.620	13.554	**21.901**
1634	5.825	5.337	4.248	**5.137**	5.012	21.600	5.958	**10.857**	Fail	4.965	Fail	**4.965**	31.766	20.496	13.554	**21.939**
1636	5.850	5.337	4.247	**5.145**	4.991	21.600	5.982	**10.858**	Fail	4.961	Fail	**4.961**	31.529	20.421	13.641	**21.864**
1638	5.821	5.358	4.230	**5.136**	5.006	21.686	5.958	**10.883**	Fail	4.977	Fail	**4.977**	31.415	20.471	13.543	**21.810**
1640	5.818	5.360	4.278	**5.152**	4.989	21.686	5.909	**10.861**	Fail	4.949	Fail	**4.949**	31.698	20.594	13.543	**21.945**
1642	5.839	5.316	4.260	**5.138**	4.999	21.656	5.905	**10.853**	Fail	4.945	Fail	**4.945**	31.643	20.569	13.532	**21.915**
1644	5.821	5.339	4.243	**5.134**	4.966	21.625	5.911	**10.834**	Fail	4.938	Fail	**4.938**	31.529	20.545	13.570	**21.881**
1646	5.839	5.339	4.241	**5.140**	4.960	21.600	5.909	**10.823**	Fail	4.919	Fail	**4.919**	31.588	20.495	13.581	**21.888**
1648	5.835	5.316	4.242	**5.131**	4.976	21.656	5.933	**10.855**	Fail	4.910	Fail	**4.910**	31.529	20.446	13.570	**21.848**
1650	5.828	5.314	4.239	**5.127**	4.994	21.540	5.956	**10.830**	Fail	4.926	Fail	**4.926**	31.529	20.520	13.548	**21.866**
1652	5.858	5.357	4.239	**5.151**	4.973	21.450	5.933	**10.785**	Fail	4.878	Fail	**4.878**	31.353	20.520	13.499	**21.791**
1654	5.835	5.335	4.221	**5.130**	4.993	21.595	5.930	**10.839**	Fail	4.894	Fail	**4.894**	31.126	20.347	13.598	**21.690**
1656	5.812	5.357	4.237	**5.135**	4.988	21.741	5.933	**10.887**	Fail	4.907	Fail	**4.907**	31.068	20.298	13.576	**21.647**
1658	5.810	5.337	4.237	**5.128**	4.966	21.480	5.954	**10.800**	Fail	4.904	Fail	**4.904**	31.181	20.643	13.565	**21.796**
1660	5.833	5.335	4.236	**5.135**	4.965	21.600	5.926	**10.830**	Fail	4.880	Fail	**4.880**	31.350	20.372	13.516	**21.746**

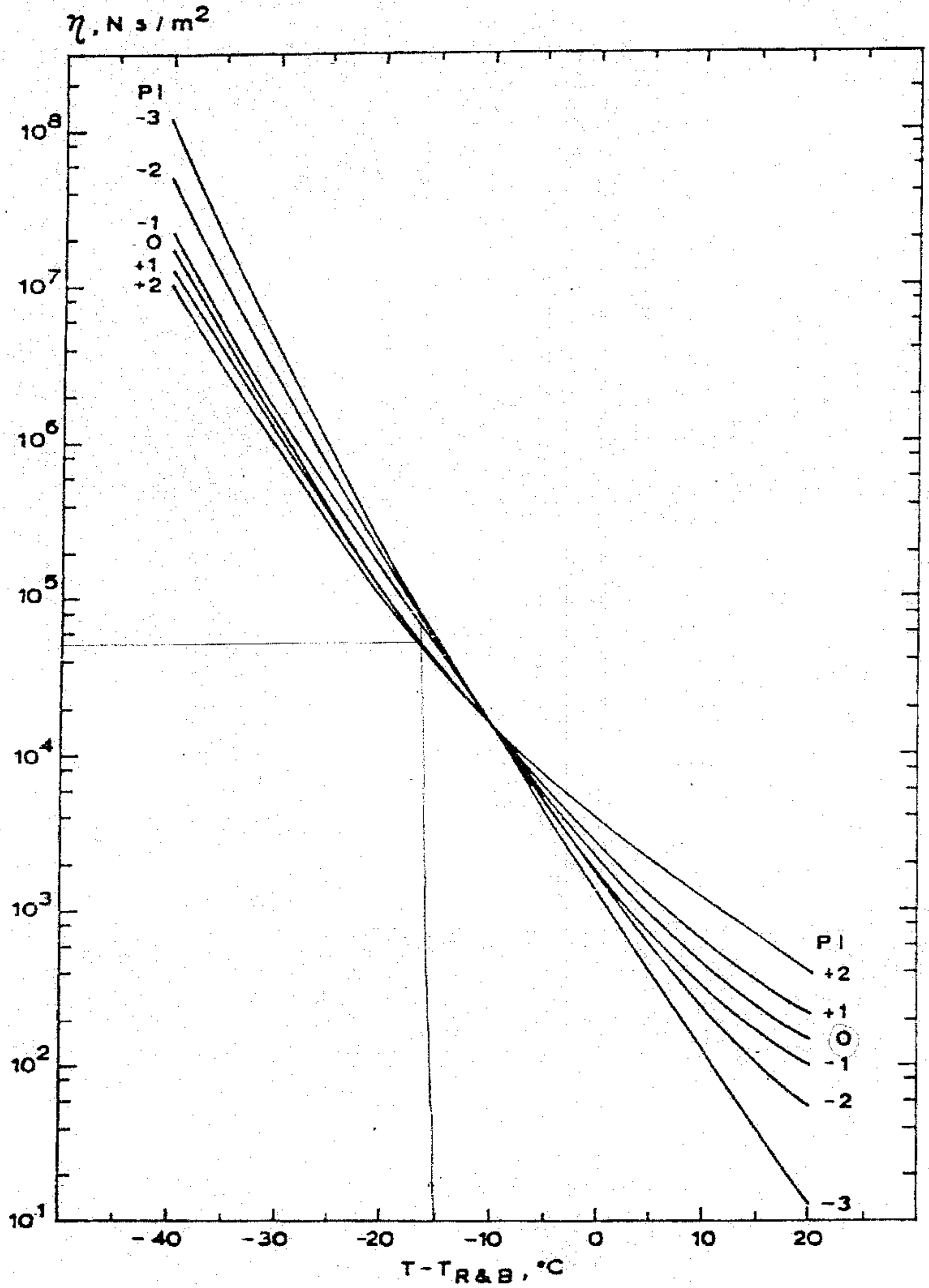
Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1662	5.828	5.313	4.236	**5.126**	4.983	21.505	5.930	**10.806**	Fail	4.896	Fail	**4.896**	31.295	20.495	13.554	**21.781**
1664	5.828	5.337	4.234	**5.133**	4.940	21.480	5.933	**10.784**	Fail	4.929	Fail	**4.929**	31.467	20.568	13.576	**21.870**
1666	5.826	5.376	4.233	**5.145**	4.939	21.480	5.909	**10.776**	Fail	4.881	Fail	**4.881**	31.237	20.372	13.592	**21.734**
1668	5.801	5.311	4.232	**5.115**	4.957	21.395	5.930	**10.761**	Fail	4.900	Fail	**4.900**	31.009	20.372	13.522	**21.634**
1670	5.824	5.332	4.248	**5.135**	4.955	21.335	5.975	**10.755**	Fail	4.873	Fail	**4.873**	31.350	20.323	13.522	**21.732**
1672	5.845	5.353	4.232	**5.143**	4.970	21.395	5.954	**10.773**	Fail	4.845	Fail	**4.845**	30.952	20.445	13.473	**21.623**
1674	5.845	5.355	4.230	**5.143**	4.951	21.420	5.928	**10.766**	Fail	4.862	Fail	**4.862**	31.179	20.396	13.560	**21.712**
1676	5.799	5.332	4.228	**5.120**	4.969	21.420	5.928	**10.772**	Fail	4.837	Fail	**4.837**	31.007	20.347	13.522	**21.625**
1678	5.819	5.332	4.246	**5.132**	4.946	21.475	5.930	**10.784**	Fail	4.815	Fail	**4.815**	31.179	20.421	13.451	**21.684**
1680	5.817	5.332	4.228	**5.126**	4.964	21.475	5.930	**10.790**	Fail	4.846	Fail	**4.846**	31.122	20.470	13.500	**21.697**
1682	5.792	5.332	4.243	**5.122**	4.939	21.505	5.930	**10.791**	Fail	4.822	Fail	**4.822**	31.232	20.153	13.646	**21.677**
1684	5.811	5.330	4.225	**5.122**	4.917	21.446	5.928	**10.764**	Fail	4.833	Fail	**4.833**	30.838	20.298	13.478	**21.538**
1686	5.813	5.330	4.241	**5.128**	4.938	21.276	5.928	**10.714**	Fail	4.848	Fail	**4.848**	31.232	20.201	13.527	**21.653**
1688	5.794	5.332	4.225	**5.117**	4.938	21.505	5.928	**10.790**	Fail	4.846	Fail	**4.846**	30.837	20.274	13.398	**21.503**
1690	5.790	5.330	4.258	**5.126**	4.954	21.446	5.954	**10.785**	Fail	4.802	Fail	**4.802**	30.838	20.348	13.457	**21.548**
1692	5.786	5.330	4.222	**5.113**	4.948	21.500	5.954	**10.801**	Fail	4.814	Fail	**4.814**	30.837	20.250	13.468	**21.518**
1694	5.829	5.349	4.221	**5.133**	4.930	21.441	5.926	**10.766**	Fail	4.809	Fail	**4.809**	31.062	20.250	13.446	**21.586**
1696	5.850	5.326	4.221	**5.132**	4.925	21.446	5.924	**10.765**	Fail	4.803	Fail	**4.803**	30.782	20.226	13.419	**21.476**
1698	5.827	5.328	4.220	**5.125**	4.904	21.272	5.952	**10.709**	Fail	4.799	Fail	**4.799**	30.949	20.178	13.387	**21.505**
1700	5.804	5.330	4.219	**5.118**	4.961	21.441	5.949	**10.784**	Fail	4.797	Fail	**4.797**	31.004	20.153	13.436	**21.531**
1702	5.783	5.326	4.237	**5.115**	4.920	21.416	5.928	**10.755**	Fail	4.812	Fail	**4.812**	30.781	20.323	13.377	**21.494**
1704	5.781	5.326	4.234	**5.114**	4.942	21.386	5.952	**10.760**	Fail	4.784	Fail	**4.784**	30.669	20.081	13.501	**21.417**
1706	5.779	5.328	4.218	**5.108**	4.974	21.247	5.924	**10.715**	Fail	4.778	Fail	**4.778**	30.669	20.105	13.452	**21.409**
1708	5.775	5.307	4.217	**5.100**	4.914	21.323	5.926	**10.721**	Fail	4.756	Fail	**4.756**	30.502	20.275	13.511	**21.429**
1710	5.829	5.347	4.217	**5.131**	4.913	21.100	5.902	**10.638**	Fail	4.788	Fail	**4.788**	30.892	20.105	13.393	**21.463**
1712	5.821	5.326	4.217	**5.121**	4.931	21.298	5.926	**10.718**	Fail	4.781	Fail	**4.781**	30.558	20.081	13.442	**21.360**
1714	5.793	5.326	4.213	**5.111**	4.906	21.298	5.949	**10.718**	Fail	4.758	Fail	**4.758**	30.724	20.057	13.355	**21.379**
1716	5.770	5.344	4.214	**5.109**	4.923	21.184	5.971	**10.693**	Fail	4.753	Fail	**4.753**	30.836	20.057	13.330	**21.408**
1718	5.770	5.323	4.195	**5.096**	4.924	21.298	5.949	**10.724**	Fail	4.766	Fail	**4.766**	30.724	19.961	13.265	**21.317**
1720	5.768	5.324	4.212	**5.101**	4.884	21.298	5.924	**10.702**	Fail	4.721	Fail	**4.721**	30.891	20.033	13.399	**21.441**
1722	5.798	5.324	4.226	**5.116**	4.920	21.100	5.947	**10.656**	Fail	4.737	Fail	**4.737**	30.779	20.130	13.324	**21.411**
1724	5.812	5.303	4.209	**5.108**	4.916	21.269	5.947	**10.711**	Fail	4.726	Fail	**4.726**	30.668	20.082	13.378	**21.376**
1726	5.766	5.321	4.194	**5.094**	4.916	21.155	5.947	**10.673**	Fail	4.706	Fail	**4.706**	30.558	20.082	13.330	**21.323**
1728	5.764	5.321	4.209	**5.098**	4.913	21.269	5.947	**10.710**	Fail	4.718	Fail	**4.718**	30.668	20.082	13.319	**21.356**
1730	5.787	5.324	4.224	**5.112**	4.892	21.210	5.898	**10.667**	Fail	4.713	Fail	**4.713**	30.613	19.890	13.357	**21.287**
1732	5.762	5.323	4.206	**5.097**	4.910	21.155	5.900	**10.655**	Fail	4.710	Fail	**4.710**	30.558	19.938	13.261	**21.252**
1734	5.760	5.300	4.206	**5.089**	4.909	21.014	5.945	**10.623**	Fail	4.684	Fail	**4.684**	30.613	19.938	13.250	**21.267**
1736	5.785	5.342	4.204	**5.110**	4.923	21.014	5.924	**10.620**	Fail	4.697	Fail	**4.697**	30.890	19.866	13.357	**21.371**
1738	5.805	5.342	4.205	**5.117**	4.881	21.152	5.945	**10.659**	Fail	4.691	Fail	**4.691**	30.337	19.940	13.288	**21.188**
1740	5.787	5.296	4.219	**5.101**	4.864	21.097	5.921	**10.627**	Fail	4.686	Fail	**4.686**	30.613	19.916	13.267	**21.265**
1742	5.760	5.300	4.219	**5.093**	4.862	21.210	5.945	**10.672**	Fail	4.663	Fail	**4.663**	30.448	20.011	13.209	**21.223**
1744	5.755	5.298	4.202	**5.085**	4.896	21.069	5.919	**10.628**	Fail	4.676	Fail	**4.676**	30.448	20.131	13.161	**21.247**
1746	5.755	5.321	4.219	**5.098**	4.854	21.181	5.919	**10.651**	Fail	4.650	Fail	**4.650**	30.393	19.868	13.246	**21.169**
1748	5.799	5.300	4.201	**5.100**	4.871	21.181	5.898	**10.650**	Fail	4.680	Fail	**4.680**	30.228	19.965	13.363	**21.185**

Cycle	Gap Graded				Continuous Graded				Open Graded				Dense Graded			
	1	2	3	Average	1	2	3	Average	1	2	3	Average	1	2	3	Average
1750	5.799	5.298	4.167	**5.088**	4.869	21.123	5.898	**10.630**	Fail	4.677	Fail	**4.677**	30.448	19.938	13.178	**21.188**
1752	5.749	5.319	4.182	**5.083**	4.869	21.069	5.945	**10.628**	Fail	4.636	Fail	**4.636**	30.558	19.940	13.178	**21.225**
1754	5.751	5.298	4.198	**5.082**	4.884	21.210	5.921	**10.672**	Fail	4.626	Fail	**4.626**	30.229	19.987	13.188	**21.135**
1756	5.749	5.338	4.181	**5.089**	4.866	21.040	5.945	**10.617**	Fail	4.624	Fail	**4.624**	30.339	19.870	13.178	**21.129**
1758	5.749	5.338	4.181	**5.089**	4.845	21.236	5.924	**10.668**	Fail	4.653	Fail	**4.653**	30.448	19.821	13.242	**21.170**
1760	5.774	5.296	4.196	**5.089**	4.879	21.011	5.919	**10.603**	Fail	4.629	Fail	**4.629**	30.339	19.940	13.120	**21.133**
1762	5.792	5.317	4.195	**5.101**	4.860	21.069	5.919	**10.616**	Fail	4.624	Fail	**4.624**	30.068	19.773	13.205	**21.015**
1764	5.763	5.315	4.195	**5.091**	4.855	21.152	5.945	**10.651**	Fail	4.583	Fail	**4.583**	30.068	19.868	13.168	**21.035**
1766	5.811	5.294	4.227	**5.111**	4.875	21.094	5.895	**10.621**	Fail	4.630	Fail	**4.630**	30.178	19.798	13.137	**21.038**
1768	5.774	5.315	4.226	**5.105**	4.852	21.037	5.940	**10.610**	Fail	4.610	Fail	**4.610**	30.068	19.775	13.232	**21.025**
1770	5.765	5.315	4.207	**5.096**	4.867	20.897	5.942	**10.569**	Fail	4.602	Fail	**4.602**	30.123	19.895	13.164	**21.061**
1772	5.763	5.338	4.176	**5.092**	4.888	20.925	5.919	**10.577**	Fail	4.600	Fail	**4.600**	30.014	19.965	13.079	**21.019**
1774	5.763	5.334	4.207	**5.101**	4.845	20.840	5.895	**10.527**	Fail	4.600	Fail	**4.600**	30.232	19.729	13.127	**21.029**
1776	5.745	5.336	4.175	**5.085**	4.859	20.871	5.895	**10.542**	Fail	4.599	Fail	**4.599**	30.016	19.871	13.117	**21.001**
1778	5.740	5.312	4.174	**5.075**	4.837	20.897	5.895	**10.543**	Fail	4.578	Fail	**4.578**	30.286	19.848	13.086	**21.073**
1780	5.779	5.315	4.188	**5.094**	4.840	21.008	5.940	**10.596**	Fail	4.598	Fail	**4.598**	30.233	19.680	13.191	**21.035**
1782	5.734	5.313	4.203	**5.083**	4.839	20.925	5.917	**10.560**	Fail	4.596	Fail	**4.596**	30.071	19.870	13.144	**21.028**
1784	5.761	5.312	4.188	**5.087**	4.855	21.008	5.942	**10.602**	Fail	4.594	Fail	**4.594**	30.016	19.777	13.086	**20.960**
1786	5.736	5.291	4.186	**5.071**	4.856	20.842	5.945	**10.548**	Fail	4.612	Fail	**4.612**	29.908	19.777	13.076	**20.920**
1788	5.757	5.292	4.186	**5.078**	4.852	21.008	5.940	**10.600**	Fail	4.573	Fail	**4.573**	29.802	19.705	13.113	**20.873**
1790	5.777	5.291	4.202	**5.090**	4.812	20.897	5.942	**10.550**	Fail	4.606	Fail	**4.606**	30.018	19.682	13.066	**20.922**
1792	5.734	5.312	4.185	**5.077**	4.832	20.869	5.940	**10.547**	Fail	4.591	Fail	**4.591**	30.286	19.543	13.046	**20.958**
1794	5.752	5.312	4.200	**5.088**	4.804	20.952	5.917	**10.558**	Fail	4.588	Fail	**4.588**	29.857	19.588	13.025	**20.823**
1796	5.798	5.310	4.182	**5.097**	4.825	20.840	5.917	**10.527**	Fail	4.570	Fail	**4.570**	29.857	19.637	13.147	**20.880**
1798	5.748	5.333	4.182	**5.088**	4.822	20.980	5.938	**10.580**	Fail	4.587	Fail	**4.587**	29.805	19.565	13.103	**20.824**
1800	**5.725**	**5.291**	**4.181**	**5.066**	**4.838**	**20.923**	**5.893**	**10.561**	Fail	**4.605**	Fail	**4.605**	**29.752**	**19.591**	**13.015**	**20.786**

APPENDIX 5: *Nomograph for stiffness modulus of bitumen*



APPENDIX 6



Viscosity of bitumen as a function of $(T - T_{R\&B})$ and PI

PENDIX 7

m nomograph, get the Stiffness modulus of bitumen, Sbit

r 80 pen bitumen, the softening point is 44 °C
ıamic creep test operating temperature is 40 °C
ıus, the temperature difference is 4 °C
ıetration index is at 0

ıix average is taken from Dynamic Creep Test result at specified cycles.

Cycles	Time of loading (s)	Smix average (Mpa)				Sbit (Mpa)
		Gap	Continuous	Open	Dense	
10	20	19.562	44.531	29.904	150.433	1.50E-03
20	40	15.275	35.38	19.761	117.495	1.00E-03
30	60	13.365	30.989	17.479	103.902	7.50E-04
60	120	10.873	25.259	14.338	82.997	5.00E-04
180	360	8.126	18.848	10.63	56.016	1.00E-04
420	840	6.618	15.273	7.947	40.488	8.00E-05
600	1200	6.115	14.028	6.761	34.908	7.00E-05
1200	2400	5.356	11.831	5.327	25.576	1.05E-05
1800	3600	5.066	10.551	4.605	20.786	1.00E-05

ıph Smix average vs. Sbit is plotted based on the above table (Figure 31).

ıd Stiffness modulus of bitumen viscosity, (Sbit)v

$$(S_{bit})_v = \frac{3\eta}{NT_w}$$

where η from Graph viscosity of bitumen (Appendix 6), get 5×10^{-3}
N = number of wheels passes standard axle, in million
Tw = loading time (0.02 s)

: *For N = 1*

$$(S_{bit})_v = \frac{3*(5E\text{-}03)}{(1)*(0.02)} = 0.75$$

e new Smix is calculated based on the linear equation shown in Figure 31.

ıix, y:

ıp $y = 81.663(x)^{0.2500}$ where x = (Sbit)v

ıntinuous $y = 208.93(x)^{0.2635}$

ıen $y = 196.37(x)^{0.3283}$

ınse $y = 1467.4(x)^{0.3681}$

For N = 1, (Sbit)v = 0.75

) y = 81.663(7.50E-01)^0.25 = 75.996
ıtinuous y = 208.93(7.50E-01)^0.2635 = 193.678
ən y = 196.37(7.50E-01)^0.3283 = 178.673
ıse y = 1467.4(7.50E-01)^0.3681 = 1319.953

N	Smix (Mpa)				(Sbit)v (Mpa)
	Gap	Continuous	Open	Dense	
1.E+00	75.996	193.678	178.673	1319.953	7.50E-01
1.E+01	42.736	105.579	83.899	565.534	7.50E-02
1.E+02	24.032	57.555	39.397	242.303	7.50E-03
1.E+03	13.514	31.375	18.499	103.815	7.50E-04
1.E+04	7.600	17.103	8.687	44.479	7.50E-05
1.E+05	4.274	9.324	4.079	19.057	7.50E-06
1.E+06	2.403	5.083	1.915	8.165	7.50E-07
1.E+07	1.351	2.771	0.899	3.498	7.50E-08
1.E+08	0.760	1.510	0.422	1.499	7.50E-09

t Depth calculation:

$$_d = C_m \times H \times \left(\frac{\sigma_{av}}{S_{mix}} \right)$$

ere Cm = dynamic efficiency (1.0 - 2.0), take 1.5
H = height of pavement between 60 - 70 mm, take 65 mm
σav = 2.5 Mpa

: *For N = 1*

ıp Rd = (1.5*65*2.5)/75.996 = 3.207 mm
ntinuous Rd = (1.5*65*2.5)/193.678 = 1.259 mm
ıen Rd = (1.5*65*2.5)/178.673 = 1.364 mm
ınse Rd = (1.5*65*2.5)/1319.953 = 0.185 mm

N	Rut depth (mm)			
	Gap	Continuous	Open	Dense
1.E+00	3.207	1.259	1.364	0.185
1.E+01	5.704	2.309	2.905	0.431
1.E+02	10.143	4.235	6.187	1.006
1.E+03	18.037	7.769	13.176	2.348
1.E+04	32.074	14.252	28.060	5.480
1.E+05	57.037	26.144	59.757	12.790
1.E+06	101.427	47.958	127.259	29.853
1.E+07	180.366	87.976	271.011	69.676