QUALITY CONTROL ANALYSIS
PART IV
FIELD SIMULATION OF ASPHALTIC CONCRETE SPECIFICATIONS

by

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ACKNOWLEDGMENT

Appreciation is extended to the District 07, 58, and 61 personnel for their time and effort in sampling, testing, and reporting of the data for this study. Special thanks are offered to the three contractors for their positive attitude toward this new concept in highway construction specifications.

ABSTRACT

The report presents some of the major findings, from a simulated study of statistical specifications, on three asphaltic concrete projects representing a total of approximately 30,000 tons of hot mix. The major emphasis of the study has been on the assessment of reduced payment for non-conforming lots. This is summarized in Tables 2, 3, and 4 of the text.

The experience gained from this study indicated (1) that the contractor will have little difficulty in assuming the responsibility of quality control of the product; (2) that the designated lot and sample size for control and acceptance of the product is adequate and realistic, except for some minor revisions for surface tolerances; (3) furthermore, that it is almost necessary for the contractor to keep abreast of the quality of his daily output in order to prevent any possible defective items, and consequently, lower economic returns.

INTRODUCTION

The data presented in this report represent findings from simulated study to evaluate statistical specifications on three asphaltic concrete projects. It represents a segment of the fourth phase of the overall Quality Control Analysis Study. Findings from the first three phases, which were used for the development of these statistical specifications, have been reported in the Department's previous publications (1, 2, 3).*

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* Underlined numbers in parentheses refer to list of references.

SCOPE

The quality control program at the Louisiana Department of Highways was initiated in the middle of 1963 in cooperation with the Bureau of Public Roads. It was divided into four separate phases. The first three phases were geared to the accumulation and analyses of historical as well as research data for obtaining statistical parameters on the following major construction items:

Asphaltic Concrete, Phase I
Soil and Aggregate Base Course, Phase II
Concrete and Concrete Aggregates, Phase III

Phase IV is geared to the development and field simulation of statistical specifications on the above major items. The matter contained in this report represent Louisiana's experience with asphaltic concrete statistical specifications. These statistical specifications were tried on a non-contractural basis on three separate state projects representing a total of approximately 30,000 tons of hot mix.

STATISTICAL SPECIFICATIONS ON ASPHALTIC CONCRETE

Development

To a certain extent the first three phases of the study could very well be considered the "shock treatment" phases. Everyone was aware of the presence of variations but not to the tune of 0.2 to 0.4 percent standard deviations for bitumen content; or a slump of six inches on individual measurements from a batch of concrete; or as much as 50 percent of the aggregate gradation to fall outside the existing specification requirements. All this and more was revealed during that period. The next major step was to put down in a clear and concise manner the needed requirements to fulfil the design needs, to protect the owner from poor workmanship, and at the same time to allow the contractor the maximum freedom to perform the work as he desires provided the end product is satisfactory.

After several revisions, the final draft was prepared for field evaluation. The text of this draft, in the form of special provisions, is given in the Appendix. The major items that have been affected by these special provisions are:

(1) Control to the contractor
  - Physical criterion for control

(2) Acceptance requirements
  - Physical criteria for acceptance
  - Lot size for acceptance
  - Sample size for acceptance

(3) Random sampling procedures

(4) Reduction in price for non-conforming lots.

A summary of various criteria for control and acceptance of asphaltic concrete is given in Table 1. The only thing "statistical" about the table is the sample size. The rest of the table reflects the ever irreplaceable engineering judgment.

Application

Since the specifications or special provisions were to be applied and evaluated on non-contractural basis, no administrative difficulty was encountered in selection of projects. However, from the point of view of size or total tonnage, not much choice was offered.

TABLE 1
SUMMARY OF PHYSICAL CRITERIA FOR ACCEPTANCE AND CONTROL OF ASPHALTIC CONCRETE

Requirements for	Lot Size	Sample Size	Frequency	Basis of Randomness
Control				
Bitumen content extracted aggregate gradation.	Day's production	2	1 in the morning 1 in the evening	Time
Acceptance				
Marshall stability	Day's production	4*	2 in the morning 2 in the evening	Time
Roadway density	Day's production	5	One from each of five equally divided segments	Pavement surface area
Surface tolerance	Day's production	500 ft. section	Entire length of section	Transverse distance

* Reduction in sample size is allowed in the event it is not possible to sample the entire lot due to plant breakdown, inclement weather or such unavoidable circumstances.

The contractors for the projects were representative for Louisiana. The projects were located in different parts of the state with Project A in the southeast section, Project B in the southcentral section and Project C in the northeast section. The plants producing the mix were essentially the same type (automatic batch type) and capable of producing on the average 100 to 120 tons of mix per hour.

Several days before the start of each project, the project engineer's and the contractor's personnel were made familiar with the purpose and scope of this research study. At the same time, they were asked to review the special provisions to further familiarize themselves of the changes.

Simulation

Since the projects were let under existing specifications, normal control procedure was also performed in addition to the simulation procedure.

Some flexibility was permitted during the simulation of these special provisions. For example, the contractor was furnished the services of the Department's inspector who was then entrusted with the responsibility of controlling the mix and any necessary adjustments to produce the desired mixture. Furthermore, flexibility was also provided for the amount of time necessary to set up the initial job mix for approval.

Evaluation of Data and Assessment of Payment

The contractors' test results for submittal of job mix and the Department's check results for approval of the job mix are given in the Appendix. Control charts showing day-to-day variation in production control also appear in the Appendix. None of the plants, except B, had difficulty maintaining adequate control on the required criteria.

The crux of this phase of this study is contained in Table 2, 3, and 4. It shows lot-by-lot evaluation of the product for acceptance with particular emphasis on the assessment of payment for out-of-specification production and/or construction. The final assessment (last column in the tables) reflects the lowest of the three assessments. For example, for Lot Number 3 in Table 2, the payment was 100 percent for stability as well as roadway density criteria; however, his payment for surface tolerance was only 80 percent and consequently he would have been paid 80 percent for that lot.

TABLE 2
LOT-BY-LOT EVALUATION OF ACCEPTANCE
TEST RESULTS & ASSESSMENT OF PAYMENT

(PROJECT A)

Lot No.	Tons Laid	Average Per Lot Marshall Stability	Average Per Lot Rdway Density	Surface Tolerance Percent Outside 1/8" Tol.	Surface Tolerance Percent Outside 3/16" Tol.	Final Payment Per Lot Percent
1	809	1319 (100)	97.3(100)	1.1	0.0(100)	100
2	663	1458* (100)	96.9(100)	0.7	0.0(105)	100
3	750	1511 (100)	97.7(100)	2.3	0.8(80)	80
4	621	1365 (100)	98.2(105)	1.0	0.0(105)	100
5	729	1339 (100)	97.8(100)	2.5	0.6(95)	95
6	669	1354* (100)	97.2(100)	0.5	0.0(105)	100
7	865	1406 (100)	97.8(100)	2.8	0.6(95)	95
8	1003	1442 (100)	97.1(100)	3.6	1.0(80)	80
9	739	1383**(100)	97.8(100)	0.0	0.0(105)	100
10	964	1390 (100)	98.1(105)	0.6	0.4(100)	100
11	856	1331 (100)	97.5(100)	0.4	0.1(100)	100
12	570	1343* (100)	97.2(100)	1.2	0.6(95)	95
13	867	1408 (100)	96.3(100)	1.0	0.0(100)	100
14	861	1427 (100)	96.7(100)	3.0	0.6(95)	95
15	849	1462 (100)	97.5(100)	0.4	0.0(105)	100
16	546	1427 (100)	97.9(100)	2.2	0.5(95)	95
17	669	1464 (100)	97.4(100)	-	-	-
18	744	1299 (100)	96.0(100)	3.6	0.5(95)	95
19	294	1390* (100)	96.6(100)	2.0	0.0(100)	100
weighted average payment for the project						95

( )Percent Pay   * Two tests per lot   ** Three tests per lot.

TABLE 3

LOT-BY-LOT EVALUATION OF ACCEPTANCE TEST RESULTS & ASSESSMENT OF PAYMENT

(PROJECT B)

Lot No.	Tons Laid	Average Per Lot Marshall Stability	Average Per Lot Rdway Density	Surface Tolerance Percent Outside 1/8" Tol.	Surface Tolerance Percent Outside 3/16" Tol.	Final Payment Per Lot Percent
1	312	1356 (100)	95.2(95)	0.6	0.0(105)	95
2	608	1650 (105)	93.9(80)	0.9	0.1(100)	80
3	632	1445 (100)	96.5(100)	0.9	0.0(105)	100
4	150	1127*(100)	93.3(80)	0.1	0.0(105)	80
5	293	1360*(100)	96.8(100)	1.0	0.0(105)	100
6	618	1474 (100)	94.9(80)	1.4	0.0(100)	80
7	168	1173*(100)	95.0(95)	2.4	0.0(95)	95
8	603	1330 (100)	95.2(95)	2.0	0.2(100)	95
9	621	1266 (100)	92.5(50)	6.6	0.0(95)	50 or remove
10	635	1008 (95)	96.2(100)	7.7	0.2(95)	95
11	445	1387 (100)	95.3(95)	5.9	2.0(50)	50 or remove
12	198	1063*(100)	94.6(80)	5.7	2.6(50)	50 or remove
weighted average payment for the project						82

( ) Percent Pay   * Two tests per lot

TABLE 4
LOT-BY-LOT EVALUATION OF ACCEPTANCE TEST RESULTS & ASSESSMENT OF PAYMENT

(PROJECT C)

Lot No.	Tons Laid	Average Per Lot Marshall Stability	Average Per Lot Rdway Density	Surface Tolerance Percent Outside 1/8" Tol.	Surface Tolerance Percent Outside 3/16" Tol.	Final Payment Per Lot Percent
1	1155	1755 (105)	95.4(95)	0.8	0.0(105)	95
2	848	1715 (105)	96.4(100)	3.0	0.6(95)	95
3	1008	1604 (100)	95.8(95)	1.4	0.0(100)	95
4	960	1972 (105)	94.0(80)	0.0	0.0(105)	80
5	1088	1986 (105)	94.6(80)	0.0	0.0(105)	80
6	910	1566 (100)	96.2(100)	0.1	0.0(105)	100
7	560	1819*(100)	96.6(100)	1.7	0.0(100)	100
	weighted average payment for the project					82

(   )Percent Pay

* Two tests per lot

The tables also indicate the necessity for the contractor to keep abreast of the quality of his daily production or construction operation. Lack of cognizance will result in inferior product or construction practice and consequently harsher assessment of payment. This point is emphasized in Table 3 for Lots 6, 7, 8, and 9 for roadway density. The adverse condition for Lots 7, 8, and 9 could have been rectified using the density data of Lot 6 as guideline.

All three projects had difficulty meeting the surface tolerance requirements which admittedly were developed from small sample statistics and therefore, may not represent absolute realistic values. As more data is accumulated, a second look will be given at these tolerances.

Analysis of Project vs Population Parameters

An interesting comparison between the sample (project) statistics and the population parameters is presented in Tables 5 and 6. The population parameters represent values that were used in development of the specification tolerance limits for various characteristics. The values for Project C in Table 5 may be misleading due to very small sample size. Project A, because of better control, was well able to stay within the population sigma. On the otherhand, the-larger-than population values on Project B are the result of inadequate control on the characteristic. This is indicated by the out-of-control data on the control charts for No. 4 sieve down to No. 80 in the Appendix.

The better-than-average overall control on Project A is once again demonstrated in Table 6. The standard deviation is the lowest encountered for stability data. Likewise, the standard deviation for density data is also considerably lower than the population standard deviation. For the other two projects, the lower mean and the higher variability resulted in some lots to fall short of the minimum requirements.

TABLE 5

COMPARISON BETWEEN PROJECT STANDARD DEVIATION AND POPULATION STANDARD DEVIATION FOR EXTRACTION DATA

Project	A	B	C	Population
n	36	20	13*	-
	STANDARD DEVIATION			
	σ	σ	σ	σ
Asphalt Content	0.20	0.24	0.10	0.24
3/4" Sieve	-	-	1.12	3.04
1/2" Sieve	0.44	1.65	1.66	4.02
3/8" Sieve	2.04	2.35	2.02	2.50
No. 4 Sieve	2.34	3.54	2.54	3.20
No. 10 Sieve	2.06	3.31	2.57	2.90
No. 80 Sieve	1.56	1.93	1.20	1.70
No. 200 Sieve	0.71	0.74	0.18	1.00

* Represents wearing (n=7) and binder (n=6) course data

TABLE 6
COMPARISON BETWEEN PROJECT PARAMETERS AND POPULATION PARAMETERS FOR STABILITY AND DENSITY DATA

Project	A			B			C			Population	
Parameters	n	$\bar{X}$	σ	n	$\bar{X}$	σ	n	$\bar{X}$	σ	$\bar{X}$	σ
Stability	67	1400	95	40	1330*	244*	14	1838	228	1571 (1361)	220 (174)
							Binder course data				
							12	1691	153		
Density	95	97.3	1.05	60	95.0	1.65	20	95.4	1.61	97.8	1.55
							Binder course data				
							15	95.9	1.29		

* Comparative population parameters are in the parentheses.

SUMMARY AND RECOMMENDATIONS

The preceding sections presented some of the findings obtained from a simulated study to evaluate statistical special provisions on asphaltic concrete. The results were based on three projects representing a total of approximately 30,000 tons of hot mix. The experience gained, from the field evaluation of this totally new concept in construction specifications, justify the following comments:

(1) The average contractor will have little difficulty in taking over the responsibility of quality control of the product. This transition period may require the contractor to borrow the services of the Department personnel at some specified cost to him. The contractor may also make use of the Department's training manual for training his technicians for control and testing of hot mix. These manuals are available to all the contractors for the cost of printing only.

(2) The designated lot size for control and acceptance of the product seems adequate at the present time. The same holds true for sample size for all the characteristics except surface tolerance for which the size should be changed from a single 500-foot section per lot to five 200-foot sections per lot.

(3) The control limits for bitumen content and gradation and the acceptance limits for stability and density seems realistic. However, the acceptance limits for surface tolerances need to be scrutinized before inclusion in the contract specifications.

(4) The contractor will have to make every effort to keep abreast of the quality of his daily production and operation in order to prevent any possible defective item, and consequently, imposition of harsher assessment of payment.

(5) It is recommended that these special provisions be further tried, with the above recommended revisions, on a contractural basis on three experimental projects.

REFERENCES CITED

(1) S. C. Shah, "Quality Control Analysis, Part I - Asphaltic Concrete," Louisiana Department of Highways, Research Report No. 15, November, 1964.

(2) S. C. Shah, "Quality Control Analysis, Part II - Soil and Aggregate Base Course," Louisiana Department of Highways, Research Report No. 23, July, 1966.

(3) S. C. Shah, "Quality Control Analysis, Part III - Concrete and Concrete Aggregates," Louisiana Department of Highways, Research Report No. 24, November, 1966.

APPENDIX

JOB MIX RELEASE

TABLE A-1

ASPHALTIC CONCRETE JOB MIX RELEASE
PROJECT A
(Type 1 W. C., 60-70 Pen. Asphalt)

Extraction Results (Average of two tests)

U. S. Sieve	Contractor's	Department's
3/4 inch	100.0	100.0
1/2 inch	99.7	100.0
3/8 inch	87.2	89.3
No. 4	62.5	65.7
No. 10	47.1	48.6
No. 40	29.0	29.3
No. 80	15.1	14.7
No. 200	7.2	7.4
Bitumen, %	5.0	4.8
Crushed, %	82.0	81.0

Marshall Test Properties (Average of four tests)

Theoretical gravity	96.0	96.1
% V. F. A.	74.0	74.6
Stability, lb.	1388	1438
Flow, 1/100 inch	7	6

Mix temperature, °F
Dry mixing time, sec.
Wet mixing time, sec.

TABLE B-1

ASPHALTIC CONCRETE JOB MIX RELEASE
PROJECT B
(Type 1 W. C., 85-100 Pen. Asphalt)

Extraction Results (Average of two tests)

U. S. Sieve	Contractor's	Department's
3/4 inch	100.0	100.0
1/2 inch	94.7	94.5
3/8 inch	84.5	82.7
No. 4	65.0	59.8
No. 10	53.3	47.8
No. 40	34.7	31.1
No. 80	13.8	13.7
No. 200	7.3	8.0
Bitumen, %	4.9	4.7
Crushed, %	90.0	90.0

Marshall Test Properties (Average of four tests)

Theoretical gravity	95.0	94.2
% V. F. A.	69.4	67.0
Stability, lb.	1650	1440
Flow, 1/100 inch	8	6
Mix temperature, °F	325	
Dry mixing time, sec.	10	
Wet mixing time, sec.	35	

TABLE C-1

ASPHALTIC CONCRETE JOB MIX RELEASE
PROJECT C
(Type 1 B. C., 60-70 Pen. Asphalt)

Extraction Results (Average of two tests)

U. S. Sieve	Contractor's	Department's
1 inch	100.0	100.0
3/4 inch	100.0	98.5
1/2 inch	84.3	84.5
No. 4	44.1	41.5
No. 10	32.2	32.2
No. 40	18.0	17.3
No. 80	11.1	10.4
No. 200	6.9	6.1
Bitumen, %	3.8	3.9
Crushed, %	78.0	80.0

Marshall Test Properties (Average of four tests)

Theoretical gravity	95.6	95.2
% V. F. A.	66.5	64.5
Stability, lb.	1690	1755
Flow, 1/100 inch	11	10
Mix temperature, °F	330	
Dry mixing time, sec.	12	
Wet mixing time, sec.	33	

TABLE C-2

ASPHALTIC CONCRETE JOB MIX RELEASE
PROJECT C
(Type 1 W.C., 60-70 Per Asphalt)

Extraction Results (Average of two tests)

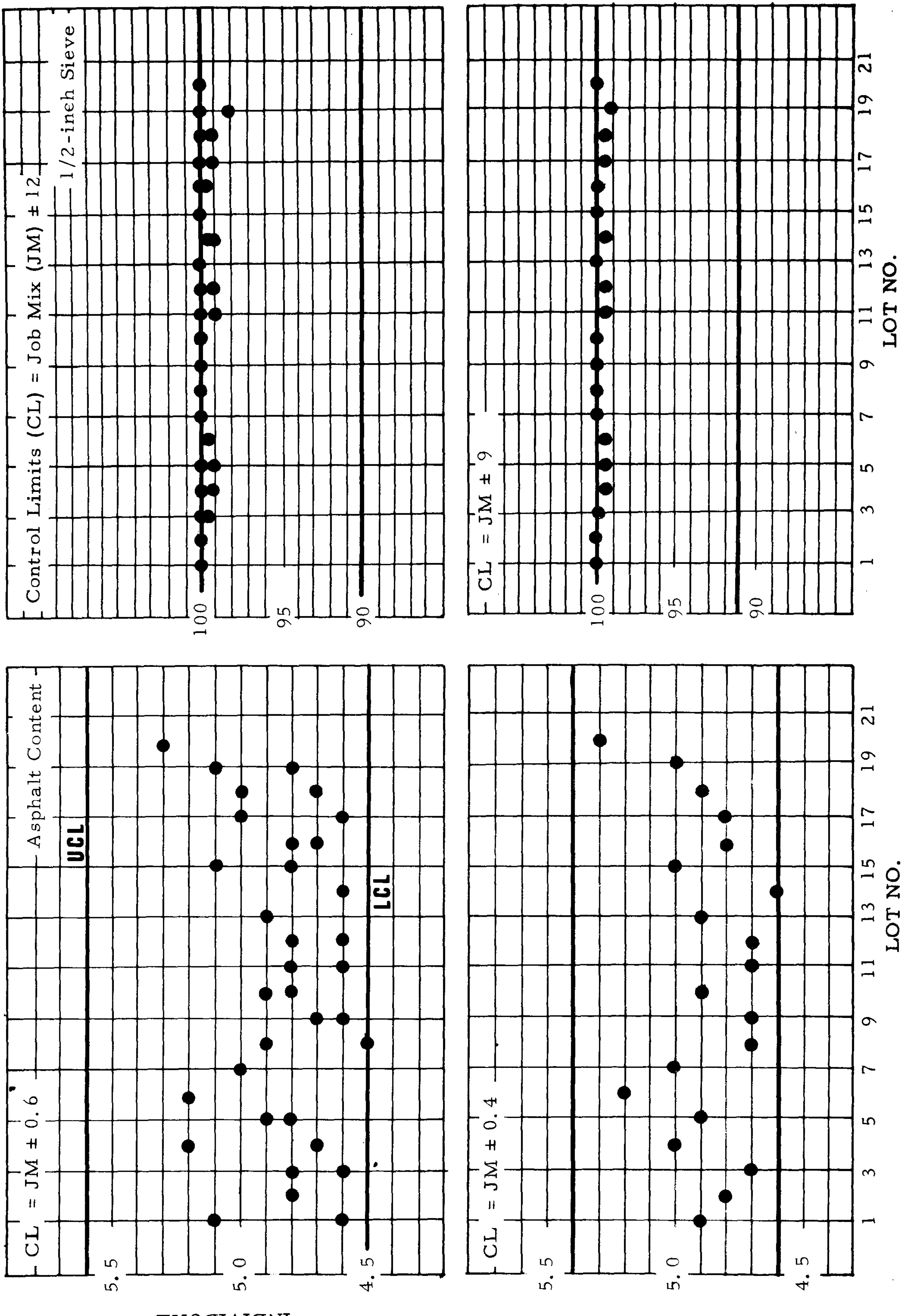
U. S. Sieve	Contractor's	Department's
3/4 inch	100.0	
1/2 inch	97.2	Same
3/8 inch	85.9	as
No. 4	60.4	the
No. 10	46.3	Contractor's
No. 40	27.0	
No. 80	15.7	
No. 200	8.3	
Bitumen, %	4.7	
Crushed, %	75.0	

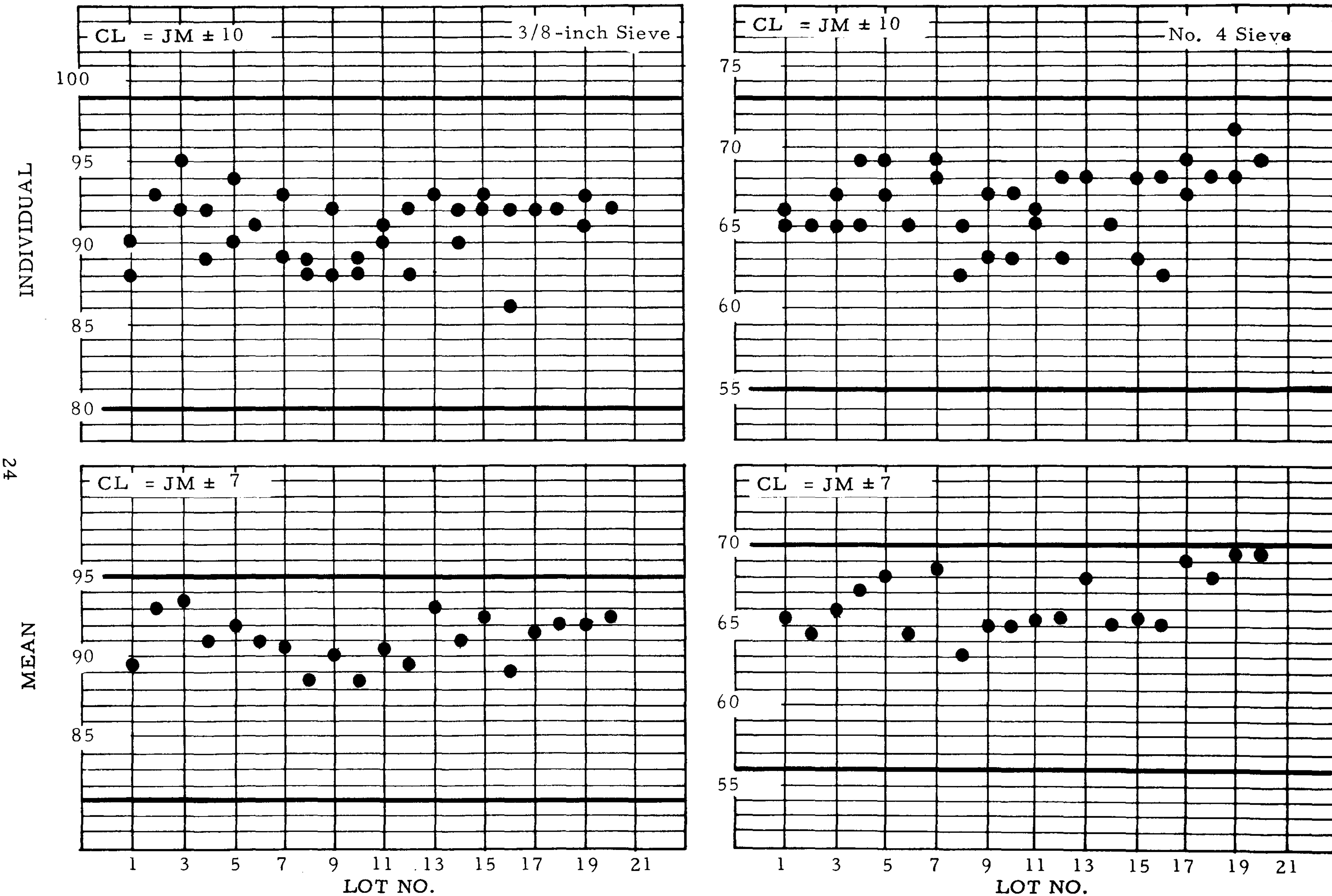
Marshall Test Properties (Average of four tests)

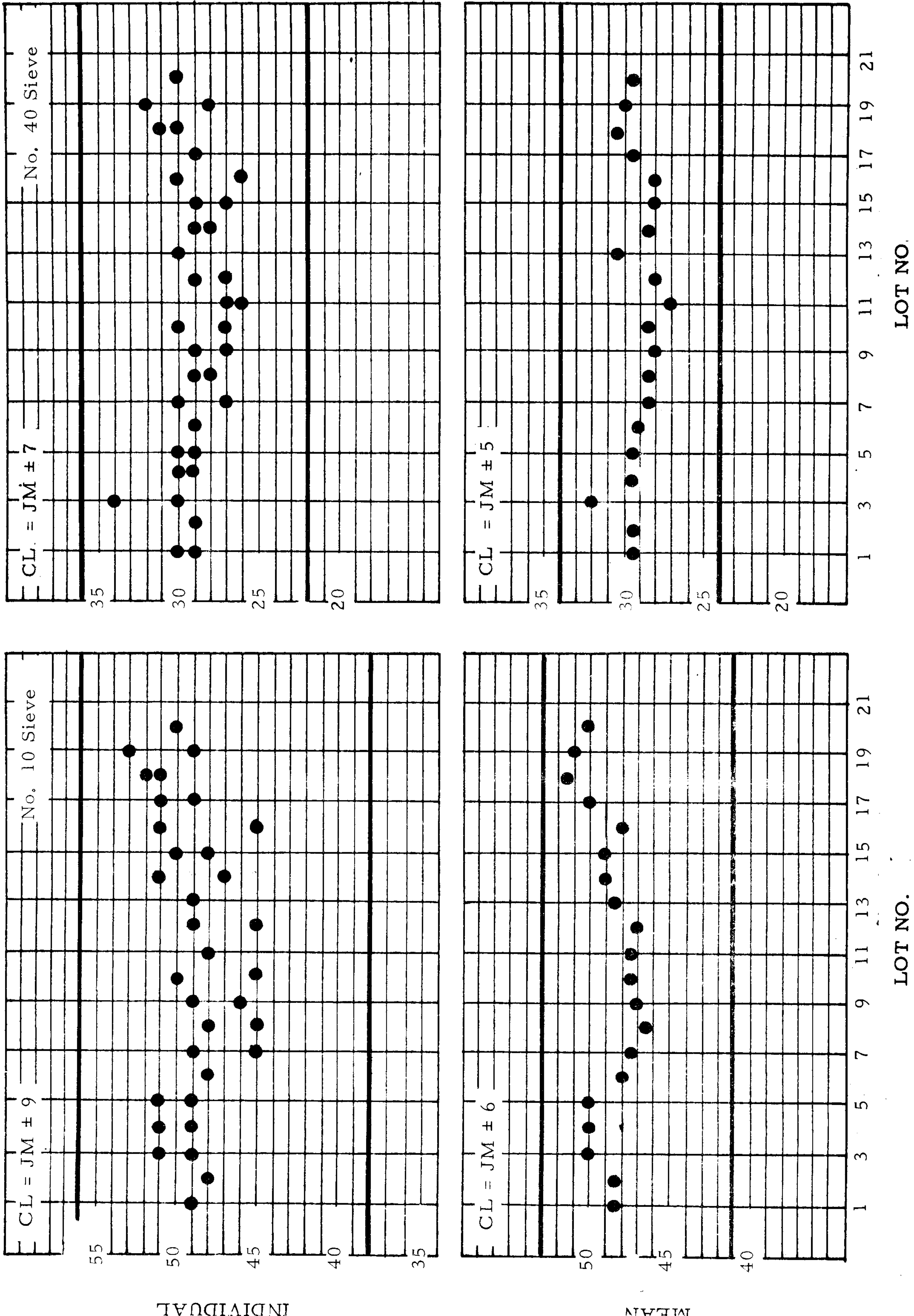
Theoretical gravity	95.9	95.5
% V.F.A.	71.1	70.4
Stability, lb.	1764	1972
Flow, 1/100 inch	8	7
Mix temperature, °F	330	
Dry mixing time, sec.	12	
Wet mixing time, sec.	33	

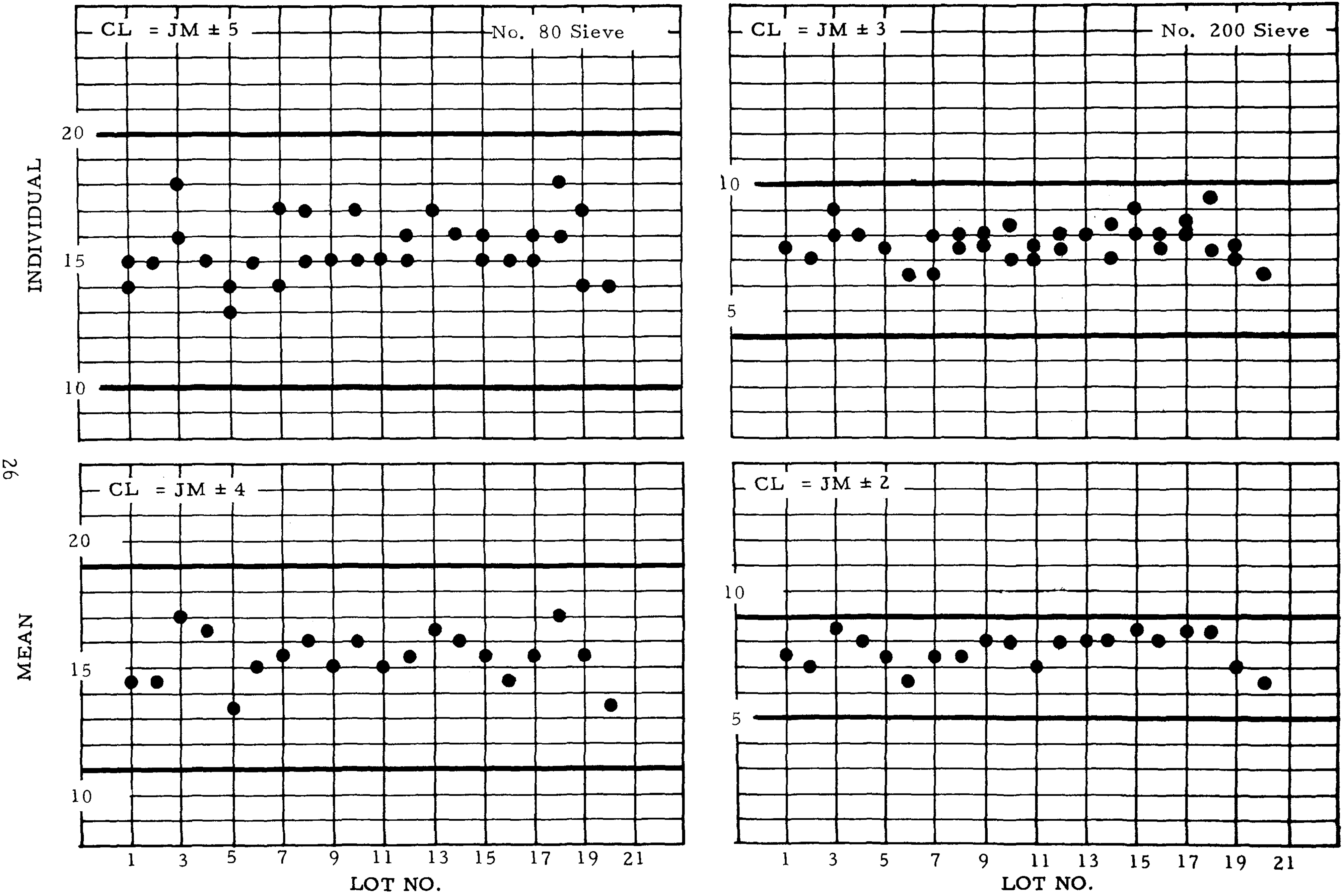
APPENDIX

CONTROL CHARTS ON PROJECT A


Asphalt Content
CL = JM ± 0.6
UCL
LCL
5.5
5.0
4.5
INDIVIDUAL
CL = JM ± 0.4
MEAN
LOT NO.
1 3 5 7 9 11 13 15 17 19 21
Control Limits (CL) = Job Mix (JM) ± 12
1/2-inch Sieve
100
95
90
CL = JM ± 9

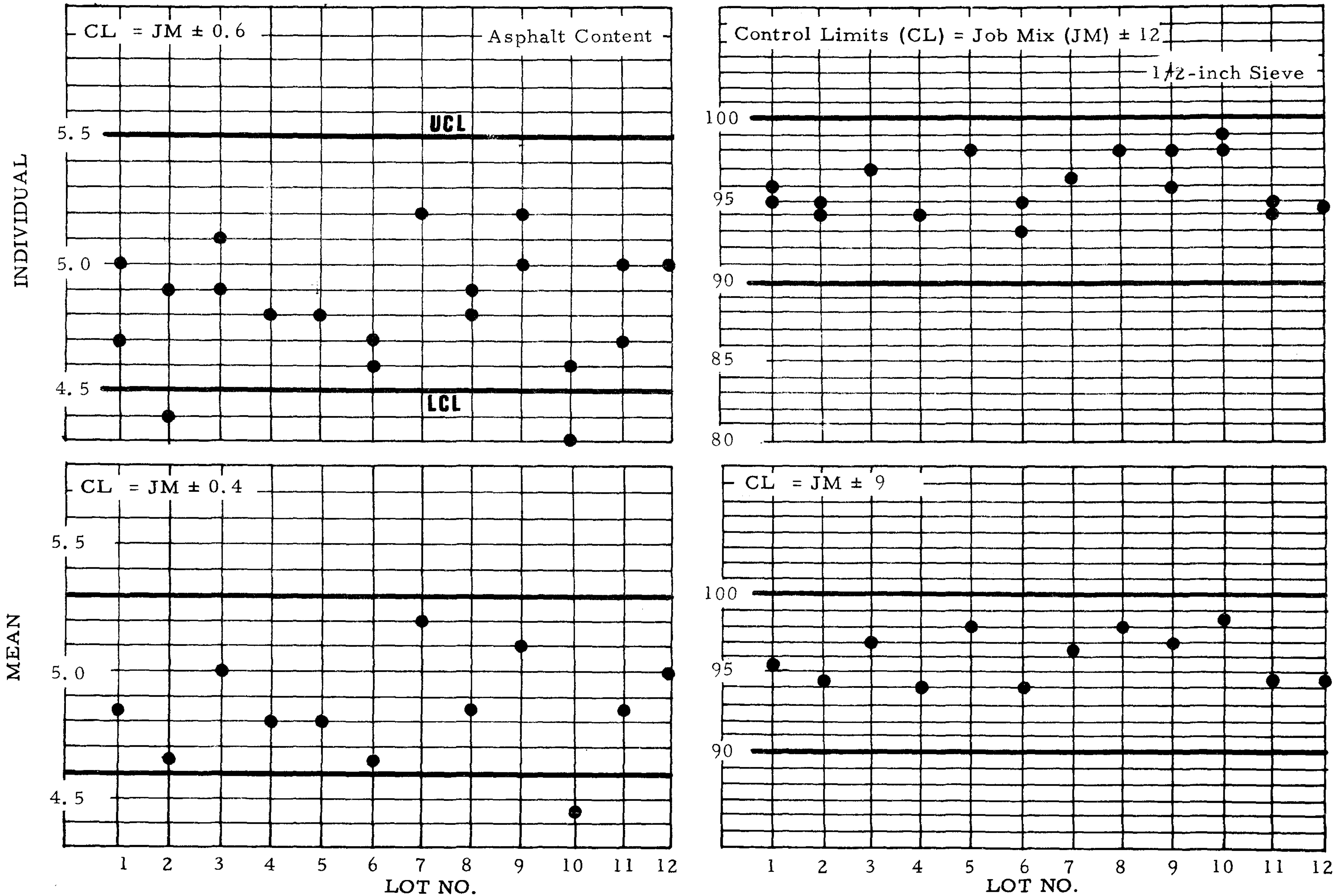

INDIVIDUAL
MEAN
CL = JM ± 10
3/8-inch Sieve
CL = JM ± 7
CL = JM ± 10
No. 4 Sieve
CL = JM ± 7
100
95
90
85
80
75
70
65
60
55
1
3
5
7
9
11
13
15
17
19
21
LOT NO.


No. 40 Sieve
CL = JM ± 7
35
30
25
20
CL = JM ± 5
35
30
25
20
No. 10 Sieve
CL = JM ± 9
55
50
45
40
35
CL = JM ± 6
50
45
40
1
3
5
7
9
11
13
15
17
19
21
LOT NO.
INDIVIDUAL
MEAN

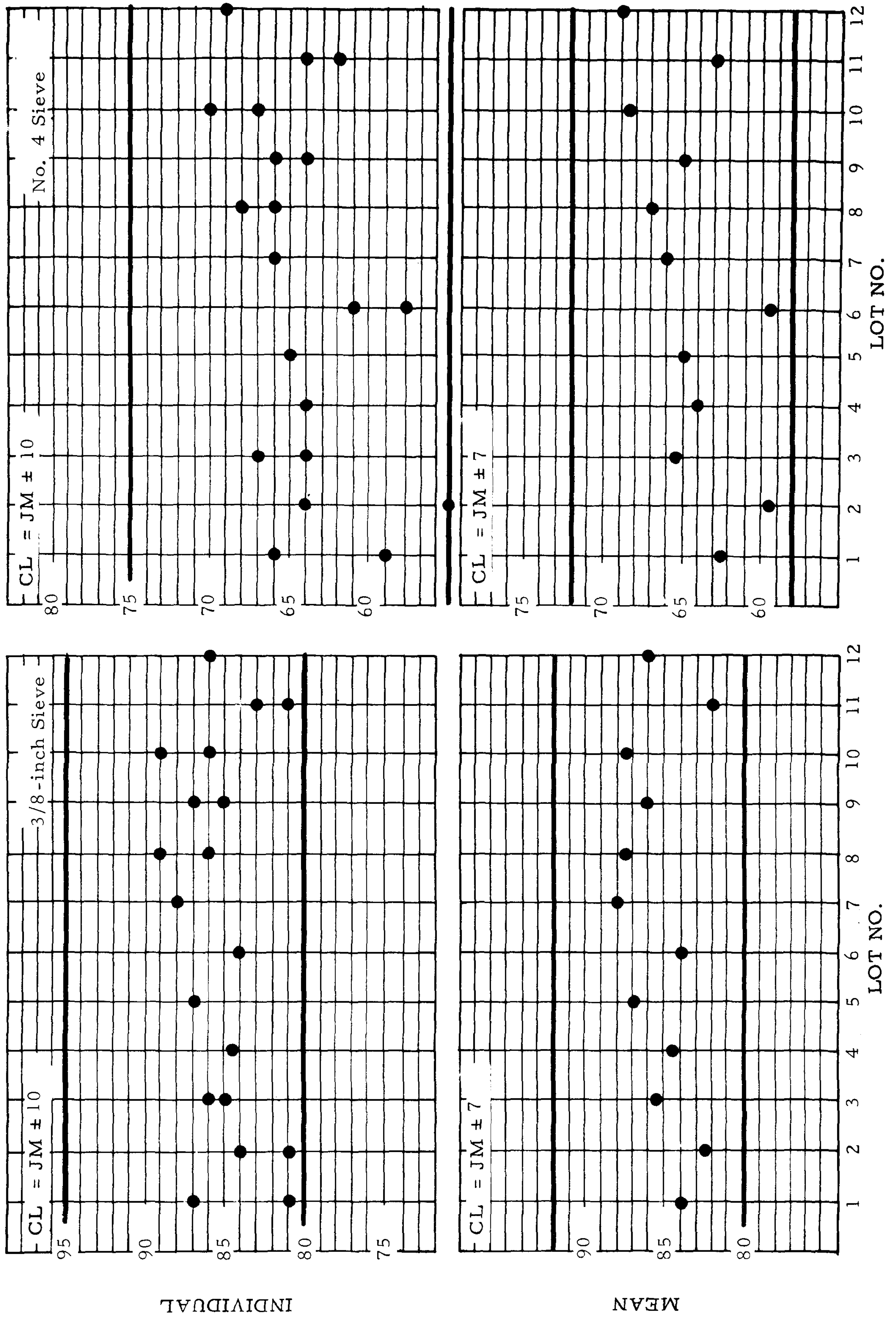

CL = JM ± 5
No. 80 Sieve
CL = JM ± 3
No. 200 Sieve
CL = JM ± 4
CL = JM ± 2
INDIVIDUAL
MEAN
LOT NO.
LOT NO.

APPENDIX

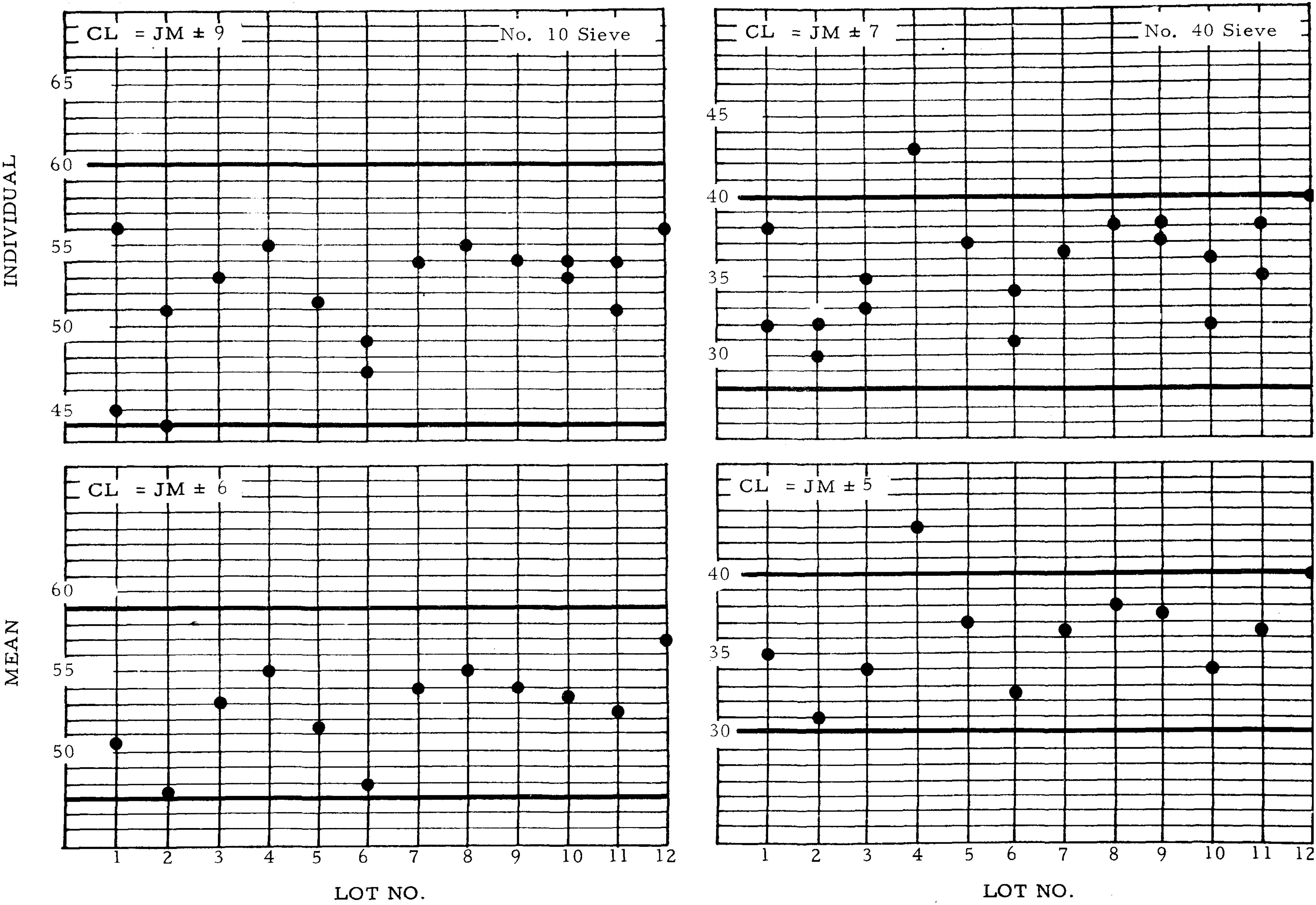
CONTROL CHARTS ON PROJECT B



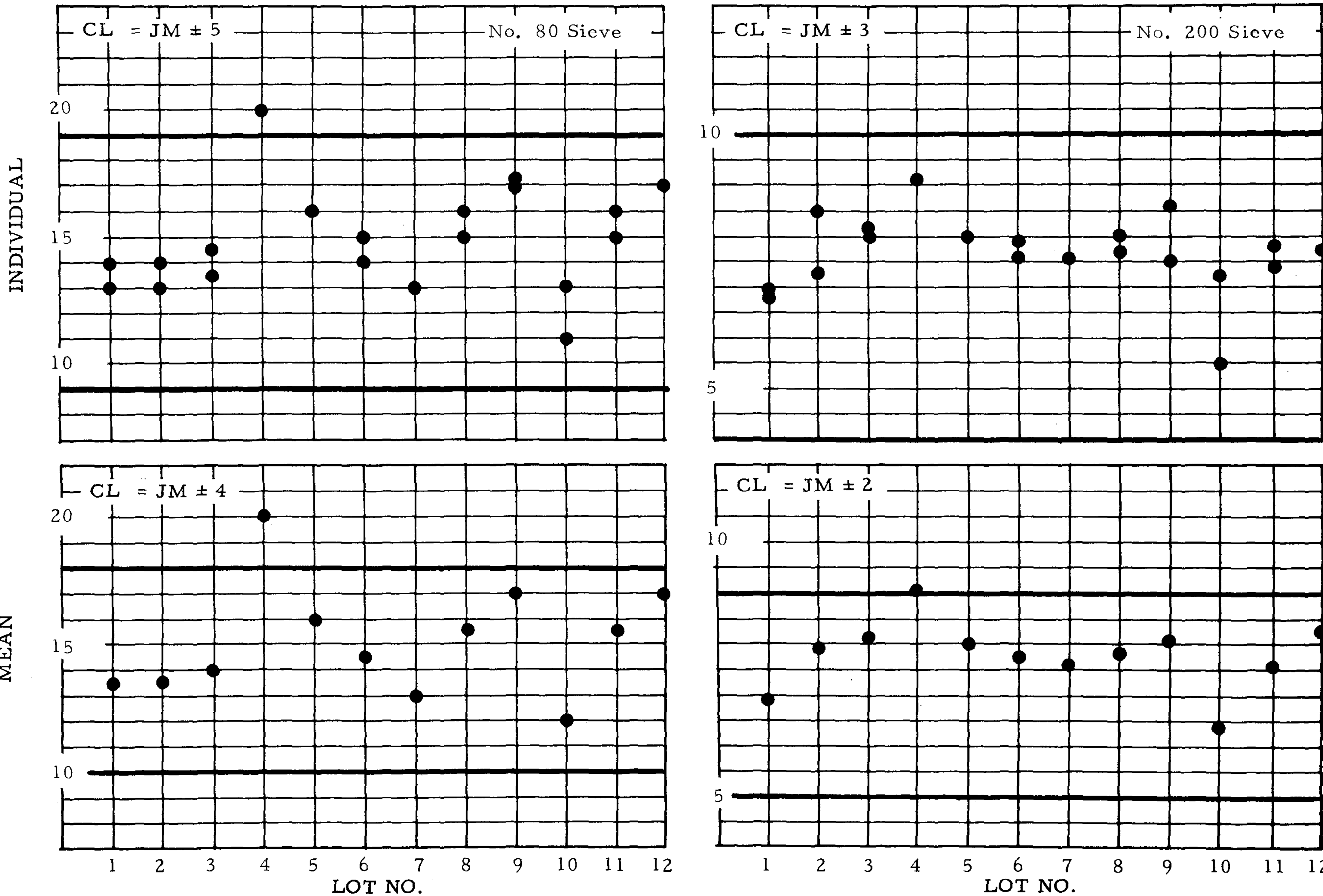
CL = JM ± 0.6
Asphalt Content
UCL
LCL
INDIVIDUAL
5.5
5.0
4.5
Control Limits (CL) = Job Mix (JM) ± 12
1 1/2-inch Sieve
100
95
90
85
80
CL = JM ± 0.4
MEAN
5.5
5.0
4.5
CL = JM ± 9
100
95
90
1 2 3 4 5 6 7 8 9 10 11 12
LOT NO.
1 2 3 4 5 6 7 8 9 10 11 12
LOT NO.



No. 4 Sieve
CL = JM ± 10
CL = JM ± 7
3/8-inch Sieve
CL = JM ± 10
CL = JM ± 7
LOT NO.
LOT NO.
INDIVIDUAL
MEAN

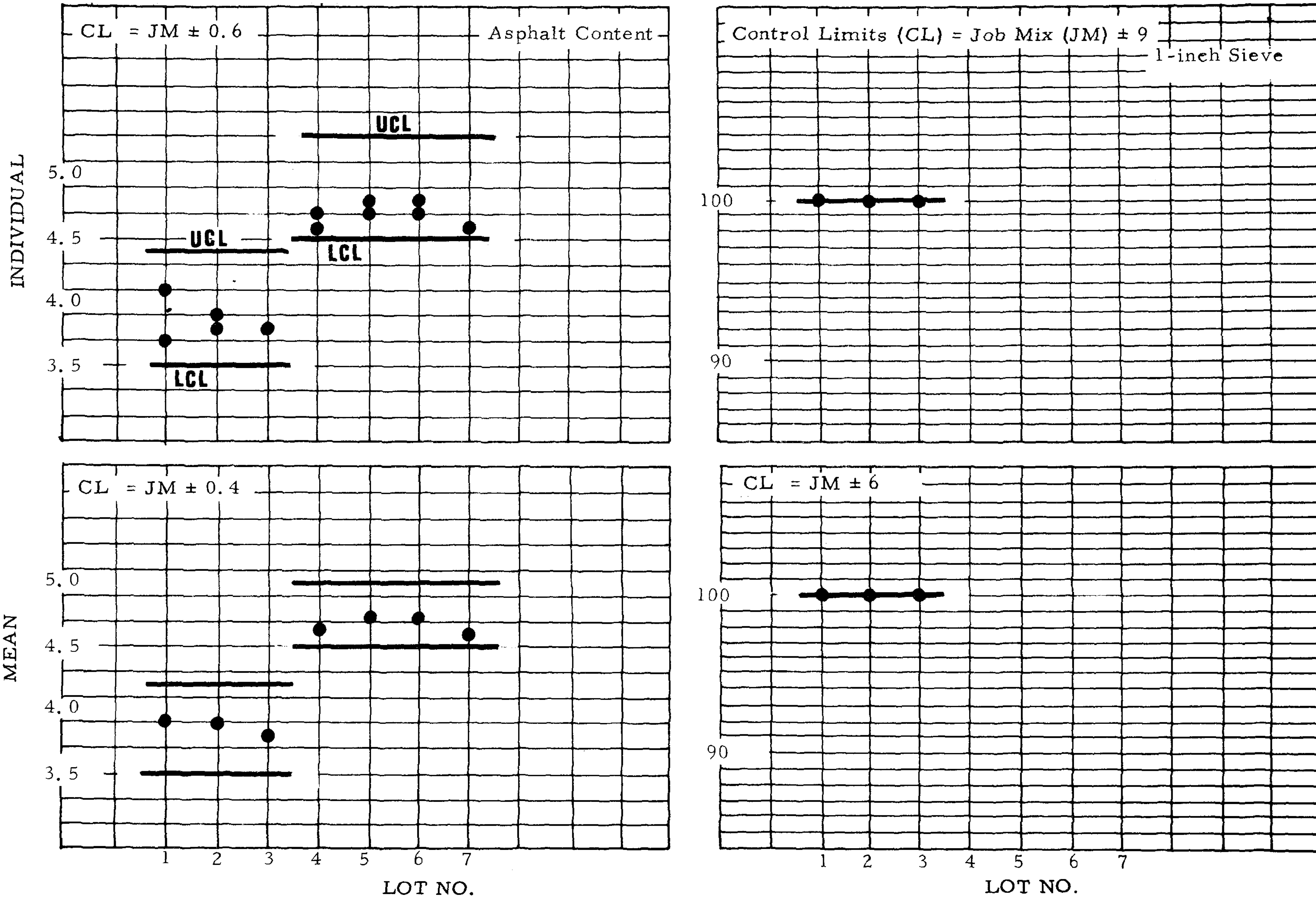


INDIVIDUAL
MEAN
CL = JM ± 9
No. 10 Sieve
65
60
55
50
45
CL = JM ± 7
No. 40 Sieve
45
40
35
30
CL = JM ± 6
60
55
50
CL = JM ± 5
40
35
30
1 2 3 4 5 6 7 8 9 10 11 12
LOT NO.
1 2 3 4 5 6 7 8 9 10 11 12
LOT NO.

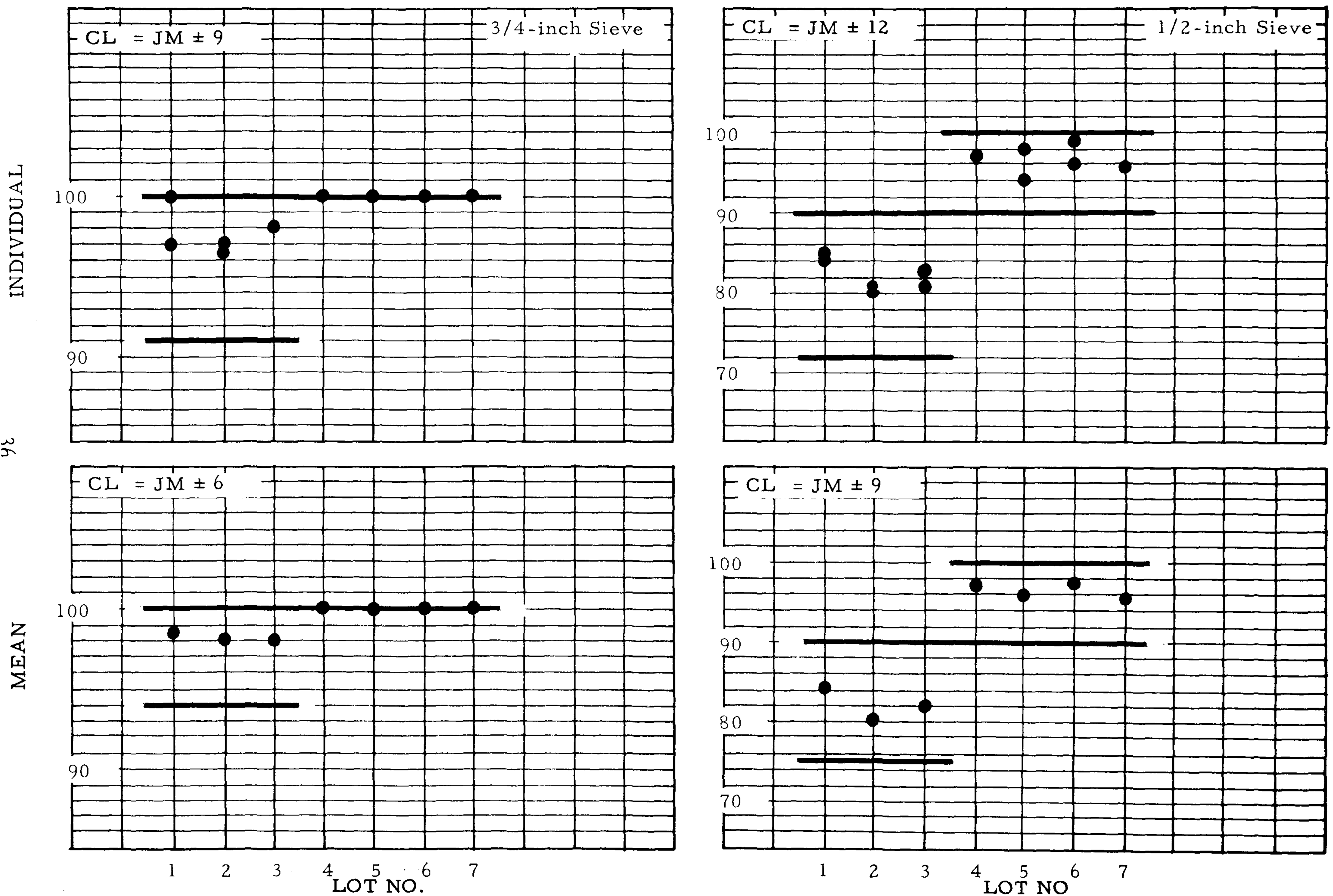

INDIVIDUAL
MEAN
CL = JM ± 5
No. 80 Sieve
CL = JM ± 3
No. 200 Sieve
CL = JM ± 4
CL = JM ± 2
20
15
10
5
1 2 3 4 5 6 7 8 9 10 11 12
LOT NO.

APPENDIX

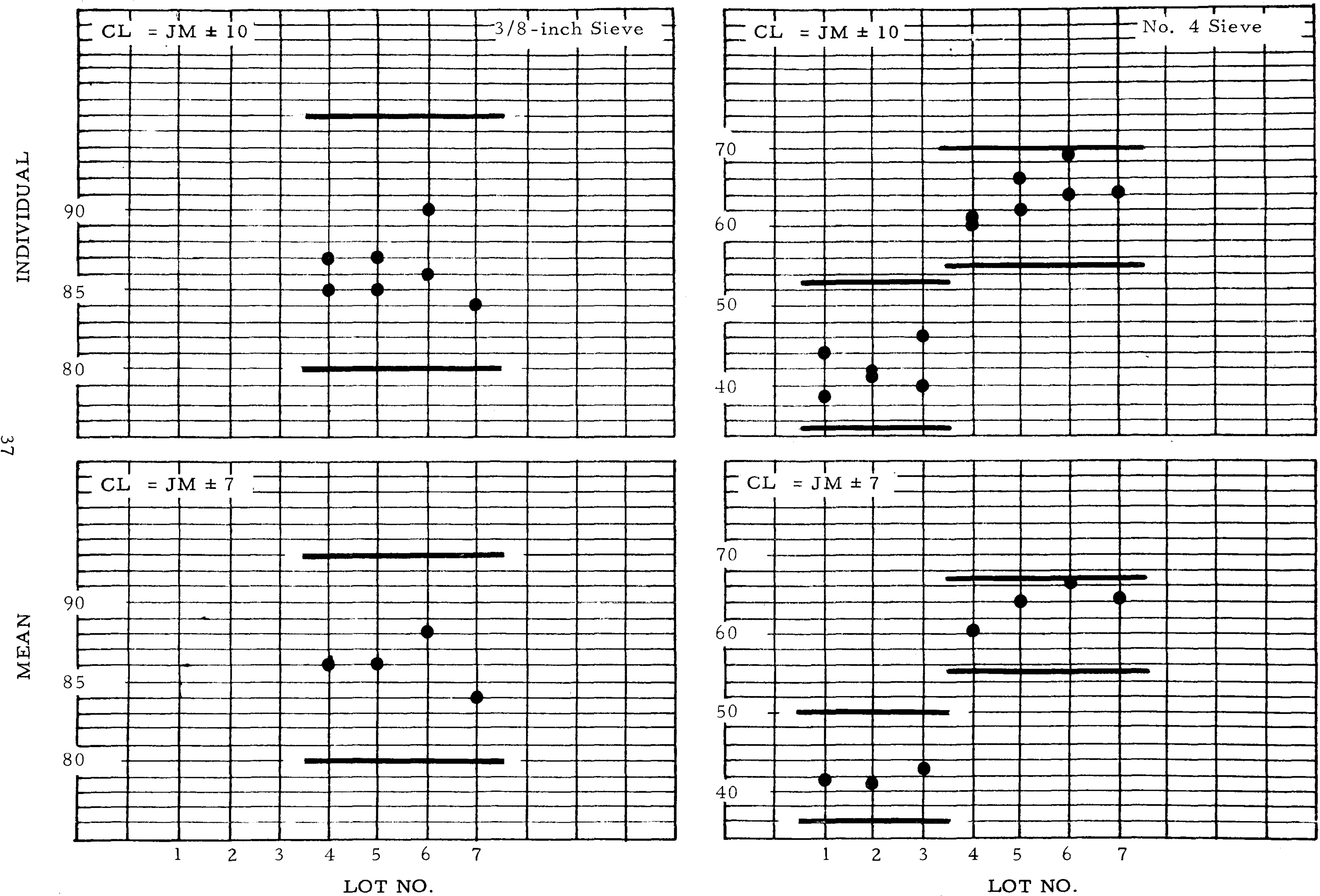
CONTROL CHARTS ON PROJECT C

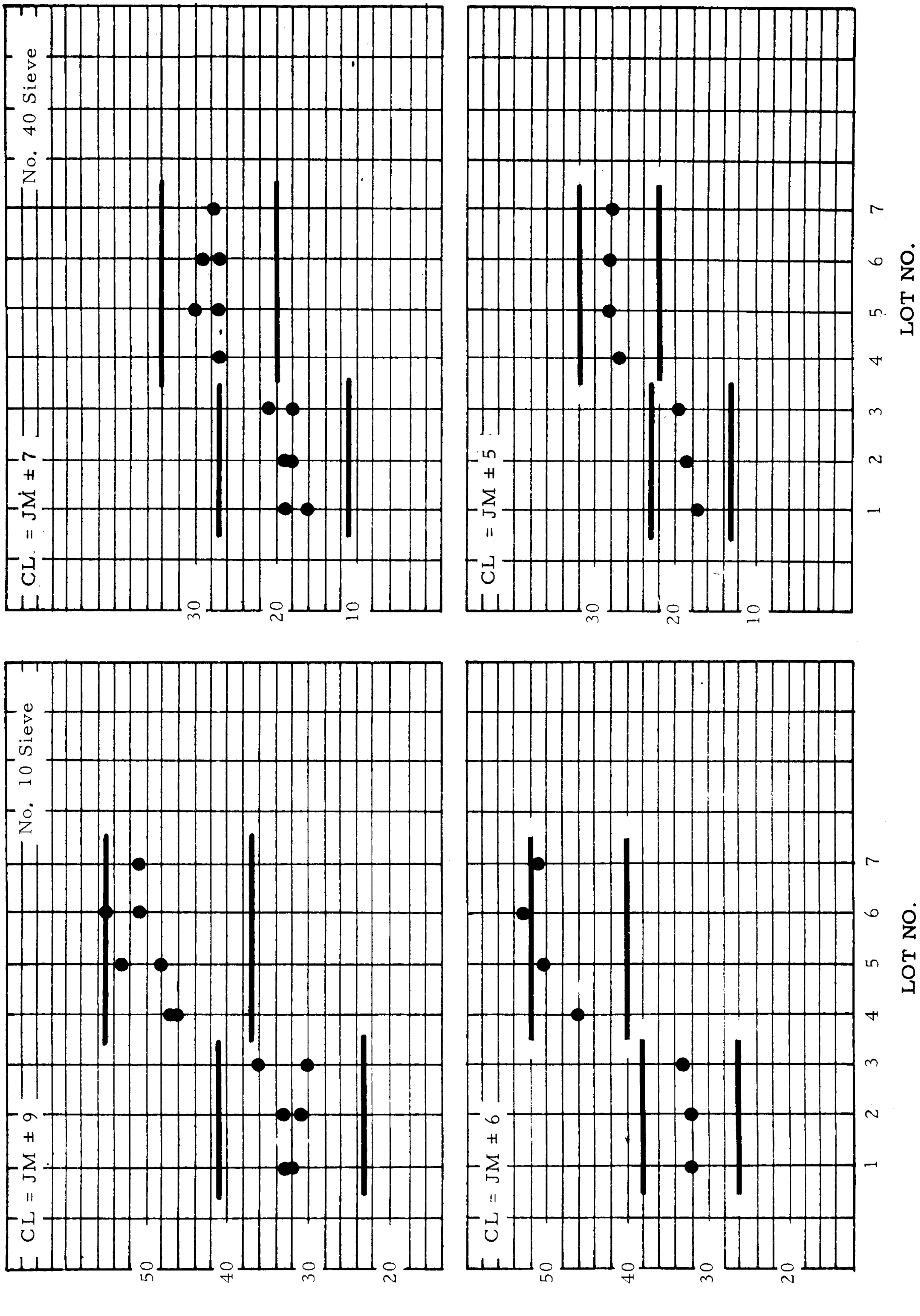


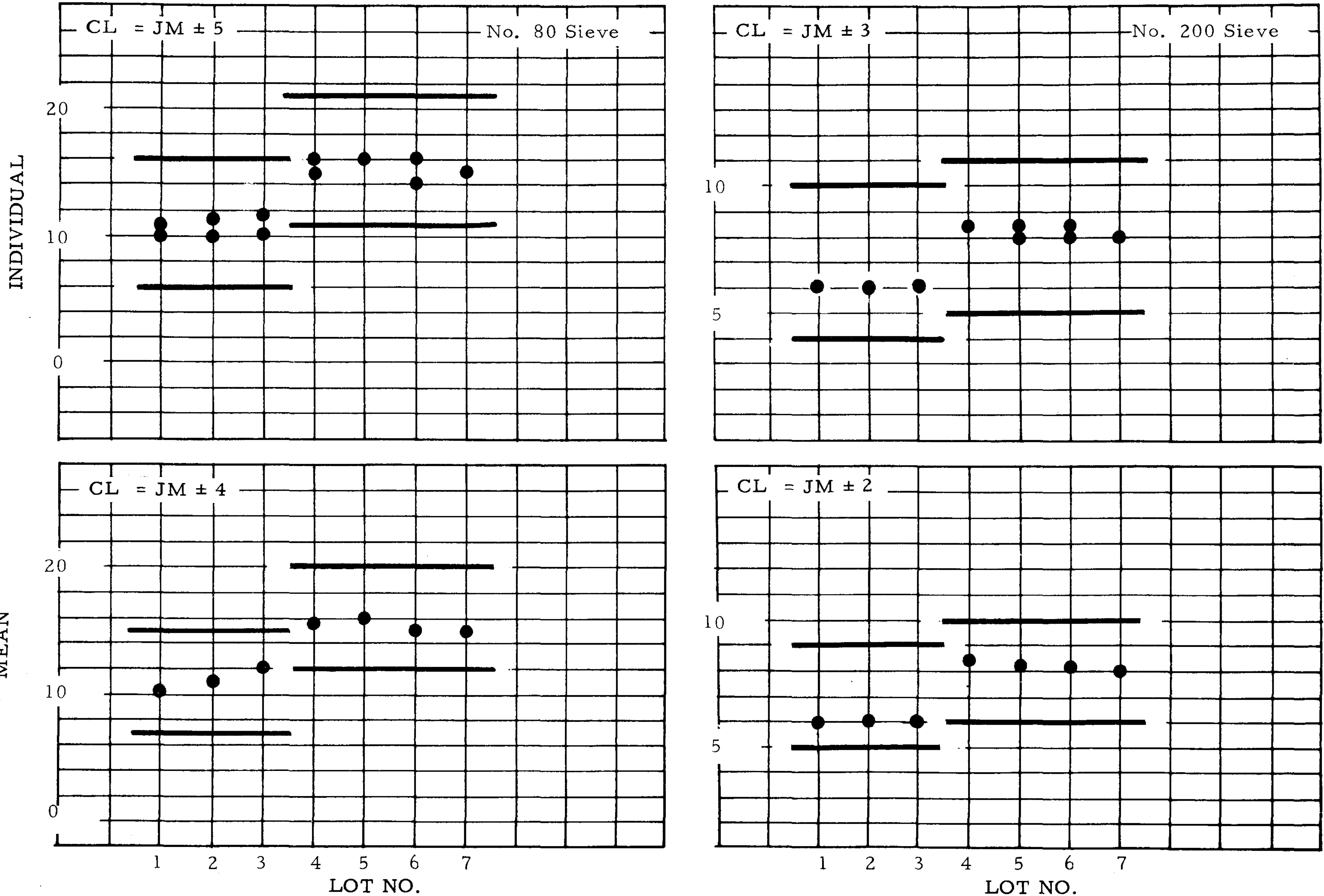
CL = JM ± 0.6
Asphalt Content
UCL
LCL
UCL
LCL
INDIVIDUAL
5.0
4.5
4.0
3.5
CL = JM ± 0.4
MEAN
5.0
4.5
4.0
3.5
1
2
3
4
5
6
7
LOT NO.
Control Limits (CL) = Job Mix (JM) ± 9
1-inch Sieve
100
90
CL = JM ± 6
100
90
1
2
3
4
5
6
7
LOT NO.



INDIVIDUAL
MEAN
CL = JM ± 9
3/4-inch Sieve
CL = JM ± 12
1/2-inch Sieve
CL = JM ± 6
CL = JM ± 9
100
90
80
70
1 2 3 4 5 6 7
LOT NO.
LOT NO


INDIVIDUAL
MEAN
CL = JM ± 10
3/8-inch Sieve
CL = JM ± 10
No. 4 Sieve
CL = JM ± 7
CL = JM ± 7
90
85
80
70
60
50
40
1
2
3
4
5
6
7
LOT NO.
LOT NO.


No. 40 Sieve
CL = JM ± 7
CL = JM ± 5
No. 10 Sieve
CL = JM ± 9
CL = JM ± 6
LOT NO.
LOT NO.
INDIVIDUAL
MEAN



CL = JM ± 5
No. 80 Sieve
CL = JM ± 3
No. 200 Sieve
CL = JM ± 4
CL = JM ± 2
INDIVIDUAL
MEAN
0
10
20
5
1 2 3 4 5 6 7
LOT NO.
LOT NO.

APPENDIX

SPECIAL PROVISIONS

SPECIAL PROVISIONS FOR BITUMINOUS PAVEMENTS

SECTION 501 & 502

OF THE STANDARD SPECIFICATIONS FOR ROADS & BRIDGES

SECTION 501 PLANT MIX PAVEMENTS — GENERAL

501.01 DESCRIPTION

The second paragraph of this subsection is amended to read as follows:

This work shall consist of one or more courses of bituminous mixture constructed on the prepared foundation in accordance with these specifications and the specific requirements of the type under contract, and in reasonably close conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established by the Engineer. Work will be accepted on a lot to lot basis as described in subsection 502.04.

501.02 COMPOSITION OF MIXTURE

Delete this subsection and substitute the following:

The bituminous plant mix shall be composed of a mixture of aggregate, filler, if required and bituminous material blended together. The several aggregate fractions shall be sized, graded and combined in such proportions that the resulting mixture meets the physical characteristics of these specifications.

(a) Quality Control of Mixes: The Contractor will assume full responsibility for the quality control of the mixes supplied to the Department. He will assume responsibility for the initial determination and all necessary subsequent adjustments in proportioning of materials used to produce the specified job mix and other physical characteristics. The Contractor will have available at all times during the plant operation, the testing equipment necessary to perform the required tests and analyses.

The Contractor will be required to have present during the initial set up and for all subsequent adjustments of the plant for quality control of the mixes, a Certified Asphaltic Concrete Technician. A Certified Asphaltic Concrete Technician is that person who is capable of designing the asphaltic concrete mixes at the plant. He will also be capable of conducting any tests and/or analyses necessary to put the plant into operation and to produce a mixture within the requirements of the specifications. The certification will be awarded by the Department upon satisfactory completion of an examination.

The Department's Inspector will also be a Certified Asphaltic Concrete Inspector. He will never assume by act or word the responsibility of testing and analysis of the mix for control purposes, calculations or the setting of dials, gages, scales and meters. Such duties are to be assumed only by the Contractor.

In the event the Contractor is not in a position to provide a Certified Asphaltic Concrete Technician as specified in the previous paragraphs for quality control of mixes, then the Department shall be so notified in writing prior to operation of the plant. Upon request from the Contractor, the Chief Engineer may furnish on a loan basis, a Certified Asphaltic Concrete Technician from within the Department's personnel, at a cost of $50.00 per day charged to the Contractor. However, this will not relieve the Contractor of the responsibility of controlling the mix. The Chief Engineer may also authorize rental of Department's Laboratory testing equipment at a rate of $5.00 per day of possession.

(b) Job Mix Formula: No work shall be started nor any mixture accepted until the Contractor has submitted in writing for approval, his intended source of all component materials and his job mix formula for the mixture he proposes to furnish. The formula so submitted shall indicate a single definite percentage of aggregate passing each required sieve size, a single percentage of bituminous material to be added to the aggregate, a single temperature at which the mixture is to be produced and the wet and dry mixing time.

(c) Approval of Job Mix Formula: Following the initial set up of the asphaltic concrete mix according to the Contractor's submitted job mix formula, the plant shall operate at least 30 minutes prior to sampling of the mix by the Engineer. Four trucks shall be sampled at random for determination of Marshall Test properties as based on one briquette per sample. Only two of these samples shall be analyzed for bitumen content and extracted gradation. The plant may continue to operate while the samples are being analyzed at the plant laboratory and the material produced prior to obtaining these results may be accepted. The average of these four samples will conform to the requirements for Marshall Stability and Flow as specified in Table 1.

TABLE 1

Type of Mix	Marshall Stability @ 140°F, lbs.	Flow 1/100"
Type 1, 2, & 4		
AC-3, BC & WC	1650	15 Max
AC-5, BC & WC	1500	15 Max
Type 3		
AC-3, Base	1650	15 Max
AC-3, Binder	1830	15 Max
AC-3, Wearing	2250	15 Max

Dry and wet mixing time shall be such as to give 95% or better coating of the coarse aggregate particles when tested in accordance with AASHO T 195. Other pertinent design properties shall be as specified in the Laboratory Manual. The bitumen content and extracted gradation shall be within the job mix formula initially submitted by the Contractor. In the event the samples fail to meet the requirements of the design criteria, immediate adjustments shall be made to correct the mix. Any mix that does not meet the design, while the plant is being adjusted until the design criteria are met, will be paid for at 50% of the contract unit price of the aggregate provided the mix is satisfactory for the use intended.

The Engineer may permit the Contractor to change the job mix formula provided the changed job mix meets all the physical requirements of the specifications. The request to make this change shall be made in writing by the Contractor to the Engineer.

(d) Application of Job Mix Formula and Allowable Tolerances for Control of Mixes: Maintenance of adequate control on the quality of bituminous mixes shall be the responsibility of the Contractor. In order to check this control, the Contractor shall obtain a minimum of two samples of the mixture from each lot. A lot shall be considered as one day's production of the mixture. He shall obtain these samples using a stratified random sampling plan. One of the samples shall represent the morning control and the other indicative of the afternoon control. The time at which to obtain these two samples shall be set by the Contractor using random number tables.

The Contractor shall conduct his operations so as to produce a mixture conforming to the approved job mix formula except that variations shall be permitted within specified control limits for individual and average of two samples. Results of each lot shall be charted on the Control Charts for Individuals and Averages. The upper and lower control limits for individuals and averages shall be set at the following values from the specified job mix formula.

TABLE 2

U. S. Sieve	Control Limits	
	Individual	Average of 2 Tests
3/4 inch and larger	± 9	± 8
1/2 inch	±12	± 9
3/8 inch	±10	± 7
No. 4	±10	± 7
No. 10	± 9	± 6
No. 40	± 7	± 5
No. 80	± 5	± 4
No. 200	± 3	± 2
% Bitumen	±.6	±.4
Temp. of Mix. °F.*	±40	±25

* As based on the approved mixing temperature measured after discharge.

When the tendency of the individual test results on the control charts indicate that the mix falls outside of the control limits for individuals, then the Contractor shall make adjustments to bring the mix into the job mix formula.

Individual materials from more than one source shall not be used alternately nor mixed when used in surface courses without the written consent of the Engineer. Where additional sources of materials are approved, a job mix formula shall be established and approved before the new material is used. When unsatisfactory results or other conditions make it necessary, the Contractor may be required to establish a new job mix formula.

501.15 MIXING

The second paragraph of this subsection is amended to read as follows:

After the required amounts of aggregate and bituminous material have been introduced into the mixer, the materials shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the bituminous material throughout the aggregate is secured. Dry and wet mixing time shall be submitted by the Contractor on the basis of a single determination and will conform to the minimum requirement given in Subsection 501. 02 (c).

501.18 SURFACE TOLERANCES

Delete this subsection and substitute the following:

(a) Job Control Testing; The Contractor shall test the surface of the completed course with a 10 foot straight edge. Necessary corrections shall be made to the Engineer's satisfaction.

(b) Acceptance Testing: The surface shall be tested by the engineer, using a rolling 10-foot straight edge at randomly selected longitudinal and transverse locations in accordance with LDH designation TR----. The sample shall consist of one path of the rolling straight edge, 500 feet in length, and shall be selected using random sampling procedures. This sample shall represent each lot. A lot shall constitute one day's production of bituminous mix. In the event that a lot results in less than 500 linear feet of roadway, then the entire lot shall be tested. All surface tolerance testing shall be done as soon as practical after the construction of the lot.

Two surface tolerance settings shall be used for the testing of a sample as shown below:

Types 1, 2 and 4 Mixes and Shoulders:	1/8 inch and 3/16 inch.
Type 3 Mix:	
Asphaltic Concrete Base Course	3/8 inch and 1/2 inch.
Asphaltic Concrete Binder Course	1/4 inch and 1/2 inch.
Asphaltic Concrete Wearing Course	1/8 inch and 3/16 inch.

Whenever sections of pavement do not meet the requirements for surface tolerances, an adjustment in the unit price for the lot of the mixture shall be made as further outlined in Subsection 502.12.

For type 3 mix the maximum deviation from grade established by the engineer or cross section at any point shall not be more than:

Asphaltic Concrete Base Course (Second and Intermediate layers)	1/2 inch.
Asphaltic Concrete Binder	3/8 inch.
Asphaltic Concrete Wearing Course and Each Successive Layer	1/4 inch.

When tested longitudinally from a stringline or comparable method applied parallel to the surface on any 25 or 50 foot section, such section shall not vary more than the specified limits given in the following schedule.

Interval	Base, Second and Intermediate Layers	Binder	Wearing
25 feet	1/2 inch	3/8 inch	1/4 inch
50 feet	5/8 inch	1/2 inch	3/8 inch

The above requirements shall be met 95 per cent of the time with no single measurement to exceed the specification requirements by more than 1/2 of the tolerance specified. Any deviation below the 95 percent tolerance will require correction of all deficient areas.

Any irregularities in the base or any intermediate course may be corrected by either skin patching, featheredging, or full depth patching, where appropriate, and where it can be completed in a satisfactory manner.

To correct the irregularities of the finished surface, skin patching will not be permitted. When the requirements specified above are not met, and the contractor elects to remove the section in question, then it will be done at his expense, to a minimum depth of one inch and replace it with additional mixture meeting these requirements. Featheredging at any intermediate point will not be permitted on the pavement except when specified on the plans or in the special provisions.

SECTION 502 ASPHALTIC CONCRETE PAVEMENT

502.04 PHYSICAL PROPERTIES OF MIXTURE FOR ACCEPTANCE

Delete this subsection and substitute the following:

The Contractor shall design his mix with the intent that compacted specimens of the mixture shall conform to the properties in Table 3 when tested in accordance with LDH Designation: TR 305, for an average of four samples taken from each lot after it is placed in the trucks using random sampling procedures. A lot shall be considered as one day's production of bituminous mix. A stratified random sampling plan shall be utilized such that two of the four samples are obtained during the morning and the other two during the afternoon using LDH Designation: S-------. The time at which these acceptance samples are obtained from the trucks shall be set by the Engineer using random number tables.

Compaction of mixtures for Marshall Stability and Flow determination shall be conducted by the Engineer's personnel at the plant. The testing and final approval of the mixture will be done by the District Laboratory.

When the average of four tests is outside of the acceptance limits specified for the average of the four test results for Marshall stability, an adjustment in the unit price for the lot of the mixture shall be made as further outlined. No adjustment in the unit price will be made for mixture being outside the limits on the individual results except as noted below.

Whenever it is not possible to sample the whole lot (four samples) due to unfavorable circumstances caused by plant breakdown or inclement weather or other causes, then the acceptance limits will be as shown in Table 3 as based on the number of tests made during the time the plant was in operation. In no event will the number of tests or samples be less than four for more than six hours of plant operation and less than two for four hours of operation.

In the event the plant operates for less than four hours and only one sample has been obtained, then the mix will be accepted on the basis of limits for one sample.

When the average of the number of tests representing the period the plant was in operation for the day is outside the acceptance limits for Marshall stability shown in Table 3 for the average of the number of samples tested during the day, an adjustment in the unit price for the lot of the mixture represented by the number of samples shall be made as further outlined in Subsection 502. 12.

No adjustment in the unit price shall be made for mixes being outside the limits on the Flow for the average of the lot or the individual test result.

502. 05 HANDLING OF AGGREGATES

Delete the second paragraph of this subsection.

502. 06 PREPARATION OF ASPHALT AND AGGREGATES

Delete the second paragraph. The third and fourth paragraphs of this subsection are amended to read as follows:

The temperature of the bituminous mixtures, when discharged from the mixer, shall be within the limits prescribed in Table 2 of Subsection 501. 02.

The dried mineral aggregate for any of the various type mixtures shall be combined in the plant in the proportionate amount of each fraction of aggregate

TABLE 3

Type of Mix	Acceptance Limits for Marshall Stability Average of: (Samples)				Control Limits for Flow Average of: (Samples)			
	4	3	2	1	4	3	2	1
Type 1, 2, & 4								
AC-3, BC & WC	1200 Min	1150 Min	1050 Min	900 Min	15 Max	15 Max	15 Max	18 Max
AC-5, BC & WC	1100 Min	1050 Min	1000 Min	800 Min	15 Max	15 Max	15 Max	18 Max
Type 3								
AC-3, Base	1200 Min	1150 Min	1050 Min	900 Min	15 Max	15 Max	15 Max	18 Max
AC-3, Binder	1450 Min	1400 Min	1300 Min	1100 Min	15 Max	15 Max	15 Max	18 Max
AC-3, Wearing	1800 Min	1700 Min	1600 Min	1350 Min	15 Max	15 Max	15 Max	18 Max
Shoulder	1100 Min	1050 Min	1000 Min	800 Min	15 Max	15 Max	15 Max	18 Max

required to meet the job mix formula. The bituminous material shall be measured and introduced into the mixer. Prior to adding bituminous material, the combined mineral aggregate shall be thoroughly mixed dry, after which the proper amount of asphalt shall be sprayed over the mineral aggregate and mixed to produce a homogeneous mixture in which all particles of the mineral aggregate are uniformly coated. The mixing time shall be submitted by the Contractor in the job mix formula and approved by the Engineer. Suitable locking means shall be provided for this regulation.

502.09 COMPACTION

The second and ninth paragraphs of this subsection are amended to read as follows:

The highest contact pressure that will give the required density will be used for the pneumatic roller.

Rolling shall continue until all roller marks are eliminated. Upon completion of the rolling procedures, five pavement samples shall be obtained from each compacted lot at locations determined in accordance with the stratified random sampling plan within 24 hours after placement of the mix. In the event this falls on a holiday or a Sunday and the Contractor's crews are not working, then the sampling will be done the following day. A lot shall be considered as the number of linear feet of mix laid during the days' operation. The linear feet laid during the day shall be subdivided into five sections of approximately equal length and one sample shall be obtained from each of the five sections using random number tables. In no event will the number of samples representing a full day's production or a fraction thereof be less than five. The density requirement for individual samples and for the average of five samples shall be as prescribed in Table 4 when determined in accordance with LDH Designation TR 304.

Payment will be made as outlined in Subsection 502.12. No adjustment in the unit price will be made for density tests outside the limits for individual tests.

In the event the sampling location as determined by random sampling procedures indicates obvious bad spots that are to be replaced,or falls within two feet of the edge of the pavement , then an additional sampling location shall be determined and used.

502.12 BASIS OF PAYMENT

Delete this subsection and substitute the following:

The quantities of aggregate and asphalt in the completed and accepted asphaltic concrete pavement will be paid for at the respective contract unit prices per ton on a lot basis.

Whenever the mix does not conform to requirements for acceptance of mixes as provided in Subsection 501.18, 502.04 and 502.09 of these Special Provisions, payment shall be made at a unit price per ton of bituminous plant mix course of the type specified in accordance with the following:

Adjustment for Stability:

(a) When the mix is to be accepted on the basis of the average of four, three, two or one Marshall stability test result, then the payment per unit price shall be made as outlined in Schedule No. 1-A, 1-B, 1-C or 1-D respectively.

TABLE 4

	Type of Mix	Acceptance Limits	Control Limits
		Average of 5 Samples	Individual Samples
Traffic Lanes	1 and 4	96% min of briq. density	93% min of briq. density
Traffic Lanes	2	92% min of briq. density	89% min of briq. density
Traffic Lanes	3- 1st lift of asphalt conc. base course	95% min of briq. density	92% min of briq. density
	-All additional layers of asph. conc. base course	97% min of briq. density	94% min of briq. density
	-WC and BC	97% min of briq. density	94% min of briq. density
Shoulders	1, 2, 3 and 4	93% min of briq. density	

(b) For shoulder mixes representing more than 2, 000 tons, the payment per unit price shall be made as outlined in Schedules 1-A through 1-D under AC-5 (column 2).

(c) No adjustment in the unit price shall be made on shoulder mixes used for turnouts, and similar miscellaneous areas representing less than 2, 000 tons.

(d) The lower percent of contract price shall be used for final adjustment in unit price for mixes that are deficient in Marshall stability, roadway density, and surface tolerances.

Adjustment for Roadway Density

For roadway density, the payment per unit price shall be adjusted as in Schedule No. 2 for the average of five samples in a lot.

SCHEDULE NO. 1 -ADJUSTMENT IN BID PRICE PER TON FOR MARSHALL STABILITY

Average of Four Marshall Stabilities				Percent of Contract Price/Ton of Aggregate Per Lot
Type 1, 2, & 4 WC, BC Type 3, Base AC-3	Type 1, 2, & 4 WC, BC AC-5	Type 3 Binder AC-3	Type 3 Wearing AC-3	
A				
1650 and higher	1500 and higher	1830 and higher	2250 and higher	105% Payment
1200 to 1649	1100 to 1499	1450 to 1829	1800 to 2249	100% Payment
1100 to 1199	1000 to 1099	1350 to 1449	1650 to 1799	95% Payment
1000 to 1099	900 to 999	1200 to 1349	1450 to 1649	80% Payment
Below 1000	Below 900	Below 1200	Below 1450	50% or Remove
B	Average of Three Marshall Stabilities			
1150 and higher	1050 and higher	1400 and higher	1700 and higher	100% Payment
1100 to 1149	1000 to 1049	1350 to 1399	1625 to 1699	95% Payment
1000 to 1099	900 to 999	1200 to 1349	1450 to 1624	80% Payment
Below 1000	Below 900	Below 1200	Below 1450	50% or Remove
C	Average of Two Marshall Stabilities			
1050 and higher	1000 and higher	1300 and higher	1600 and higher	100% Payment
1000 to 1049	950 to 999	1250 to 1299	1525 to 1599	95% Payment
900 to 999	800 to 949	1100 to 1249	1350 to 1524	80% Payment
Below 900	Below 800	Below 1100	Below 1350	50% or Remove
D	One Marshall Stability Test Result			
900 and higher	800 and higher	1100 and higher	1350 and higher	100% Payment
Below 900	Below 800	Below 1100	Below 1350	50% or Remove

SCHEDULE NO. 2 - ADJUSTMENT IN BID PRICE PER TON FOR ROADWAY DENSITY

Average of Five Roadway Samples				Percent of Contract Price/ Ton of Aggregate Per Lot
Type 1 & 4 (WC, BC)	Type 3 (1st lift of Base Course)	Type 3 (Additional lifts of Base Course, AC & BC)	Type 2 (WC & BC) & Shoulder Mix	
100.1% & More	100.1% & More	100.1% & More	100.1% & More	100% Payment
98 - 100%	97 - 100%	99 - 100%	97 - 100%	105% Payment
96 - 97.9%	95 - 96.9%	97 - 98.9%	92 - 96.9%	100% Payment
95 - 95.9%	94 - 94.9%	96 - 96.9%	90 - 91.9%	95% Payment
93 - 94.9%	92 - 93.9%	94 - 95.9%	89 - 89.9%	80% Payment
Below 93%	Below 92%	Below 94%	Below 89%	50% or Remove

Adjustment for Surface Tolerance

For surface tolerances, when measured by 10 foot rolling straight edge, the payment per unit price shall be adjusted as in Schedule No. 3 for the sample in a lot.

SCHEDULE NO. 3 - ADJUSTMENT IN BID PRICE PER TON FOR SURFACE TOLERANCE

Linear Percent of Sample Exceeding Surface Tolerance		Percent of Contract Price/Ton of Aggregate Per Lot
Lower Tolerance Setting	Upper Tolerance Setting	
1% or less.	None	105 % Payment
1 to 2%.	0.5% or Less.	100 % Payment
More than 2%.	0.5 to 0.75%.	95 % Payment
More than 2%.	0.75 to 1.5%.	80 % Payment
More than 2%.	More than 1.5%.	50 % or Remove

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