CHAPTER 1
INTRODUCTION

During the early 1960s, the Virginia Department of Transportation undertook a program to upgrade aggregate materials. The Department felt this was necessary since the highway construction program was booming and there was a real problem in maintaining passing aggregate materials from the stockpile to the roadway. With an expanded building program, aggregate producers were building large stockpiles and, even though the material met specifications when produced, it often failed after being placed in the roadway. This was due to stockpile segregation and/or so much handling before use. Failing materials caused the Department and Contractor a great deal of trouble as the materials had to be tested, reblended, roadway mixed and then tested again.

As a solution, The Virginia Department of Transportation decided to require that all aggregate base and subbase materials be pugmill mixed in a central mix aggregate plant. This is a process that requires aggregate materials to be mixed and brought to a proper gradation and moisture content just prior to being placed in the roadway. These materials became known as Central Mix Aggregates.

Aggregates are, for the most part, base or subbase aggregate materials, which range in sizes from 1 ½ inch (37.5 mm) in diameter to particles as fine as dust. These sizes are controlled by screening and blending operations at the aggregate producer's crushers and/or at the central mix aggregate pugmill mixers.

The central mix aggregate plant is required to be equipped with a pugmill mixer and such other equipment as necessary for blending different size aggregates and water into a homogeneous mixture. For special requirements, such as stabilized aggregates, central mix aggregate plants are also required to be equipped with feeders to introduce cement into the mixture. With the blending of aggregates and adding of water and, sometimes, other stabilization agents, the central mix aggregate plant operation is able to produce an aggregate material to meet rigid specifications and, thus, the high strengths required by modern highways.

When the decision was made to require aggregate base materials to be central mixed, provisions were also made to test the materials at the source. This required a laboratory at the production plants and qualified technicians and inspectors to oversee the operation.

With controls in place to insure a uniform gradation and thorough mixing of aggregates and additives, it was time to look at the whole picture of production testing and not just individual loads - statistical quality control was initiated for aggregate bases, subbases and select material.

Statistical quality control was needed to insure that all material has an equal opportunity to be tested without arbitrarily selecting an individual location or time. Central Mix Aggregate Producers are aware that under statistical quality control all of their material has an equal chance of being tested. Therefore, quarry technicians were needed to run their own samples. It was now a dual testing system.

Noting this duplication of testing, the Virginia Department of Transportation established a Quality Assurance Program consisting of an industry run sampling and testing program with the Department monitoring the process.

With the question of base and subbase quality control answered, select material and open graded coarse and fine aggregate quality control needed to be addressed. It was determined that select material, if mixed in a pugmill at the source, could be included in a Quality Assurance Program with its own criteria for acceptance and adjustment.

The Modified Acceptance Program was developed for any material other than Select Material Type I, or any type subbase or base dense graded material specified in sections 208 and 209 of the Road and Bridge Specifications. It was agreed on by the Department and Industry with a mandatory starting date of October 1, 1986. This program states that the aggregate producer is to certify on the delivery ticket and TL-102A's that the aggregates have been sampled and tested and meets all specification requirements. The Department, in turn, would conduct a monitoring program to verify the acceptability of the product. Unlike the QA program, which is sampled from location on trucks, the Modified Acceptance Program can be sampled from stockpiles, barges, conveyors and other points which accurately represent the material being produced and shipped.

Along with efforts to insure quality material going to projects, it was determined that there was a need to control the overloading of trucks carrying materials to construction sites. A threefold Bonded Weighperson Program was developed with industry weighpersons, project inspectors, and Department Material technicians working together to insure that overloaded trucks were kept to a minimum. The program included the provision that the Department would not pay for material delivered in excess of legal limits.

The Virginia Department of Transportation currently awards a certificate to those individuals who have successfully completed a program of study which qualifies them to be Aggregate Inspectors or Technicians. This program is presented by the Virginia Department of Transportation and is taught by members of industry and the Materials Division. The purpose of this program is to supply the prospective inspector or industry technician with a good basic knowledge of aggregates, and to familiarize the individual with the specifications that relate to the production and placement of these aggregates, and to acquaint the individual with the tests that are to be run on this material. This study guide serves as a text for this program and is a good reference book for the inspector or technician at the project or plant where aggregates are used.

Mix design requirements form an essential part for all aggregate mixtures. The agency or authority responsible for construction (Department of Transportation) usually establishes the mix design range and the design requirements. Once these are established, it becomes the responsibility of the Producer and their technician to develop the mix within the framework of the design requirements.

To properly design an aggregate mixture for a specific application, consideration must be given to the desirable mix properties. Open graded aggregates used in concrete pavement and other concrete construction, in drainage applications, in surface treatment and for any other use have been designed, through gradation design ranges, abrasion and soundness requirements, to provide the needed properties for each application. The requirements for open graded aggregates are covered in Tables II-1 through II-5 of the Road & Bridge Specifications:

Secton 202.02

TABLE II-1
Fine Aggregate

Grading	Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Mass)							
	3/8 inch 9.5 mm	No. 4 4.75 mm	No. 8 2.36 mm	No. 16 1.18 mm	No. 30 600 µm	No. 50 300 µm	No. 100 150 µm	No. 200 75 µm
A	Min. 100	95-100	80-100	50-85	25-60	5-30	Max. 10	
B	Min. 100	94-100					Max. 10	
C	Min. 100	94-100				Max. 25		

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TABLE II-2
Soundness

Use	Soundness Loss (Max. %)	
	Magnesium Sulfate (5 Cycles)	Freeze and Thaw (100 Cycles)
Hydraulic Cement Concrete	18	8
Asphalt concrete surfaces and surface treatments	25	15
Asphalt concrete bases	30	15

Table II-3															
Sizes of Open Graded Course Aggregates															
Amounts Finer Than Each Laboratory Sieve (Square Openings) (% by Weight)															
VA Size No.	**4 in.**	**3 ½ in.**	**3 in.**	**2 ½ in.**	**2 in.**	**1 ½ in.**	**1 in.**	**¾ in.**	**½ in.**	**⅜ in.**	**No. 4**	**No. 8**	**No. 16**	**No. 50**	**No. 100**
	100 mm	**87.5 mm**	**75 mm**	**62.5 mm**	**50 mm**	**37.5 mm**	**25 mm**	**19 mm**	**12.5 mm**	**9.5 mm**	**4.75 mm**	**2.36 mm**	**1.18 mm**	**300 µm**	**150 µm**
1	Min. 100	90-100		25-60		Max. 15		Max. 5							
2			Min. 100	90-100	35-70	Max. 15		Max. 5							
3				Min. 100	90-100	35-70	0-15		Max 5						
357				Min. 100	95-100		35-70		10-30		Max. 5				
5						Min. 100	90-100	20-55	Max. 10	Max. 5					
56						Min. 100	90-100	40-85	10-40	Max. 15	Max. 5				
57						Min. 100	95-100		25-60		Max. 10	Max. 5			
67							Min. 100	90-100		20-55	Max. 10	Max. 5			
68							Min. 100	90-100		30-65	5-25	Max. 10	Max. 5		
7								Min. 100	90-100	40-70	Max. 15	Max. 5			
78								Min. 100	90-100	40-75	5-25	Max. 10	Max. 5		
8									Min. 100	85-100	10-30	Max. 10	Max. 5		
8P									Min. 100	75-100	5-30	Max. 5			
9										Min. 100	85-100	10-40	Max. 10	Max. 5	
10										Min. 100	85-100				10-30

Through many years of laboratory testing and actual road application, the Department has established design ranges for aggregate mixtures in Virginia. (See Road and Bridge Specifications, Table II - 9 for dense graded aggregate and Section 207.02 for Select Material, Section 202 for fine aggregates, and Section 203 for coarse.) In this section we will generally discuss the design ranges and types of aggregate mixtures used for highway construction.

Section 203.03

TABLE II-4
Soundness

Use	Max. Soundness Loss (%) Magnesium Sulfate (5 Cycles)	Freeze and Thaw (20 Cycles)
Hydraulic cement concrete	12	5
Asphalt surface courses	15	6
Asphalt and aggregate bases	20	7
Select material (Type I) and subbase	30	12

Table II - 5
Abrasion

Use	Max. Los Angeles Abrasion Loss (%) 100 Rev	500 Rev.
Grade A stone	9	40
Grade B stone	12	45
Grade C stone	14	50
Slag	12	45
Gravel	12	45

(b) **Soundness:** Soundness shall conform to the requirements of TableII-4. Tests will be performed in accordance with the requirements of AASHTO T103 or T104. The requirement for soundness test for crushed glass is waived due to its preclusion from the applications shown in TableII-4

(c) **Abrasion Loss:** Abrasion loss shall conform to the requirements of Table II-5. Tests will be performed in accordance with the requirements of AASHTO T96 on aggregate with a grading the most nearly identical with the grading to be used in the work.

(d) Deleterious Material: The amount of deleterious material shall not be more than the following

Crusher Run

Section 205.03

(a) **Grading:** Grading shall conform to the following when tested in accordance with the requirements of AASHTO T27:

% by Mass of Materials Passing Sieve

Size No.	2 ½ in. 63 mm	2 in. 50 mm	1 ½ in. 37.5 mm	1 in. 25 mm	¾ in. 19.0 mm	No. 4 4.75 mm
24	Min. 100	95±5				32±18
25			Min. 100	95±5		32±18
26				Min. 100	95±5	38±22

Dense Graded Aggregates

Dense graded aggregates: base and subbase material and select material, are used in pavement construction. The following are important for aggregates used for this purpose:

1. Stability — The ability of an aggregate mixture to resist deformation from imposed loads.
2. Durability — The ability of an aggregate mixture to resist disintegration by weathering and traffic.
3. Workability — The ease with which aggregate mixtures may be placed and compacted.

The design ranges as presented in Table II - 9 of the Road and Bridge Specifications have taken into consideration the above mentioned desirable mix properties. Therefore, Table II - 9 is actually stating that a mix design or job mix within the design range for a specific application or size will possess the desirable mix properties discussed above.

Section 208

TABLE II-9
Design Range for Dense Graded Aggregates

Amounts Finer Than Each Laboratory Sieve (Square Openings[1]) (% by Weight)						
Size No.	**2 in.**	**1 in.**	**3/8 in.**	**No. 10**	**No. 40**	**No. 200**
21A	100	94-100	63-72	32-41	14-24	6-12
21B	100	85-95	50-69	20-36	9-19	4-7
22	---	100	62-78	39-56	23-32	8-12

[1] In inches, except where indicated. numbered sieves are those of th U.S.Standard Sieve Series.

207.01

TABLE II-6
Design Range: Select Material, Type I

% by Mass of Material Passing

3 in. Sieve	2 in. Sieve	No. 10 Sieve	No. 40 Sieve	No. 200 Sieve
100	95-100	25-55	16-30	4-14

There are many types of dense graded aggregate mixtures used in highway construction. In Virginia, however, there are three basic types that are used in the construction of a pavement: Select Material, Aggregate Subbase Material and Aggregate Base Material.