S. G. Research Services, L.L.C.

AGGREGATE RESEARCH DOCUMENTATION SERVICES

Phase 2: Contract 02-0300

The Evolution and Application Of MDOT Aggregate Specifications

Final Report
To
Michigan Department of Transportation

PDF version

By

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16. Abstract:

This was a two-part study in which Phase 1 consisted of making a thorough search of all documentation relative to aggregates in Michigan DOT's files and Research Library to develop a database covering the history and application of the department's aggregate specifications.

Phase 2 consisted of writing a comprehensive report on the chronological changes in the department's aggregates over the past eighty years, providing details on the "who, when, why" and circumstances on important decisions.

Much of the documentation was a result of first-hand knowledge and involvement in the various aggregate topics during the author's career at Michigan DOT.

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An attempt was made to answer the many questions posed and the suggestions made by the Program Managers and the Review Team Members. In addition, other topics believed to be important by the author were also addressed and not left to the reader to explore. Certain reoccurring topics in dealing with various industry groups in which the author has first hand knowledge were covered in greater detail than other aggregate areas.

Disclaimer

This document was created under the sponsorship of the Michigan Department of Transportation (MDOT) in the interest of documenting their research, specifications, and testing of aggregates over the past eighty plus years.

This information exists in many different formats, such as collections of single sheets stored in files, individual reports, bound volumes, microfilm rolls, floppy discs, CDs, conference summaries and books scattered throughout the Research Library, the Specifications Office and in many individual offices and storage areas in the Construction and Technology Division, now known as the Construction and Technology Support Area.

The facts referenced are based on existing documentation and first hand knowledge of the author during his many years working in The Research Lab and The Testing Lab, and as The Engineer of Specifications. Any opinions expressed are solely those of the author and do not necessarily reflect the views of MDOT.

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The Evolution and Application Of MDOT Aggregate Specifications

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Executive Summary

This report was the culmination of two contracts in which The Evolution and Application of Michigan DOT Aggregate Specifications were documented.

Phase 1 consisted of the "discovery" portion in which a thorough search of all available documentation relative to Michigan DOT's aggregate history was made in order to construct a comprehensive aggregate related data base.

Phase 2 consisted of the writing of this report covering the evolution and application of Michigan DOT's standard aggregate specifications over the past eighty years.

Details on the who, when, why and circumstances behind certain important decisions have been included. Much of this information was a result of first hand knowledge and involvement during this author's career in the department.

This report was not meant to be all-inclusive, but was intended to document the more important topics and serve as a guide for other researchers who may want to investigate their unanswered questions. The Appendices contain information and references which can be used as starting points for other aggregate related questions that may occur over time. Thus, this report can serve as a valuable resource for future research investigations.

The most important results in this report include:

- Background of the Michigan DOT Freeze/Thaw Test Procedure, including why "vacuum saturation" of coarse aggregate for Portland Cement Concrete (PCC) should not be dropped,

- History of slag coarse aggregate, including:
  a. Early decisions affecting the use of slag aggregates,
  b. US-23 Test Road crack results to date (graph on page 49),
  c. Cost of Repairs as a function of aggregate type (slag vs. natural gravel vs. limestone), and

- Information in "Appendices: Historical Aggregate Files".

From these results, one can see why using quality aggregate materials will extend the life of our pavements and make Michigan's construction dollars go further.

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Timelines:

Department and World Events Timeline:

1901: Governor Aaron Bliss created the Michigan Highway Commission.
1905: Michigan State Highway Dept. (MSHD) created by State Reward Highway Law.
1909: First Concrete Pavement built in Michigan (M-1, Detroit).
1918: WW I ended.
1919: First Michigan State Highway map produced.
1919: Testing Laboratory established at U of M.
1924: Division of Investigation & Research created.
1927: Name Changed to: Division of Research & Statistics.
1927-1933: Research operated separate from Statistics.
1929: Stock Market crashed.
1933: Testing & Research Division formed from Ann Arbor Testing Lab & Lansing Research Division.
1939: Separate Research Laboratory created at Mich. State College (Olds Hall).
1940: Michigan Test Road started (Design Project & Durability Project).
1942: Research Div. & Testing Div. combined to form T & R.
1943: Air-entrained concrete specified for all concrete pavements.
1945: WW II ended.
1951: Loss of Department records in January Fire @ Lewis Cass Bldg.
1956: Federal Highway Act of 1956 created the Interstate System.
1957: "Big Mac" Bridge linked Michigan's Two Peninsulas.
1958: First Continuous Reinforced Concrete (CRC) Pavement built in Michigan.
1960: Research Lab moved to "Old Motor Wheel Building".
1969: Man stepped on the Moon.
1973: The Oil Embargo began.
1974: Vietnam War ended.
1977: Research Lab. relocated to new T & R Building @ the Secondary Complex.
1978: Testing Lab. relocated to new T & R Building @ the Secondary Complex.
1982: Post-tensioned, precast segmental concrete Zilwaukee Bridge tilted.
1985: T & R Division renamed Materials & Technology Division.
1992: Aggregate Durability Test Road on US-23 @ Ohio Line constructed.
1996: Metric Standard Specifications adopted.
2001: Interim Standard Specifications converted back to English units.
2003: Standard Specifications in English units.

The "Department" has changed names several times over the years. Using the years of publication for the *Standard Specifications For Construction* Books as references, the following titles have been used:

Michigan State Highway Department (MSHD), 1905.
Michigan Department of State Highways (MDSH), 1973.
Michigan Department of State Highways & Transportation (MDSHT), 1976.
Michigan Department of Transportation (MDOT), 1979-Date.

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Base Aggregate Timeline:

1919: Aggregate base consisted of "bank run gravel" for gravel surface and concrete base for pavements.

1934: The following base courses appeared in the Standard Specifications:

a. Sub-base consisting of 32A coarse aggregate and 5SB fine aggregate,
b. Gravel base course made up of 21A base course gravel,
c. Concrete base course consisting of 4A, 10A course aggregate and 2NS fine aggregate,
d. Bituminous base course consisting of 32A coarse aggregate and 5SB fine aggregate, and
e. Water-bound macadam base course consisting of 1A coarse aggregate and 13A filler chips.

1942: The following base courses appeared in the Standard Specifications:

a. Stabilized aggregate base - road mix using 21A,
b. Stabilized aggregate base - plant mix using 21A, and
c. Soil - cement base.

1950: Modifications to the Standard Specifications included:

a. Aggregate base course consisting of 21A and soil binder,
b. Water-bound macadam base consisting of 1A and 30A filler screenings, and
c. Bituminous base made up of 9A coarse aggregate and 3BC fine aggregate.

1957: Standard aggregate base consisted of 22A, 5SS stamp sand and soil binder.

1970: Base modifications included:

a. Aggregate base for bituminous surfaces composed of 19, 21, 22 Series and 5SS stamp sand, and
b. Aggregate base for concrete surfaces composed of 22 and 24 Series.

1973: Stabilized in place bituminous aggregate base was added.

1980: EOC approved (OGDC) as experimental base material.

1982: OGDC was adopted as the alternate for 22A on interstate and high volume construction with the M 21 relocation as the first major project.

1982: Cement stabilization option added to asphalt stabilized permeable base design.

1984: First Standard Specifications to specify OGDC gradations for bases.

1989: Compacted 3G became standard OGDC for stability.

Concrete Coarse Aggregate Timeline:

1934: First use of Michigan Series/Class numbering of aggregates.

1940: Coarse aggregates (4A plus 10A) specified for concrete pavement.

1954: Database started for Freeze/Thaw (F/T) test results.

1956: F/T test method upgraded from two to three beams per batch per test (from 6 to 9 total) to improve reliability.

1960: First Standard Specifications to specify that all coarse aggregates intended for exposed concrete be approved by the Engineer based upon adequate freeze-thaw resistance (either field performance and/or laboratory testing).

1963: Coarse aggregate (10A) deleted; 6A down-sized for concrete pavements.

1970: Coarse aggregate (4A) dropped.

1972: Slag coarse aggregate first tested in F/T.

1976: First Standard Specifications to specify a numerical limit for coarse aggregate durability (DF = 20 for 6A) and sulfate soundness testing dropped. Slag coarse aggregate exempted from vacuum saturation conditioning in F/T.

1979: Due to Secondary Complex move, new laboratory began F/T testing.

1983: M 21 relocation approved for higher durability coarse aggregate (DF = 40 for 6A or 30 for 17A).

1984: Detailed Michigan Test Methods (MTMs) 113, 114, 115 written for F/T testing.

1986: Remaining I 696 projects approved for higher durability coarse aggregate.

1987: 40+ durability CA required for freeways having at least 5,000 vehicles/day/lane and the F/T descriptor changed from "durability factor" to "dilation".

1989: "Outlier Test" option added to F/T test results.

1992: Aggregate Durability Test Road constructed on NB US 23 @ Ohio line.

1996: First use of larger sized 4AA (Modified)/6AAA premium natural coarse aggregate as Grade P1 (Mod.) PCC for pavements.

2003: First Standard Specifications to allow 4AA slag in concrete pavements.

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Portland Cement Concrete Pavement Timeline:

1909: The world's first mile of paved concrete; Woodward Avenue (M-1).

1934: First Standard Specifications to allow use of slag coarse aggregate (CA) for Portland cement concrete (PCC) pavements.

1935: Slag coarse aggregate first used in concrete pavements.

1940: Coarse aggregates (4A plus 10A) specified for concrete pavement.

1941: The first urban limited expressway in the US; Woodward Avenue (M-1).

1943: Air-entrained concrete specified for all concrete pavements.

1956: Federal Highway Act of 1956 created "The Interstate Highway System".

1958: First Continuous Reinforced Concrete (CRC) pavement built in Michigan.

1963: PCC pavement standard joint spacing reduced from 99" to 71"2" and coarse aggregates 10A deleted and 6A were down-sized for concrete pavements.

1967: Slip-forming construction became an allowed option to conventional paving.

1970: First Standard Specifications to drop use of 4A coarse aggregate in PCC pavements.

1979: PCC pavement standard joint spacing reduced from 71"2" to 41' and a moratorium was placed on the use of CRC.

1983: M 21 relocation approved for higher durability coarse aggregate (DF = 40 for 6A or 30 for 17A).

1986: Remaining I 696 projects approved for higher durability CA (40 for 6A).

1987: 40+ durability CA required for freeways having at least 5,000 vehicles/day/lane.

1990: PCC pavement standard joint spacing reduced from 41' to 27'.

1996: First use of 4AA (Modified) plus 6AAA premium natural coarse aggregate as Grade P1 (Mod.) PCC for pavements.

2003: First Standard Specifications to allow 4AA slag in concrete pavements.

2003: PCC pavement standard joint spacing of 15' adopted for Plain Concrete.

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Bituminous/HMA Aggregate Timeline:

1919: Bituminous Macadam and Bituminous Concrete were the standards.

1934: Sheet Asphalt, Bituminous Concrete, Oil-Aggregate, Bituminous Retread and Bituminous Surface Courses were the standards.

1950: Dense-Graded Bituminous Mixtures first appeared.

1975: FHWA concluded that no separation layer was completely effective in stopping reflective cracking in bituminous overlays.

1976: MDOT research concluded that bituminous stablized aggregate separation course results in less reflective cracking than either untreated aggregate separation course or no separation course.

1979: First Standard Specifications where the bituminous pavement compaction policy changed from number of roller passes to 98% of maximum density.

1981: Bituminous wearing course based on new index, “Michigan Polish Number (MPN)”, soon changed to “Aggregate Wear Index (AWI)”.

1982: Moratorium placed on the use of open graded friction course.

1984: New AWI specification for bituminous wearing courses went into effect.

1994: Bituminous QC/QA was approved for 1996 Standard Specifications.

1996: SuperPave Asphalt Binder Specifications approved; first Standard Specifications not to include coarse aggregate gradations for bituminous mixtures.

2000: Revised AWI numbers for Bituminous surfaces approved and term “hot mix asphalt (HMA)” replaces “bituminous”.

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Introduction:

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Current Status of Aggregate Research Documentation

Prior to the late 1970's, the Research Laboratory conducted a large quantity of high quality in-house research. The final reports reflected MDOT's national cutting edge reputation. Today, only a very few individuals in the C & T Division now produce Research Reports. As is the case through out MDOT, the early-out retirement programs have depleted the ranks of the senior workers. The Department now relies upon research generated under contract by Michigan State University, The University of Michigan, and Michigan Technological University through their respective Centers of Excellence.

The existing documentation consists of reports, books, microfilm and files in several different formats, namely: individual reports, bound volumes of reports for each year, microfilmed closed research files and paper files for ongoing investigations and projects, plus various scientific periodicals and books.

Deficiencies of the Existing Research Library System

Several difficulties exist in the present Research Library:

1. The information exists in many different type of incompatible formats, some not easily accessible due to no concise index,
2. There no longer is a trained librarian to archive new materials or to help researchers find articles, reports or books,
3. As the physical space keeps getting reduced and the library is moved from one location to another, more and more of the valuable documentation has been thrown out, and
4. Materials can not be searched for or read on line from individual PC's either in the central or the various field office locations.

Purpose of this Project and Intended Users

The purpose of this project is to prepare a reference document of available aggregate-related records located in the C & T Division or Support Area to assist employees by providing references in the evolution of aggregate research, testing and specification development.

In addition to depicting "timelines" for various aggregate topics as they evolved, recommendations are presented concerning: document storage, staffing options, and a cataloging and retrieval system for these historical aggregate records, files and reports.

The intended users of this document will be any Department employees dealing with aggregates. Also, interested persons in the Federal Highway Administration and various Civil Engineering Departments may find this compilation of value.

Section I: Aggregate Material Definitions.

Section I:

Aggregate Material Definitions:

Some basic definitions (56, 62) are required to standardize the following discussion. This is not an all-inclusive set of definitions but will serve as a starting point for the interested reader and includes:

Natural Aggregates:

Natural aggregates originate geologically from stone quarries, gravel deposits, or igneous and metamorphic mine rock deposits found above or below the water table and may be a combination of rounded and crushed particles. Natural gravel aggregates consist predominately of particles retained on the No. 4 sieve.

Quarried Carbonate: These aggregates are derived from crushing quarried limestone or dolomite bedrock.

Gravel: Consists of many different rock types found in granular material deposits formed primarily by the Wisconsin Glaciation, the most recent ice sheet to cover the entire State of Michigan. Present information (56) indicates that this glacier began retreating about 14,000 years ago and exposed all of Michigan about 8,000 years ago.

Natural Sand: An accumulation of unconsolidated rock fragments derived from the physical and/or chemical disintegration of rocks as part of the natural weathering process and is uniformly graded in size from coarse to fine as defined in Table 902-4 in (57). Natural sand aggregates consist predominately of particles passing the No. 4 sieve.

Cobblestone: Cobblestone or cobble rock fragments, usually rounded or semi rounded, with an average dimension between 3 and 10 inches.

Man-made Aggregates:

Man-made aggregates are those aggregates which do not occur naturally and are mutually exclusive with natural aggregates. These aggregates include all forms of slag and crushed concrete.

Slag: Slag aggregates are by-products formed in the production of iron, copper, and steel and shall consist of clean, durable pieces of uniform density and quality.

Iron blast-furnace slag is a non-metallic by-product produced simultaneously with pig iron in a blast furnace. *Reverberatory-furnace slag* is a non-metallic by-product resulting from refining copper ore. *Steel-furnace slag* is a by-product of basic oxygen, electric or open-hearth steel furnaces.

Crushed Concrete: Crushed concrete aggregate is produced by crushing Portland cement concrete.

Section I:

Manufactured Fine Aggregate: Manufactured fine aggregate is produced totally by crushing rock, gravel, iron blast-furnace slag, reverberatory-furnace slag, steel-furnace slag, or Portland cement concrete.

Stone Sand: A fine aggregate manufactured by crushing gravel, carbonates, or waste mine rock meeting all the physical requirements of 6A coarse aggregate and is uniformly graded in size from coarse to fine as defined in Table 902-4.

RAP: RAP is reclaimed asphalt pavement and is used as one ingredient of HMA mixtures.

Aggregate Gradation Classes:

The five basic gradation definitions for describing aggregates are updated versions of those found in MDOT's *Procedures For Aggregate Inspection* (62).

Coarse Aggregates: Those aggregates retained on the No. 4 sieve with negligible amounts of material finer than the No. 4 sieve. The highest quality aggregates are used in Portland cement concrete and hot mix asphalt pavements.

Fine Aggregates: Those aggregates basically composed of unconsolidated particles finer than the No. 4 sieve and coarser than the No. 200 sieve. These are generally blended with coarse aggregates to produce Portland cement concrete and HMA surface treatments.

Dense-Graded Aggregates: Those aggregates composed of rock fragments basically finer than 1 inch in diameter and are uniformly graded to finer than the No. 200 sieve. When properly produced and compacted sufficiently, these aggregates can achieve high density and stability. They are generally used for traditional base courses, shoulders, and in HMA mixtures.

OGDC Aggregates: These aggregates consist of coarse, including pea gravel, gradations with minor amounts of material finer than the No. 200 sieve. They are used as super-draining base materials immediately below the premium grades of Portland cement concrete pavements and as under-drain material.

Granular Materials: These aggregate classes are used as fill, trench back-fill and sub-base material meeting the physical requirements of Table 902-3 in (57).

Section II: Base Aggregates.

Section II:

Concrete Base Aggregates:

Prior to the 1934 Standard Specifications for Road and Bridge Construction, concrete pavements were in limited use because most roadways of this time period were constructed of various types of gravel surfaces. Many of the individual specification requirements did not have numerical limits due to lack of acceptable testing procedures, thus leaving the approval of many materials to the subjective approval of The Engineer. Starting with the oldest set of standard specifications available in the Construction & Technology Division, namely: the 1919 Standard Specifications for Road Construction, it was noted that the department used:

Concrete Base for Pavements: This base mixture consisted of 1 part Portland cement, 2.5 parts fine aggregate, and 5 parts coarse aggregate constructed on the prepared sub-grade in one course to form a foundation as shown on the plans.
Combination base and curb was constructed as an integral unit where the base mixture was the same as detailed above and the curb mixture was composed of 1 part Portland cement, 2 parts fine aggregate, and 3.5 parts coarse aggregate.

The fine aggregate was required to consist of clean, hard, durable sand, or screenings obtained from crushing hard, durable rock or gravel, having a French coefficient of wear (see note below) of not less than 10 or a combination of such sand and screenings. It was to be free of clay lumps and crusts of hardened material at the time of use. The fine aggregate had to be well graded from coarse to fine and meeting:

1919 Fine Aggregate Gradation:

Passing the ¼ inch screen	100%
Passing the No. 50 screen	0 - 25%
Passing the No. 100 screen	0 - 5%

The coarse aggregate was to consist of clean, tough, durable gravel or crushed stone containing no vegetable or other deleterious matter, and be free from soft, flat or elongated pieces. The gravel or crushed stone was specified to be well graded from coarse to fine, meeting the gradation as follows:

1919 Coarse Aggregate Gradation:

Passing the 2 inch screen	100%
Retained on the 1 inch screen	25 - 100%
Passing the 1 inch screen	25 - 100%
Retained on the ¼ inch screen	90%

Standard Specifications for Road Construction for 1920 and 1921 remained the same as the 1919 version.

Note: The *French coefficient of wear* was a early test used by state highway agencies (borrowed from agriculture testing methods) and described in U. S. Dept. Of Agriculture Bulletin No. 357, now out of print. The French coefficient of wear test was replaced by the Deval abrasion tests (T3 for stone and T4 for gravel) in Michigan's 1934 Standard Specifications and was described in the American Association of State Highway Officials (AASHO) methods. In 1950, the Los Angeles abrasion test (T96) first appeared in the Standard Specifications for concrete aggregates while dense graded aggregates continued to be tested by the Deval Method. Deval testing was dropped from the 1979 Standard Specifications when T 96 became the standard for all aggregates requiring abrasion testing. It should be noted that the Deval and Los Angeles abrasion test limits are loosely related inversely to the French coefficient of wear limit. More specifically, one desires a French coefficient of wear test result over a given specification limit while it is desirable to have Deval and Los Angeles abrasion test results below given specification limits for aggregates used in highway construction.

The 1922 Standard Specifications for Road Construction contains a rewrite of the sections covering **Concrete Base for Pavements** including modified fine and coarse aggregate gradations.

Concrete Base for Pavements: The base course consisted of a foundation for a top or wearing course as shown on the plans, composed of 1 part Portland cement, 2 parts fine aggregate and 4 parts coarse aggregate by volume, laid on the prepared sub-grade. Combination base and curb was constructed as an integral unit with the same 1:2:4 composition as above.

The fine and coarse concrete base aggregate gradations were the same as that specified for the 1922 One Course Concrete Pavement fine and coarse aggregates, respectively:

1922 Fine Aggregate Gradation:

Passing the ¼ inch circular screen	95 - 100%
Passing the No. 10 mesh sieve	65 - 95%
Passing the No. 20 mesh sieve	25 - 65%
Passing the No. 50 mesh sieve	5 - 25%
Passing the No. 100 mesh sieve	0 - 5%

1922 Coarse Aggregate Gradation:

Passing the 2 ½ inch sieve	100%
Passing the 2 inch sieve	95%
Passing the 1 inch sieve	25 - 75%
Passing the ¼ inch sieve	0 - 15%
Retained on the No. 8 sieve	95 - 100%

Non-screened gravel or non-screened crushed stone could not be used as coarse aggregate.

The 1923 book made changes in the proportioning of cement, fine aggregate and coarse aggregate in the concrete base mixtures such that the quantity of cement was reduced and an option for reinforcement was added. In the concrete pavement mixes, the limit on clay content and silt in fine aggregate was reduced from 3% to 2%. The limit on clay and silt in coarse aggregate was reduced from 3% to 1%. Steel reinforcement and a central joint specification were added, along with a reduction in cement content.

In The 1924 Standard Specifications for Road Construction, we find:

Section II:

Concrete Base Course (Plain and Reinforced): This base consisted of a foundation for a top or wearing course as shown on the plans and composed of 1 part Portland cement, 2.5 parts of fine aggregate and 5 parts of coarse aggregate, by volume, laid on the prepared sub-grade as specified. Fine and coarse aggregates were as specified in the section on Concrete Pavement (Plain and Reinforced).

Fine aggregate consisted of clean, hard, durable sand free from clay lumps and all organic and other deleterious matter, and at the time of use, free from lumps and crusted material. The clay and silt could not exceed 2 per cent by weight and the clay content could not occur as a coating on the sand particles. The fine aggregate was required to be uniformly graded from coarse to fine as:

1924 Fine Aggregate Gradation:

Passing the ¼ inch circular screen	95 - 100%
Passing the No. 10 mesh sieve	65 - 95%
Passing the No. 20 mesh sieve	25 - 65%
Passing the No. 50 mesh sieve	5 - 25%
Passing the No. 100 mesh sieve	0 - 5%

Coarse aggregate consisted of either gravel or crushed stone composed of clean, hard, tough, durable stone particles having a French coefficient of wear of not less than 7, free from thin or elongated pieces, soft material or rock which readily disintegrates, organic or other deleterious material. The clay and silt content could not be greater than 1 per cent by weight and no clay could occur as a coating on the stone particles or as free lumps. The stone particles were to be uniformly graded on a set of sieves with circular openings as:

1924 Coarse Aggregate Gradation:

Passing the 2 ½ inch sieve	100%
Passing the 2 inch sieve	95%
Passing the 1 inch sieve	25 - 75%
Passing the ¼ inch sieve	0 - 15%
Retained on the No. 8 sieve	95 - 100%

Non-screened gravel or non-screened crushed stone were not allowed.

Post-1934 Base Aggregates:

Before discussing the various gradations used for aggregate base courses, one should review the functions of a base course. Meininger (23) lists the following functions:

1. Structural Capacity,
2. Drainage,
3. Expedition of Construction,
4. Prevention of Pumping,
5. Protection Against Frost Action, and
6. Prevention of Sub-grade Volume Change.

Section II:

A flexible pavement depends upon aggregate interlock, particle friction and cohesion for stability. Angular, rough textured particles provide stability for flexible pavements. Optimum stability, not necessarily the maximum, results from a well-graded material having 6% - 9% fines, while maximum density, not necessarily the optimum, comes from 8% - 11% fines.

The function of an aggregate base under a rigid pavement is to prevent pumping. To prevent pumping, the aggregate base must be permeable enough to prevent water form being trapped below the slab and to provide uniform support across the joints and under the slab. Some highway designers believe that open graded aggregate bases are the answer to this requirement. The optimum for drainability is almost no fines.

Thus Meininger notes that a dense graded base, considered optimum for stability, has very low drainability. So the question becomes: What gradation is best for balancing this conflicting set of requirements of optimum stability and optimum drainability. The ongoing questions argued in the Department continue to be: Which is best: <u>dense-graded base</u> or <u>open-graded base</u>? How do I get both?

Stepping back in time, one finds that in the 1934 and 1940 books, several types of aggregate base courses were specified as:

1934 Aggregate Base Courses:

Base Course	Coarse Aggregate	Fine Aggregate	Dense-Graded
Gravel BC			21A
Bituminous BC	32A	5SB	
Water-bound Macadam BC	1A + 13A Filler chips		
Sub-base	32A	5SB	

1940 Aggregate Base Courses:

Base Course	Coarse Aggregate	Fine Aggregate	Dense-Graded
Aggregate BC		Soil Binder	21A
Stab. Agg. - Road		Soil Binder	21A
Stab. Agg. - Plant		Soil Binder	21A
Water-bound Macadam BC	1A + 30A		
Bituminous BC	5A	2NS	

In the 1942 book, 2NS fine aggregate requirement was changed to 3BC fine aggregate in bituminous bases.

In the 1950 book, Grade B porous back-fill was added to water-bound macadam base course and 5A coarse aggregate changed to 9A in bituminous base course.

In the 1957 book, the aggregate base courses were pared down to:

Section II:

1957 Aggregate Base Courses:

Base Course	Coarse Aggregate	Fine Aggregate	Dense-Graded
Aggregate BC		5 SS + soil binder	19A, 21A, **22A***, 22B, 22C, and 22D
Bituminous BC	9A	3BC	

* Unless otherwise specified in the proposal, 22A was to be used.

In the 1965 book, 21AA, 22AA and 22E were added to the aggregate base course selections.

At the request of Roy L. Greenman, Engineer of Testing and Research, the Soils Research Unit of the Research Laboratory began a study (7) in October 1968 to determine the feasibility of continuing the use of open hearth and basic-oxygen slags for base and sub-base aggregates. The reason behind this study was extensive heaving observed in slag-base medians constructed on the Fisher Freeway (I 75) in Detroit. Open hearth slag had been used both as select sub-base and for class AA shoulders during construction from 1965 -1968. As a result of his work on this study, J. H. DeFoe, Lead Soils Research Engineer investigated this problem and concluded:

1. Heaving of open hearth slag was not an occasional occurrence but had happened in varying degrees to more than 80% of the median area constructed on slag base in Control Section 82194.

2. Samples tested for expansion in the Research Laboratory showed no improvement due to acid treatment, the method proposed by the producer to eliminate expansion of the slag.

3. X-ray diffraction analysis indicated two compounds as possible sources of trouble: periclase (MgO) and pseudowollastonite ($CaSiO3$), which can not be controlled by either the slag aggregate producers or the Department.

4. No heaving had been observed where open hearth slag had been used in unconfined areas such as outside shoulders.

DeFoe recommended that open hearth slag be used <u>only</u> where expansion would not be detrimental.

In the 1970 book, the aggregate base course specifications became:

1970 Aggregate Base Courses:

Base Course	Coarse Aggregate	Fine Aggregate	Dense-Graded
Aggregate BC for Bituminous Surface		5SS	19A, 21AA, 21A, or 22 Series
Aggregate BC for Concrete Surface			22A, 22B, or 24A

Dense-Graded Bases:

The 1973 Standard Specifications for Highway Construction was the first book to partition Table 8.02-1 into <u>Coarse</u> and <u>Dense-Graded</u> Aggregate sections.

Dense-Graded aggregates were composed of the 19, 20, 21, 22, 23, and 24 Michigan Series. These aggregates could consist of gravel, stone, or blast-furnace slag, in combination with natural sand, stone sand, or slag sand.

Section II:

Salvaged concrete could also be used to produce these aggregates for certain applications. The primary dense-graded base gradation was 22A (Table below) unless otherwise specified.

Gravel and stone sources for 22A were required to be a minimum of 25% crushed.

1973 22A Dense-Graded Base:

Series/ Class	Sieve Analysis: Total Percent Passing							LBW %
	1”	3/4”	1/2”	3/8”	#4	#8	#30	
22A	100	90-100		65-85		30-50		4-8

In 1980, DeFoe (69) summarized the Department’s research and testing conducted over the previous 20 years to determine the suitability of steel furnace slag (open hearth, basic oxygen, and electric furnace) for use in highway base and sub-base construction. He found that steel furnace slag meeting Department specifications for a 22A base and sub-base gradation had not proven to be a satisfactory construction material for the following reasons:

1. The material was frost susceptible and exhibited differential heaving tendencies under a pavement surface,
2. Steel slag had poor drainability with self-clogging tendency due to the formation of solid leachates,
3. The slag exhibited unpredictable volume changes (expansion) due to internal chemical constituents which caused heaving of pavement surfaces, and
4. Chemical composition of the slag was extremely variable and could not be controlled by the manufacturing process.

He further concluded that 22A steel furnace slag should not be used for highway base or sub-base construction. Thus, any future industry requests for this particular application should be rejected.

The 1979 book added a Los Angeles Abrasion maximum limit of 40 on 22A. For applications as aggregate base coarse under concrete surfaces, the LA maximum was increased to 50.

The 1984 book specified the LA maximum on 22A at 50 for all applications which remained unchanged in the 1990, 1996 and 2003 books.

The 1990 and 1996 books permitted steel furnace slag dense-graded aggregates in bituminous mixtures. This application remains in the 2003 book under the new title of HMA mixtures.

In the 1996 book, 23A dense-graded aggregate was permitted to be produced from steel furnace slag only when used as an unbounded aggregate surface course or as unbounded aggregate shoulders.

Open-Graded Bases:

In 1980, the Engineering Operations Committee approved the use of OGDC as experimental base material and OGDC was adopted in January of 1982 as an alternate for 22A on interstate and high volume construction. The relocation of M 21 was the first major project approved for open-graded base.

Section II:

Cement stabilization was added as an option to the asphalt stabilized permeable base design in 1982.

The 1984 Standard Specifications for Construction was the first book to list Open-Graded Aggregates as a partitioned area of Table 8.02-1. Open-Graded aggregates listed were Series 5G, 8G, and 34G.

In the 1990 book, 3G and 34R were added and steel furnace slag was permitted as OGDC material except when in conjunction with a drainage system that included a geotextile wrapped core or pipe.

In the 1996 book (57), 2G was added; 8G and 34G were deleted.

Dr. W. Hansen (18) in 1998 investigated transverse cracking of Michigan's PCC pavements over Open-Graded Drainage Course bases. He concluded that deterioration of PCC pavements over OGDC bases in terms of transverse cracking, spalling and faulting was found to be project specific and related to factors other than OGDC itself.

In the 2003 book (68), 4G was added and a modified 34G returned. Many of these OGDC changes resulted from the experimental nature of these gradations. They were modified from project to project in the form of Special Provisions to improve either the drainage or stability issues.

The present OGDC gradations in the 2003 book are:

2003 Open-Graded Aggregate Gradations:

Matl. Type	Sieve Analysis (MTM 109) (b)								LBW (MTM 108) % (b)
	1.5"	1"	3/4"	1/2"	3/8"	#4	#8	#30	
2G (h)	100	85-100		40-70			0-10	0-8	5.0 max.
3G	100	85-100		40-70			0-30	0-13	5.0 max.
4G (i)	100		60-80	35-65			10-25	5-18	6.0 max.
34R				100	90-100		0-5		3.0 max.
34G				100	95-100		0-5		3.0 max.

b. Based upon dry weights.
h. For use with stabilized aggregate base.
i. Acceptance gradation at production site only.

Section III: Portland Cement Concrete (PCC) Aggregates.

Section III:

Pre-1934 Pavement Aggregates:

Prior to the 1934 Standard Specifications for Road and Bridge Construction, concrete pavements were in limited use because most roadways of this time period were of various types of gravel surfaces in design. Many of the individual specification requirements did not have numerical limits due to lack of acceptable testing procedures, thus leaving the approval of many materials to the subjective approval of The Engineer.

Starting with the oldest set of standard specifications found in the Construction & Technology Division, namely: the 1919 Standard Specifications for Road Construction, it is noted that the department used:

One Course Concrete Pavement (Class F): This pavement consisted of a single course of concrete of the cross section on the plans laid upon the specified prepared sub-grade. The concrete was proportioned in one of two allowed mixtures, by volume:

1. 1 part cement, 1.5 parts fine aggregate and 3 parts gravel and amount of water as specified by the engineer, or

2. 1 part cement, 1.75 parts fine aggregate and 3 parts crushed stone and amount of water as specified by the engineer.

Fine aggregate was specified to be composed of hard, durable stone and contained not more than 2 per cent, by weight, of clay or silt, and to be free from clay lumps, all vegetable or other deleterious substances. The gradation consisted of:

1919 Fine Aggregate Gradation:

Passing the ¼ screen	100%
Passing the No. 20 screen	20 - 60%
Passing the No. 50 screen	0 - 20%

Coarse aggregate consisted of gravel or crushed stone meeting the following:

1. The gravel was composed of hard, sound, durable particles of stone and contained not more than 2 per cent, by weight, of clay or silt. No clay was permitted if it occurred as a coating on the stone particles. It also could not contain any clay lumps or particles of soft sandstone, shale, slate, or other material which may disintegrate. The stone particle gradation read as: 100% passing the two inch screen, not less than 25% retained on the one inch screen, not less than 25% passing the one inch screen and not less than 95% retained on the one-fourth inch screen.

1919 Coarse Aggregate Gradation:

Passing the 2 inch screen	100%
Retained on the 1 inch screen	25 - 100%
Passing the 1 inch screen	25 - 100%
Retained on the ¼ inch screen	95 - 100%

2. The crushed stone was the portion of the crusher product that passed a revolving screen having 2.25 inch circular openings and retained in a revolving screen having 0.25 inch circular openings when the crusher was adjusted so that the maximum

distance between the fixed and moving elements is not less than 2.25 inches. Not less than 5% could pass a circular 0.25 inch screen and the aggregate had to be free of clay lumps and soft and disintegrated stone. The sample was required to have a toughness of not less than 8 and a French coefficient of wear of not less of 10.

Standard Specifications for Road Construction for 1920 and 1921 remained the same as the 1919 version.

The 1922 Standard Specifications for Road Construction contains a rewrite of the sections covering **One Course Concrete Pavement** including modified fine and coarse aggregate gradations.

This pavement consisted of a single concrete course as shown on the plans composed of 1 part Portland cement, 1.5 parts fine aggregate and 3 parts screened gravel or 1 part Portland cement, 1.75 parts fine aggregate, and 3 parts crushed stone, laid on a prepared sub-grade per the plans.

1922 Fine Aggregate Gradation:

Passing the ¼ inch circular screen	95 - 100%
Passing the No. 10 mesh sieve	65 - 95%
Passing the No. 20 mesh sieve	25 - 65%
Passing the No. 50 mesh sieve	5 - 25%
Passing the No. 100 mesh sieve	0 - 5%

1922 Coarse Aggregate Gradation:

Passing the 2 ½ inch sieve	100%
Passing the 2 inch sieve	95%
Passing the 1 inch sieve	25 - 75%
Passing the ¼ inch sieve	0 - 15%
Retained on the No. 8 sieve	95 - 100%

Non-screened gravel or non-screened crushed stone could not be used as coarse aggregate.

In the concrete pavement mixes, the limit on clay content and silt in fine aggregate was reduced from 3% to 2%. The limit on clay and silt in coarse aggregate was reduced from 3% to 1%. Steel reinforcement and a central joint specification were added, along with a reduction in cement content.

In The 1924 Standard Specifications for Road Construction, we find:
Concrete Pavement (Plain and Reinforced). This pavement consisted of a single course of concrete composed of 1 part Portland cement, 2 parts of fine aggregate, and 3.5 parts coarse aggregate, by volume, laid on the prepared sub-grade as specified on the plans.

Fine aggregate consisted of clean, hard, durable sand free from clay lumps and all organic and other deleterious matter, and at the time of use, free from lumps and crusted material. The clay and silt could not exceed 2 per cent by weight and the clay content could not occur as a coating on the sand particles. The fine aggregate had to be uniformly graded from coarse to fine as follows:

1924 Fine Aggregate Gradation:

Passing the ¼ inch circular screen	95 - 100%
Passing the No. 10 mesh sieve	65 - 95%
Passing the No. 20 mesh sieve	25 - 65%
Passing the No. 50 mesh sieve	5 - 25%
Passing the No. 100 mesh sieve	0 - 5%

Coarse aggregate consisted of either gravel or crushed stone composed of clean, hard, tough, durable stone particles having a French coefficient of wear of not less than 7, free from thin or elongated pieces, soft material or rock which readily disintegrates, organic or other deleterious material. The clay and silt content could not be greater than 1 per cent by weight and no clay could occur as a coating on the stone particles or as free lumps. The stone particles were to be uniformly graded on a set of sieves with circular openings as:

1924 Coarse Aggregate Gradation:

Passing the 2 ½ inch sieve	100%
Passing the 2 inch sieve	95%
Passing the 1 inch sieve	25 - 75%
Passing the ¼ inch sieve	0 - 15%
Retained on the No. 8 sieve	95 - 100%

Non-screened gravel or non-screened crushed stone could not be used.

In The 1926 Standard Road and Bridge Specifications, fine aggregates for cement concrete consisted of clean, hard, durable, non-coated sand particles. The aggregate material was to be free from lumps of clay, soft or flaky material, and at the time of use from lumps or crusts of hardened or frozen material. The clay and silt content had a maximum limit of 2.5% and was to be free from organic impurities as exhibited by a color not darker than Plate 3 (Light Brown). The fine aggregate was to be uniformly graded and meet the requirements in the table below.

1926 Fine Aggregate Gradation:

Passing the 3/8 inch screen	100%
Passing the ¼ inch screen	90 - 100%
Passing the No. 10 screen	60 - 90%
Passing the No. 20 screen	25 - 65%
Passing the No. 50 screen	7 - 25%
Passing the No. 100 screen	0 - 5%

Stone screenings, either alone or in combination with sand, was not to be used in concrete.

Section III:

Coarse aggregates for cement concrete was either gravel or crushed stone consisting of clean, hard, tough, durable, non-coated stone particles meeting:

1. Not more than 1% by weight of clay and silt,
2. No clay coating adhering to particles, feeling slick to the touch when wet,
3. No clay lumps,
4. No organic or other deleterious matter,
5. Not more than 3% by weight of thin or elongated pieces,
6. Not more than 3% by weight of soft and non-durable particles (shale, sandstone, weathered schist, or floaters),
7. Not more than 10% incrustations or chemical salts including coated or incrusted, and
8. Percent of Wear (abrasion):
    a. Not more than 10% for gravel,
    b. Not more than 6% for crushed stone.

In addition, the coarse aggregates were graded according to four different classes depending upon their respective nominal maximum as follows:

1926 Class A (2 inch nominal aggregate):

Passing 2.5 inch	100%
Passing 2 inch	90 - 100%
Passing 1 inch	30 - 70%
Passing ½ inch	10 - 40%
Passing ¼ inch	0 - 10%
Passing No. 8	0 - 5%

1926 Class B (1.5 inch nominal aggregate):

Passing 2 inch	100%
Passing 1.5 inch	85 - 100%
Passing 1 inch	50 - 85%
Passing ½ inch	20 - 45%
Passing ¼ inch	0 - 15%

1926 Class C (1 inch nominal aggregate):

Passing 1 inch	85 - 100%
Passing ½ inch	20 - 60%
Passing ¼ inch	0 - 15%

1926 Class D (3/4 inch nominal aggregate):

Passing 1 inch	100%
Passing ¾ inch	85 - 100%
Passing ¼ inch	0 - 15%

Section III:

Post-1934 PCC Coarse Aggregates:

Beginning with the 1934 Standard Specifications for Road and Bridge Construction, the department has used many different coarse aggregate gradations of different types of gravel, mine rock, slag, and recycled crushed concrete with varying degrees of success.

Coarse aggregate intended for use in PCC was required to be gravel, crushed stone, crushed boulders, or slag, all of which had to conform to the gradations in Table 1 (partially shown below) and the additional physical properties of Table 2 of the 1934 Standard Specifications.

1934 Coarse Aggregate Gradations:

Passing Sieve	4A	10A
2 ½ inch	100	
2 inch		
1 ½ inch	50-80	100
1 inch	0-30	90-100
¾ inch		
½ inch	0-5	30-60
¼ inch		0-10

Moving along to the 1940 book, coarse aggregate was required to be 6A, 10A, 17A or a 50:50 combination (+/- 10%) of 4A and 10A with the following gradations and meet the 1940 specified physical requirements. Several things to note are the changes in certain sieve sizes and percents passing for the 4A and 10A.

1940 Coarse Aggregate Gradations:

Passing Sieve	4A	6A	10A	17A
2 ¼ inch	100			
2 inch	95-100	100		
1 ½ inch	65-90	95-100	100	
1 inch	10-40	60-90	95-100	100
¾ inch				90-100
½ inch		25-55	35-65	50-75
3/8 inch	0-5			
No. 4		0-8	0-8	0-8

In the 1942 Standard Specifications, a 0.8% maximum loss by washing (LBW) on the No. 200 sieve requirement was added for PCC aggregates. The 6A coarse aggregate was specified for concrete pavements of less than 5 inches in thickness.

Section III:

1942 Coarse Aggregate Gradations:

Passing Sieve	4A	10A	6A
2 ¼ inch	100		
2 inch	95-100		100
1 ½ inch	65-90	100	95-100
1 inch	10-40	95-100	60-90
¾ inch			
½ inch		35-65	25-55
3/8 inch	0-5		
No. 4		0-8	0-8
No. 200	0.8 max	0.8 max	0.8 max

In the 1950 Standard Specifications, the 2 ¼ inch top screen for the 4A gradation was replaced by the 2 ½ inch, similar to the 1934 grading, but with the addition of the requirement on the ½ inch screen. Thus, we have for 1950 and 1957:

1950 and 1957 Coarse Aggregate Gradations:

Passing Sieve	4A	10A	6A
2 ½ inch	100		
2 inch	95-100		100
1 ½ inch	65-90	100	95-100
1 inch	10-40	95-100	60-90
¾ inch			
½ inch	0-20	35-65	25-55
3/8 inch	0-5		
No. 4		0-8	0-8
No. 200	0.8 max	0.8 max	0.8 max

For the 1960 Standard Specifications, the 4A and 10A remained the same, however, the 6A top sizes were increased to 100% passing the 2 ½ inch, 95-100% passing the 2 inch and 90-100% passing the 1 ½ inch screens on the top three screens.

The interesting new physical requirement pertaining to Freeze/Thaw specifications was footnote (g) to Table 2 of the 1960 Standard Specifications. It stated that: "All aggregates intended for use in exposed concrete will be required to demonstrate, to the satisfaction of the Engineer, adequate freeze-thaw resistance for the particular use, either by means of extended field record in similar concrete, similarly exposed, or by accelerated laboratory freeze-thaw tests, or both."

Section III:

1960 Coarse Aggregate Gradations:

Passing Sieve	4A	10A	6A
2 ½ inch	100		100
2 inch	95-100		95-100
1 ½ inch	65-90	100	90-100
1 inch	10-40	95-100	60-90
¾ inch			
½ inch	0-20	35-65	25-55
3/8 inch	0-5		
No. 4		0-8	0-8
No. 200	0.8 max	0.8 max	0.8 max

For the 1963 Standard Specifications, 4A remained the same and 10A was dropped. The most significant changes for 1963 were that 6A was specified with a considerably finer gradation and the 50:50 combination (+/- 10%) of 4A and 6A replaced the 4A and 10A coarse aggregate combination for concrete pavement.

1963, 1965 and 1967 Coarse Aggregate Gradations:

Passing Sieve	4A	6A
2 ½ inch	100	
2 inch	95-100	
1 ½ inch	65-90	100
1 inch	10-40	95-100
¾ inch		
½ inch	0-20	30-60
3/8 inch	0-5	
No. 4		0-8
No. 200	0.8 max	0.8 max

In the 1970 Standard Specifications, the 4A grading was dropped, leaving only 6A for use as PCC coarse aggregate. The 6A gradation remained the same as used in the 1963, 1965 and 1967 books. Thus, the large aggregate PCC mixes disappeared for many years to come.

In the 1973 Standard Specifications, the loss by washing (LBW) requirement was opened up slightly from 0.8 to 1.0% maximum with the additional footnote allowing a LBW of 1.5% maximum for material produced entirely by crushing rock, boulders, or slag.

In the 1976 Standard Specifications, the first durability factor numerical limit of “20” was specified for 6AA, 6A, 17A and 26A PCC coarse aggregates based upon the ASTM C 666 procedure as modified by the Department.

Section III:

1976 and 1979 Coarse Aggregate Gradations:

Passing Sieves	6AA and 6A	17A	26A
1 ½ inch	100		
1 inch	95-100	100	
¾ inch		90-100	100
½ inch	30-60	50-75	95-100
3/8 inch			60-90
No. 4	0-8	0-8	10-30
No. 8			0-12
No. 200	1.0 max	1.0 max	3.0 max

The 1984 26A exhibited one grading change, namely; the 10-30 changed to 5-30% passing the No. 4 screen.

The 1990 Standard Specifications, 6AA/A, 17A and 26A gradations remained the same. The freeze-thaw limit descriptor (58) changed from durability factor (DF) to dilation (d). Note that, the old DF = 20 is equivalent to the new d = 0.067.

The 1996 Standard Specifications were written in terms of metric units instead of English units per a Federal government requirement. In order to assist the reader, the author has inserted the English units in parenthesis even though this was not in the 1996 book.

Several new premium PCC coarse aggregates were added in an attempt to add some quality and increase the life of our concrete pavements at minimal cost.

1996 Metric Coarse Aggregate Gradations:

Passing Sieves	4AA	6AAA	6AA/A
50 mm (2 inch)	100		
37.5 mm (1 ½ inch)	90-100	100	100
25.0 mm (1 inch)	20-55	95-100	95-100
19.0 mm (3/4 inch)	0-15	60-85	
12.5 mm (1/2 inch)		30-60	30-60
9.5 mm (3/8 inch)	0-5		
4.75 mm (No. 4)		0-8	0-8
0.075 mm (No. 200)	1.5 max	1.0 max	1.0 max

The 2003 book contains modified 4AA and 6AAA gradations as indicated below:

Section III:

2003 Coarse Aggregate Gradations:

Passing Sieves	4AA	6AAA	6AA/A
2 ½ inch	100		
2 inch	90-100		
1 ½ inch	40-60	100	100
1 inch		90-100	90-100
¾ inch	0-12	60-85	
½ inch		30-60	30-60
3/8 inch			
No. 4		0-8	0-8
No. 200	2.0 max	1.0 max	1.0 max

One of several interesting facts found in the 2003 book is the rewrite of the first paragraph of Section 902.03 allowing slag to be used in the 4AA and 6AAA gradations. The 4AA and 6AAA gradations were included in the 1996 Standard Specifications requiring natural aggregates only possessing premium physical requirements. The objective for 4AA was to provide aggregate interlock while still providing high freeze-thaw durability. The goal concerning 6AAA was to place a requirement on the ¾ inch sieve to produce a more well graded course aggregate for the concrete mixture and to obtain a superior durability as compared to normal 6A.

Post-1934 PCC Fine Aggregates:

Beginning with the 1934 Standard Specifications for Road and Bridge Construction, the department has used many different fine aggregate gradations of many different types of aggregate: crushed and uncrushed gravel, crushed mine rock, slag, recycled concrete, etc. with varying degrees of success.

Looking at just the gradation series/class designations, the primary fine aggregate for use in Portland cement concrete has been denoted as 2NS for many decades. However, the percentages passing each sieve, in addition to the sieve size changes have varied. To illustrate these changes, the following set of tables track this evolution process. Using 1934 as the beginning of the new era of pavements, we have:

1934 2NS Fine Aggregate Gradation:

Passing the 3/8 inch sieve	100%
Passing the No. 4 sieve	90 - 100%
Passing the No. 10 sieve	60 - 90%
Passing the No. 20 sieve	25 - 65%
Passing the No. 50 sieve	5 - 25%
Passing the No. 100 sieve	0 - 5%
Loss by elutriation (clay & silt)	0 - 2.5%

Then moving on to the next book of specifications (1940), one notes that the No. 10 & 20 sieves for 2NS have been replaced by the No. 8, 16 & 30. Also, the percentage ranges passing the No. 4 & the No. 50 have been tightened.

Section III:

1940 2NS Fine Aggregate Gradation:

Passing the 3/8 inch sieve	100%
Passing the No. 4 sieve	95 - 100%
Passing the No. 8 sieve	65 - 95%
Passing the No. 16 sieve	35 - 75%
Passing the No. 30 sieve	15 - 55%
Passing the No. 50 sieve	8 - 25%
Passing the No. 100 sieve	0 - 5%
Loss by Washing	0 - 2.5%

In 1942, the range on the No. 50 changed again, plus the ranges on the No. 100 and the Loss by Washing were opened up.

1942 2NS Fine Aggregate Gradation:

Passing the 3/8 inch sieve	100%
Passing the No. 4 sieve	95 - 100%
Passing the No. 8 sieve	65 - 95%
Passing the No. 16 sieve	35 - 75%
Passing the No. 30 sieve	15 - 55%
Passing the No. 50 sieve	10 - 30%
Passing the No. 100 sieve	0 -10%
Loss by Washing	0 - 3%

In the 1950 book, the No. 30 range was opened by 5% on the low end and a fineness modulous was added.

1950 - 1973 2NS Fine Aggregate Gradation:

Passing the 3/8 inch sieve	100%
Passing the No. 4 sieve	95 -100%
Passing the No. 8 sieve	65 - 95%
Passing the No. 16 sieve	35 - 75%
Passing the No. 30 sieve	20 - 55%
Passing the No. 50 sieve	10 -30%
Passing the No. 100 sieve	0 - 10%
Loss by Washing	0 - 3%
Fineness Modulus (FM)	2.60 - 3.35

In the 1976 book, a maximum variation range of +/- 0.20 was added to the fineness modulus obtained on a representative sample from within the allowed 2.50 - 3.35 range. The percentages passing the sieves remained unchanged.

The 2NS gradation remained unchanged for the 1984, 1990, 1996 and the 2003 books. Details concerning other fine aggregate gradations, such as 2SS, 2PCS, and 2MS can likewise be researched in the set of Standard Specifications books found either in the Research Library or the office of the Engineer of Specifications, both being located in the Construction and Technology Division, in the Secondary Governmental Complex.

Coarse Aggregate Freeze-Thaw Durability:

A number of interesting topics should be discussed under this general topic and are as follows:

Freeze-Thaw Testing Program:

The Testing Laboratory began compiling test results in 1954 in their Ann Arbor location in the old Engineering Building on the campus of the University of Michigan. A computerized data base is now available covering the results from 1954 - to date.

Several recommended readings for anyone having an interest in freeze-thaw testing of coarse aggregates should include:

1. Frank E. Legg, Jr.'s 1956 paper (1) covering his pioneering work and presented at the 35th Annual Highway Research Board Meeting in Washington, D. C.,

2. R. H. Vogler and G. H. Grove's 1987 paper (3) summarizing procedures used by MDOT and other Agencies,

3. ASTM's C 666 Standard Test Method (11), and

4. MDOT's Michigan Test Methods 113, 114 ,115 and 124 (12, 13,14, 15) covering the overall, detailed, coarse aggregate freeze-thaw testing program for both the confined and unconfined methods as performed at MDOT.

Coarse Aggregate Moisture Conditioning:

Only when the coarse aggregate particles and paste become critically saturated, which is generally assumed to be greater than 91%, will freezing exert enough force to cause damage to the surrounding concrete.

"Saturated" can mean different things to different readers because of different definitions being used. In ASTM C 127, "saturated" means the amount of water contained in the aggregate particles after 24 hours of soaking in water. In AASHTO T85, "saturated" means the amount of water contained in the aggregate particles after 15 hours soaking.

A progressively increased amount of moisture will be found in aggregate particles as the length of soaking time increases through various levels of vacuum saturation and finally to stream-wet conditions (a condition similar to centuries of immersion).

According to Vogler and Grove (3), the degree of saturation or moisture conditioning of the aggregate sample prior to freeze-thaw testing should be similar to that which is anticipated to be experienced by the aggregate within the concrete while in service.

Cady and Carrier (2) reported that the moisture in concrete pavement can reach in excess of vacuum saturation at the bottom of the slab in as little as three months after construction. Therefore, it appears reasonable that coarse aggregates tested in freeze-thaw should be vacuum saturated prior to casting the concrete test beams. One could logically infer that this procedure should be applied to all types of coarse aggregate.

Section III:

The How, When, and Why of the "20" Freeze-Thaw Limit:

The 1960 Standard Specifications was the first book to place any limit on freeze-thaw durability. This was by way of footnote (g) to Table 2, pages 504 -506. It read:

"All aggregates intended for use in exposed concrete will be required to demonstrate, to the satisfaction of the Engineer, adequate freeze-thaw resistance for the particular use, either by means of extended field record in similar concrete, similarly exposed, or by accelerated laboratory freeze-thaw tests, or both."

The original numerical "20" freeze-thaw durability factor specification limit was placed on the Series 6 coarse aggregates in the 1976 Standard Specifications. The how, when, why and who behind setting the limit at "20" has been a frequent topic of discussion in recent years. The rumor behind the "who?" usually centers around a group of the department's aggregate experts at that time, including: Myron Brown, Ralph Vogler, Don Malott, George Gallup and several others. Of course, all the key players are now retired and several are deceased.

However, some light can be shed on this topic from an office memorandum, dated 04/17/1986, from the Engineer of Testing to the Engineering Operations Committee (36). The third paragraph stated:

"The 20 freeze-thaw durability specification requirement was selected many years ago in Ann Arbor on the basis that a large supplier, American Aggregate Corporation, Green Oaks Pit, had a durability of 22. They were a major supplier at the time and their product was considered satisfactory. Several other sources of lesser quality and field performance had a durability factor of around 16 to 18, thus "20" seemed a natural break point."

Vogler (4, 5) in 1992 included similar supporting paragraphs on the "20" limit and how it was selected.

Change from Durability Factor to Dilation:

In the late 1970's, the Concrete Testing Laboratory became concerned about the hiring restrictions effect on obtaining adequate staff to run the Freeze-Thaw test program and the lack of availability of replacement for their aging sonic modulus test measurement equipment.

They began looking into simpler techniques whereby they could use some other durability descriptor requiring fewer technicians needed to run the test. One possibility was to use "dilation" or an elongation measurement requiring one less person to run the test. The other good news being that the required equipment was readily available. Thus, the Concrete Testing Laboratory ran both durability factor (DF) and dilation (d) measurements for each freeze-thaw test over the next seven consecutive years (1979 - 1985) to establish an adequate data base to analyze statistically. All 196 Freeze-Thaw tests were analyzed for the Concrete Testing Laboratory by Holbrook, Senior Statistician in the Research Laboratory Statistical Unit and a summary was presented by Grove (58). Each of these 196 data points consisted of nine concrete test beams per the Michigan Test Method 113 -114 -115 procedures, yielding an overall 0.965

correlation with a standard error of 0.203. A breakdown of the results for the seven years of testing is as follows:

Durability Factor (DF) - Dilation (d) Correlation:

Year	No. Sources	Correlation x(10)-3	Standard Error x(10)-3
‘79	31	968	--
‘80	24	969	--
‘81	34	954	--
‘82	30	975	--
‘83	30	974	--
‘84	19	990	--
‘85	28	958	--
Totals	196	965	203

Based upon this high correlation between the Durability Factor and dilation, the results were presented to the Aggregate Acceptance Criteria Committee (AACC) on 02/17/87 for consideration in making the change to “dilation”. Following the AACC recommendation (67) by Chairman Malott, the Engineering Operation Committee (EOC) approved the change in their 05/06/87 meeting beginning with the 1988 construction season projects.

At the June 23, 1987 ASTM Symposium on Concrete Problems, Vogler and Grove (3) presented the following equation relating Durability Factor (DF) and dilation (d) for State of Michigan coarse aggregates:

$$d = 0.2772 - \mathrm{SQRT}\left\{0.02016\left[\mathrm{Ln(DF)}\right] - 0.01613\right\}.$$

From this equation, it can be shown how the old DF limits were converted to the new dilation (d) numbers. Any other conversion needed but not found in this table could also be calculated.

Table 1: Major Comparison Points

Durability Factor	20	40	60	80	100
1000d	67	36	19	8	0

And as certain new dilation limits are proposed, occasionally, one needs to know the equivalent durability factor limit. Rearranging the equation to solve for Durability Factor in terms of dilation, we have:

$$\mathrm{DF} = e^{\left\{\left[(0.2772 - d)**2 \;+\; 0.01613\right]/0.02016\right\}}$$

Section III:

Some of these equivalent durability factor verses the dilation values are:

Table 2: Major Comparison Points

1000d	40	20	10	5	2
Durability Factor (DF)	36	59	76	88	95

Freeze-Thaw Outlier Test Procedure:

In determining the durability factor prior to 1989, due to the variability of certain natural gravel sources containing significant, but allowable amounts of deleterious material, produced peculiar results. For example, one source tested in 1985 (Testing Lab Report 84A-3720) yielded the following Durability Factors for the 9 test beams in descending rank order: [54, 52, 19, 12, 11, 10, 10, 7, and 7]. Granted, the average is 20 and thus passed the test. However, it does not seem appropriate to pass a source when 7 of the 9 test beams failed.

So the question became: What is happening here and how do we address these skewed types of results? It was decided that as part of the calculated durability descriptor (DF prior to 1987 and dilation thereafter) in MTM 115, one needs to test for “outliers” which can statistically be deleted from the data set prior to calculating the durability factor or dilation average.

One of three different possibilities can exist. These are discussed in ASTM E 178 and each requires a different statistical analysis method. To determine which analysis method to apply, arrange the durability test results for the nine freeze-thaw beams in ranked order (can be either ascending or descending order) as:

[x1, x2, x3, x4, x5, x6, x7, x8, x9].

Then, decide which <u>one</u> case needs investigating from the following three possibilities:

1. For the most common case, where the smallest (x1) or the largest (x9) data point in the set of nine ranked durability factors or dilation values <u>appears</u> to be an outlier, use the one-sided T test,
2. For the case where the two smallest (x1, x2) or two largest (x8, x9) data points appear to be outliers, use the Grubbs test, and
3. For the least frequent case where the smallest (x1) <u>and</u> the largest (x9) data points appear to be outliers, use the Tietjen-Moore statistic.

When testing for one suspected outlier (or two outliers) and the test fails, then the procedure is considered complete without deleting any data points.

If it is confirmed that one outlier or two outliers exist and subsequentally are deleted, then the procedure is complete.

Further discussion of this method is detailed in reference (35) and this outlier test has been incorporated in the Annex of Michigan Test Method 115.

Section III:

Freeze-Thaw Repeatability:

In 1994, the Concrete Testing Laboratory conducted a repeatability study (29) on four sources of coarse aggregate, two limestone and two natural gravel sources, in a series of three replication tests. The standard MDOT test consists of nine (9) test beams for each of three rounds of testing, resulting in a total of 27 beams per source.

The study verified that the MDOT freeze-thaw durability test procedure yields repeatable dilation results when coarse aggregate produced at one point in time is used. Therefore, the testing procedures do not introduce variations into the test results.

The aggregate industry sites the beam to beam variation of test results as proof that Freeze/Thaw testing is not repeatable. Due to the fact that a single aggregate particle may cause a test beam to fail, statistical analysis recommends averaging the results of multiple test beams to give a more realistic rating for a given aggregate source. This results in a more favorable test for the aggregate producer in approving their material for MDOT construction projects. Multiple test beam averaging is far more critical for natural gravel sources where the particles are made up of many aggregate types having highly variable properties. Some state agencies test only one beam for their approval or disapproval decision as discussed in reference (3).

MDOT may want to consider modifying their MTM 113-115 freeze/thaw procedure to reduce the number of test beams per sample from 9 to 1 and reduce the amount of work involved in approving or rejecting aggregate sources.

Attempts to Replace Freeze-Thaw Testing:

Several attempts have been made by MDOT over the years to replace the time-consuming standard freeze/thaw test with a simpler, less time consuming test method.

Korhonen and Charest (33) of the U. S. Army Cold Regions Research and Engineering Laboratory (CRREL) in a joint project with MDOT, titled "*Assessing Cryogenic Testing of Aggregates for Concrete Pavements*", in the early 1990's concluded that:

1. Pore size distribution measurements revealed a specific range of pore sizes critical to freeze/thaw durability. They found that aggregates containing more than 75% of their total pore volume between 0.01 and 5 micrometers were nearly always frost susceptible.

2. Based upon the limited testing done in the CRREL/MDOT project (20 samples), the cryogenic freeze/thaw test appears to have potential as a very rapid test for identifying aggregates that should not be considered for highway use.

3. For those aggregates passing the cryogenic test, it appears that some sort of pore distribution measurement, such as high pressure mercury porosimetry, should be used to single out freeze/thaw [coarse] aggregates acceptable for highway pavement.

4. More research is needed to determine the suitability of this test combination [cryogenic freeze/thaw test plus high pressure mercury porosimetry] for general aggregate testing.

Another attempt by Hansen, Snyder and Janssen (26) focused upon a rapid test for determining aggregate durability by use of the existing Washington Hydraulic Fracture Test (WHFT) and the Hydraulic Fracture Index (HFI) for Michigan aggregates.

Section III:

The WHFT involved subjecting a silane treated aggregate sample of approximately 200 particles having a total mass of 2,600 - 3,000 grams in a water filled chamber to high pressure nitrogen for five minutes over ten (10) cycles to cause breakdown of the particles. This was repeated over five days for a total of 50 cycles to generate the Hydraulic Fracture Index. After extensive work and several equipment modifications, it was concluded that:

1. MDOT should not adapt the Hydraulic Fracture Test as either a replacement or screening test for MTM 115, which assesses the potential freeze/thaw durability of coarse aggregates intended for use in Portland cement concrete in Michigan.

2. MDOT should consider further research using a larger test chamber and modified test procedure.

Much aggregate research has been done by Muethel at MDOT. In one such report (30), he concluded:

1. The results of freeze/thaw tests show that the rock types designated as *deleterious* in the [1973] MDOT Standard Specifications For Construction, produce low freeze/thaw durability in concrete,

2. Durable aggregates show no ill effects from vacuum saturation,

3. The results of the Iowa Pore Index tests indicate that most of the deleterious rock types display undesirable pore characteristics similar to the D - cracking carbonates investigated in Iowa,

4. The specific gravity and absorption data indicate that most of the deleterious lithological components in Michigan glacial gravel can be removed by use of a properly adjusted heavy media separation process.

In summary, Muethel recommended that the results of his investigation indicate that the rock types classified as deleterious in the MDOT classification should remain unchanged.

In a recent attempt, Ohio DOT has posted a Request For Proposal (PS-07-07: "*Rapid Test Methods for Determining Freeze Thaw Durability of Concrete and Concrete Aggregate Mixes*") on their web-site for research to be conducted in FY 2007 leading to an operational piece of test equipment and a standard test procedure to replace the existing freeze-thaw test procedure (which takes 6 weeks or more to complete) with a new field test procedure (taking 2 days or less) for evaluating their aggregate sources in Ohio.

PCC Paving Mixtures:

There have been a number of significant papers written on generating concrete mix designs based upon the *Mortar Voids Method*. Several references include:

1. Fulton, Roy S., "*Mortar Voids Method of Design and Field Control of Cement Concrete Mixtures*", MSHD Testing Laboratory, University of Michigan, June 19, 1936,

2. Shehan, Eugene L., "*The Mortar Voids Method of Proportioning Concrete as Used by the Michigan Department of State Highways*", September 1, 1970, and

3. Legg, F. E., Jr., and Vogler, R. H., "*Proportioning Concrete For Michigan State Highway Department Projects*", MSHD Testing Laboratory, June, 1962.

Section III:

The Mortar Voids computer program in use up to 1997 was written in a very old and undocumented computer code that was no longer supported by the State of Michigan DOT. Thus, in 1997, Robert D. Miller, Senior Data Systems Analyst at MDOT, reprogramed and expanded the original program, plus authored a User's Manual for operating the new mix design program and customizing the software in the future if needed.

Over the years, the developers behind this old, but extremely valuable mortar voids method have retired, resigned or passed away. Along with upgrading of the software, it was decided that documentation of the theory behind the actual Mortar Voids Method needed updating including the addition of examples in both metric and English units. Thus, a contract was let to Grove, while at the University of Michigan, to update and expand the documentation supporting the Mortar Voids Method. This work resulted in the 1998 Research Report RC-1399 (16). The Mortar Voids Method for designing concrete pavements has been used successfully by MDOT for many years and continues to do so.

Oehler and Holbrook (59) produced an excellent summary of the performance of Michigan's 1880 miles of post - WW II concrete pavement up through 1970. Only natural gravel and quarried carbonate sources (no slag) were investigated.

In the 1982 Transportation Research Board (TRB) meeting in Washington, DC, several papers (64, 65, 66) were presented that addressed the D- cracking of PCC pavements in Missouri, Illinois and Ohio. For many years, MDOT administrators were not convinced of the existence of D- cracking aggregates in Michigan. Eventually, the Engineer of Research (28) convinced the Department that Michigan does appear to have some D- cracking aggregate sources.

Buch and Van Dam (22) performed Phase I of a study of materials-related Distress (MRD) in Michigan's PCC pavements during the late 1990's and found that ASR- like cracking, aggregate polishing, pop-outs, and staining seem to be the most common MRD's in Michigan based upon this study. If background is needed, Dr. Hover (24) presents a short but concise description of Alkali-Silica Reaction (ASR).

An interesting and far-ranging web-site by a retired Iowa DOT Geologist, Dubberke, (63) covers his observations, comments and opinions on evaluating aggregates and the various test methods. His comments are based upon his Iowa experiences but could be studied for applications relevant to Michigan.

Premium Durability PCC Coarse Aggregates:

On 01/19/83, after a presentation by C. J. Arnold, Engineer of Research, on D - cracking problems (28) associated with different types of coarse aggregates, the EOC decided that the Department's Standard Specifications would remain unchanged.

However, they requested that a Special Provision be prepared for the upcoming M-21 paving projects, in which the minimum freeze-thaw durability factor be increased from 20 to 40 for 6A, with an alternate option of furnishing a 17A gradation with a minimum durability of 30. The requested Special Provision, dated 03/02/83, addressed coarse aggregate requirements for Grade 35P and 30P concrete used in pavements and shoulders on M-21 projects only. An economic study of the M-21 area indicated that this specification change would afford improved pavement life without increased cost.

Section III:

Discussion of the plan for using premium coarse aggregate on the I-696 projects was another matter. A specification change was not made due to potential industry concerns.

On 03/16/83, Kent Allemeier reported to the Aggregate Acceptance Criteria Committee (AACC) that MDOT would be establishing durability requirements for concrete coarse aggregates on a job-by-job basis until further information is available. In this same meeting C. J. Arnold recommended that concrete overlays have a minimum durability of 85, however, no action was taken.

In the 09/05/84 EOC meeting, The Supplemental Specification for Pre-stressed Beams was discussed and at the time was under review both inside the Department and by industry. The requirements included natural quarried crushed stone 6AAA aggregate having a minimum durability of 80 (vacuum saturated). Such aggregates were considered “premimum” and were needed because of the 50 plus year design life expectancy of pre-stressed beams. The Supplemental was approved by EOC.

In the 04/18/86 EOC meeting, the committee reaffirmed its earlier decision that the freeze-thaw durability factor for 6A aggregates be increased from 20 to 40 for the remaining I-696 projects. The Materials and Technology Division was directed to review the broader subject of aggregate durability for other roads and bridges and make a general durability recommendation back to the EOC. Types of roadways, traffic volumes, and costs were to be considered. Design Division was directed to make an appropriate addendum for the remaining I - 696 projects to increase to 40 durability coarse aggregate.

As a result of the directive to the Materials & Technology Division on general durability, the AACC proposed to the EOC in a 10/09/86 memorandum that a series of aggregate classes having different freeze-thaw durability limits for PCC aggregates be specified.

This recommendation in Table 1 was presented to the EOC on 12/03/86 for their review and was to be considered at the following meeting of the EOC.

Table 1: Series 6 Coarse Aggregate Durability Classes, Limits and Uses:

Class	Durability Factor	Uses
N	None	Buried and interior concrete not exposed to weather.
M	Minimum of 20	Pavements (less than 5000 ADT per lane), curb & gutter, median barriers
F	Minimum of 40	Structural construction such as bridge decks, retaining walls, freeways & roadways having 5000+ ADT per lane, rural & urban.
B	Minimum of 80	Pre-stressed beams.

Section III:

In the 01/07/87 EOC meeting, the committee reiterated that EOC had approved (12/03/86 meeting) that freeway pavements should be built with aggregates of at least 40 durability. Further discussion led to the conclusion that off-freeway roadways with heavy traffic volumes also warrant higher durability aggregates. M & T recommended that above 5,000 vehicles per day per lane should be the limit. The recommended durability classes in Table 1 above were discussed in detail along with industry's concern that MDOT's upgraded aggregate specifications would affect other markets for their aggregates. EOC suggested that because of the very high costs of building new pavements, the aggregate durability should be even higher than those proposed. They requested M & T to provide additional data on costs and availability of higher durability aggregate sources.

On 05/06/87, AACC recommended that a minimum durability factor of 60 be required for concrete pavement and shoulders on trunk lines having 5,000+ ADT per lane. Information on aggregate sources availability and costs where also submitted to EOC. They also reported that the Aggregate Laboratory had performed long term measurements correlating the traditional durability factor and the easier dilation descriptor and recommended that "dilation" be the measurement of the future for freeze-thaw work. EOC approved the changes of increasing Class M to 40 and Class F to 60, along with the corresponding dilation limits as indicated in Table 2 below. They also approved the use of "dilation" for future reporting of testing results and specification requirements. The units used for dilation are expansion per 100 cycles of freezing and thawing when tested according to Michigan Test Methods 113, 114, 115 (12, 13, 14). The new specification was to be in effect beginning with the 1988 construction season.

Table 2: Series 6 Coarse Aggregate Durability Classes, Limits and Uses:

Class	Durability Factor, Dilation	Uses
N	None	Buried and interior use not exposed to weather.
M	Minimum of 40 DF, Maximum of 0.036 dilation	Pavements with less than 5000 ADT per lane, curb & gutter, median barriers, etc.
F	Minimum of 60 DF, Maximum of 0.019 dilation	Structural construction such as bridge, retaining walls, all freeway pavement, shoulders, curb & gutter; plus other pavement, shoulders, c & g, median barrier when required (5000+ ADT per lane) and when requested on Grade Inspection in lieu of Class M.
B	Minimum of 80 DF, Maximum of 0.008 dilation	Pre-stressed beams.

Section III:

In the 01/26/88 meeting, due to existing testing equipment breakdowns and new equipment delivery delays, EOC approved the 01/14/88 AACC recommendation that full implementation of the new aggregate specification be delayed until the 1989 construction season. Existing durability testing information was to be used for high volume road construction projects on a project by project (Special Provision) basis for the 1988 season or until additional testing had been completed.

A Special Provision for Concrete Pavements was specified with a slightly modified limit of 0.040 maximum dilation (36 minimum DF) instead of the limit of 0.036 maximum dilation (40 minimum DF) from the EOC approved Table 2.

After equipment problems were solved and sufficient freeze-thaw testing data became available, the EOC approved durability class specification was never implemented. The topic never again appeared on the EOC agenda.

In 1992, Reincke, Engineer of Research, (25) stated that MDOT research over the years has indicated that the use of low durability aggregates is one of the causes negatively affecting pavement performance. He further recommended the use of premium materials [aggregates] in spite of industry resistance.

Buch (60) in 2000 concluded that pavements containing manufactured coarse aggregates appear to have more transverse cracks than those using natural aggregates. He indicated that this is probably due to a greater tendency for shrinkage cracking in slag (due to mix water absorption by porous aggregates) and recycled pavements (due to late hydration of un-hydrated cement from recycled concrete aggregates).

In the 1996 Standard Specifications, the new, higher quality, Series 6AAA coarse aggregate was specified at 0.040 dilation and Series 6A received a footnote requirement of 0.040 dilation for freeway and trunk line projects exceeding 5,000 ADT per lane.

In the 2003 Standard Specifications, footnotes to Table 902-2 revised Series 6AAA and 6A durability requirements to allow slag aggregate sources.

Large Top-Size PCC Coarse Aggregate:

M. G. Brown (32) of the Highway Research Laboratory in 1968 concluded that: In general, it would seem advisable to eliminate the usage of 4A gravel and use only 6A aggregate in pavement concrete. Good quality 4A gravel was in very short supply, and past experience has shown that many large, conspicuous and sometimes damaging pop-outs will result from the use of many of our present [1967 4A] sources meeting specifications.

As a consequence, the 1970 Standard Specifications, dropped the 4A coarse aggregate gradation leaving the 6A gradation for concrete pavement construction.

The importance of “aggregate-interlock” from the use of large top-sized coarse aggregate in PCC may be far more important than originally suspected. For example, Jointed Reinforced Concrete Pavement (JRCP) may develop transverse cracking as drying and thermal shrinkage of the concrete slabs is resisted by friction relative to the foundation layers. These cracks normally deteriorate with time and traffic loading, due to loss of aggregate-interlock load transfer capacity. However, rapid deterioration of these cracks were observed in the early 1990’s on some MDOT projects constructed during the late 1980's. This rapid crack deterioration lead to accelerated maintenance requirements and shortened service life.

The question became: Why had this deterioration become more pronounced and what can be done to minimize these effects at a reasonable cost.

As a result of these questions, Professor Mark B. Snyder (19, 20) in several research studies in the early 1990's concluded the following:

1. The load transfer efficiency (LTE) and pavement endurance was significantly higher (better) for limestone and gravel than for slag Series 6A coarse aggregate coarse aggregate.

2. Transverse crack load efficiency and endurance decreased slightly when the coarse aggregate gradation was reduced in size from Series 6A (1 inch nominal top size) to Series 17A (3/4 inch nominal top size).

3. The use of 100% recycled Series 6A gravel concrete decreased the load transfer efficiency and endurance considerably as compared to concrete made using virgin Series 6A gravel.

4. A blend of 50% virgin two-inch nominal top size limestone and 50% recycled Series 6A gravel concrete decreased the load transfer efficiency and endurance considerably compared to concrete made from virgin Series 6A gravel.

The aggregate-interlock transfer capacity of transverse cracks is related to the texture to the crack face in the concrete slab. The crack face texture is primarily a function of the type, size, and number of coarse aggregate particles at the crack face and the mode of fracture. When cracks develop <u>around</u> the coarse aggregate particles (i.e., virgin crushed stone and virgin gravel), the concrete slabs developed higher initial load transfer efficiencies and maintained this higher level over a considerably larger number of load cycles than specimens in which the cracks developed <u>through</u> the aggregate (i.e., virgin slag and recycled aggregates).

Concrete slabs prepared using natural aggregate (gravel and limestone) provided better crack deterioration performance than did concrete prepared using manufactured aggregates (recycled concrete and slag) when all other factors were held constant. This was attributed mainly to the reduction in crack face texture associated with the use of inherently weaker particles (e.g., slag and certain recycled concrete products) and/or the reduced quantity of relatively harder natural aggregates at the crack face to provide aggregate-interlock and improved abrasion resistance.

The inclusion of larger coarse aggregate particles appears to be effective in providing improved aggregate-interlock at transverse joints and cracks when all other factors are held constant and the grading used does not adversely affect the strength of the concrete.

Both recycled concrete and virgin Series 6A coarse aggregate appear to be improved by blending with quantities of virgin coarse aggregate of larger nominal top size natural aggregate.

W. J. Nowlen (73) concluded that endurance of joint effectiveness, when load transfer was accomplished solely by <u>aggregate interlock</u>, was improved by the use of:

1. Larger maximum aggregate sizes,
2. Increased aggregate hardness, and

3. Increased aggregate angularity.

From this, it can be inferred to also be true for mid-slab pavement cracking.

Professor W. Hansen and E. A. Jensen (76) found that the load transfer efficiency (LTE) as related to crack-width for fully cracked jointed plain concrete pavement (JPCP) slabs was improved by large gravel coarse aggregate particles at crack widths up to 2.5 mm. The improved load transfer was associated with a rougher crack texture, as the gravel particles did not fracture in contrast to the limestone and slag particles.

W. Hansen, E. A. Jension and P. Mohr (74) noted that several aggregate characteristics of the concrete pavement mixtures were found important in achieving good long-term pavement performance. These properties included aggregate inertness with respect to alkali aggregate reactivity (AAR) and freeze/thaw, and strong, large sized coarse aggregate to ensure good crack resistance and aggregate interlock. In addition, well-graded aggregates were beneficial in reducing the paste volume fraction, thus reducing thermal expansion effects and reducing drying shrinkage.

Hansen and Jension (77) found that tough, large sized coarse aggregate reduced slack and sliding in the concrete slab cracks and maintained high load transfer.

In the reconstruction of certain concrete pavements built prior to WW II made from much larger coarse aggregates, it was observed that many were still performing well after 50 years of service. This and further conversations with other department aggregate experts led to the idea that maybe MDOT should re-look at using large aggregate mixes. The real key here was to use very high durability large top size aggregate instead of using the 4A gravel allowed previously.

The Materials Research Group investigation (9) into the development of high durability pavement (HDP) mixes using large coarse aggregate proved that this problem could be solved.

In a 1997 EYE ON RESEARCH article, John Staton (34) summarized these field observations and the work of the Materials Research Group. As a result, the development of a Special Provision to this end is being used on a project-by-project basis to work out any unforeseen construction difficulties.

In the Special Provision for Portland Cement Concrete Grade P1 (Modified) on US-23, dated 12/16/02, an on-site blend by weight of 40% 4AA (Modified) and 60% 6AAA coarse aggregate is specified on a job-by-job basis. The gradations for each ingredient of the blend are listed as:

Grading for 4AA (Modified) Coarse Aggregate:

Sieve Analysis (MTM 109) Total Passing				LBW (MTM 108)
2-1/2”	2”	1-1/2” (a)	3/4”	No. 200
100	90-100	40-60	0-12	2.0 max

(a) Target percentage is 50%.

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Grading for 6AAA Coarse Aggregate:

Sieve Analysis (MTM 109) Total Passing					LBW (MTM 108)
1-1/2"	1"	3/4"	1/2"	No. 4	No. 200
100	90-100	60-85	30-60	0-8	1.0 max

The on-site blending shall be proportioned so as to produce an overall distribution of particles on the ¾ inch and 1 inch sieves as follows:

Combined Grading for ¾ inch and 1 inch Sieves:

Sieve Analysis (MTM 109) Total Passing	
1"	3/4"
60-70	40-55

In a 09/13/04 Special Provision for High Performance Portland Cement Concrete Grade P1 (Modified), a blend of a generic large coarse is shown below:

Generic Large Coarse Aggregate Gradation:

Total Percent Passing						
Sieve Analysis (MTM 109)						LBW (MTM108)
2 inch	1 ½ inch	1 inch	¾ inch	½ inch	3/8 inch	No. 200
100	90-100	60-85	30-60	10-30	0-8	1.0 max

Combined with an intermediate (Series 26A or 29A) and fine aggregate (2NS) is required to meet a composition gradation as follows:

Composite Gradation:

Sieve Size	% Retained
2 inch	0
1 ½ inch	0-5
1 inch	8-18
¾ inch	8-18
½ inch	8-18
3/8 inch	8-18
No. 4	8-18
No. 8	8-18
No. 16	8-18
No. 30	8-18
No. 50	< 18
No. 100	< 5
No. 200	< 2

Section III:

Freeze/thaw testing and evaluation of large top size coarse aggregate normally requires six by six cross-section beams to be tested according to the Department's MTM 113, 114 and 115 procedures. An attempt was made by Hansen (21) to see if large top size coarse aggregate could be screened for use in MDOT concrete pavement construction by running the standard Series 6 gradation aggregate in freeze/thaw and calculating the Series 4 results. Both the confined methods (12, 13, 14) and the unconfined method (15) of freeze/thaw testing were investigated. Since final approval and publication are still incomplete, conclusions and recommendations will not be referenced here. However, the reader should follow up and read this document when it becomes available.

Recycled Concrete Aggregates (RCA):

David Smiley presented a summary (75) detailing how, when and why the Department became involved with the concept of recycling concrete pavement into coarse aggregate for Michigan's highway construction projects. It began in the early 1980's and the reasons behind it were twofold.

1. Although virgin aggregate is considered to be superior product at a similar cost, it is not always readily available nearby, and
2. If the old pavement is not recycled, it would be wasted in landfill.

Since the pavements to be replaced had experienced D - cracking problems, namely; poor resistance to freeze/thaw, old pavements were crushed to a smaller top-size gradation. The smaller top-size gradation along with other factors set up a serious chain of events. Because recycled aggregates contain old mortar added to the new mortar in the mixture, RCA exhibits higher shrinkage thus resulting in wider transverse cracks. Speculation was that the smaller top-size of the recycled concrete aggregate, which should reduce D - cracking, may have adversely affected the coarse aggregate's interlock load transfer capacity. Aggregate interlock is <u>necessary</u> for concrete pavement to transfer shear loads across transverse cracks in the concrete pavement. The resulting impact became an accelerated maintenance schedule and related shortened concrete pavement service life.

Dr. Hansen (61) in 1995 concluded that many factors affecting recycled concrete pavement are also common to virgin aggregate concrete. High load transfer across cracks is indicative of good aggregate interlock and adequate foundation support. Poor load transfer indicates ineffective joints. Recycled concrete is sensitive to hot weather construction resulting in early shrinkage cracking and in-homogeneous concrete, similar to slag aggregate concrete. Hansen suggested that the addition of large top-size premium virgin aggregate to the recycled aggregate can increase the recycled aggregate durability as well as improve aggregate interlock and abrasion resistance.

Dr. Buch (60) in 2000 concluded that pavements containing manufactured coarse aggregates appear to have more transverse cracks than those using natural aggregates. He indicated that this is probably due to a greater tendency for shrinkage cracking in <u>slag</u> (due to mix water absorption by porous aggregates) and <u>recycled pavements</u> (due to late hydration of un-hydrated cement from recycled concrete aggregates). With all other variables constant, increased shrinkage cracking of the concrete slab results in lower sheer strength.

History of Slag PCC Coarse Aggregates:

In the early days, Great Lakes Steel Corporation made numerous attempts (37, 39) to convince the Department that blast-furnace slag would be the best coarse aggregate for PCC pavements. The industry claimed that other steel producing states such as PA, NY, OH, and the Bureau of Public Roads were using it with no adverse effects and that MI was the only steel producing state not allowing its use. The Department's three main concerns in the early 1930's were:

1. the specific gravity of slag varied too greatly to guarantee that a uniform concrete was consistently being used throughout the project,

2. slag does not produce as heavy a concrete as natural aggregate, and

3. allowing slag coarse aggregate would permit the use of large amounts of out-of-state slag from Ohio and Indiana to be brought into Michigan.

As a result of industry pressure, in August of 1933, the Department prepared a tentative (4A, 10A) coarse aggregate slag specification for concrete pavement (38, 40).

In September 1933, the State Highway Laboratory reported (41) the following observations:

1. In order to obtain a workable mix, more sand and water are required with slag CA, thus resulting in lower strengths than with gravel or crushed stone mixes. This is due to the fact that slag CA is weaker than the mortar, unlike natural CA, resulting in cracking through the slag CA instead of through the mortar fraction at lower loads.

2. The structural strength of the CA affects the strength of the concrete; slag CA being weaker than natural CA. Although, the slag concrete strengths could be improved, the researchers felt no need to include this in the study since they were obtaining satisfactory concrete with the standard six sack mixes using gravel or crushed stone.

The 1934 <u>Standard Specifications for Road and Bridge Construction</u> was the first book allowing slag CA for use in PCC pavements in state projects.

The 1940 and 1942 books also allowed use of slag CA in pavements.

In the 1947 Research Report No. 97 (42), the conclusion and recommendations concerning aggregates were as follows:

"Aggregates are definitely associated with the ultimate serviceability of the concrete in which they are used. This being true, greater emphasis should be placed by the Department on the selection of aggregates to be used on future highway construction projects. In view of the performance record of the slag projects on the Willow Run and Detroit Industrial Expressway systems and on account of the difficulties encountered in obtaining uniform quality material and in controlling slag concrete mixtures in order to realize a continuous uniform concrete product, it is recommended that slag, as an aggregate for concrete pavement slabs, should not be considered on future construction projects or at least until such time that more definite information can be obtained on the behavior of slag concrete in pavement."

In the 1953 Survey, Research Report No. 202, "Cracking Experiences of

Concrete Pavements Containing Slag Coarse Aggregate" (43), several pavements were studied.

1. In the Willow Run and Detroit Industrial Expressway Systems, over a ten year period ".....the cracking in the slag aggregate (all from Great Lakes Steel, Zug Island) pavement is on the average about 3.5 times the cracking in gravel aggregate pavement."

2. In the Dix Highway, US-25 from US-24 to Ecorse project, it was stated that: "Although the gravel aggregate pavement was eight years older than the slag aggregate pavement, the slag aggregate surface had approximately three times more lineal feet of cracks per mile-lane than the gravel pavement. This is significant because the gravel aggregate project was constructed with 100 ft continuous slabs whereas the slag aggregate project was constructed with 25 ft slabs. It is generally expected that the cracking of short slabs should be much less than that of long slabs but such is not the case here."

Several comments in the summary of Research Report 202 (43) included the following quotes:

1. "Aggregates which produce materially different flexural strength characteristics should receive special consideration in pavement design. On the basis of the cracking experience presented herein, slag aggregate is definitely one of these materials."

2. "The problem of providing adequate flexural strength in pavements containing low strength aggregates may be approached in either of two ways ..... first, by increasing the cross-sectional area of the pavement or, second, by possibly increasing the flexural strength of the concrete by addition of greater amounts of cement per unit volume of concrete."

3. "..... concrete, due to the inherent physical properties of slag particles - namely, brittleness and softness, may fail more rapidly by fatigue than concrete made from other types of aggregate."

4. "Another factor .... associated with the unusual cracking characteristics of slag aggregate concrete is the relatively low thermal conductivity and high moisture absorption of slag aggregates."

Recommendations found in Research Report 202 (43) included:

"When slag aggregates are approved for concrete pavement construction, it is recommended that the pavement thickness be increased over that which would normally be required for natural aggregates by a value of not less than 1 inch to compensate for apparent loss in flexural strength of slag aggregate concrete as manifested by high crack experience." " ....it is further suggested that the cement content per cubic yard be increased from 5.5 sacks to a minimum of 6 sacks to compensate for loss in mortar richness. This would offset to a certain degree the loss in mortar strength due to air entrainment and, in addition, it would impart greater durability to the concrete. The amount to increase the cement content should be determined from controlled laboratory tests."

Note: To assist the reader on the importance of air entrainment and cement content required for concrete, one can consult any of the references (8, 10, 17, 24, 27, 70) for background information.

Section III:

In the preparation (44, 45, 46) of the 1957 Standard Specifications book, the LA abrasion limit was increased from 40 to 42 on slag aggregates, 4A & 10A CA, et. al. The Levy Company was in favor of removing the LA limit on slag entirely. The 1950 book required a minimum weight of 75 lbs/cu ft - rodding procedure. The Department was in favor of increasing this to 80 but Mr. Levy, Jr. prevailed in holding the 75 limit.

The 1959 Levy PR letter (47) promoting slag states: "Here slag is really King of the Aggregates."

In the July 9, 1959 Supplemental for Slag Coarse Aggregates (48), including 4A, 10A, etc., the LA limit was lowered back to 40.

According to the Research Report No. 356 cover letter (49), cracking of slag aggregate concrete on Gratiot Avenue In Detroit built in 1947 developed 25.6%, 84.5%, 95.4% and 97.4% cracked slabs for the surveys of 1948, 1953, 1956, and 1960 respectively.

Cracking of Slag Aggregate Concrete on Gratiot Ave. (built 1947):

Survey Year	% Cracked Slabs
'48	25.6
'53	84.5
'56	95.4
'60	97.4

Industry continued (50, 51, 52) their pressure to water down the Department's slag aggregate specifications.

In spite of the MDSH teletype of October 25, 1968 (53) directing that the use of open hearth slag be discontinued immediately, a penciled note in the file dated 3 days later states that this decision may be modified.

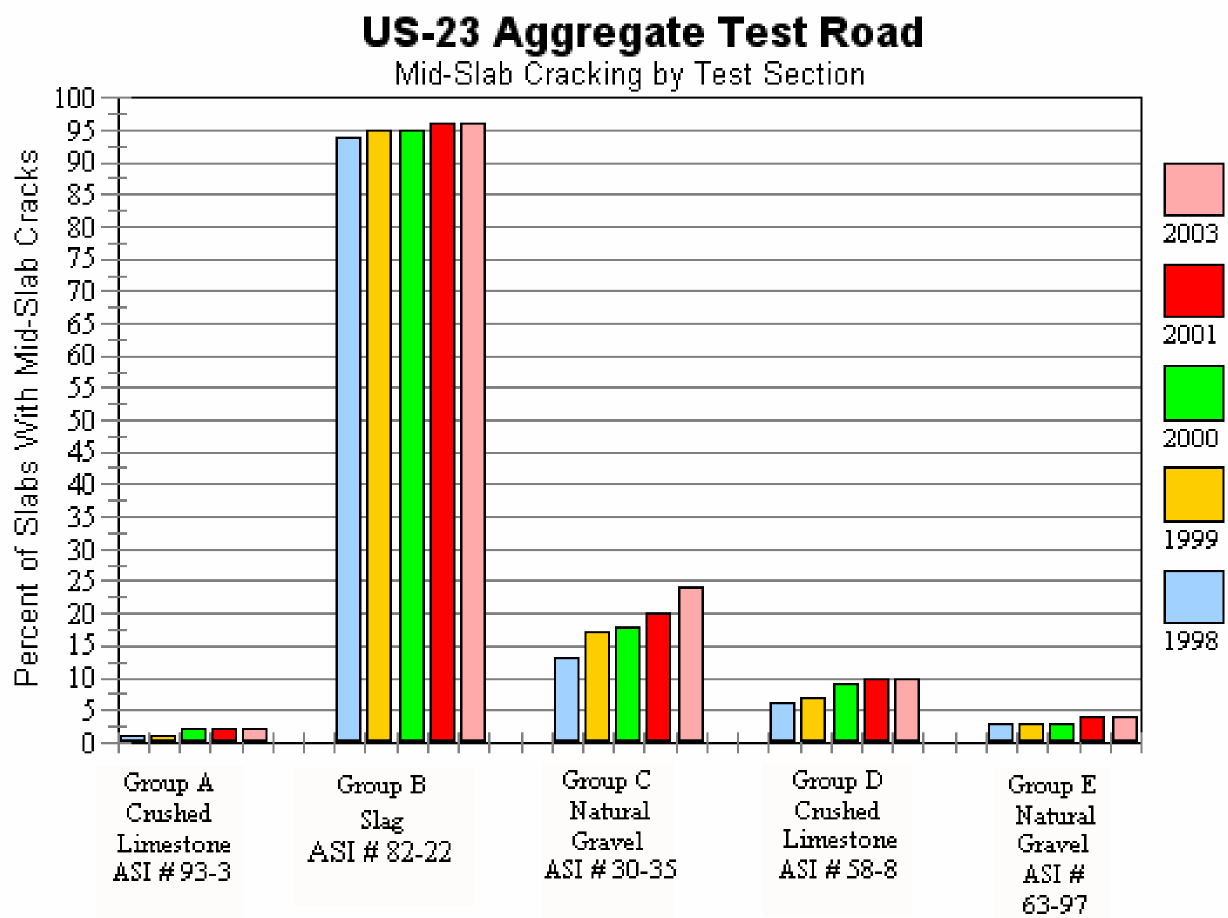
The 1975 industry meeting memo (54) included Levy Slag personnel complaints about the freeze-thaw testing that the Department intended to use on aggregates for concrete.

In 1987 (55), the Deputy Director at that time overruled the Department's aggregate experts on the wording of the Special Provision for Coarse Aggregate for Concrete Pavement and Shoulders by the removal of the word "natural" as applied to aggregates. The Deputy Director's rationale was that the Department was attempting to get a gas tax increase passed in the legislature and he didn't want anything more to get in the way. He further directed that no moratorium on the use of slag be issued until after the gas tax passes in December.

In a 1992 summary, The Engineer of Testing (4, 5) indicated that freeze/thaw testing of slag coarse aggregate began in 1972 with some slag aggregates performing poorly when tested in the vacuum saturated condition. In 1976, slag was exempted from vacuum saturation. From then on, slag was tested in freeze/thaw with 24 hour soak conditioning. This resulted in all freeze/thaw tests on slag coarse aggregate passing with flying colors.

Several research projects of limited scope investigated concrete pavements exhibiting substandard performance.

In 1992, a six mile section of SB US 23 in Monroe County was reconstructed to study the durability of concrete pavement using five different coarse aggregates, including one slag with various physical properties. Issue 70 of MATES (6) describes the project layout and the Department's effort in doing condition surveys at periodic intervals over at least 20 years to compare the effects of the various coarse aggregate types and specific sources. Even the research is incomplete as of this date, the first five surveys have been plotted to indicate the general trends. The performance of the various aggregates in this project can be seen in the chart below.



In a recent study (79), Alan C. Robords, Geologist in MDOT's C & T Support Area, reported that several concrete pavements have not performed up to expectations, resulting in modifications to specification requirements for concrete pavement aggregates. These deficiencies in performance were in terms of reduced anticipated pavement service life plus unanticipated repairs necessary to maintain safe travel for the motoring public.

In addition, the Department has had two very prominent failures in which blast furnace slag was the coarse aggregate. Those failed sections of US-23 and I-94 will cost the department millions of dollars to reconstruct.

This has prompted the Construction and Technology Support Area (previously known as the C & T Division) to begin a new investigation into pavement performance. The quickest way to determine if the coarse aggregate has a significant impact on pavement service life, is to locate adjoining sections of concrete pavements in which only the coarse aggregate varied. Those pavements must have the same design structure, joint spacing and traffic loading. To date, two recent sections on I 69 and three older sections on M 59, I 75 and I 94 have been located. A survey of each section was carried out to determine the extent and cost of repairs which have been completed. This information is one measure of pavement performance. The results of these evaluations are presented in the following table.

Table 1: Cost of Repairs per Lane Mile (2003 Dollars)

Project Location	Const. Year	Survey Year	Aggregate Costs ($)		
			Slag	Gravel	Limestone
I-94, Masonic Blvd to St. Clair Hwy	1963-1964	1989	109,539*	14,710*	0
I-75, Mt. Morris Rd. to Bridgeport	1958 grav. 1961 limst.	1989	None used	113,317*	0
M-59, Dequindre Rd. West 2.94 mi	1972	2003	131,149	45,623	None used
I-69 EB, US-127 to 1.4 mi East of M-52	1991 slag 1990 grav. 1988 limst.	2003	97,952	7,004	14,636
I-69 WB, 1.4 mi East of M-52 to US-127	1991 slag 1990 grav. 1988 limst.	2003	107,043	18,862	10,478

*1989 dollars were converted to equivalent 2003 dollars using a 1.51259 factor.

In addition, the dollar amount spent on M-59 does not give a clear indication of the condition of the present pavement. Every panel of the slag section had at least two cracks and some panels had eight cracks. Many of the cracks were faulted.

These direct comparisons lead the Department to prohibit the use of slag as a coarse aggregate in high volume Portland cement concrete pavements until a complete system wide analysis can be completed. The impact on the local economy and user cost when these high volume roads need to be repaired or reconstructed is so high the Department must make every effort to ensure extreme longevity in any new construction project.

In the first of a 1990’s two-part study (19, 20), Dr. Mark Snyder concluded that:

“The aggregate interlock load transfer capacity of transverse cracks is related to the texture of the crack face. The crack face texture is primarily a function of the type (gravel, crushed stone, slag or recycled concrete coarse aggregate), the coarse aggregate top size, the number of coarse aggregate particles at the crack face, and the mode of fracture. It was observed that the slab specimens (10 ft by 4.5 ft slab, 9 in thick at the induced crack) in which cracks developed around the aggregate (ie, virgin crushed stone and virgin gravel) developed higher initial load transfer efficiencies and were able to maintain this higher level over a considerably larger number of load cycles than slab specimens in which the crack developed through the aggregate (ie, virgin slag and recycled [concrete] aggregates)."

Dr. Snyder further recommended (20):

"Pavements made with concrete derived from recycled concrete aggregate or slag should feature structural designs that minimize reliance on aggregate interlock in any area of the design (ie, at joints or cracks). A conservative approach might be to avoid using recycled concrete or slag aggregate in JRCP pavements.", and

"Transverse crack deterioration appeared to be strongly correlated with concrete strength. Thus, pavements made with concrete that includes relatively weak aggregate particles, such as slag and recycled concrete, should:

1) use mix designs that provide concrete strengths that are comparable to those of concrete made with virgin (natural) aggregates,

2) use structural designs that reduce pavement stresses to levels that are appropriate for the strength that will be obtained, or

3) both."

Another possible consideration to allow use of recycled concrete or slag aggregates in concrete pavement designs may be the use of thicker concrete slabs on top of thicker, stiffer bases.

Section IV: Bituminous/Hot Mix Asphalt (HMA) Aggregates.

Section IV:

Pre-1934 Bituminous Aggregates:

The 1919 Standard Specifications, Bituminous Macadam Surface specified the same aggregate gradations as specified for Water-bound Macadam Surface as follows:

1919-1921 Bituminous Macadam Surface Course:

Physical Requirements:

Physical Property	Limestone (%)	Cobbles, Granite, Trap Rock (%)
French Coefficient of Wear, not less than	7	10
Toughness, not less than	9	10
Hardness, not less than	14	16

Bottom Course Gradation:

Per Cent	Limestone (%)	Cobbles, Granite, Trap Rock (%)
Passing 3.5" screen	100	100
Retained on 2.5" screen	85	
Retained on 2" screen		85

Top Course Gradation:

Per Cent	Limestone (%)	Cobbles, Granite, Trap Rock (%)
Passing 3" screen	100	
Retained on 2" screen		100
Retained on 1" screen, not less than	85	
Retained on 3/4" screen, not less than		85

Screenings Gradation:

Per Cent	Limestone (%)	Cobbles, Granite, Trap Rock (%)
Passing 1" screen	100	
Passing 3/4" screen		100
Passing 1/8" screen, not more than	20	20

1919-1921 Bituminous Concrete Wearing Course:

The total mineral aggregate consisted of a uniform mixture of broken stone, sand, and mineral filler meeting:

Mineral Filler:

Passing # 30 sieve 100%
Passing # 200 sieve, not less than 65%

Section IV:

Total Mineral Aggregate Gradation:

Screens & Sieves	Acceptance (%)
Passing 1/2” & Retained on 1/4” screen	5 - 10
Passing 1/4” & Retained on #10 sieve	11 - 25
Passing #10 & Retained on #40 sieve	7 - 25
Passing #40 & Retained on #80 sieve	11 - 36
Passing #80 & Retained on #200 sieve	10 - 25
Passing #200 sieve	5 - 11

The 1924 Bituminous Macadam Surface Course aggregate gradations were:

Top Course Gradation:

Per Cent	Limestone (%)	Cobbles, Granite, Trap Rock (%)
Passing 3” circular openings	100	100
Passing 1.5” circular, not more than	15	15
Retained on #8 sieve, not less than	97	97

Coarse Chips Gradation:

Screens & Sieves	Acceptance (%)
Passing 1.25” circular openings screen	100
Retained on 3/4” circular, not less than	90
Retained on #8 sieve, not less than	97

Fine Chips Gradation:

Screens & Sieves	Acceptance (%)
Passing 3/4” circular openings screen	100
Retained on 1/4” circular, not less than	85
Retained on #8 sieve, not less than	95

The 1924 Standard Specifications for Bituminous Concrete Pavement specified:

Broken Stone for Mineral Aggregate (Coarse Aggregate):

This coarse aggregate must consist of angular pieces of trap rock, granite, or limestone, free from soft or disintegrated stone, dirt or other objectionable matter and shall not contain more than 15% by weight of flat or elongated pieces. The French coefficient of wear and its toughness shall not be less than 7 and meet the following:

Coarse Aggregate Gradation:

Screens	Acceptance (%)
Passing 1.25” screen	100
Passing 3/4” screen	45 - 75
Passing 1/4” screen	10 - 25

Section IV:

Sand for Mineral Aggregate (Fine Aggregate):

This fine aggregate must consist of sound durable stone particles, free from clay or loam coating and meet the gradation below:

Fine Aggregate Gradation:

Sieves	Acceptance (%)
Passing #10 sieve, retained on #40 sieve	20 - 30
Passing #40 sieve, retained on #80 sieve	40 - 50
Passing #80 sieve, retained on #200 sieve	25 - 35
Retained on #200 sieve, not less than	95

Mineral Filler:

The mineral filler shall consist of limestone dust, dolomite dust, Portland cement or natural cement free of objectionable material meeting:

Passing #30 sieve 100%
Passing #200 sieve, not less than 65%

Composition of Wearing Course:

The wearing course shall be composed of a mixture of coarse aggregate, fine aggregate, mineral filler and bituminous material in the following proportions by weight:

Coarse Aggregate .... 45 - 60%
Fine Aggregate .... 25 - 45%
Mineral Filler .... 3.5 - 7.5%
Bitumen soluble in carbon disulfide .... 5.5 - 7.5%

The 1926 Standard Specifications included other bituminous paving mixtures such as: Sheet Asphalt Pavement which consisted of a top course or wearing course of asphaltic binder and sheet asphalt surface placed either on concrete base course on prepared sub-grade or on a prepared base course. There were different aggregate gradations for stone, gravel and slag in the various mixtures too numerous to repeat here. By the advent of the 1950 book, the aggregate materials for Sheet Asphalt consisted of 9A coarse aggregate, 3SAW fine aggregate and 3MF mineral filler.

Post-1934 Bituminous Aggregates:

From 1934 on, a number of bituminous type pavement mixtures have been used. Some mixtures which at first sight appear to be entirely different are actually slight modifications of an earlier mixture with a new name. One example of this process over the past 70 years from 1934 through 2003 involves the “oil-aggregate” mixtures change into the “dense-graded” mixtures or the change from using “bituminous” to “HMA” mixtures. Some of the evolution is due to changes in certain sieves or screens used in the mechanical analysis, the percentages of material passing each sieve and the phasing out of one name into the next “flavor of the month” designation. An attempt has been made to cover some of the important flexible pavement mixtures over the years, all though this is far from complete in this report.

Section IV:

Bituminous Concrete Surface Course: The 1934 aggregates specified where 9A binder course, 24A wearing course, and 9A, 24A wedge course for coarse aggregate. The fine aggregate included 3BC binder, wearing, and wedge courses. The mineral filler was 3MF.

Oil-Aggregate Surface Course: In the 1934 Standard Specifications, this work consisted of coating the present road surface with a prime coat and constructing thereon an oil-aggregate surface course composed of mineral aggregate and asphaltic oil combined either by plant mix or road mix methods. The mineral aggregate consisted of natural sand-gravel, crushed or uncrushed; slag, crushed stone, crushed mine rock, stamp sand and/or finely divided mineral matter, supplied separately or in combination to conform to the following, by weight:

Passing ¾ inch screen 100%
Passing ½ inch screen .... 60 - 90%
Passing # 10 sieve .... 35 - 50%
Passing # 40 sieve .... 20 - 40%
Passing # 200 sieve .... 5 - 10%
Clay balls or mud balls, not more than 2%

In the 1940 book, two oil-aggregate surface courses were specified; one being Road Mix (Class B-1) and the other Plant Mix (Class B-2). Their gradations were:

Oil-Aggregate Surface Courses:

Type	Per Cent Passing				
	3/4"	3/8"	# 10	# 40	# 200
Road Mix Class B-1	100	65 - 90	40 - 60	20 - 35	5 - 10
Plant Mix Class B-2	100	60 - 80	40 - 50	15 - 30	0 - 5

In the 1942 book, Class B-1 Road Mix Oil-Aggregate Surface Course continued as is while Class B-2 Plant Mix Oil-Aggregate Surface Course used 20A surfacing aggregate plus 3OAF Mineral Filler meeting the following gradation blend:

Passing ¾ inch sieve 100%
Passing 3/8 inch sieve .... 65 - 85%
Passing # 10 sieve .... 40 - 55%
Passing # 40 sieve .... 18 - 35%
Passing # 200 sieve .... 5 - 10%

In the 1950 book, Class B-2 Plant Mix Oil-Aggregate Surface Course used a combination of 20A surfacing aggregate plus 3MF Mineral Filler meeting the same gradation specified in the 1942 book shown above. The 1950 book was the last to reference the term "Oil-Aggregate" surface courses and the first to list "dense-graded". Terminology began to change and Department references began to evolve into

"Bituminous Dense-Graded" aggregate mixes, which will be discussed later in this Section.

Bituminous Retread Surface Course: This work consisted of a wearing course of 7A (sometimes 17C) retread coarse aggregate and bituminous material, with a seal coat and 25A cover material, constructed on the prepared foundation.

Bituminous Surface Treatment: This work consisted of one or two applications of bituminous material applied to the prepared surface and a covering of stone chips, gravel, slag, or stamp sand meeting 10B, 17B, or 25A per the contract.

Bituminous Aggregate Surface Courses: By the time the 1957 book came along, the "oil-aggregate" terminology had evolved into three "dense-graded" bituminous paving references as follows:

1. Dense Graded - Road Mix: This 1957 mixture specified 20B.

2. Dense Graded - Plant Mix: This 1957 mixture specified 20B.

3. Dense Graded - Hot Plant Mix: This 1957 mixture specified 20A and 3MF mineral filler.

The 20A and 20B gradations could consist of gravel, stone, or slag or blends thereof meeting:

1957 Dense-Graded Aggregates:

Series/ Class	Per Cent Passing Sieve Analysis						
	3/4"	1/2"	3/8"	#4	#10	#40	#200
20A	100		60 - 80		40 - 50	15 - 30	0 - 5
20B	100		65 - 85		40 - 60	18 - 35	2 - 10

The 20A and 20B gradations remained the same in the 1960 and 1963 books. In the 1965 book, certain sieves were changed (#10 to #8, #40 to #30) and the respective percent passing numbers were modified as follows for the 20A and 20B.

1965 Dense-Graded Aggregates:

Series/ Class	Per Cent Passing Sieve Analysis						
	3/4"	1/2"	3/8"	#4	#8	#30	LBW
20A	100		60 - 85		40 - 60	20 - 35	0 - 7
20B	100		60 - 90		40 - 65	20 - 40	2 - 10

In the 1967 book, the 20A and 20B mineral aggregate gradations remained the same as in the 1965 book. There were no aggregate changes to the dense-graded road mixture.

However, the dense-graded plant mixture added 20B and coarse aggregates 25A, 25B, 25C, 31AA, 31A, and 31C plus 2MS, 3BC, 3BCS, or 3NS fine aggregate plus 3MF mineral filler to the blend. The dense-graded hot plant mixture added coarse aggregates 25A, 25B, 31AA, 31A, and 31C plus 2MS, 3BCS, and 3NS fine aggregates to the blend. Additional specifications on the mixture compositions are available in the 1967 book.

The 1970 book dropped 31AA coarse aggregate and changed to 3FS and 3CS fine aggregate for the plant mixture. The 1967 Bituminous Aggregate Surface Course, Hot Plant Mix evolved into the 1970 Bituminous Aggregate Pavement including the addition of dense-graded 20AA. The combination of 20AA or 20A with 3MF mineral filler shall meet the composition gradation, by weight:

Composition Gradation:

Series/ Class	Per Cent Passing Sieve Analysis					
	3/4"	1/2"	3/8"	#8	#30	#200
20AA	100	95-100	65-90	45-70	20-40	3-10
20A	100		60-90	45-65	20-40	3-10

Mixtures could also be produced using 25 and 31 series aggregates in place of 20AA or 20A.

In the 1973 book, 20AA was added to the list of aggregates for the road mixture and a couple of minor adjustments were made on the percent passing on the #8 and #30 for the composition grading for Bituminous Aggregate Pavement mixtures.

Composition Gradation:

Series/ Class	Per Cent Passing Sieve Analysis					
	3/4"	1/2"	3/8"	#8	#30	#200
20AA	100	95-100	65-90	45-70	**20-45**	3-10
20A	100		60-90	**40-65**	20-40	3-10

In the 1976 book, the Plant Mixed Bituminous Mixtures required 9A, 25A, 31A coarse aggregates, 20AA, 20A, 20B, 20C dense-graded aggregates, 3FS, 3CS fine aggregates and 3MF mineral filler with composition requirements in Table 7.10-2.

In the 1979 book, the bituminous base and surface courses were renamed as follows:

1. <u>No. 5 Bituminous Mixture</u> replaced 3.05 Bituminous Base Course,

2. <u>No. 9 Bituminous Mixture</u> replaced 4.09 Bituminous Aggregate Surface Course, Plant Mix.

3. <u>No. 11 Bituminous Mixture</u> replaced 4.11 Bituminous Aggregate Pavement,

4. <u>No. 12 Bituminous Mixture</u> replaced 4.12 Bituminous Concrete Pavement, and

5. <u>No. 13 Bituminous Mixture</u> replaced 4.13 Sand Asphalt Surface.

Also in the 1979 book, the 4.03 Temporary Bituminous Patching required 21 and 22 Series aggregates and Class I, II Granular Backfill material. The 4.06 Bituminous Seal Coats required 25 Series coarse aggregates and 3CS, 5NS, and 5SS fine aggregate for cover materials. The 4.07 Stabilized In Place Bituminous Aggregate Base Course required 20A or 22A when additional aggregate was needed. The 4.08 Bituminous Aggregate Surface Course, Road Mix required 20B dense-graded aggregate.

In 1984, mixture names changed again. The numbers became 500, 700, 900, 1100, 1300, 1500, and 1800. Each number was followed by a capitol “L” for leveling or “T” for top course designation, followed by the aggregate Series/Class (ie, 20AAA, 20A, 20B or 20C). The No. 12 mixes were retained but with letter designations following the number based upon use. The seal coat mixes added 28B, 28C, and 31A coarse aggregate cover material.

In 1990, the No. 12 mixes disappeared from the book, while the 500, 700, ..., 1800 number references remained.

In 1996, the key phrase was “Job-Mix-Formula (JMF)” and resulting in new mixture numbers again. Seems the desire for *stability* does not pertain to the number designations on the mixtures but only applies to the mixture character while placing and in service. The new numbers are: 2B, 2C, 3B, 3C, 4B, 4C, 13, 13A, 11A, and 36A.

The blended aggregates had to meet:

1. Gradation (ASTM C 136, ASTM C 117),

2. Crushed Particle Content (MTM 117),

3. Deleterious Particle Content (MTM 110), and

4. Fine Aggregate Angularity Index (MTM 118).

The loose bituminous mixtures had to meet:

1. Theoretical Maximum Density, TMD (ASTM D 2041),

2. Marshall Density (ASTM D 1559 Par. 4.5),

3. Air Voids (Calculated),

4. Voids in Mineral Aggregate, VMA (Calculated), and

5. Mixture Composition, Asphalt Binder Content (Options I, II, III, IV, or V).

HMA Aggregates:

The term “Bituminous” has apparently fallen out of favor in the flexible pavement industry and has been replaced by “HMA” in the 2003 Standard Specifications. Thus, we now have:

Coarse aggregates for HMA mixtures consist of natural aggregate, iron blast-furnace slag, reverberatory-furnace slag, steel-furnace slag, or crushed concrete meeting the grading and physical requirements of the contract documents.

Fine aggregates for HMA mixtures consist of clean, hard, durable, uncoated particles, free of clay lumps, organic materials, soft or flaky materials, and other foreign matter. These aggregates must be natural sand, manufactured fine aggregate, or a uniformly graded blend meeting the grading and physical requirements of the contract documents.

Fine aggregates for HMA surface treatments such as slurry seal and micro-surfacing consist of crushed material from a quarried stone, natural gravel, slag source or a blend meeting the grading requirements of Table 902-4 and have a maximum LA abrasion of 45 percent (MTM 102).

Slurry seal aggregate (2FA) with Angularity Index (MTM 118) less than 2.0 may not exceed 50 percent of the fine aggregate blend.

Micro-surfacing aggregate (2FA and 3FA) must have a minimum AWI of 260 (MTM 111), a minimum sand equivalent (ASTM D 2419) of 60 percent and a minimum angularity index (MTM 118) of 4.0 for natural gravel, quarried stone or slag.

Several general references relative to flexible pavement technology include: The Asphalt Handbook (71) and The Engineering Characteristics of Michigan’s Asphalt Mixtures (31).

Section V: Miscellaneous Applications.

Section V:

Porous Backfill:

In the June 6, 1935 Errata and Changes to the 1934 Standard Specifications, we find: "Bank run gravel or coarse aggregate for Porous Back-fill shall consist of a mixture of sand and pebbles or broken stone conforming to the following composition limits, by weight:

Passing 3 ½ inch screen 95-100%
Passing ¼ inch screen 0-80%
Clay and silt .... not more than 10%.

In addition, reference to *Porous Back-fill* in Table 1 as Intended Use for 32A was to be deleted.

In the 1940 book, coarse aggregate for use as Grade A porous back-fill consisted of a mixture of pebbles or broken stone and sand conforming to the following grading requirements:

Passing 2 inch sieve 100%
Passing 1 inch sieve 60-100%
Passing No. 4 sieve 0-25%
Loss by washing .... not more than 10%

The 1950 book specified three porous back-fill gradations as shown below. Grade A could be used unless otherwise specified.

Porous Back-fill Gradations:

Matl. Grade	Per Cent Passing							LBW %
	2.5"	2"	1"	1/2"	#4	#40	#100	
A	100		60-100			0-100	0-30	0-7
B		100		45-100	20-100	5-30		0-5
C			100	75-100	50-100	15-30		0-15

In the 1957 book, two changes on Grade A porous back-fill included: no requirement on the #40 screen and a tightening of the LBW to 0-5%.

The 1960 Standard Specifications specified Grades A, B, C and a sand-gravel mixture as:

Porous Material Gradations:

Matl. Grade	Per Cent Passing								LBW %
	3"	2.5"	2"	1"	0.5"	# 4	#40	#100	
A		100		60-100				0-30	0-5
B			100		45-85	20-85	5-30		0-5
C				100	75-85	50-85	15-30		0-15
Sand-Gravel	100								0-10

Section V:

In the 1963 book, the LBW for Grade A was increased from 0-5 to 0-7%.

In the 1965 book, the #40 sieve was replaced by the #30 sieve and the percent passing for Grades B and C changed as follows:

Porous Material Gradations:

Matl. Grade	Percent Passing								LBW %
	3”	2.5”	2”	1”	0.5”	# 4	#30	#100	
A		100		60-100				0-30	0-7
B			100		45-85	20-85	5-40		0-5
C				100	75-85	50-85	20-35		0-15
Sand-Gravel	100								0-10

Granular Materials:

The 1967 *Standard Specifications For Road and Bridge Construction* was the first book to have a specific paragraph detailing granular materials. These materials were to consist of sand, gravel, crushed stone, foundry sand, slag, or a combination meeting the specified requirements. Materials which may be cementitious or not suitable for water percolation could not be used. The amount of non-durable shale particles were limited to not be excessive.

When used for trench backfill, no stones larger than 2 inches could be placed within 12 inches of the pipe.

Foundry sand had to be free of combustible material and contain only negligible quantities of iron. It could not be used for fill over sewers with open joints or perforated pipe or over metal utility pipe or conduits.

Foundry sand could not be used for sub-base.

Four classes of granular material having the gradations shown in the table below were allowed. Note that Grade B Porous Material evolved into Class I Granular Material. Similarly, Sand-Gravel Porous Material became Class III and Grade A Porous Material became Class I. Grade C was dropped.

Granular Material Gradations:

Matl. Class	Total Percent Passing								LBW %
	3”	2.5”	2”	1”	0.5”	# 4	# 30	# 100	
I			100		45-85	20-85	5-30		0-5
II		100		60-100				0-30	0-7*
III**	100								0-10*
IV***	100								0-25*

* The LBW had to be determined on the portion of the sample passing the 1.5 inch sieve.

** Maximum size could be increased to 6 inches if used as peat swamp backfill.
*** Could be used only for fill or backfill below the bottom of sub-base at locations on the plans or authorized.

The 1970 *Standard Specifications for Highway Construction* added specific uses for granular materials as: fill, trench backfill, sub-base and filter aggregates. It also required the approval of the Engineer for the amount of shale particles. The Class IV gradation was dropped and the LBW on Class III opened up to 0-15%.

The 1973 book restricted slag to be blast-furnace slag only. Sub-base material could be from salvaged concrete meeting the grading provided it contained only negligible steel reinforcement. The top size on Class II and Class III increased one sieve size as follows:

1973 Granular Materials:

Matl. Class	Sieve Analysis: Total Percent Passing									LBW %
	6”	3”	2.5”	2”	1”	0.5”	# 4	# 30	# 100	
I				100		45-85	20-85	5-30		0-5
II**		100			60-100				0-30	0-7*
III	100	95-100								0-15*

* To be determined on the portion of the sample passing the 1 inch sieve.
** Except for granular blankets, the total percent passing the # 100 is 0-35% and the LBW is 0-10% for Class II from sources in Arenac, Bay, Genesee, Gladwin, Huron, Macomb, Midland, Monroe, Oakland, Saginaw, Sanilac, St. Clair, Tuscola, and Wayne counties.

In addition, whenever certain Classes were specified, other Classes could be substituted as follows:

Granular Materials Substitution Chart:

Specified Class of Granular Material	Allowed Class Substitution
Class II	Class I
Class III	Class I or II

In the 1976 book, the footnote on Class II was expanded to include Lapeer and Shiawassee counties and the LBW and Sieve Analysis are based on dry weights.

In the 1979 book, the statement prohibiting foundry sand as sub-base material was dropped.

In the 1984 book, reverberatory furnace slag was added to the types of allowed materials. Also, the exception in the footnote on Class II for granular blankets was given the Class IIA name and respective gradation was added to the Table.

In the 1990 book, a statement prohibiting the use of foundry sand on all department projects was added.

Section V:

In the 1996 book, steel-furnace slag was allowed for embankment and fill when permitted on the plans or in the proposal. Granular material made from crushing Portland cement concrete was allowed for swamp backfill, embankment (except the top one meter below sub-grade) and as trench backfill around only nonmetallic culvert and sewer pipes without associated under-drains. All other uses are unacceptable.

In the 2003 book, steel furnace slag may be acceptable below the top three feet of embankment and fill when permitted by the contract documents. Table 902-3 for granular gradations for 1996 and 2003 are:

Table 902-3 Grading Requirements for Granular Materials

Matl. Class	Sieve Analysis (MTM 109) % Passing (a)									LBW % (a,b)
	6”	3”	2”	1”	1/2”	3/8”	# 4	#30	#100	
I			100		45-85		20-85	5-30		0-5
II(c)		100		60-100					0-30 (d)	0-7 (d)
IIA(c)		100		60-100					0-35	0-10
III	100	95-100								0-15
IIIA						100			0-30	0-15

a. Test results based on dry weights.

b. Use MTM 108 for Loss by Washing.

c. Except for granular blankets and under-drain backfill, Class IIA may be substituted for Class II on projects in: Arenac, Bay, Genesee, Gladwin, Huron, Lapeer, Macomb, Midland, Monroe, Oakland, Saginaw, Sanilac, Shiawassee, St. Clair, Tuscola, and Wayne counties.

d. Grading requirements are 0-20 on the # 100 sieve and 0-5 LBW when used as backfill for under-drains.

In addition, whenever certain Classes are specified in the 2003 book, other Classes may be substituted as follows:

Granular Materials Substitution Chart:

Specified Class of Granular Material	Allowed Class Substitution
Class II	Class I
Class III	Class I, II, IIA, or IIIA

Section VI: The Research Library Options.

Section VI:

Problem Introduction and Identification:

At present, with the long-term down-sizing of the C & T Division research staff, in particular the retiring of the most senior researchers, very few of those remaining remember or take the opportunity to spend any significant amount of time reading and reviewing the older reports, files, or microfilm records on aggregates or any other topic. Thus, the Department has many records relative to ongoing problem areas including aggregates, but many of the remaining staff just do not know they have all this useful information available.

One example was the 1997 case in which the Department wanted to update and document the "concrete mix design program". This required an understanding of the theory behind the mortar-void technique. Reference (16) is a fresh documentation of the theory and application plus associated background information to support the new software written by R. D. Miller. Although this report (RC-1399) contains new material, some older references were buried in the scattered files and Research Library, unknown to present users.

Thus the present staff, in effect, may have to "recreate the wheel" instead of building upon the work of their predecessors when updating or extending existing techniques. Several of the current difficulties for users that exist are that:

1. The information exists in numerous and sometimes incompatible formats, some not easily accessible due to the lack of a complete and concise index,

2. There is no longer a trained librarian to assist researchers with data retrieval and archiving of new materials,

3. As physical space keeps getting reduced and the library area is shuffled from one location to another, more and more of the valuable documentation has been either lost or discarded,

4. Materials cannot be searched for or viewed on-line from individual workstations or at central office locations.

After visiting several documentation centers or libraries to view and discuss their experiences in archiving and retrieval, the goal was to make detailed recommendations concerning: document storage, staffing options, and a cataloguing and retrieval system for the Construction & Technology Division's publications. Negatives and positives were to be addressed, plus estimated costs for each option provided to assist the Department in the decision-making process.

Background on the Construction & Technology Library:

The present Construction and Technology Division is now composed of several laboratories and work sections which came into being at different dates and in different geographical locations:

Section VI:

1. The Testing Laboratory was established at the University of Michigan in the East Engineering Building in 1919. Documentation consisted mainly of material test reports stored in files.

2. The Research Laboratory was created at Michigan State College (now Michigan State University) in Olds Hall in 1939. Documentation was primarily in the form of published Research Reports.

3. The Research Division and the Testing Division were combined to form the Testing & Research Division in 1942.

4. The Research Lab temporarily moved to the old Motor Wheel factory building in North Lansing in 1960 because of the need for increased work area. This facility supported a library with a librarian and support staff plus a graphics group and photography section preparing research reports and technical investigation needs.

The Department had future plans for building two new laboratory buildings, with the new Testing Lab to be located on North Campus of UM and the New Research Lab to be attached to the south end of the Engineering Building at MSU.

Because of a major disagreement between several high ranking individuals at Michigan State University (MSU) and in the Michigan State Highway Department (MSHD), the new Research Lab at MSU was cancelled. The Department after much discussion decided to delay the two new laboratory buildings. Many years later, the Department eventually combined the two laboratories on the newly acquired property in south-west Lansing called the Secondary Governmental Complex.

5. The Testing Lab at UM and the Research Lab in the old Motor Wheel building both relocated to a new jointly-occupied laboratory building at the Secondary Complex. The Research Section moved in the fall of 1977 and the Testing Section moved in the spring of 1978.

6. The Testing & Research Division was unnecessarily renamed the Materials & Technology Division in 1985 because of lack of communication in the chain-of-command.

The testing staff and the research staff are no longer separate and have been melded together to cover the increasing workload with a decreasing staff.

Also commingled with remaining Testing Lab and Research Lab personnel, we have the Specifications Section (with associated specifications library), the Materials Section and the Central Office Construction staff from the main transportation building in downtown Lansing.

Section VI:

Other groups such as the Environmental Group and the Contracts Section have come and gone over the years but are not a concern since they did not maintain any significant amount of library materials separate from the downtown library.

Identification and Analysis of Potential Proposals:

A. Maintaining Status Quo (De-Centralized):

<u>Negatives</u>:

1. Continued down-sizing of library area,
2. Continued loss of important, special and valuable documents/reports,
3. Non-utilization of materials by staff (especially younger),
4. Poor access and usage in present formats, and
5. Continued under-utilization of space.

<u>Positives</u>:

1. Relatively low maintenance costs
    a. No librarians or archivists required.

B. Revitalization/Enhancement of the Paper-Based Archives/Library (Centralized):

<u>Negatives</u>:

1. Not full utilization of storage space,
2. Increased costs,
    a. Brian Hawkins, Vice President for Academic Planning and Administration at Brown University, has been questioning the financial viability of the traditional research library in a series of papers. He makes this sobering assessment in his most recent paper: *While the problems associated with the acquisition of new information are alarming, focusing on this set of costs masks the magnitude of the real problem. If we proceed with the library model as we have known it, the costs associated with storing and archiving the information will bankrupt our institutions of higher education.*

    b. In the same paper, Hawkins estimates the cost of physically housing a single volume at $20, assuming new building costs at $170 per square foot. In addition, he estimates annual maintenance costs at approximately $1 per volume at Brown University. Malcolm Getz in an unpublished 1994 study estimates the capital cost of construction of open shelf space at $17.85 per volume.
3. Less than optimal access and usage
    a. Reports will still be paper-based, thus take up on-site space that could be used for more cost effective means (offices, lab space, etc.).

<u>Positives</u>:

1. Important, special and valuable documents/reports will be maintained, and
2. Access and Usage
    a. Reports would be centralized and available for researchers use, and

b. Librarians would be reinstated to archive the collection and assist researchers in retrieval.

C. Creation of a Digital Archives/Library by C & T (network):

Negatives:

1. High initial costs,
    a. Expenses would include:
        i. Human time – takes human time to create, implement, and maintain,
        ii. Digital formatting, and
        iii. Network creation or use of existing.
2. Requires storage space/servers/infrastructure.

Positives:

1. Lower long-term costs,
    a. Cheaper than paper-based, and
    b. Requires only routine IT maintenance.
2. Important, special and valuable documents/reports will be maintained,
3. Better access and usage,
    a. Central IT librarians would assist networked researchers.
4. Requires less storage space/servers/infrastructure than paper-based/status quo.

D. Out-Source The Creation and Maintenance of a Digital Archives/Library (network).

Negatives:

1. Potential initial costs/maintenance
    a. Expenses would be determined by winning contractor.

Positives:

2. Low long-term costs,
    a. Initial one-time cost, then routine maintenance costs
3. Important, special and valuable documents/reports will be maintained,
4. Custom access and usage,
    a. Determined by contract and Department's desire
5. Requires no storage space/servers/infrastructure like paper-based/status quo/ self-digitalized.

Recommendations:

1. Move physical collection off-site,
    a. Free up on-site space which can be utilized to achieve optimal efficiency.
2. Have collection managed by an independent digital archivist contractor, thus achieving the following:
    a. Proprietary approach that stresses access and use,
    b. Reduction of cost and an improvement on access,
    c. Fixed cost for storage and maintenance and a variable cost based on use,

Section VI:

d. More efficient management if out-sourced than if done in-house, and
e. Consultation services.

Discuss Out-Sourcing (ie; contracting with <u>The History Factory</u>) in Greater Detail.

1. Assessment and Appraisal:
    a. Determines archival value – (aesthetic qualities, completeness of record, age, information provided).
    b. Determines whether each particular resource is worthy of inclusion.
    c. Resources deemed unnecessary or duplicated, determine alternate value – (donation or sale to university or other such institute).

2. Preservation:
    a. Smaller-scale preservation – (remove fasteners, protection through acid-free media)
    b. Larger-scale preservation – (photocopy, microfilm/scan, digitize, and reformat)
    c. Special required services – (repair, rebinding, special storage)

3. Processing, Cataloging and Database Development:
    a. Act of Processing:
        i. Preservation
        ii. Arrangement
        iii. Description
    b. Cataloging
    c. Database Development

4. Scanning and Digitization:

5. Reference and Research:

6. Collection Management:

7. Storage and Maintenance:

Conclusions:

With the long-term down-sizing of the Construction and Technology Division research staff, there remain very few who actually remember the existence of -- let alone taken the opportunity to spend any significant amount of time reading and reviewing -- the older reports, files, microfilm records on aggregates or other topics housed in the slowly deteriorating library. Thus, many of the remaining Departmental staff have yet to recognize that many records covering ongoing problem areas are readily available. They have, in effect, been "recreating the wheel" time and time again instead of building upon the earlier work of their predecessors. However, by opting to have the collection managed by an independent digital archivist, this information could be quickly archived and disseminated in a cost-effective manner. Lower costs mean that projected budget funds once marked for the paper-based upkeep can be redirected to other areas of need. In addition to the step of out-sourcing, moving the physical collection off-site will prove beneficial. The freeing up of the library's now-occupied storage space will permit a more efficient usage as well as further lowering maintenance costs. Finally, the knowledge retained by preserving the library will provide invaluable insight to solving many of the Department's ongoing problems and save countless amounts of future budget funds by negating re-researching solutions to already solved problems.

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Comments and Recommendations:

Comments and Recommendations:

It should be noted that an all-inclusive document covering every memo and letter ever written on aggregates and pavements, plus every report and book stored in the Research Laboratory along with a discussion on each of these items is well beyond the scope of this project. However, this task could be addressed while upgrading the Research Library as discussed in Section VI. An effort was made to discuss the most important aggregate related topics as they evolved over the years and as they affected the standard specifications.

The historical aggregate files from Phase 1, in the appendices, may be used as a starting point for the reader to investigate further on topics involving aggregates and pavements.

The Department's history of research, testing and specification development has spanned the years from the early 1900's to the present day and stand as a testimonial to the many highly trained and experienced staff members over the years. It is hoped that those remaining staff members after the series of early-out retirements and the few new hires will hold things together until the next rebuilding phase of the Department's Research and Testing Services begins.

A major concern is the ongoing request by the aggregate industry to eliminate "vacuum saturation" of the coarse aggregate in the department's standard freeze/thaw test procedure (12, 13, 14) for ranking coarse aggregate sources for use in Portland cement concrete. This request is not in the best interest of the citizens of Michigan, if long-lasting pavements are to be provided. The reasons being:

1. It has been recommended (3) that the degree of saturation or moisture conditioning of the aggregate sample prior to freeze/thaw testing should be similar to that which is anticipated to be experienced by the aggregate within the concrete while in service.
2. Other experts in concrete pavement research (2), have shown that the moisture in concrete pavement can reach in excess of vacuum saturation at the bottom of the concrete slab in as little as three months after construction.
3. The large database of test results dating back to 1954 will be useless for comparing with future test results if vacuum saturation is dropped.
4. Future "non-vacuum saturated" test results would not have enough spread in the dilation numbers to allow meaningful ranking of coarse aggregate sources for use in making concrete. The distribution of test results tend to be bunched up or clustered when not vacuum saturated.

There is more aggregate research documentation to be done and it is recommended that Phase 3 should be considered. Two potential projects are:

1. US-23 Aggregate Test Road Distress Analysis, Including 2005 Field Data, and

2. Distress Effects on Concrete Pavements Containing Slag Aggregates.

Appendices: Historical Aggregate Files.

Standard Specifications Book Transitions:

Michigan's first comprehensive standard specifications for roadway construction appears to be the 1919 version, based upon the standard specifications books found throughout the various libraries and files in the Construction & Technology (C & T) Laboratory in the Secondary Governmental Complex. Several earlier dated manuals and booklets address specific areas such as bridges/structures and are not considered to be a total compilation of standard specifications for Michigan highway construction. Special Provisions are project specific and sometimes short-lived, therefore are not covered here. Supplemental Specifications normally were upgraded and included in the next update of the Standard Specifications provided all of the potential problems were worked out in the field. Occasionally, a Supplemental falls into disuse prior to the next update and thus disappears prior to making it into the new book. These anomalies were considered of lesser importance in the scheme of things and not detailed in this project. Therefore, we will start with the 1919 book as the base reference and focus on those sections covering aggregates and closely related roadway topics such as base courses, concrete and bituminous pavements.

1919 Specifications for Road Construction:

The following types of surfacing applications were detailed in the 1919 specifications book:

1. Concrete Base for Pavements:
2. One Course Gravel Surface:
3. Lean Gravel Surface:
4. Gravel Surface:
5. Stone Gravel or Slag-Gravel Surface: Only blast-furnace slag is listed.
6. Water-bound Macadam Surface:
7. Bituminous Concrete Pavement:
8. One Course Concrete Pavement:
9. Bituminous Concrete Pavement:
10. Concrete for Structures:

1920 Specifications for Road Construction:

The Standard Specifications were reissued with no changes for 1920, however no copy is available in the C & T Laboratory.

1921 Specifications for Road Construction:

The Standard Specifications were reissued with no changes, with a copy located in Room 130A of C & T.

1922 Specifications for Road Construction:

The Standard Specifications were modified and expanded for 1922 as follows:

1. Sub-base: A new specification appeared.
2. Concrete for Pavements: The "**Concrete Base for Pavements**" section contained a major rewrite of the aggregate materials and construction methods.

3. One Course Gravel Surface: This is a rewrite from 1919 with bank run gravel being replaced by higher quality processed gravel.
4. Sand-Clay-Gravel Surface: "**Lean Gravel Surface**" contained a major rewrite from 1919.
5. Stamp-Sand Surface: This is a new specification.
6. Gravel Surface: The materials and construction methods were modified.
7. Stone-Gravel Surface: This portion was separated from the "**Stone-Gravel or Slag-Gravel Surface**" section and modified.
8. Slag-Gravel Surfaces: This portion was also separated from the "**Stone-Gravel or Slag-Gravel Surface**" section and modified.
9. Water-bound Macadam Surface: Some modification of aggregate specifications and construction methods are evident.
10. Bituminous Macadam Surface (Penetration Method): Several changes include increased details on the stone chips, minor modification of bituminous material specifications, new test methods (USDA references became ASTM references) and some changes in construction methods.
11. One Course Concrete Pavement: New fine and coarse aggregate gradations, cement test method, and modified construction methods appeared.
12. Bituminous Pavement (Topeka Specifications): The title changed, in addition to a change in the top sieve size requirement for Broken Stone and Total Mineral Aggregate gradations from passing the ½ sieve to passing the ¾ -inch.
13. Bituminous Pavement (Sheet Asphalt Specifications): This section now includes updated specification details.
14. Cement Concrete in Structures: The name changed plus: a new "**1:2:3 Concrete Class**", new fine and coarse aggregate gradations, and changes in making and placing concrete appeared in the 1922 version.

1923 Specifications for Road Construction:

The Standard Specifications were modified and expanded for 1923 as follows:

1. Sub-base: The top sieve size for gravel passing the 4 -inch was changed to the 3 ½ -inch screen.
2. Concrete Base for Pavements (Plain and Reinforced): Concrete Class 1:2:4 was changed to Class 1:2 1/2:5 below top course application. Class 1:2:4 changed to Class 1:1 1/2:3 below combined base and curb application. The quantity of cement was reduced, finishing modified, and curing specification was improved. An option for using steel reinforcement was added.
3. One Course Gravel Surface: The retained on No. 8 -mesh sieve requirement changed from 60-85% to 75-85%. A change in "**Construction, Surfacing**" included the requirement of sideboards to obtain the proper depth.
4. Sand-Clay-Gravel Surface: No changes were noted.
5. Stamp-Sand Surface: Specific details for "**Construction, Surface**" were added instead of referencing inappropriate section in the 1921 "**One Course Gravel Surface**" section.
6. Gravel Surface: A small change was made in the "**Construction, Top Course"** section.
7. Stone-Gravel Surface: The Base Course and Filler gradations were modified.

8. <u>Slag-Gravel Surface:</u> No changes were made.

9. <u>Water Bound Macadam Surface:</u> Base Course Stone, Filler, and Top Course Stone gradations changed. Addition of the 500 ft minimum requirement for rolling in "Construction, Base Course" was added.

10. <u>Bituminous Macadam Pavement:</u> Separate specification limits and sieves for different types of top course aggregate appeared.

11. <u>Concrete Pavement (Plain and Reinforced):</u> The choice between two concrete Classes (1:1 1/2:3) or (1:1 3/4:3) was changed to Class (1:2:3 ½). The 3% clay content limit now reads 2% on clay and silt in the fine aggregate while the limit of 3% clay and silt was changed to 1% in the coarse aggregate. Additional details were added on the joint filler material. Steel reinforcement and central joint specifications were included. The required quantity of cement was reduced, plus there were also some changes in the "Construction" section of this specification.

12. <u>Bituminous Concrete Pavement:</u> The name of this specification changed, reference to the "Topeka Specification" was dropped. Some changes were also made in the Bituminous material specifications. A new ASTM D-4 committee test on water in bituminous appeared. The Melting Point Test D36-21 was dropped. Coarse and fine aggregate specifications were changed. New specifications on Wearing Course were included for 1923. The Seal Coat Aggregate specification was added. The 7-11% bituminous range was changed to 5 ½ - 7 1/2%. Several construction method modifications were added.

13. <u>Sheet Asphalt Pavement:</u> The name of this specification changed. A gradation limit of 92% passing the ¾ -inch screen was added on broken stone for the binder course. The roller weight for compacting the wearing course changed and a testing surface requirement was added.

14. <u>Concrete for Structures</u>: No changes in aggregate materials or construction methods were noted.

1924 Specifications for Road Construction:

The Standard Specifications were modified and expanded for 1924 as follows:

1. <u>Sub-base:</u> Addition of a 4% limit on clay and silt content in appeared in "**Gravel**".

2. <u>Concrete Base Course:</u> No aggregate changes were noted, however, new wording was added in "**Cement Furnished by Contractor**". The time between placement of curb and base was reduced from 30 to 20 minutes in "**Placing Concrete**". Wording was changed in the "**Finishing Concrete Surface**" section. Curing specifications were improved in "**Protection of Concrete**".

3. <u>One Course Gravel Surface:</u> No changes were noted.

4. <u>Sand-Clay-Gravel Surface:</u> No changes were noted.

5. <u>Stamp-Sand Surface:</u> No changes were noted.

6. <u>Gravel Surface:</u> The 100% passing requirement was changed to the 1-inch sieve instead of the 2-inch sieve in "**Base Course Gravel**".

7. <u>Stone-Gravel Surface:</u> No changes were noted.

8. <u>Slag-Gravel Surface:</u> 100% instead of 95% passing the 3 ½-inch circular openings in "**Base Course Slag**" is now the normal.

<u>Standard Specifications</u> Book Transitions:

9. <u>Water Bound Macadam Surface:</u> 100% passing the 4 -inch became 95 - 100% passing the 3 ½ -inch circular openings in "**Base Course Stone**". 100% passing the 3 -inch became the 2 ½ -inch in "**Top Course Stone**". Paragraph two was added to "**Construction, Top Course**".

10. <u>Bituminous Macadam Surface (Penetration Method):</u> 100% cobbles, granite and trap rock passing the 3 -inch became the 2 ½ -inch circular openings in "**Top Course**".

11. <u>Concrete Pavement:</u> No aggregate changes appeared.

12. <u>Bituminous Concrete Pavement:</u> No aggregate changes appeared.

13. <u>Sheet Asphalt Pavement:</u> No aggregate changes appeared.

14. <u>Concrete Structures:</u> The name was changed and the "**Description**" section was rewritten. No aggregate changes were noted. The "**Consistency**" paragraph was redone, plus the slump test requirement was added. New requirement was added relative to the ten (10) day cure of footings before pouring abutments and floor for slab or T- beam culverts in "**Placing Concrete**". A sentence limiting the amount of grout used to plaster coat the surface in "**Finishing Concrete**" was included.

1926 Standard Road and Bridge Specifications:

The Standard Specifications were expanded and major changes were made in the organization of the booklet. Divisions 3 and 4 were devoted to the construction details of <u>Base Courses</u> and <u>Surface Courses and Pavements</u>, respectively. The materials details were moved to Sections 3, 4 and 5 of Division 12. Selected changes in the aggregate specifications include but were not limited to the following:

<u>Section 3. Fine Aggregates:</u>

<u>*Mineral Filler.*</u>- The passing No. 200 -mesh sieve, not less than changed from 65% in "**Bituminous Concrete Pavement**" and "**Sheet Asphalt Pavement**" changed to 75%.

<u>*Fine Aggregates for Cement Concrete.*</u>- Fine aggregate specifications for "**Concrete Pavement**" both in gradation and other details have changed.

<u>*Sand for Binder Course.*</u>- No change from " **Sheet Asphalt Pavement**".

<u>*Sand for Bituminous Mixtures.*</u>- No change from "**Sheet Asphalt Pavement**".

<u>*Stamp Sand.*</u>- No change from "**Stamp-Sand Surface**".

<u>*Sand for Sub-Base.*</u>- New gradation includes just the sand fraction, previous was for the more-general term: gravel.

<u>Section 4. Coarse Aggregates:</u>

<u>*Coarse Aggregates for Cement Concrete.*</u>- Coarse aggregates are now separated into four classes: A, B, C and D. Now allows up to 3% thin and elongated instead of none, also allows up to 3% soft and non-durable instead of none. Up to 10% incrustations or chemical salts now allowed. Wear of 7% is now limited to 10% for gravel and 6% for crushed stone.

(a) *Class A (2 inch):* Updated version of Coarse aggregates from "**Concrete Pavement**", where: "not less than 95%" on 2-inch now reads 90-100%, 25-75% passing 1-inch now 30-70%, "not more than 15% passing ¼ inch now 0-10%. Another addition included 10-40% passing ½ inch screen.

(b) *Class B (1 ½ inch):* New gradation.

(c) *Class C (1 inch):* New gradation.

(d) *Class D (3/4 inch):* New gradation.

Stone Chips.-

(a) *Filler Chips for Water Bound Macadam:* No change from "**Water Bound Macadam Surface**".

(b) *Coarse Chips for Bituminous Macadam Surface Course:* No change from "**Bituminous Macadam Surface**".

(c) *Fine Chips for Bituminous Macadam Surface Course & Surface Treatments:* No change from "**Bituminous Macadam Surface**".

Crushed Stone.- No change in general requirements for "Broken Stone" in "**Water Bound Macadam Surface**"

(a) *Stone for Sub-Base:* No gradation change.

(b) *Stone for Water Bound Macadam Base Course:* No gradation change. Toughness and wear limits were modified and there is no distinction between limestone verses cobbles, granite and trap rock. The hardness limit was dropped.

(c) *Stone for Water Bound Macadam Surface Course:* Dropped the 25% limit retained on 2 -inch sieve for cobbles, granite and trap rock. No other gradation changes. Toughness and wear limits were modified and no distinction between limestone verses cobbles, granite and trap rock.

(d) *Stone for Bituminous Concrete (CA) - Class 1:* Wear limit was opened up from 6% to 7% from "**Bituminous Concrete Surface**". Gradation separated into Class 1 and Class 2.

(e) *Stone for Bituminous Concrete (CA) - Class 2:* Wear limit loosened from 6% to 7% from "**Bituminous Concrete Surface**". Gradation separated into Class 1 and Class 2.

(f) *Stone for Bituminous Macadam Surface Course:* No gradation changes for "Top Course".

(g) *Stone for Sheet Asphalt Binder Course:* No gradation change. Wear limit of 6% was opened up to 7%.

Gravel.-

(a) *Gravel for Sub-Base:* No changes were noted.

(b) *Gravel for Gravel Surfacing:* A limit on % crushed was added. A limit of 50-75% passing the ½ -inch screen and 60-85% retained on the 8-mesh now reads 70-80%. A new 10% limit on clay and silt appeared.

(c) *Sand-Gravel and Clay-Gravel:*

Sand-Gravel for Base: The 40-85% retained on 8-mesh now reads 40-80%.

Clay-Gravel for Base: The 40-85% retained on 8-mesh now reads 40-80% and a limit of 10 - 25% clay content range was added.

Sand-Gravel for Surface: The 40-85% retained on the 8-mesh is now 40-80%.

Clay-Gravel for Surface: The 40-85% retained on the 8-mesh is now 40-80% and the 10-30% clay content range became 10-25%.

(d) *Gravel for Bituminous Concrete (CA):* Specifications on wear and flat & elongated were dropped. Sieves sizes and % passing were modified.

(e) *Pea Gravel for Surface Treatment:* New specification.

Slag.- No change, but one should be aware that only blast-furnace slag is allowed.

(a) *Slag for Sub-Base:* No change.

(b) *Slag for Bituminous Concrete (CA):* New application appeared, including a gradation and 70 lbs/cu ft loose measure limit.

(c) *Slag for Surface Treatment:* The 40-80% passing the 1/4-inch circular openings now reads 50% passing the ¼ screen. The retained 90% on the 8-mesh became 15% passing, for "Filler" in "**Slag-Gravel Surface**". A new 70 lbs/cu ft loose measure limit was added.

1934 Standard Specifications for Road and Bridge Construction:

Major changes in the 1934 book included the following:

1. First use of a bound hardback (4 1/2 by 7 3/4 inch page size) format, previously used 8 ½ by 11 inch booklets.
2. "**Division 8 Material Details**" now covers coarse aggregate (CA) in Section 8.03 and fine aggregate (FA) in Section 8.04.
3. First use of Michigan Series/Class numbering of aggregate gradations.
4. New gradations for 1934: 1A, 3A, B & C, 4A, 6A, 7A, 9A, 10A & B, 11A, 13A, 17A, B, C, D & E, 19A, 21A, 22A & B, 24A, 25A, 27A, 29A, 31A, and 32A.
5. First use of a table layout (Table 1 for gradations and Table 2 for physical requirements) cover coarse aggregate specifications.

Note: There were no general revised books published between 1934 and 1940 according to the Forward of the 1940 book.

1940 Standard Specifications for Road and Bridge Construction:

The separate Division format on material specifications from the 1934 book was dropped, with material details on Base Course Aggregates, Coarse Aggregates and Fine Aggregates being covered together with their construction methods for each application, similar to the older stand-alone layout used in the 1919 - 1926 books.

Base Courses:

3.01 Aggregate Base Course using 21A coarse aggregate and natural soil binder.

3.02 Stabilized Aggregate Base - Road Mix using 21A coarse aggregate, natural soil binder and admixtures.

3.03 Stabilized Aggregate Base - Plant Mix using 21A coarse aggregate (modified from 1934 both on sieve sizes and % passing certain sieves), natural soil binder and admixtures. A stabilized 21B composition of coarse aggregate and binder gradation was also specified.

Standard Specifications Book Transitions:

3.04 Water-bound Macadam Base Course using 1A and 30A coarse aggregates.
3.05 Bituminous Base Course using 5A coarse aggregate and 2NS fine aggregate.
3.06 Concrete Mortar Bed using regular Grade B concrete aggregates or no coarse aggregate for thinner coatings.
3.07 Concrete Base Course normally using aggregates used as specified in 4.14.03.

Surface Courses and Pavements:
4.01 Aggregate Surface Course using 22A coarse aggregate and natural soil binder as specified under 4.03.02-a.
4.02 Stabilized Aggregate Surface - Road Mix using 22A coarse aggregate and natural soil binder.
4.03 Stabilized Aggregate Surface - Plant Mix using 22A (modified from 1934, sieves sizes and % passing). A stabilized 22B composition of coarse aggregate and binder was also specified.
4.04 Stamp Sand Surface using 5SS.
4.05 Water-bound Macadam Surface Course using 3A and 30A coarse aggregates.
4.06 Class A Non-Skid Surface Treatment using 18A, 26A, 26B, 31A or 32A coarse aggregate and 2NS or 5SS fine aggregate.
4.07 Class B-1 Oil Aggregate Surface Course - Road Mix using mineral aggregate grading and physical specifications.
4.08 Class B-2 Oil Aggregate Surface Course - Plant Mix using 20A coarse aggregate grading and physical specifications.
4.09 Class C-1 Bituminous Aggregate Surface Course - Road Mix using a non-numbered mineral aggregate Specification.
4.10 Class C-2 Bituminous Retread Surface Course using 7A and 17C coarse aggregates (modified from 1934).
4.11 Class I-1 Non-Skid Resurfacing (Hot-Plant Mixed) using 26A and 31A coarse aggregate, 3BC fine aggregate and 3MF mineral filler.
4.12 Class I-2 Bituminous Surface Course using 9A for the binder course, 24A for the wearing course and either 9A or 24A for the wedge course along with 3BC fine aggregate and 3MF mineral filler.
4.13 Class J Sheet Asphalt using 9A coarse aggregate, 3SAW fine aggregate and 3MF mineral filler.
4.14 Concrete Pavement using a combination of 4A and 10A coarse aggregate plus 2NS and 2SS fine aggregate.

In summary, the gradations dropped included 3B & C, 10B, 11A, 13A, 17B, D & E, 19A, 25A, 27A, and 29A, while the gradations added were 5A, 18A, 20A, 21B, 26A & B, and 30A.

Thus, the 1940 selection of gradations included: 1A, 3A, 4A, 5A, 6A, 7A, 9A, 10A, 17A & C, 18A, 20A, 21A & B, 22A & B, 24A, 26A & B, 30A, 31A, and 32A.

<u>Standard Specifications</u> Book Transitions:

<u>Changes in Gradations:</u>

Several sieve sizes were changed for <u>all</u> gradations and the % passing were modified from 1934 on many of the coarse aggregates.

<u>Changes in Physicals:</u>

Due to the different formats between the 1934 and the 1940 books, comparisons are difficult, but definitely should be verified in detail by the researchers involved.

1942 Standard Specifications for Road and Bridge Construction:

Major changes in the 1942 book included:

1. New stand-alone '**Division 7 Material Details**" now covers coarse aggregates and surfacing aggregates in Section 7.02 and fine aggregate in Section 7.03. This is more of an update of the 1934 book than the 1940 due to the general layout reverting back to that used in 1934.
2. Gradations dropped: 32A.
3. Gradations added: 6B, 19A & B, 20B, 23A, B & C, 25A, 31B & C, 50B.

Thus the 1942 selections were: 1A, 3A, 4A, 5A, 6A & B, 7A, 9A, 10A, 17A & C, 18A, 19A & B, 20A & B, 21A & B, 22A & B, 23A, B & C, 24A, 25A, 26A & B, 30A, 31A, B & C, 50B.

<u>Changes in Gradations & Physicals:</u>

Due to the differences in format going from the 1940 book to the 1942 book, it is difficult to make comparisons, thus should be verified in detail for your area of interest. An example being the 1940 grading requirement of 65-85% passing the 3/8 sieve for 26A and 26B was dropped for 1942.

1950 Standard Specifications for Road and Bridge Constructions:

Major changes in the 1950 book included:

1. Gradations dropped: 5A, 24A, and 50B.
2. Gradations added: 26D and 31D.

Thus the aggregate selections for 1950 were: 1A, 3A, 4A, 6A & B, 7A, 9A, 10A, 17A & C, 18A, 19A & B, 20A & B, 21A & B, 22A & B, 23A, B & C, 25A, 26A, B & D, 30A, 31A, B, C & D.

<u>Changes in Gradations:</u>

5/8 sieve added to table for 25A. 10-20% passing 200 now 5-15% on 21B& 22B.

Complete new 25A.

Added 60-85% passing on the 3/8 and changed 15-45% to 10-35% on the #4 for 26A & B.

Added 35-65% passing on the #4 for 31A, B & C.

<u>Standard Specifications</u> Book Transitions:

<u>Changes in Materials & Intended Use:</u>

Gravel and slag dropped as material for 25A.

Gravel, stone and slag 26D & 31A intended use as cover for surface treatment and retread.

<u>Changes in Physicals:</u>

Deval Abrasion testing on coarse aggregates was replaced by Los Angeles Abrasion testing.

Deval Abrasion testing was retained on base aggregates.

Testing limits were added for slag materials.

1957 Standard Specifications for Road and Bridge Construction:

Major changes in the 1957 book included:

1. Dropped 1A, 3A, 7A, 17C, 21B, 23B & C, 30A.
2. Added 22C & D, 29A.

Thus the selections for 1957 were: 4A, 6A & B, 9A, 10A, 17A, 18A, 19A & B, 20A & B, 21A, 22A, B, C & D, 23A, 25A, 26A, B & D, 29A, 31A, B, C & D.

<u>Changes in Gradations:</u>

40-55% passing # 10 now 40-60% and 5-10% passing 200 now 2-10% for 20B.

0-10% passing 200 now 3-8% for 21A.

Complete change on all sieves for 22A.

All except passing 3/8 changed for 22B.

Complete change on 23A.

100% passing ½ now 90-100% for 26A, B & D.

<u>Changes in Materials & Intended Use:</u>

Slag can be used for 6A, 6B, 17A, 18A, 25A, 26A & B.

Gravel has been dropped as material for 9A.

Aggregate Base Course use added to 19A.

Oil Aggregate Surface Course became Bituminous Aggregate Surface Course for 20A & B.

Aggregate Resurfacing became Aggregate Shoulders, Approaches and Select Sub-base for 23A.

<u>Changes in Physicals:</u>

LA Abrasion testing was dropped for slag.

Soundness limits modified for slag.

Deval Abrasion limits were increased on 22B and 23A.

Soundness limits were dropped on 26B and 26D.

LA Abrasion limit were increased from 32 to 36 for 26B and 31B.

1960 Standard Specifications for Road and Bridge Construction:

Major changes in the 1960 book included:

<u>Standard Specifications</u> Book Transitions:

1. Dropped 19B, 29A.
2. Added 10B, 24A.

Thus the selections for 1960 were: 4A, 6A & B, 9A, 10A & B, 17A, 18A, 19A, 20A & B, 21A, 22A, B, C & D, 23A, 24A, 25A, 26A, B & D, 31A, B, C & D.

<u>Changes in Gradations:</u>

The 3 ½ and 3 -inch sieves were dropped from Table 1.
The "No. 200" heading replaced "Loss by Washing".
100% passing 2-inch now reads 95-100% for 6A & B.
95-100% passing the 1 ½ screen now reads 90-100% for 6A & B.
3-8% LBW now reads 3-7% for 21A, 22A, B, C & D.
5-15% LBW now reads 7-15% for 23A.
The 50-80% specification on the 3/8 sieve was added for 25A.

<u>Changes in Materials & Intended Use:</u>

Added Aggregate Shoulders to 22A uses.
Dropped Select Sub-base from 23A uses.
New 24A now used as Select Sub-base.

<u>Changes in Physicals:</u>

Soundness limits on gravel and stone coarse aggregates for concrete and stone bituminous aggregate were lowered from 12 to 9.

Freeze-Thaw Durability limits on concrete coarse aggregates were first introduced as having to be approved by the Engineer.

1963 Standard Specifications for Road and Bridge Construction:

Major changes in the 1963 book included:
1. Gradations dropped: 6B, 10A & B.
2. Gradations added: 6AA, 21A mod., 22C Mod.

Thus the selections for 1963 were: 4A, 6AA & A, 9A, 17A, 18A, 19A, 20A & B, 21A & A Mod., 22A, B, C, C Mod. & D, 23A, 24A, 25A, 26A, B & D, 31A, B, C & D.

<u>Changes in Gradations:</u>

6A concrete coarse aggregate was down-sized.
40-50% passing the #10 sieve now reads 40-55% for 20A.
65-85% passing the 3/8 now reads 60-90% for 20B.

<u>Changes in Materials & Intended Use:</u>

New uses on Pavement, Base Course, Sidewalk, Curb, etc. and use as Bridges and Maintenance Patches were dropped for down-sized 6A.

<u>Changes in Physicals:</u>

LA Abrasion limits were increased for 25A, 26A, and 31A stone.
Soft limits were tightened from 3.0 to 2.5% for 4A and 6A gravel.

<u>Standard Specifications</u> Book Transitions:

1965 Standard Specifications for Road and Bridge Construction:

Major changes in the 1965 book included:

1. Gradations dropped: 21A Mod., 22C Mod., 26A, B & D.
2. Gradations added: 21AA, 22AA & E, 25B & C, 31AA.

Thus the selections for 1965 were: 4A, 6AA & A, 9A, 17A, 18A, 19A, 20A & B, 21AA & A, 22AA, A, B, C, D & E, 23A, 24A, 25A, B & C, 31AA, A, B, C & D.

<u>Changes in Gradations:</u>

There was a **major change** in sieve sizes; the 1 ¼ & 5/8 sieves were dropped, the #10 was replaced by the #8 and the #40 was replaced the #30 in the Table 1. Grading Requirements. Some changes in the % passing also occurred and are noted below:

100% passing the 1 ¼ now reads 100% passing the 1-inch and 45-65% passing the ¾ now reads 60-80% for 9A aggregate.

0-15% passing the #10 now reads 0-15% passing the #8 for 18A aggregate.

15-35% passing the #10 now reads 15-40% passing the #8 for 19A aggregate.

60-80% passing the 3/8 now reads 60-85%, 40-55% passing the #10 now reads 40-60% passing the #8, 15-30% passing the #40 now reads 20-35% passing the #30 and 0-5% LBW now reads 0-7% for 20A aggregate.

40-60% passing the #10 now reads 40-65% passing the #8, 15-35% passing the #40 now reads 20-40% passing the #30 for 20B aggregate.

40-65% passing the ½ now reads 40-75%, 20-35% passing the #10 now reads 20-40% passing the #8 for 21A aggregate.

30-45% passing the #10 now reads 30-50% passing the #8 for 22A aggregate.

25-40% passing the #10 now reads 25-45% passing the #8 for 22B aggregate.

20-35% passing the #10 now reads 20-40% passing the #8 for 22C & D aggregates.

25-50% passing the #10 now reads 25-55% passing the #8 for 23A aggregate.

30-50% passing the #10 now reads 30-55% passing the #8 for 24A aggregate.

90-100% passing the ½ now reads 98-100%, 50-80% passing the 3/8 now reads 60-90%, 0-10% passing the #10 now reads 0-12% passing the #8 for 25A aggregate.

100% passing the 3/8 now reads 98-100%, 0-15% passing the #10 now reads 5-25% passing the #8 for 31A, B, C & D aggregates.

<u>Changes in Materials & Intended Use:</u>

Cover for Surface Treatment was added for 25A use.

<u>Changes in Physicals:</u>

Individual limits on Chert and on Hard Absorbent no longer specified.

The Coke, coal, iron and soft limit on Series 4, 6, 17, 18, 25, 26 and 31 slag opened up from 3% to 5%.

1967 Standard Specifications for Road and Bridge Construction:

Major changes in the 1967 book included:

<u>Standard Specifications</u> Book Transitions:

1. Gradations dropped: 31B & D.
2. Gradations added: 26A, B & D returned with modified gradations.

Thus the selections for 1967 were: 4A, 6AA & A, 9A, 17A, 18A, 19A, 20A & B, 21AA & A, 22AA, A, B, C, D & E, 23A, 24A, 25A, B & C, 26A, B & D, 31AA, A & C.

The 2WS fine aggregate specification for white concrete was dropped.

<u>Changes in Gradations:</u>

Added "Gravel material before crushing shall be retained on a 1 ¼ inch sieve" for 9A, 19A.

"Gravel material before crushing shall be retained on a 1-inch sieve" for 25A, 26A, 31AA & A.

"Gravel material before crushing shall be retained on a 7/8 inch sieve" for 31C.

95 - 100% passing the #4 was changed to 100% passing for 3BC sand.

<u>Changes in Materials & Intended Use:</u> No changes.

<u>Changes in Physicals:</u>

Soundness limit was increased back to 12% for sources that exhibited satisfactory service over 5 years for 4A, 6A, 17A, 25A, 26A, 31AA & A gravel and stone.

A fineness modulus limit of 2.60 - 3.35 was added for 2NS fine aggregate for concrete.

1970 Standard Specifications for Highway Construction:

Major changes in the 1970 book included:

1. "**Division 8. Material Details**" now contains all aggregates in Section 8.02.
2. Gradations dropped: 4A, 26A, B & D, 31AA.
3. Gradations added: 20AA.

Thus the selections for 1970 were: 6AA & A, 9A, 17A, 18A, 19A, 20AA, A & B, 21AA & A, 22AA, A, B, C, D & E, 23A, 24A, 25A, B & C, 31A & C.

Class IV granular material was dropped.

Fine aggregates 3BC, 3NS and 3BCS were replaced by 3FS and 3CS for Bituminous Mixtures.

<u>Changes in Gradations:</u>

100% passing the 1-inch now reads 95-100% for 9A.
Added 7% maximum LBW for 19A, 20AA & A.
Added 2-10% LBW for 20B.
Added 3-7% LBW for 21AA & A, 22AA, A, B, D & E, 24A.
Added 7-15% LBW for 23A.
10-25% passing the #4 now reads 10-30% for 25A, B & C.
98-100% passing the 3/8 now reads 95-100% for 31A & C.
100% passing the #8 now reads 95-100% passing for 2MS.

<u>Standard Specifications</u> Book Transitions:

<u>Changes in Materials & Intended Use:</u>

Slag added as material for 19A, 31C.

Dropped Bituminous Base and Binder for use of 9A.

Shoulders was added as use for 22C, D & E, 23A.

Bituminous Mixtures were added as use for 25B & C, 31C.

Added "for Bituminous Surface" to " Aggregate Base Course" for 19A, 21AA & A, 22C.

New definition was added for use of 24A.

<u>Changes in Physicals:</u>

Minimum % crushed limits were lowered from 100% to 95% on 9A, 19A, 21AA, 25A, 31A & C gravel and stone.

LBW limits on blast furnace slag were dropped.

1973 Standard Specifications for Highway Construction:

Major changes in the 1973 book included:

1. Table 8.02-1 was separated into two areas: "<u>Coarse Aggregates</u>" and "<u>Dense Graded Aggregates</u>".

2. Coarse Aggregate Gradations: 18A was dropped and 28B added.

3. Dense-Graded Gradations: 24AA was added.

Thus the selections for 1973 were: 6AA & A, 9A, 17A, 25A, B & C, 28B, 31A & C for coarse aggregates and 19A, 20AA, A & B, 21AA & A, 22AA, A, B, C, D & E, 23A, 24AA & A for dense-graded.

<u>Changes in Gradations:</u>

Dropped 2 ½ & 2-inch sieves from Table 8.02-1.

0.8% maximum LBW now 1.0% for 6AA & A, 17A.

3% maximum LBW now 5% for 9A. 3-7% LBW now 4-8% for 21AA & A, 22AA, A, B, C, D & E.

Major change in 9A. 98-100% passing ½ now 95-100% for 25A, B & C.

There were several changes in the Class II and III granular material gradations, generally resulting in a slightly larger top-size for each.

The gradations for fine aggregates were first presented in table format, namely: Tables 8.02-4.

2PCS fine aggregate for cement concrete and mortar was added.

The Seal Coat Sand was given the 5NS designation.

<u>Changes in Materials & Intended Use:</u>

Materials now referenced as "type" of material and have "use" section numbers instead of wording.

<u>Changes in Physicals:</u>

There were no changes in existing coarse and dense-graded aggregate physical properties.

<u>Standard Specifications</u> Book Transitions:

1976 Standard Specifications for Highway Construction:

Major changes in the 1976 book included:

1. Coarse Aggregate Gradations: A finer 26A was added (back again).
2. Dense-Graded Gradations: 22AA, 24AA & A were dropped and 20C was added.

Thus the selections for 1976 were: 6AA & A, 9A, 17A, 25A, B & C, 26A, 28B, 31A & C for coarse aggregates and 19A, 20AA, A, B & C, 21AA & A, 22A, B, C, D & E, 23A for dense-graded.

<u>Changes in Gradations:</u>

25-55% passing #8 now 25-60% for 23A.

7-15% LBW now 9-16% for 23A.

Most of the fine aggregates now have a +/- 0.20 or 0.25 maximum variation on their fineness modulus.

The range of fineness modulus for 2NS and 2SS fine aggregate changed to 2.50 to 3.35.

<u>Changes in Materials & Intended Use:</u>

Many uses were dropped or the section number references were changed, especially for 3CS and 3FS. Details should be verified by the reader.

<u>Changes in Physicals:</u>

The LA Abrasion limit was standardized at 40 for all gravel and stone coarse aggregates and 19A dense-graded gravel and stone

The first numerical specification of 20 minimum was set for freeze-thaw durability on 6AA, 6A, 17A, and 26A gravel, stone and slag coarse aggregate for concrete.

The limit on the sum of soft and chert was dropped for 9A, 25A, 31A & C gravel and stone concrete coarse aggregate.

Soundness limits were dropped for all slag aggregates.

1979 Standard Specifications for Construction:

Major changes in the 1979 book included:

1. Coarse Aggregate Gradations: 28C added.
2. Dense-Graded Gradations: 19A, 20AA, 22C, D & E dropped..

Thus the selections for 1979 were: 6AA & A, 9A, 17A, 25A, B & C, 26A, 28B & C, 31A & C for coarse aggregates and 20AA, A, B & C, 21AA & A, 22A & B, 23A for dense-graded.

<u>Changes in Gradations:</u>

None in continued coarse, dense, and fine aggregates, mineral filler and granular materials.

Standard Specifications Book Transitions:

Changes in Materials & Intended Use:

Several uses changed via section numbers modifications. This will be left to the reader.

Changes in Physicals:

The LA Abrasion maximum limit of 40 was set for all dense-graded aggregates except 50 was set for 22B and 23A. One other exception involved using a limit of 50 for 22A whenever it was used as aggregate base course under concrete construction.

The limit of 15 for thin or elongated particles was dropped for all gravel, stone and BF slag aggregates.

1984 Standard Specifications for Construction:

Major changes in the 1984 book included:

1. A section was delineated and titled in Table 8.02-1 for "Open-Graded" aggregates.
2. Coarse Aggregate Gradations: No changes were made.
3. Dense-Graded Gradations: 22B was dropped and 20AAA, 35A were added.
4. Open-Graded Gradations: 5G, 8G, 34G were added.

Thus the selections for 1984 were: 6AA & A, 9A, 17A, 25A, B & C, 26A, 28B & C, 31A & C for coarse aggregates, 20AAA, AA, A, B & C, 21AA & A, 22A, 23A, 35A for dense-graded and 5G, 8G, 34G for open-graded.

Changes in Gradations:

Dual units (English & Metric) were used on sieve sizes in Table 8.02-1.
The #16 sieve column containing 0 - 12% passing was added for 8G.
10-30% passing the #4 now reads 5-30% for 25A, B & C, 26A.
20-40% passing the #8 now reads 20-45% for 21AA & A.
Class IIA granular material was added to Table 8.02-3.

Changes in Materials & Intended Use:

The use as Bituminous Seal Coats was added for 31A.

Changes in Physicals:

Minimum crushed limit of 40 was increased to 60 for 28B.
The LA Abrasion limit of 40 was increased to 50 for 21AA, 21A, and 22A.
The soft limit was opened up on gravel and stone 6A and 17A.
Maximum chert limits of 7.0 for 6A and 8.0 for 17A were added to Table 8.02-2 for gravel and stone.

1990 Standard Specifications for Construction:

Major changes in the 1990 book included:

1. Page size format was increased to 5 3/8 by 8 ¼ pages.
2. Coarse Aggregate Gradations: 31C was dropped and none were added.
3. Dense-Graded Gradations: 35A was dropped and 36A & B were added.

4. Open-Graded Gradations: None were dropped and 3G, 34R were added.

Thus the selections for 1990 were: 6AA & A, 9A, 17A, 25A,B & C, 26A, 28B & C, 31A for coarse aggregates, 20AAA, AA, A, B & C, 21AA & A, 22A, 23A, 36A & B for dense-graded and 3G, 5G, 8G, 34G & R for open-graded.

<u>Changes in Gradations:</u>

95-100% passing the ½ inch now reads 90-100% for 20AAA & AA.
30-60% passing the #8 now reads 30-55% for 20C.
Class IIIA granular material was added for 1996.
2PCS, 3CS, 3FS, 5SS and 5NS fine aggregates were dropped.
2FA and 3FA fine aggregate gradations were added.

<u>Changes in Materials & Intended Use:</u>

Assorted dropped uses occurred.
9A, 25A, and 31A are no longer used in plant mixed bituminous mixes.
5G and 8G are no longer used for under-drains.
9A, 5G, and 8G are now used on bicycle paths.
3CS and 3FS are no longer used in Bituminous Mixtures - Plant Mixed or Bituminous Patching Mixtures.

<u>Changes in Physicals:</u>

The LA Abrasion limit of 40 was increased to 45 for gravel and stone.
The freeze-thaw limit is now set at 0.067% / 100 cycles for 6AA, 6A, 17A, and 26A coarse aggregate.
Minimum crushed content limits were numerically set for 3G, 5G, 8G, 34G and 34R open-graded aggregates.

1996 Standard Specifications for Construction:

Major changes in the 1996 book included:

1. This update was a major rearrangement and complete renumbering of the Sections.
2. This was the first <u>metric-only</u> book. (It appears to be the <u>only</u> metric unit book that will be published by MDOT)
3. "**Division 9. Materials**" now contains all aggregates in Section 902.
4. Coarse Aggregate Gradations: 9A, 25A, B & C, 28B & C, 31A were dropped and 4AA, 6AAA, 29A were added.
5. Dense-Graded Gradations: 20AAA, AA, A, B & C, 36A & B were dropped and none were added.
6. Open-Graded Gradations: 8G, 34G were dropped and 2G was added.

Thus the selections for 1996 were: 4AA, 6AAA, AA & A, 17A, 26A, 29A for coarse aggregates, 21AA & A, 22A, 23A for dense-graded and 2G, 3G, 5G, 34R for open-graded. (Although 4AA, 6AAA and 17A have no standard uses listed, they were included in order to be specified on an as-needed basis by special provision for specific projects.)

<u>Standard Specifications</u> Book Transitions:

<u>Changes in Gradations:</u>

English sieve sizes were dropped from Table 902-1.

The 50 mm screen was added while the 1.18 mm sieve was dropped.

No % passing gradation changes were made in any of the continued gradations.

<u>Changes in Materials & Intended Use:</u>

Complete renumbering of the sections of the standard specifications book took place for this update.

<u>Changes in Physicals:</u>

No changes here.

2003 Standard Specifications for Construction:

The major changes in the 2003 book included:

1. Return to English units, metric units were replaced.
2. Coarse Aggregate Gradations: 4AA, 6AAA were modified and 25A returned.
3. Dense-Graded Gradations: No additions or deletions here.
4. Open-Graded Gradations: 5G was dropped, 4G was added, and a modified 34G returned.

Thus the selections for 2003 are: 4AA, 6AAA, AA & A, 17A, 25A, 26A, 29A for coarse aggregates, 21AA & A, 22A, 23A for dense-graded and 2G, 3G, 4G, 34R & 34G for open-graded.

<u>Changes in Gradations:</u>

1. 4AA: Generally increased in coarseness (nominal top size increased from 1.5 to 2.0 inch) and the loss by wash (% passing the No. 200) increased from 1.5 to 2.0 maximum.
2. 6AAA: 90-100% passing the 3/8 in sieve changed to 95-100% passing.

<u>Changes in Materials & Intended Use:</u>

1. 4AA: Slag is now allowed.
2. 6AAA: Slag is now allowed.
3. Item of Work section numbers have been added for gradations 4AA, 6AAA and reactivated for 17A.

<u>Changes in Physicals:</u>

Minimum crushed content has been set at 95% for 25A and 29A coarse aggregates.

A Maximum of 20% crushed was set for 34R open-graded aggregate.

8% maximum soft and 8% maximum sum of soft and chert was set for 29A.

Limits for flat and elongated were set for 4AA, 25A and 29A.

<u>Standard Specifications</u> Book Aggregate Sections:

Year	Section	Pages	Section Title
1934	8.03	265 - 271	Coarse Aggregate
	8.04	272 - 275	Fine Aggregate

1940 No separate Materials Section for Aggregates. The Standard Specifications are back in the earlier stand-alone format. See pages listed below for aggregate materials.

	Section	Pages	
	3.01	81	
	3.02	82	
	3.03	83 - 86	
	3.04	86 - 87	
	3.05	88 - 91	
	4.01	99	
	4.02	101	
	4.03	107 - 110	
	4.04	114 - 115	
	4.05	116 -117	
	4.06	119 - 121	
	4.07	133 - 134	
	4.08	140 - 141, 148	
	4.09	151	
	4.10	156 -158	
	4.11	162, 165	
	4.12	166 - 168, 172	
	4.13	174 - 176, 194	
	4.14	198 - 203	
	4.16	242	

Year	Section	Pages	Section Title
1942	7.02	385 - 398	Coarse Aggregates & Surfacing Aggregates
	7.03	399 - 404	Fine Aggregates & Soil Binder
1950	7.02	431 - 446	“
	7.03	447 - 453	“
1957	7.02	439 - 452	“
	7.03	453 - 459	“
1960	7.02	493 - 506	“
	7.03	507 - 514	“
1963	7.02	505 - 518	“
	7.03	519 - 526	“
1965	7.02	557 - 570	“
	7.03	571 - 577	“

<u>Standard Specifications</u> Book Aggregate Sections:

1967	7.02	603 - 614	“
	7.03	614 - 620	“
1970	8.02	558 - 575	Aggregates
1973	8.02	506 - 520	“
1976	8.02	518 - 531	“
1979	8.02	536 - 548	“
1984	8.02	492 - 505	“
1990	8.02	486 - 498	“
1996	902	9.3 - 9.15	Aggregates
2003	902	691 - 703	“

Specifications Office Aggregate Archive Files:

This set of files, commonly referred to as the Specification Section “archives”, is the only known set of documented changes available and are located in Room 130A of the Construction & Technology Building.

Individual Aggregate Related Folders:

3.01: Aggregate Base Courses (Folder 1)
3.01.01: Aggregate Base for Bituminous Surfaces
3.01.04: Stabilized Aggregate Base

3.01: Aggregate Base and Surface Courses (Folder 2)
3.01.05: Aggregate Base for Concrete Surfaces
3.01.08: Aggregate Base for Concrete Ramp

3.09: Aggregate Shoulders and Approaches
3.09.01: Stabilized Aggregate Shoulders and Approaches
3.09.02: Aggregate - Fly-ash - Lime Shoulders
3.09.03: Aggregate Shoulders and Approaches

3.20: Base Stabilization
3.20.01: Calcium and Sodium Chloride Stabilization
3.20.02: Bituminous Stabilization
3.20.03: Lime - Fly-ash
3.20.04: Crushed Stone
3.20.05: Soil Cement
3.20.06: Cement Stab. Base Course

8.02.01: Coarse Aggregate (CA) and Surfacing Aggregates - General
8.02.02: Sieves
8.02.03: Unit Weights - Coarse Aggregate
8.02.04: LA Abrasion Requirements
8.02.05: Soundness of Coarse Aggregates
8.02.06: Coarse Aggregate Series 4, 6, 7, 10, 11
8.02.07: Aggregate Series 20
8.02.07#2: Aggregates for Bituminous Mixes, Series 9,18,20,25,26,28,31,50
(Series 20 covered in previous file, Series 35 should also be included here)
8.02.08: Base Course/Surface Aggregates - Series 21/22/23/24
8.02.09: Maintenance Aggregates - General
8.02.10: Slag Aggregates for Concrete
8.02.11: Slag Aggregates - General
8.02.12: Bank Run Gravel
8.02.13: Granular Materials
8.02.14: Lightweight Fill
8.02.15: Lightweight Aggregates
8.02.16: Crushed Concrete Aggregates
8.02.17: Shale Particles in Surfacing and Base Course Aggregates

Specifications Office Aggregate Archive Files:

8.02.18: Aggregate Blending - Gradation Controls
8.02.19: Manufactured Aggregates
8.02.20: Aggregate Wear Index (AWI)
8.02.21: Open-Graded Aggregates
8.02.22: Soft Particles
8.02.23: RailRoad Ballast
8.02.24: Stockpiling Aggregates
8.02.25: Granular Material for Fill and Sub-base
8.02.50: 2NS Fine Aggregate (FA)
8.02.51: 2SS Stone Sand
8.02.52: Mineral Filler
8.02.53: 3BCS Slag Fine Aggregates for Bituminous Mixes
8.02.54: Fine Aggregates Used in Bituminous Mixes
8.02.55: 2NS Modified, 3NS Fine Aggregates for Bituminous Mixes

Other Documentation:

1. Other State Transportation Agency Standard Specifications Books,
2. ASTM Books,
3. AASHTO Manuals, and
4. Miscellaneous Individual Publications.

Aggregate Related Michigan Test Methods:

The following set of Michigan Test Methods (MTM's) act as a more detailed set of test procedures when the national procedures such as ASTM or AASHTO are lacking in details of what MDOT normally does for a standard aggregate test. All MTM's have been converted back to English units from the metric units used in the 1996 Standard Specifications for Construction book.

MTM No.	Title
101	Water Asphalt Preferential Test.
102	Abrasion Resistance of Aggregate by the Los Angeles Machine.
103	Determination of Insoluble Residue in Carbonate Aggregates.
104	Petrographic Analysis of Aggregates.
105	Determining Specific Gravity & Absorption of Coarse Aggregates in Petrographic Analysis Samples.
106	Determining Adsorption of Coarse Aggregates in Petrographic Analysis Samples.
107	Sampling Aggregates.
108	Materials Finer Than No. 200 Sieve in Mineral Aggregates by Washing.
109	Sieve Analysis of Fine, Dense Graded, Open Graded and Coarse Aggregates in the Field.
110	Determining Deleterious and Objectionable Particles in Aggregate.
111	Determining an Aggregate Wear Index (AWI) by Wear Track Polishing Tests.
112	Determining an Aggregate Wear Index (AWI) from Sample Petrographic Composition and Wear Track AWI Factors.
113	Selection and Preparation of Coarse Aggregate Samples for Freeze-Thaw Testing.
114	Making Concrete Specimens for Freeze-Thaw Testing of Concrete Coarse Aggregate.
115	Testing Concrete for Durability by Rapid Freezing in Air and Thawing in Water.
116	Identifying Aggregates That Produce Calcium Carbonate Precipitate.
117	Determining Percentage of Crushed Particles in Aggregates.
118	Measuring Fine Aggregate Angularity.
119	Sampling Open-Graded Drainage Course (OGDC) Compacted in Place.
120	Preparing Concrete Pavement Cores to be Tested for Durability by Rapid Freezing in Air and Thawing in Water.
121	Testing Concrete Pavement Cores for Durability by Rapid Freezing in Air and Thawing in Water.
122	Determination of the Drainability Characteristics of Granular Materials.
123	Field Determination of the Dry Unit Weight (Loose Measure) of Coarse Aggregates.
124	Determining Aggregate Durability by Unconfined Freezing and Thawing.
128	Determination of Iowa Pore Index of Coarse Aggregates.

Research Black Book File:

The various research projects assigned to the staff of the Research Laboratory Section of C & T (previously referred to as T & R, M & T plus several earlier descriptors unknown to nearly everyone still alive) are grouped into several areas. Those projects relating to aggregates and closely associated areas such as concrete and bituminous pavements are listed as follows:

As in other areas of this document, some lengthy titles have been abbreviated by the use of dot leaders to cover unnecessary verbiage.

The two digit number preceding the capital letter(s) represents the last two numbers of the year in which the project was assigned. For example, “52” represents “1952”, while “00” represents “2000”.

A: Aggregates:

36A-1: Chert Investigation.
36A-2: Investigation of LA Rattler.
36A-3: Soundness of Aggregates.
36A-4: Correlation of Round & Square Screens.
36A-5: Determination of Moisture Content by Core Method.
36A-6: Stabilized Gravel Investigation.
47A-7: Evaluation of Aggregate Sources.
47A-8: Material Surveys.
47A-9: Durability of Dolese-Shepard Surfacing Aggregate
49A-10: Study of Crusher Residue.
51A-11: Klumpp Aggregate Investigation.
51A-12: Wallace Stone Investigation.
51A-13: Survey of Bituminous Concrete .... France Stone.
51A-14: Survey of Bituminous Concrete .... Lincoln Stone.
52A-15: Heavy Media Separation Process for Gravel.
54A-16: Investigation of Bichler Brothers Gravel
54A-17: Use of Mine Rock and Stamp Sand in Concrete Pavements.
54A-18: Variation in Gradation of Aggregate Before and After Ship Loading.
59A-19: Performance Survey .... Big Cut Aggregate
60A-20: Open Hearth Slag.
63A-21: Evaluation of Aggregate Sources of Glacial Origin.
64A-22: Investigation of Limestone Coarse Aggregate from Waterville, Ohio
64A-23: Performance of Aggregate from Clarence Sweet Pit in Concrete Pavement.
64A-24: Investigation of Popouts in Slag Concrete M-39 over I-696.
67A-25: Aggregate Source Study .... Bayport Limestone.........
76A-26: Comparison of Lab Tests with Field Performance of Aggregates
86A-27: Freeze/Thaw Durability and Pore Characteristics of the Major Rock Constituents in Glacial Gravel.
90A-28: CRREL Rapid Method to Determine Freeze/Thaw Resistance of Aggregate.
90A-29: Petrographic Analysis of Aggregates.

Research Black Book File:

92A-30: Performance Evaluation of Concrete Pavement With Varying Aggregate Durability, SB US 23.
94A-31: Petrograhic Analysis for Washington Hydraulic Fracture Test Project.
97A-32: Freeze/Thaw Durability Testing for 4AA Acceptance.

B: Cement and Concrete:

36B-1: Concrete Proportioning and Grading.
39B-11: Concrete Durability Studies.
46B-20: Investigation of Slag in Concrete.
55B-31: Study of Freeze/Thaw Methods for Testing Durability of Concrete and Concrete Aggregates.
62B-65: Service Record of Killins Sand in Structures.
66B-79: Performance of Limestone Coarse Aggregate in Bridge Deck Construction.
78B-99: Recycling of Concrete Pavement.
84B-101: Laboratory Testing to Determining Strength of Various Recycled Concrete Mixtures.
92B-105: Construction and Performance Monitoring of European Concrete Pavement Design, I 75.
94B-107: Lab Work for SPR Project “Physical & Mechanical Properties of Recycled Portland Cement Concrete Aggregate Concrete.

C: Bituminous Materials:

36C-1(4): Condition Survey-Oil Aggregates.
71C-13: Study of Aggregate and Mix Requirements for Durable and Skid Resistant Bituminous Concrete.
77C-18: Evaluation of Performance of Bituminous Wearing Course Concrete Arenaceous Limestone.
84C-20: Use of Steel Furnace Slag as Aggregate for Bituminous Mixes.

D: Bituminous Mixtures:

36D-2: Report of 1936 Oil Aggregate Program.
36D-4: Oil Aggregate Inspectors Manual.
36D-5: Specification Changes for Oil Aggregate.
36D-6: Oil Aggregate Field Control Tests.
36D-7: Investigation of Mineral Filters.
46D-13(1): Bituminous Concrete verses Oil Aggregate Capping.
50D-17: Oil Aggregate Failure.
55D-22: Experimental Slag Bituminous Concrete Resurfacing.
58D-23: Fine Aggregate Bituminous Experimental Project.
73D-28: Experimental Evaluation of Wet Bottom Slag for Bituminous Shoulders.
81D-41: Foamed Asphalt Sand Stabilization.
82D-42: Effects Coarse Aggregate Have on Durability of Bituminous Mixes.
82D-43: Predicting Bituminous Mix Stability by Fine Aggregate Angularity.
84D-47: Experimental Fly Ash Base Course Mixtures.
86D-54: Shear Strength and Stability of Dense Graded Bituminous Mixes.

95D-61: Test Method to Determine the Existence of Segregation in Bituminous Mixtures.

E: Soil Mechanics:

68E-43: Feasibility Of Open Hearth Slag for Bases.

F: Structural Mechanics:

73F-136: Experimental Short Slab Pavements, etc.
83F-162: Performance Evaluation of Concrete Pavement Overlays.
90F-168: Performance Evaluation of Concrete Pavement Overlays to Reduce Reflective Cracking.
92F-171: Factors Affecting Transverse Crack Deterioration in JRCP.
93F-172: Evaluation of Pavement Foundation Drainage Features.
95F-174: Causes of Distress in JRCP on OGDC.

G: Miscellaneous:

52G-63: Foundry Sand as an Abrasive for Ice Control.
54G-74: Survey of Friction Properties of MDOT Pavement Surfaces.
72G-191: Quality Control (QC) for Aggregate Gradation.
74G-210: Bituminous Aggregate Resurfacing with High Shale Content Aggregates.
76G-222: Statistical Analysis of Aggregate Base Course Inspected by End Result Aggregate Specifications.
80G-249: Acceptance Sampling Plans Assuming the Percentage of In-Place 22A Aggregate within the Specification Limits.
85G-265: Pavement Management System.
88G-272: Strategic Highway Research Program (SHRP).
92G-279: Long Term Performance Evaluation of Rubblized Concrete Pavements.

TI: Technical Investigations:

70TI-17: Effects of Minus-200 in Asphalt Mixes.
71TI-26: Permeability Tests of Sub-base Supplemental Specifications.
72TI-90: Evaluation of 100% Crushed Aggregate from American Aggregates.
72TI-93: Relative Strength of 100% Crushed Aggregate (Green Oaks).
74TI-248: Salvaging Base Aggregate, M-28.
74TI-264: Use of Pea Gravel as Blending Material.
75TI-288: Use of Pea Gravel in Sidewalk.
75TI-300: Porous Pea Stone Concrete as Alternate to ATPB.
76TI-336: Correlation of Pavement Performance with Freeze/Thaw Durability of Coarse Aggregate.
77TI-387: Statistical Analysis of Bituminous Extraction Data.
77TI-413: Evaluation of Open Graded Asphalt Friction Course for Bishop Airport, Flint.
77TI-444: Statistical Analysis of Deval and LA Abrasion Tests for Wear Properties of Aggregates.

Research Black Book File:

77TI-445: Evaluation of Shattering Existing Concrete Pavement......... For Reducing Reflective Cracking.
78TI-454: Statistical Analysis of 1978 Bituminous Concrete Extraction Results.
78TI-468: Updating Research Project and Reports Book.
78TI-475: Unusually High Skid Coefficient for Concrete with Fine Aggregate from Pit 63-7.
78TI-483: Statistical Anal. of Aggregate Testing Methods: Mechanical verses Hand Shaking.
78TI-510: Petrographic Analysis for Other Sections in T & R.
79TI-578: Statistical Analysis of Aggregate Testing Procedure.
80TI-643: Degradation of Steel Furnace Slag as Base Course for Concrete Pavements.
80TI-678: Possible Infiltration of Sand Sub-bases into Overlaying OGDC.
80TI-705: Test of 21AA Gravel Materials for Open Graded Bases.
80TI-718: Experimental Use of 21AA for Shoulder Base, M-59....
82TI-788: Statistical Analysis of Aggregate Wear Index (AWI).
83TI-913: I-69 Sampling Plan for 22A Aggregate.
83TI-916: Investigation of Freeze/Thaw Durability for Aggregates in Bituminous Mixes in the UP.
84TI-985: Freeze/Thaw Estimation for Michigan.
85TI-1102: Performance Investigation of Bituminous Pavement with High Clay-Iron Stone Content.
87TI-1227: Requirements for Technical Services Investigation of Steel Furnace Slag as OGDC.
87TI-1237: Test for Calcium Carbonate Precipitate in Aggregate.
87TI-1240: Investigation of Recycled Concrete Fines Used as Base and Fill.
87TI-1260: Performance Evaluation of MI Limestone in PCC Pavements.
87TI-1276: Calcium Carbonate Precipitate from Crushed Concrete Open Graded 5G.
88TI-1304: Identification of PCC Pavements with Low Durability Aggregates.
88TI-1323: Freeze/Thaw Evaluation of Selected Rock Types from Composite Sample of Michigan Gravel.
88TI-1350: Elemental Analysis of Blast Furnace Slag.
89TI-1393: Evaluation of Aggregates for Base Course under Concrete Pavement.
90TI-1482: PCC Performance verses Aggregate Sources.
90TI-1513: Permeability Evaluation of OGDC Stabilization, I-75, Monroe County.
90TI-1521: Benchmark Aggregate Specific Gravity.
90TI-1528: Drainability Specification for Class II Granular Materials.
91TI-1543: Experimental Construction of Stone Mastic Asphalt Surfacing.
91TI-1568: Wear Track Evaluations.
91TI-1578: Development of Plans and Documentation for SHRP, SPS-2.
91TI-1583: Investigation of Cement Stab. OGDC’s.
92TI-1620: Investigation of Alkali-Silica Reactivity (ASR).
92TI-1656: Petrographic Analysis of European Concrete and Aggregates.

Research Black Book File:

94TI-1733: Freeze Thaw (F/T) Data Logger.
94TI-1736: Preliminary Mix Design for 40 HDP Concrete.
95TI-1747: Investigation of Low 28-Day Strength of PCC.
95TI-1757: Investigation of PCC Pavement Using Ground Granulated BF Slag (GGBFS).
96TI-1815: Evaluation of GGBFS Concrete Bridge Decks............

U: University Contracted:

0001: A Study of Materials-Related Distress (MRD) in Michigan's PCC Pavements (Phase2).
0004: Aggregate Absorption as Related to Anti-Icing for .... Bridge Deck Overlays.
0005: Development of Lab Performance Test Procedures and Trial Specifications for Hot Mix Asphalt.
0007: Evaluation of Dynamic Fracture Characteristics of Aggregate in PCC Pavements.
0008: Analysis of Bituminous Pavement Surface Characteristics and their Effects on Friction Properties.
0009: Identification Causes for Under-Performing Rubblized Concrete Projects. - Phase II.
0015: Freeze/Thaw Evaluation of Coarse Aggregates Using MDOT's Confined and Unconfined Methods.
0017: Investigation of Early Cracking on Selected JPCP Projects.
0042: Qualify Transverse Cracking in PCC Pavement from Loss of Slab-Base Contact.

Notes: "A, ...,G, TI" denote in-house research projects.
"R" denotes completed in-house research reports.
"U" denotes university contracted projects.
"RC" denotes completed university contracted project reports.

Research Reports:

In September, 1939, a new research Division was started. The documented Aggregate research reports or related areas that are available in the MDOT Materials & Technology Library are listed as follows:

Note that report titles that were considered too lengthy have been shortened by use of the use of "...................." to cover unnecessary verbiage.

Research & Testing Division (1934 - 1939): "OR" stands for "Office of Research".

<u>Binder OR 1-10:</u>

OR-1. Correlation of Round Screens to Square Sieves in Mechanical Analysis of Coarse Aggregate.

OR-2. Correlation of Round and Square Screens for Sieve Analysis.

OR-3. Vibrated Concrete Pavement.

OR-4. Investigation of a New Method for Determining the Moisture Content of Aggregates.

OR-5. Appendix III. Concrete Mix Design.

<u>Binder OR 11-23:</u>

OR-15. Circular Track Studies on Calcium Chloride Stabilized Road Mixtures.

OR-23. Investigation of Structural Failures in Concrete Pavement.

<u>Binder OR 24-34:</u>

(No Aggregate Related Reports.)

<u>Binder OR 35-39:</u>

OR-39. Wallace, Bay Port, Crushed Stone Service Behavior Investigation of Pavements.

Research Division (1939 - 1962): "P" stands for "Progress Report".

<u>Binder P 1-8:</u>

P-4. Instructions for Observations on Concrete Road Durability Study. (Freeze/Thaw testing)

<u>Binder P 9-20:</u>

P-19. Mechanical Analysis of Concrete by Dunagan Method.

<u>Book P 21-29:</u>

P-21. Preliminary Study to MI Test Road Durability Section.

P-23. An aggregate related report with no title given (or possibly the cover sheet is missing.)

P-24. Analysis of Manufactured Sand in Concrete Pavement on Degree and Intensity of Scale.

P-27. General Instructions & Codes for Concrete Pavement Scaling Study.

P-28. Inspectors Manual, Bituminous Sand Road-Mix Stabilization.

Research Reports:

P-29. Inspectors Manual, Soil Cement Stabilization.

Binder P 30-33:

P-30. The Action of Sodium Chloride and Calcium Chloride on Concrete and Constituents.

P-31. Instructions for Vibrated Concrete Pavement. (Contains Mix Design Examples, 1941)

P-33. Mortar Voids Method of Design of Concrete.

Binder P 34-44:

P-34. Grayling Soil-Cement Project.

P-35. Construction and Subsequent Studies of the Michigan Test Road Concrete Durability Project.

P-36. Inspection of Vibrated Concrete Pavement.

P-38. Experimental Soil-Cement Stabilization Near Stockbridge, MI.

P-39. Base Stabilization with Bit. Materials.

P-40. Vibrated Concrete Pavement Construction in MI.

P-43. Second Annual Durability Study of Michigan Test Road.

Binder P 45-65:

P-51. Concrete Durability Studies, Freeze/Thaw of Concrete Core Specimens, Michigan Test Road.

P-52. Freeze/Thaw of Concrete Field Specimens.

P-54. Supplemental Report on Sub-Grade Modulus Studies.

P-55. Other Concrete Scaling Studies.

P-56. Test Road Durability Study.

P-57. Effect of Air Entraining Agents on the Voids in Concrete.

P-58. Research in Air-Entraining Concrete.

P-60. Slag Production at BF Plant of Great Lakes Steel Corporation, Detroit. (Zug Island)

P-64. Effect of Haulage Upon Road Durability on Edsel Ford Expressway.

Binder P 66-87:

P-69. Abstract of Michigan's Study of Slipperiness of Stone Sand Concrete Pavement.

P-71. Control of Scaling of Portland Cement Concrete Pavements Resulting from Use of Chloride Salts.

P-73. Use of Portland-Natural Cement Blends and Pozzolith Admixture in Concrete Pavements.

P-79. Blast Furnace Slag. (Suitability as Coarse Aggregate in Structures, Mix Data included)

P-82. A Durable Concrete Road Slab.

Research Reports:

Bound Volumes: "R" stands for "Research".

1940:

R1. Research Activities of Michigan State Highway Department.
R3. Michigan Test Road.
R4. Investigation of Concrete Pavement in Michigan.

1941:

R8. Summary Michigan Test Road.
R11. Concrete Durability Studies.
R12. Construction of Michigan Test Road.
R14. Fundamental Principles and Factors Embodied in The Michigan Test Road.
R15. A Report on Manufactured Stone Sand and Its Use in Concrete Mixtures.
R18. Construction and Subsequent Studies of Concrete Durability Project - Michigan Test Road.
R19. The Library - Laboratory Approach.
R21. The Michigan Test Road.
R23. General Observations on Concrete Scaling.

1942:

R28. Summary of Research Projects.
R29. "Agrifil" as a Mineral Filler for Bituminous Mixtures.
R34. Limestone Dust in Mortar.
R39. Concrete Durability Study. (Grading of Aggregates, pages 533-537; Limestone Aggregates. pages 538-541)
R41. A Digest of The Michigan Test Road for American Concrete Institute.

1943:

R43. Research Activities 1939 - 1943.
R46. Design Recommendations for Industrial Express Highway.
R47. Determination of Young's Modulus of Frozen and Thawed Concrete Specimens by Sonic Method.

1944:

R51. The Research Laboratory.
R54. Air-Entrained Concrete. (Effects on mix designs, finishing, strengths, workability, durability)
R64. Pavement and Sub-grade Moisture - Michigan Test Road.

1945:

R75. Factors to be Considered in the Use of Air-Entrained Concrete for Highway Construction.

1946:

(No direct or indirect aggregate projects.)

Research Reports:

1947:

R93. Gradation and Consolidation of Porous Backfill.
R97. Abnormal Cracking and Settlement of Pavement Slabs........

1948:

R107. Consolidation of Porous Backfill.
R109. The Use and Treatment of Granular Backfill. (Specification included.)
R112. More Durable Concrete by Air - Entrainment.
R117. Slippery Condition of Stone Sand Concrete Pavement. (Supplement R143.)

1949:

R119. Improved Sonic Apparatus for Determining the Dynamic Modulus of Concrete Specimens.
R124. Relative Resistance to Thermal and Mechanical Shock of Various 26A Modified Aggregates.
R129. Longitudinal Cracking on F17-42, M28.
R132. The Michigan State Highway Research Lab., Facilities, Functions, and Activities.
R137. Michigan Test Road Design Project, Nine Year Progress Report.
R140. Progress Report on Design Project Michigan test Road.
R143. Skidding Accidents Occurring on Stone Sand Concrete Pavements.
R144. Experience with Air-Entraining Concrete in New Jersey.

1950:

R145. Curing Concrete Pavements with Membranes.
R149. Pavement Roughness Surveys.
R155. Michigan's Experience in the Use of White-Pigmented Membrane Curing Compound.
R156. Investigation of Concrete Pavement in Michigan Design Project - Michigan Test Road -10 Years.

1951:

R164. Vibrated Concrete in Michigan.

1952:

R169. Investigation of Slippery Conditions on US-2 Stone Sand Concrete Pavement.
R170. Wallace Stone Investigation, Part I.
R176. Investigations of Klumpp Aggregates.
R179. Lincoln Stone as a Material for Bituminous Concrete Resurfacing.
R180. Foundary Slag as an Abrasive for Icy Pavements.
R182. France Stone as a Material for Bituminous Concrete Resurfacing.
R184. Results of Skidding Tests on Stone Sand Concrete Pavements.

Research Reports:

R186. Condition Survey of Bituminous Concrete Projects Containing Wallace Stone.

1953:
R191. Wallace Stone Investigation Part III.
R195. Evaluation of Aggregate Sources. (Details on early Freeze/Thaw, including vacuum saturation procedures). Note that the 3 by 3 beams were too small in cross-section for the 1950 Standard Specifications Series 4 and 6 Gradations. (Even 6 by 6 in. beams are considered marginal by many researchers!)
R201. Wallace Stone Investigation Part II.
R202. Cracking Experience of Concrete Pavements Containing Slag Aggregate - 1953 Survey.

1954:
R208. Concrete Spalling on US-41 in UP. (Aggregate problem)
R222. Survey of Skid Resistance of Michigan State Highway Surfaces - Confidential.

1955:
R229. Investigation of the Influence of Soil Particles Passing the No. 200 Sieve on the Stabilization of Gravel.
R234. Investigation of Bichler Brothers Gravel.
R242. Abstracts from Michigan's Studies of Slipperiness of Concrete Pavements Constructed with Stone Sand as Fine Aggregate.

1956:
R253. Supplemental Progress Report on Experimental Slag Bituminous Concrete Project.
R266. Cracking of Slag Aggregate Concrete on Gratiot Ave.

1957:
R275. Sub-grade Embankment Soil: AASHO Road Test.

1958:
R283. Michigan's Skid Testing Program.
R294. Michigan's Skid Testing Equipment.
R295. Relative Skid Resistance of Pavement Surfaces based on Michigan's Experience.
R300. Determination of Cement Content of Pavement Concrete.

1959:
R302. Final Report - Design Project, Michigan Test Road.
R306. Performance of a 20 Year Old Section of US 27.
R314. An Experimental Continuously Reinforced Concrete Pavement in Michigan.
R317. Highway Research Program.

Research Reports:

1960:

R322. The Michigan Test Road Durability Project. (Air-Entrainment was the most important result. Used 3 by 6 by 15 rectangle specimens and 4D by 16 cylinders, and field prepared Freeze/Thaw beams).

R324. 1959 Summaries of Pavement Roughness.

R325. Roughness Measurements of Bridge Decks and Approaches.

R332. Deterioration of Concrete Highways and Bridges Containing Big Cut Aggregates.

R335. Cement Content of Pavement Concrete: US 12.

1961:

R356. Cracking of Slag Aggregate Concrete on Gratiot Ave.

R366. 1960 Summary of Pavement Roughness.

R367. Aggregate Source and Pop-out Frequency: I 94.

1962:

R375. Comparison of Stone Dust and Natural Soil Particles as Used for Fines Fraction of Aggregate Base Course Mixtures, First Progress Report.

R377. Influence of Minus 200 Fraction on Engineering Properties of Soil and Gravel.

R396R. Aggregate Source & Pop-out Frequency, I 94 from Stevensville to Marshall.

1963:

R408R Condition of the Stockbridge Soil-Cement project after 21 Years.

R423. Soil-Aggregate Cushions for Prevention of Reflective Cracking of Resurfaced Pavements - First Progress Report.

1964:

R447. Summary of Bituminous Concrete Skid Test Data relative to Materials. (aggregate effects)

R470. Soil-Aggregate Cushions for Prevention of Reflective Cracking of Resurfaced Pavements - Second Progress Report.

1965:

R507. Test Road Skidometer for 1964 Test Year.

R513. Performance of Aggregate from the Clarence Sweet Pit (3-65) in I 196.

R521. Skidproofing Treatments at South Cedar Street at Holmes and Baker in Lansing.

R523. Pavement Evaluation of I 94, CS 82022, Detroit.

R526. Summaries of Michigan Pavement Roughness, 1963-64 Test Program.

R535. Experimental Shoulder Stabilization on US 23 North of Alpena.

R539. Pavement Evaluation of I 94 CS 81041, 81062, 81063.

R541. US 127 Blowup South of Jackson.

Research Reports:

R545. Joint Blowup, I 94 East of US 127 Bypass, Jackson Co.
R558. Investigation of Limestone Coarse Aggregate from Waterville, Ohio Quarry, France Stone.

1966:
R571R. Evaluation of Stamp Sand as ......Sand Sub-base.
R572. Highway Quality Control Program: Statistical Parameters.
R596R. Degradation of Base Course Aggregates. (from acceptance to tested in-place on job).
R598. Base Course Stabilization with Asphalt Emulsion: US 131 S. of Cadillac.
R599R. Soil-Aggregate Cushions for Prevention of Reflective Cracking of Resurfaced Pavements: Third Progress Report.
R600. Evaluation of Speedy Moisture Tester.
R609. Procedure for Design of Continuously Reinforced Concrete Pavements.

1967:
R490. Determination of Air Content in Hardened Concrete by Gamma-Ray Transmission.
R624. Stabilization of Granular Base Materials with Rock Salt.
R649. Michigan Investigation of Soil Aggregate Cushions......
R658. Development of a One-Point Cone Test for Determining Maximum Density of Granular Materials.

1968:
R663. Evaluation of “Peneprime” as a Stablizing Agent for Aggregate Shoulders.
R671. Study of Frost Action in Class AA Shoulders Near Pontiac.
R684. Feasibility of Portland Cement Concrete Shoulder Construction.
R685. Stabilization of Base Course Aggregates with Rock Salt.

1969:
R711. Performance of Michigan’s Postwar Concrete Pavement.
R719. Prediction of Subjective Response to Road Roughness Using the GM-MDSH Rapid Travel Profilometer.
R723. Determination of Cement Content of Hardened Slag Concrete.

1970:
R731. Evaluation and Application Study of the GM Rapid Travel Profilometer.
R739. Evaluation of Open Hearth Slag as a Highway Base Material. (Do not use under pavements!)
R743. Pavement Joint Spacing in Portland Cement Concrete Pavements.
R746. Evaluation of Aggregate Sources of Glacial Origin.
R749. Evaluation of Quasi-Elastic Modulus of Granular Base Material.
R753. The Effect of Fines (P-200) on Bituminous Base Mixtures.

Research Reports:

1971:

R765. Design Recommendation for Continuously Reinforced Pavements (CRCP) in Michigan.

R769. Further Evaluation of Open Hearth Slag as a Highway Base Material.

R771. Report on Ten -Year Service of Experimental CRCP in Michigan.

R781. Permeability Characteristics of Various Sub-base Materials.

R792. Performance Evaluation of Mixed-in-Place Bituminous Stabilized Shoulder Gravel.

1972:

R805. A Method of Determining Sub-base Drainability.

R816. Effect of Temperature on Elastic Response of Asphalt - Treated Base Materials.

R817. Field Evaluation of Acid-Treated Open hearth Slag Base Course.

R835. Glacial Aggregate Evaluation in Kalamazoo Co. and Vicinity Michigan.

1973:

R884. Feasibility of Open Hearth Slag for Bases.

R893. Drainability Analysis of Samples ....District Soils Engineers.

R895. Faulting of Short Slab Concrete Pavements.

1974:

R898. Experimental Concrete and Bituminous Shoulders (Progress Report).

R905. General Evaluation of Current Concrete Pavement Performance in Michigan, ...

R914. An Investigation of the Definition of Frost Heave Textured Material.

R923. In-Place Stabilization of Soil-Aggregate Mixtures with Bituminous Materials.

R943. Experimental Concrete and Bituminous Shoulders.

1975:

R977. Design Binder Course Bituminous Concrete Pavement Mixtures.

1976:

R991. Sub-base Drainage Criteria.

R994. Accident Rates and Surface Properties................

R998. Petrographic Analysis of Coarse Aggregate: Superior S & G, 31-45.

R1000. Petrographic Analysis of Coarse Aggregate: Gogebic S & G, 27-55.

R1001. Development and Evaluation of a Field Drainability Test Method.

R1003. Petrographic Analysis of Coarse Aggregate: Wallace Stone, 32-4.

R1004. (Same title as R1003.)

R1006. Petrographic Analysis of Coarse Aggregate: Caspian Lumber # 2, 36-40.

R1007. Petrographic Analysis of Coarse Aggregate: Construction Aggregates, 70-9.

R1010. Petrographic Analysis of Coarse Aggregate: Lindberg, 22-69.

R1024. Aggregate Gradation Quality Control.

Research Reports:

R1025. Thickness Equivalencies for Asphalt-Treated and Untreated Aggregate Base Course Layers.

R1032. Petrographic Analysis of Coarse Aggregate: Gaspardo Pit, 31-65.

R1035. Experimental Concrete and Bituminous Shoulders (Progress Report).

R1036. Petrographic Analysis of Coarse Aggregate: Boyd Pit, 54-54.

1977:

R1038. Determination and Improvement of Relevant Pavement Skid Coefficients.

R1040. Statistical Analysis of Aggregate Base Course Inspection Using End Result Aggregate Specifications.

R1041. Drainage and Foundation Studies for an Experimental Short Slab Pavement.

R1044. Construction of a Cold-Mix Emulsion Black Base.

R1046. Comparison Study on the Performance of Bituminous Stabilized Bases (M66 & M20).

R1048. Evaluation of Cold-Mix Emulsion Black Base (M150 and Auburn Rd.).

R1049. Summaries of Michigan Pavement Skid Resistance, 1975 Test Program.

R1051. Mixed-in-Place Stabilization of Highway Base Aggregates and Pulverized Bituminous Surfaces Using Asphalt Stabilizers.

R1054. Petrographic Analysis of Coarse Aggregate: American Aggregates, Milford, 63-97.

R1055. Petrographic Analysis of Coarse Aggregate: Mickelson # 3, 63-88.

R1056. Petrographic Analysis of Coarse Aggregate: Wallace Stone, 32-4.

R1059. Petrographic Analysis of Coarse Aggregate: Emmons Pit, 54-22.

R1060. Petrographic Analysis of Coarse Aggregate: Glancy Pit, 62-3.

R1070. Petrographic Analysis of Coarse Aggregate: Marblehead Quarry, Marblehead, Ohio.

R1071. Petrographic Analysis of Coarse Aggregate: Pickett # 1, 34-26.

R1072. Study of Supplemental Drainage Methods for Preventing Frost Heave in Full Depth Concrete Shoulders.

1978:

R1080. Petrographic Analysis of Coarse Aggregate: Champion, Moon Lake Pit, 22-4.

R1081. Report on the Cause of Deterioration of Sections of Flexible I 94 Pavement.

R1083. Petrographic Analysis of Coarse Aggregate: Arthur # 2, 72-5.

R1084. Petrographic Analysis of Coarse Aggregate: Champion, Dishneau Pit, 52-1.

R1085. Summaries of Michigan Pavement Skid Resistance, 1976 Test Program.

R1086. Petrographic Analysis of Coarse Aggregate: US Forest Service Pit, 27-68.

R1088. Use of RAP in ..... a Bituminous Stabilized Base, I 75........

R1093. Petrographic Analysis of Coarse Aggregate: Paquin Gravel # 2, 21-19.

R1094. Statistical Analysis of Potential Relationships Between Selected Concrete and Aggregate Properties and Concrete Pavement Performance.

Research Reports:

R1098. MDOT Circular Wear Track - Results of Preliminary Aggregate Polishing Tests, First Progress Report.

<u>1979:</u>

R1107. Evaluation of Sodium Chloride for Stabilizing an Aggregate Base Course.
R1115. Performance Evaluation of Non-Reinforced Ramps.
R1119. Development of Base Layer Thickness Equivalency.
R1120. Continuously Reinforced Concrete (CRC) Pavement in Michigan, A Historical Summary.
R1124. Study to Evaluate the Performance of Bituminous Wearing Course Containing Sandy Limestone.
R1126. Investigation of Pavement Problems on I 275.
R1128. Investigation of Pavement Heaving on Bridge Approaches, I 275.
R1129. Evaluation of Sulfur-Asphalt Binder Bituminous Paving Mixtures, Progress Report.

<u>1980:</u>

R1132. MDOT Circular Wear Track - Results of Supplemental Aggregate Polishing Tests, Interim Progress Report.
R1133. Precessions of the Aggregate Sample Splitter and Testing Method.
R1134. Evaluation of Sprinkle Treatment for Improving Skid Resistance of Asphalt Surfaces.
R1136. Petrographic Analysis of Coarse Aggregate: County Road Commission # 3, 17-62.
R1143. Investigation of Pop-out Problems on M 14.
R1146. Blended Aggregates tested on the MDOT Circular Wear Track. (ADT Limits on aggregates.)
R1147. Evaluation of 22A gradation Open Hearth Slag as a Base and Sub-base Construction Material.
R1149. Petrographic Analysis and Insoluble Residue of Coarse Aggregate: Thorton Quarry, 21-67.
R1152. Base and Sub-base Properties Affecting Longitudinal Cracking of I 275.
R1156. Study of Cores for Potential Recycled Concrete Pavement.

<u>1981:</u>

R1158. The relationship of Aggregate Durability to Concrete Pavement Performance, and Associated Effects of Base Drainability.
R1159. Petrographic Analysis of Coarse Aggregate: Salem Gravel, 63-56.
R1160. Evaluation of Cold-Mix Emulsion Black Base at the Secondary Complex (Final Report).
R1169. Jointed Concrete Pavements - Design, Performance and Repair.
R1171. Concrete Pavement Performance Problems and Foundation Investigation of I 75, OH Line to Huron River.
R1172. Petrographic Analysis of Coarse Aggregate Extracted from Bituminous Cores, M 55.
R1174. Petrographic Analysis of Coarse Aggregate: Wallace Stone, 32-4.

Research Reports:

R1176. Petrographic Analysis of Crushed Stone Coarse Aggregate: Michigan Foundation, 82-6.

1982:

R1186. Petrographic Analysis of Crushed Stone Coarse Aggregate: Lindberg # 3, 52-9 plus County Road Commission, 52-67.

R1188. Degradation of Steel Furnace Slag as an Open Graded Base Course for Concrete Pavement.

R1189. Evaluation of Sulphlex as a Binder in Pavement Resurfacing Mixes, Progress Report.

R1190. Petrographic Analysis of Combined Crushed and Natural Gravel Coarse Aggregate: Glancy Pit, 60-29.

R1191. Early Cracking of a Bituminous Concrete Section of US 2.

R1192. Petrographic Analysis of Crushed Stone Coarse Aggregate: Gogebic Range Pit, 27-74.

R1194. Frost Heave Investigation of I 275.

R1195. Evaluation of Wet Bottom Slag Bituminous Wearing Course, I 94, Dearborn Heights.

R1203. Further Evaluation of Black Base and Aggregate Base Construction (M 20 and M 66).

R1206. Petrographic Analysis of Coarse Aggregate: Wallace Stone, 32-4.

R1207. Petrographic Analysis of Coarse Aggregate: Wallace Stone, 32-4.

1983:

R1208. Degradation of Acid-Treated and Untreated Steel Furnace Slag as an Open Graded Base Course for Concrete Pavement.

R1209. Use of RAP in ....Bituminous Stabilized Base, I 75.

R1210. Evaluation of the Straight Line Gradation Chart and Particle Index Test.

R1211. Infiltration of Sub-base Sand into OGDC Bases.

R1216. Investigation of Steel Furnace Slag OGDC Base on I 69.........

R1217. Benkelman Beam Testing of Shoulder and Pavement Recycling Projects.

R1218. In-Place 22A Aggregate Acceptance Sampling Procedures.

R1220. Evaluation of Sulfur-Asphalt Binder for Bituminous Resurfacing Mixtures.

R1223. Evaluation of Sprinkle Treatment for ....Asphalt Surfaces, Final Report.

R1225. An Analytical Survey Procedure for Flexible Pavements.

R1226. Stabilized Fly Ash as Lightweight Fill.

R1228. MDOT Circular Wear Track Results........................

R1232. An AWI Reduction Factor for Uncrushed Material in Gravel, Summary Report.

R1233. Load Carrying Capacity of I 75 Bituminous Shoulders in Flint Area.

R1234. Petrographic Analysis of Coarse Aggregate: Michigan Stone, 58-3.

1983-1984:

R1238. Comparison of Aggregate and Bituminous Treated Bases, I 75 South of Grayling.

Research Reports:

R1239. Evaluation of Suphlex as a Binder in Pavement Resurfacing Mixtures, Final Report.

R1240. Petrographic Analysis of Dense-Graded Gravel Aggregate: Butkovich # 2, 49-74.

R1240(1). Petrographic Analysis of Dense-Graded Gravel Aggregate: Garfield # 2, 49-104.

R1240(2). Petrographic Analysis of Dense-Graded Gravel Aggregate: Ozanich Pit, 49-97.

R1240(3). Petrographic Analysis of Dense-Graded Gravel Aggregate: Peters Pit, 49-23.

R1240(4). Petrographic Analysis of Dense-Graded Gravel Aggregate: DNR Pit, 49-101.

R1251. Field Trial of Foamed Asphalt Stabilization, Final Report.

R1254. Investigation of Low Stability Bituminous Base Course, US 131 Mecosta Co., Final Report.

1985:

R1257. Cost and Energy Considerations Involved in the Recycling of Portland Cement Concrete.

1986-1988:

R1271. Experimental Concrete and Bituminous Shoulders - Interim Report.

R1273. Polishing Resistance of Argenaceous Limestone from the Bayport Bedrock Formation.

R1276. ......Performance of Bituminous Wearing Course Containing Sandy Limestone - Final Report.

R1281. Evaluation of Lime, Fly Ash Base Course Mixtures - Construction Report.

R1286. Development of Test for Calcium Carbonate Precipitate in Aggregates.

R1293. Comparison of Cracked and Uncracked Flexible Pavements in MI - Final Report.

1989-1992:

R1297. Calcium Carbonate Precipitate from Crushed Concrete.

R1301. Freeze/Thaw Evaluation of Selected Rock Types from Composite Samples of Michigan Gravel.

R1303. Performance Evaluation of Concrete Pavement Overlays, Final Report.

R1305. Appendix B. Special Provision for Separation Course 9A.

R1306. Evaluation of MDOT Maintenance Division Seal Coat Projects - Final Report.

R1310. Evaluation of Lime, Fly Ash Base Course Mixtures - Final Report.

R1311. Freeze/Thaw Durability and Pore Characteristics of the Major Rock Constituents in Glacial Gravel.

R1312. Fine Aggregate Tested on the MDOT Circular Wear Track.

Research Reports:

Single Reports:

1994:

R1333. Construction of European Concrete Pavement on NB I 75, Detroit.

1995:

R1332. Investigation of Air Content of Plastic verses Hardened Concrete.

R1338. First Year Performance of European Concrete Pavement on NB I 75, Detroit.

1996:

R1343. Second Year Performance of European Concrete Pavement on NB I 75, Detroit.

RC1345. Adoption of a Rapid Test for Determining Aggregate Durability in Portland Cement Concrete.

1997:

RC1363. Test Method to Determine the Existence of Segregation in Bituminous Mixtures.

1998:

RC1399. Concrete Mix Design Process Manual (completed in 1998 and inadvertently not numbered until 2001).

RC1401. Investigation of Transverse Cracking on Michigan Portland Cement Concrete Pavements over Open-Graded Drainage Courses (Separate Report containing appendices, completed and numbered in 2001).

2000:

RC1381. Cost Effectiveness of European Demonstration Project: I-75 Detroit.

RC1387. White-topping Project on M-46 between Carsonville and Port Sanilac.

2001:

RR1390. Inspection of Pavement Problems on I-275 and I-75 from Ohio Line Northerly to Huron River.

Microfilm Files:

There are two microfilm storage locations in the C & T Building, namely:

Storage Area 1:

A set of 93 rolls, numbered from 100 - 192 are located in the shelving units behind the Research Conference Room between Rooms 105 and 106. This set of films contains the closed projects assigned in the Research Lab, commonly known as the "Black Book" projects. This set of films contains aggregate related assignments in addition to many other types of research projects.

Storage Area 2:

A second set of films, which are construction project related containing much more detail than just aggregate materials, are housed in the "Microfilm Reader Room" inside Room 118. This set of 1828 film rolls (numbered from 1 - 156 and 501 - 2172) is much more extensive and utilizes a 3 by 5 paper card system to locate the proper roll to be viewed. There are two Reader/Printer machines (Cannon Microprinter 90 plus an older 3M Reader Printer) to view these rolls.

It is unclear if the roll numbers 157 - 500 were ever used and are located elsewhere or never used. Viewing the contents of all these microfilm rolls in the two sets is far beyond the scope of either Phase 1 or Phase 2, however, the younger research staff should make use of this older, yet valuable, work, if interested in future research. The condition of this second set of microfilms is unclear, but are suspect due to the fact that rolls 1080 - 1098 are marked as being dark. Preliminary viewing of several of these dark reels confirms that at least some, possibly all, are hard to read. Whether or not this condition can be improved has not been determined at this point in time.

Mates and **Eye On Research** **Publications:**

The following **Mates** issues, located in Room 118 at the C & T Laboratory, number and title, provide valuable background information to the general reader looking for an overview of various aggregate related topics:

Issue No.	Title
2	The ABC's of Hot Mix Asphalt - Part I.
4	ABC's of Hot Mix Asphalt - Part II: Marshall Mix Design.
5	Notes on Concrete Recycling and Associated Specification Changes.
6	Why Add Chemicals to Concrete?
	ABC's of Hot Mix Asphalt - Part III: Bituminous Plants.
7	D-Cracking of Concrete Pavements.
8	The Beginning of The End.
10	High Friction Bituminous Pavement Surfaces Through Application of MDOT's Aggregate Wear Index (AWI).
14	Joint Faulting in Concrete Pavements.
15	Drainage - The Solution to the Three Problems Critical to Pavement Performance.
	A Cooperative Search for a Better Bituminous Pavement.
18	Compaction - The Only Way to Quality Asphalt Pavements.
19	Concrete Recycling.
21	Flexible pavement Distress - Part I.
23	The Origin of Natural Gravel Deposits and The Effect of Crushed Particles on Aggregate Stability.
24	D -Cracking Pavements.
29	Premature Rutting can be Prevented.
30	Gradation and Segregation of Bituminous Aggregates.
32	Concrete Pavement Cracking and Seating.
33	Rubblizing.
34	Concrete Pavement Repairs.
37	The Thumper is Here.
38	Tear it Up or Cover it Up? (Concrete Overlays).
39	Bird-watchers and Asphalt Pavers Unite!
40	Here Today, Gone Tomorrow: The Case of the Vanishing Resources.
43	Permeability of Concrete.
44	Why All the Fuss Over Aggregates.
57	What's New in Flexible Pavement Research?
	Jointed PCC Pavements: Michigan's Experience.
60	Concrete Pavement Repair Update.
63	Stone Mastic Asphalt.
64	Everything You Ever Wanted To Know About Specifications.... But Were Afraid to Ask.
66	Development of MDOT's Freeze-Thaw Testing of Coarse Aggregates in Concrete.

Mates and **Eye On Research** Publications:

70	Aggregate Durability and The Performance of PCC Pavements. Our Mission to Improve Quality and Provide Longer Lasting Pavements.
71	European Pavement Inspection Tour.
76	Paving The Way to Success: Cooperation Leads to Pavement Research Center.
77	Cracking Up: Rapid Deterioration of Transverse Cracks in Recycled Concrete Aggregate Pavements.
81	Evaluating Pavement Patching Materials.
86	Mechanistic Design for Flexible Pavement and Overlays.
91	Restoring Portland Cement Concrete.

The following **Eye On Research** Articles pertaining to Aggregates are as follows:
January 15, 1997: In The Beginning.

April 11, 1997: Open-Graded Bases - Under Debate Again.

June 6, 1997: Pavement Durability.... is Large Coarse Aggregate the Answer?

September 12, 1997: Research Report RC-1345 Adoption of a Rapid Test for Determining Aggregate Durability in Portland Cement Concrete.

Aggregate Acceptance Criteria Committee (AACC) Notes:

The set of AACC minutes is presently located in one of the file cabinets in Room 123 outside Al Robords' office. These minutes contain the discussions relative to many of the aggregate specification changes over the years, who requested or suggested the changes, who decided to make or reject the changes and when they were placed in effect. Included are modifications, additions and deletions. Following each meeting date, a list of topics discussed during each meeting is included.

Note: Several abbreviations were used to shorten the phrase on each line. Examples include: "**SP**" for Special Provision; "**SS**" for Supplemental Specification; "**F/T**" for Freeze/Thaw; "**OG**" for Open Graded; "**OGDC**" for Open Graded Drainage Course; "**AWI**" for Aggregate Wear Index; "**PCC**" for Portland cement concrete; "**CA**" for coarse aggregate; "**FA**" for fine aggregate.

Meeting Dates:

01/12/76: The AACC was started on this date by several T & R Division Staff for the purpose of dealing with aggregate issues. Original members included: M. G. Brown, G. H. Gallup and R. H. Vogler. Minutes were taken by RHV.

02/24/76: This meeting was held to select a name and discuss goals, however, no copy of these minutes could be found in the files.

10/21/77: The AACC was expanded during the second year of its existence by the addition of four new members, namely: D. F. Malott, L. T. Oehler, J. W. Burge, and M. E. Witteveen. Minutes by JWB.

Calibration of new F/T Cabinet:
Freeze/Thaw (F/T) Testing of Discrete Particles (T-103):
Wear Track Policy:
Background Aggregate Source Data:
Analysis of Existing and Future Test Data:
Aggregate Source Test data:
PCC coarse aggregate (CA):
Bituminous Concrete CA:
Dense Graded Aggregates (20AA, 20A, 20B):
Dense Graded Aggregates (everything else):
Fine aggregate (FA):

05/16/78: Minutes by JWB.

New F/T Machine:
T-103 Test:
Wear Track:
Background Aggregate Source Data:
Analysis of test data:
Aggregate Source data:
Dilation measurement of beams:

F/T and Petrographics:
Insoluble Residue Procedure:
Crushed Content - Stability, etc:
Aggregate Quality Related to Pavement Performance:
LA Abrasion Requirements for Slag:
Sulfate Soundness Test:

06/20/78: Minutes by JWB.
New F/T Machine:
T-103 Test:
Wear Track:
Background Aggregate Source data:
Analysis of Test data:
Aggregate Source Data:
Aggregate Source Inventory:
Dilation Measurement of Beams:
Staffing Problems - F/T and Petrograhics:
Insoluble Residue Procedure:
Crushed Content verses Stability, etc:
Aggregate Quality Related to Pavement Performance:

09/07/78: Minutes by JWB.
Lansing/AnnArbor F/T Machine Comparison:
T-103 Test:
Wear Track:
Background Aggregate Source Data:
Analysis of Test Data:
Aggregate Source Inventory:
Dilation Measurement of Beams:
Staffing Problems - F/T and Petrographics:
Insoluble Residue Procedure:
Crushed Content verses Stability Study:
Test Procedures:
21 Series Aggregate:
Aggregate Schools:
Sacrificial Surfaces:
Two Peter Hudac Papers:

11/07/78: Minutes by JWB.
Written F/T Procedure:
T-103 Test:
Wear Track:
Background Aggregate Source Data:
Analysis of Test Data:
Aggregate Source Inventory:

Dilation Measurement of Beams:
Staffing Problems - F/T and Petrograhics:
Insoluble Residue Procedure:
Crushed Content verses Stability:
Test Procedure - Petrographic Analysis, Adsorption, Absorption:
21 Series Aggregate:
Aggregate Training Schools:
Sacrificial Surfaces:

01/10/79: Minutes by JWB.
F/T Machine:
T-103 Test:
Wear Track Report R-1098:
Wear Track Committee:
Background Aggregate Source Data Form:
Analysis of Test Data:
Agg. Source Inventory:
Staffing Problems - F/T and Petrograhics:
Insoluble Residue Procedure:
Crushed Content verses Stability:
Test Procedure - Petrographic Analysis, Adsorption, Absorption:
21 Series Aggregate:
Aggregate Training Schools:
Sacrificial Surfaces:
LA and Deval Abrasion on Dense Graded Material:

03/15/79: Minutes by JWB.
Analysis of Test Data:
Crushed Content verses Stability:
Void Content in FA:
F/T Results:
T-103:
Wear Track Report R-1098:
Wear Track Committee:
Background Aggregate Source Data Form:
Aggregate Source Inventory:
Staffing Problems - F/T and Petrograhics:
Test Procedure - Petrographic Analysis, Adsorption, Absorption:
21 Series Aggregate:
Aggregate Training Schools:
Sacrificial Surfaces:
Deval and LA Abrasion Sample Size:
Physical Requirements - End Result Specifications:
Gradation for F/T Testing:
74G-210, Bituminous Aggregate Resurfacing With High Shale Content:

Aggregate Acceptance Criteria Committee (AACC) Notes:

05/10/79: Minutes by GHGallup.
F/T Durability Testing:
Crushed Content verses Stability:
Void Content in FA:
F/T Dilation Measurements:
Wear Track Report R-1098:
Wear Track Committee:
Aggregate Source Data Form:
Test Procedure - Petrographic Analysis:
Deval and LA Abrasion Sample Size:
Gradation for F/T Testing:

07/12/79: Minutes by GHGallup.
F/T Durability Testing:
Crushed Content verses Stability:
Void Content in FA:
F/T Dilation Measurements:
Wear Track Report R-1098:
Test Procedure - Petrographic Analysis:
F/T testing - Mix Design Change:
Wear Track:

11/08/79: Minutes by JWB.
Bituminous FA Study:
M-37 Problem:
Clay in High Stability 4.11 Modified Mixes:
Selection of F/T Durability Samples:
Sulfate Soundness Test:
Alkali-Carbonate Rock Reaction:
Precision of Aggregate Testing Methods:
Wear Track:
Comparison F/T Testing (with other states):
F/T Machine:

01/08/80: Minutes by JWB. (G. Grove’s first mtg.)
Bit. FA Study:
M-37 Problem:
Clay in High Stability 4.11 Modified Mixes:
Selection of F/T Durability Samples:
Alkali-Carbonate Rock Reaction:
Precision of Aggregate Testing Methods:
Wear Track:
Comparison F/T Testing:
F/T Machine:
Alkali Reactive Aggregates:

Aggregate Acceptance Criteria Committee (AACC) Notes:

Restricted Chert Content:
Mechanical Loss by Washing Machine:
Maximum Size of Concrete CA:
Jim Mitchell Crushed Content Method:
Sacrificial Surfaces:

03/18/80: Minutes by JWB.
Bituminous Samples on Wear Track:
F/T Machine:
Alkali- Reactive Aggregate:
Restricted Chert Content:
Mechanical Loss by Washing Machine:
Maximum Size of CA:
Sacrificial Surfaces:
Wear Track Results:
Aggregate Source Inventory:

05/23/80: Minutes by JWB.
Blending Specification:
Specification for Skid Resistant Blends:
Mechanics for Approving Proposed Blends:
Wear Track:
F/T Machine:
Restricted Chert Content:
Mechanical Loss by Washing Procedure:
F/T Evaluation, Max. Top Size CA:
Aggregate Source Inventory:
Wayne Co. Rd. Commission (WCRC) Limestone Problem:
Future Statistics Research:

07/29/80: Minutes by JWB.
Pre-Blending Procedure:
Specification for Skid Resistant Blends:
Research Lab Blend Evaluation Procedure:
Wear Track:
F/T Machine:
Restricted Chert Content:
Mechanical Loss by Washing Procedure:
WCRC Limestone Problem:
Need for New Petrographer:
Indiana #11 - Michigan 25A:
20AA Gradation:
Abrasion Samples:
Relation Between <u>Friction Value</u> and <u>% Loss</u>:
Small Independent Assurance Samples:

Aggregate Acceptance Criteria Committee (AACC) Notes:

09/23/80: Minutes by JWB.

20AA Gradation:
Abrasion Samples:
Specification for Skid Resistant Blends:
Research Lab Blend Evaluation Procedure:
Wear Track:
F/T Machine:
Absorption - Adsorption Test:
Restricted Chert Content:
Mechanical Loss by Washing Procedure:
WCRC Limestone Restriction:
New Petrographic Position:
Procedure for Testing Aggregate contaminated with Bituminous:
Zilwaulkee F/T Beams:

11/13/80: Minutes by JWB.

20AA Gradation:
Abrasion Samples:
Spec. for Skid Resistant Blends:
Research Lab Blend Evaluation Procedure:
Wear Track:
F/T Machine:
Absorption - Adsorption Test:
Restricted Chert Content:
New Petrographic Person:
Procedure for Testing Aggregate contaminated with Bituminous:
White Pine Slag:
Special Provision for Bituminous Wearing Course:
Marblehead Stone:
Ed Novaks Drainability Test:
Particle Index Test - % Crushed Required for OGDC:
Gravel Pit Inventory:
21AA Material:

01/13/81: Minutes by JWB.

20AA Gradation:
Abrasion Samples:
Research Lab Blend Evaluation Procedure:
Wear Track:
F/T Machine:
Absorption - Adsorption Test:
Restricted Chert Content:
New Petrographer needed:
Procedure for Testing Aggregate contaminated with Bituminous:
White Pine Slag Study:

Ed Novak's Drainability Test:
Particle Index Test:
21AA Material:
Merit of different aggregate specifications for structures:
Novak's Proposed OGDC Changes:
Iowa Pore Index Test:

03/17/81: Minutes by JWB. Only two special items covered:
OGDC:
Research Report R-1158:

04/01/81: Minutes by GHGallup.
OGDC:
Research Report. R-1158:
20AA Gradation:
Abrasion Samples:
Research Lab Blend Evaluation Procedure:
Wear Track:
F/T Machine:
Absorption - Adsorption Test:
Restricted Chert Content:
White Pine Slag:
Ed Novak's Drainability Study:
Particle Index Test:
Merit of different aggregate specifications for structures:
Iowa Pore Index Test:
Aggregate evaluation - Pit 82-6:
LA Abrasion Modifications:

05/19/81: Minutes by DFM.
OGDC:
Research Report. R-1158:
Dense Graded Bituminous Aggregate:
Abrasion Samples:
Wear Track:
Research Lab Blend Evaluation Procedure:
F/T Machine:
Absorption - Adsorption Test:
Restricted Chert Content:
White Pine Slag:
Ed Novak's Drainability Study:
Particle Index Test:
Merit of different aggregate specifications for structures:
Iowa Pore Index Test:
Aggregate Evaluation - Pit 82-6:
Durability Testing:

Aggregate Acceptance Criteria Committee (AACC) Notes:

LA Abrasion Modifications:

07/21/81: Minutes by GHGallup.
OGDC:
Dense Graded Bituminous Aggregate:
Abrasion Samples:
Wear Track:
Determination of AWI:
F/T Machine:
Absorption - Adsorption Test:
Restricted Chert Content:
Ed Novak's Drainability Study:
Particle Index Test:
Merit of Different Aggregate Specifications for Structures:
Iowa Pore Index Test:
Adsorption Cabinet:
Aggregate Evaluation, Pit 82-6:
Durability Testing:
LA Abrasion Modification:

09/22/81: Scheduled but no minutes in file.

10/07/81: Minutes by GHGallup.
OGDC:
Dense Graded Bituminous Aggregate:
Wear Track:
Determination of AWI:
F/T Machine:
Absorption -Adsorption Test:
Ed Novak's Drainability Study:
Particle Index Test:
Merit of Different Aggregate Specifications for Structures:
Iowa Pore Index Test:
Adsorption Cabinet:
Aggregate evaluation, Pit 82-6:
Durability Testing:
LA Abrasion Modification:

12/16/81: Minutes by DFM.
OGDC:
Dense Graded Bituminous Aggregate:
Wear Track Update:
Wear Track Passes:
F/ T Update:
Adsorption - Absorption Test:
Drainability Study:

Particle Index Test:
Merit of Different Aggregate Specifications for Structures:
Iowa Pore Index Test:
Adsorption Test:
Durability Testing:
LA Abrasion Modification:
Assignment - Petrographer:
Foreign Material in Crushed Concrete:
Argenacious Limestone Study:

02/09/82: Minutes by JWB.
OGDC:
Dense Graded Bituminous Aggregate:
Wear Track Update:
Wear Track Passes:
F/T Testing Update:
Adsorption - Absorption Test:
OG Base Drainability Study:
Particle Index Test:
Merit of Different Aggregate Specifications for Structures:
Iowa Pore Index Test:
Absorption Test:
LA Abrasion Modification:
ASTM Revision to C-666:
Foreign Material in Crushed Concrete:
Steel Furnace Slag Blends:
Stone Sand in Bituminous Mixes:

03/17/82: Minutes by JWB.
Dense Graded Bituminous Aggregate:
AWI - Addendum Change:
AWI - Adjusted Computed Values and Pit Variation:
AWI Variation Within Sources:
Use of Limestone Fines in Bituminous Wearing Course:
Steel Furnace Slag Blends:
Sprinkle Treatment:
Vacuum Saturation verses 24 Hour Soak F/T Test:
Wear Track Update:
F/T Machine:
Crushed Concrete Specification:

04/21/82: Minutes by JWB.
Crushed Concrete Specifications:
Revised Designations for CA and Dense Graded Aggregate:
R-1168 Degradation of Steel Furnace Slag as OG Base Course for Concrete Pavement:

Polishing Aggregate in Recycled Mixes:
AWI Testing Problems:
MMRA 04/22/82 Meeting:
1984 Concrete Aggregate Specifications:
Use of Limestone Fines in Bituminous Wearing Course:
AWI Variation Between Sources:
F/T Durability, Vacuum Saturation verses 24 Hour Soak:
F/T Machine:

06/2/82: Minutes by JWB.
Crushed Concrete Specifications:
Revised Designation for CA and Dense Graded Aggregate:
R- 1168 Steel Furnace Slag as Open Graded Base for Concrete Pavement:
Polishing Aggregate in Recycled Mixes:
Use of Limestone Fines in Bituminous Wearing Course:
AWI Variation Between Sources:
F/T Machine:
AWI Samples:
Draft - Evaluation of Straight Line Gradation Chart and Particle Index:

08/3/82: Minutes by JWB.
Use of Limestone Fines in Bit. Wearing Course:
AWI Variation Between Sources:
F/T Machine:
AWI Samples:
Draft - Evaluation of Straight Line Gradation Chart and Particle Index:
R-1168 Steel Furnace Slag as Open Graded Base for Concrete Pavement:
Relationship Between % Crushed and AWI:
Minimum AWI Number:
Iowa Pore Index Test on Crushed Concrete:
F/T Data - Groveland Pit:

10/5/82: Minutes by JWB.
Use of Limestone Fines in Bit. Wearing Courses:
F/T Machine:
Draft - Evaluation of Straight Line Gradation Chart and Particle Index:
R-1168 Steel Furnace Slag as Open Graded Base for Concrete Pavement:
Relationship Bet. % Crushed and AWI:
Minimum AWI Number:
Iowa Pore Index Test:
Moisture Condition of CA Samples:
F/T Durability Factor Spec Changes:
1984 Aggregate Specifications:

01/19/83: Minutes by JWB.
Research Report: In-Place 22A acceptance sampling procedure:

OGDC Specification:
I-696 Arch. Concrete:
I-696 Premium Concrete:
F/T Cabinet:
Aggregate Moisture Study:

03/15/83: Minutes by JWB.
Wear Track:
F/T Machine:
Creep testing:
In-Place Drainability Testing - OGDC:
Department Position - Durability Requirements for Concrete Aggregate:
Blending Steel Furnace and Blast Furnace Slag to Make OGDC:
Concrete Durability Studies:
US-2 Bituminous Aggregate:

05/17/83: Minutes by JWB.
Wear Track:
F/T Machine:
26A Gradation:
Ed Novak's Suggested Revisions to OGDC:
EOC Request- Evaluation of Straight Line Gradation Report:
Abrasion Testing - Stability Mixes:
F/T Questionnaire:
UP Bituminous Aggregate Problem:
Michigan Foundation Quarry:

07/20/83: Minutes by JWB.
AWI:
F/T Machine:
Straight Line Gradation Chart:
Abrasion Testing:
F/T Questionnaire:
UP Bituminous Aggregate Problem:
Use of Slag in OGDC:
Pea Stone as Concrete Aggregate for Shoulders:
Soft Stone Requirement for 20 Series Material:

09/20/83: Minutes by JWB.
MMRA and MAPA Agenda Items:
MMRA Item - 1984 Aggregate Specification Changes:
F/T Machine:
Straight Line Gradation Chart:
Abrasion Testing:
F/T Questionnaire:
UP Bituminous Aggregate Problem:

Aggregate Acceptance Criteria Committee (AACC) Notes:

Pea Stone as Concrete Aggregate:
Soft Stone Requirement for 20 Series Wearing Courses:

09/28/83: Minutes by JWB.
AWI:
Iowa Pore Index Test:
Pea Stone:
F/T Machine:
OGDC:

11/08/83: Minutes by JWB.
Status of AWI Implementation:
Draft Procedure - Sampling Bituminous Aggregate:
Crushed Concrete:
Lodge Concrete Recycling Project:
F/T Questionnaire:
F/T Machine:
Pea Stone Project:
Iowa Pore Index test:
Michigan Stone Pit:

01/12/84: Minutes by JWB.
Status of AWI Implementation:
Lab Aggregate Handling Procedure:
F/T Machine:
Michigan Stone Pit:
Straight Line Gradation Chart:

03/15/84: Minutes by JWB.
Status of AWI Implementation:
Sprinkle Treatment:
Agg. Handling Procedures:
F/T Machine:
F/T Tests, Rockwood, Pit 58-8:
Michigan Stone, Pit 58-3:
Straight Line Gradation Chart:
Recycled Concrete Chloride Content:
F/T Testing Procedure:
Bituminous Aggregates:
Recycled Concrete Coarse Aggregate:

05/9/84: Minutes by JWB.
F/T Machine:
AWI Implementation:
Aggregate Source Inventory:
Clay Ironstone:

Straight Line Gradation Chart:
8G OGDC Material:
In Lab Flow of Aggregate Samples:
Ajax Soft Stone Problem:
Blending of Sandstone to Improve AWI:
Recycled Concrete Aggregate Chloride Data:

06/5/84: Minutes by JWB. F/T questionnaire responses from 10/83 documented by RHV.

American Aggregates Letter and Bowser-Mourner Report:
Summary of F/T Questionnaire Responses:
Evaluation of Carbonate Rock Types:
Pre-stressed Concrete Aggregate Specifications:
Certification of Aggregates:
AWI Testing:
Straight Line Gradation Chart:

07/31/84: Minutes by JWB.

Aggregate Source Inventory:
Evaluation of Carbonate Rock Types:
Pre-stressed Concrete Aggregate Specifications:
Crushed Requirements for OGDC:
F/T Testing:
Unconfined F/T Testing:

10/2/84: Minutes by JWB.

Aggregate Specifications for Pre-stressed Concrete:
OGDC Specifications:
Sprinkle Treatment:
Significance of Specification Limits:
Stockpiling Recycled Concrete CA:
Unconfined F/T Testing:
Deleterious Materials-Dense Graded Aggregate:
Specification Conflicts:
Percent Crushed-Stability Mixes:

12/4/84: Minutes by JWB.

Aggregate Specifications for Pre-stressed Concrete:
F/T Cabinet:
Unconfined F/T Testing:
Soft Stone Test Procedure:
Use of Pea Stone as PCC Aggregate:
SS for Open Graded Under-drain:
Review of Specification Provisions by Industry:
SS - Sprinkle Treatment:
F/T Durability, Hersey Pit:

Aggregate Acceptance Criteria Committee (AACC) Notes:

AWI Update:

02/08/85: Minutes by JWB.

US Steel Fines Study:
AWI Status:
Aggregate Specification for Pre-stressed Concrete:
F/T Cabinet:
Unconfined F/T Testing:
Soft Stone Test Procedure:
Use of Pea Stone as PCC Aggregate:
SS for OGDC:
Review of Special Provisions by Industry:
SS for Sprinkle Treatment:
F/T Durability - Hersey Pit:
AWI Update:
AWI for Crushed Concrete:
Assignment of Pit Numbers:
Consultant AWI Testing:

04/16/85: 06/18/85 minutes indicate 04/16 meeting was held, but no minutes in file. Agenda indicated need for new chairman. Minutes by JWB.

Clare Test Rd:
AWI Status:
Unconfined Aggregate F/T Testing:
Soft Stone Test Procedure:
Use of Pea Stone as PCC Aggregate:
SS for OG Underdrain:
SS for Sprinkle Treatment:
Consultant AWI Testing:
F/T Durability Testing Problems:

- Variability of Test Beams: Outlier Test Example attached.
- Air Content in the F/T Tests:
- F/T Durability Test Procedure, in General:

Hersey Pit Durability:
MMRA Meeting Agenda:
New Chairman: D. Malott selected G. Gallup as new Chairman.
Lab Aggregate Handling Procedure:
LA Abrasion Machine:

06/18/85: Minutes by GHGallup.

Unconfined Aggregate F/T Testing:
Soft Stone Test Procedure:
Use of Pea Stone as PCC Aggregate:
Consultant AWI Testing:
F/T Durability Testing Procedure:
New F/T Machine:

Aggregate Acceptance Criteria Committee (AACC) Notes:

Lab Aggregate Handling Procedure:
Amount of Testing for Aggregate Producers:
Test FA for Potential Alkali Reactivity:
Modified Abrasion Test - LA or Deval:
Local Service Aggregate Test Requirements:
Particle Index Test:
Certified Aggregate Suppliers:
Sources with MDOT Imposed Restrictions:
Light Weight Fill - Holloway Construction:
Aggregate Source Inventory:

08/20/85: Minutes by Gallup.
Unconfined Aggregate F/T Field Survey:
Use of Pea stone as PCC Aggregate:
Consultant AWI Testing:
F/T Durability Testing Procedure:
New F/T Machine:
Lab. Aggregate Handling Procedure:
Particle Index Test:
Cert. Aggregate Samples:
Light Weight Fill - Holloway Construction:
Aggregate Source Inventory:
SS for AWI:
SS for Under-drains:
ID of Quarried Carbonates from Cores:
Structurally Weak Deleterious Particles:
Limestone Fines in Concrete CA's:
AWI Updates:
AWI Implementation:
Clay Ironstone Particle Limitation in Dense-Graded Aggregates:
Concrete Pavement - End Result Specifications:
Shale in Dense-Graded Aggregates:

10/15/85: Minutes by Gallup.
Unconfined Aggregate F/T Field Survey:
Use of Pea Stone as PCC Aggregate:
Consultant AWI Testing:
F/T Testing Procedure:
New F/T Machine:
Particle Index Test:
Certified Aggregate Producer List:
Light Weight Fill - Holloway Construction:
Aggregate Source Inventory:
SS for AWI:
Structurally Weak particles:

Aggregate Acceptance Criteria Committee (AACC) Notes:

Limestone Fines in Concrete CA:
AWI Updates:
Clay Ironstone Limit in Dense Graded Aggregate:
Concrete Pavement - End Result Specifications:
Shale in Dense Graded Aggregate:
Crushed Concrete CA - Specification Change:
Independent Assurance Testing - Tolerances:

12/17/85: Handwritten Minutes (no typed copy, topics unclear) by Gallup.

02/11/86: Minutes by Gallup.
Unconfined Aggregate F/T Field Survey:
AWI Determination (MTM - 112):
New F/T Machine:
Aggregate Source Inventory - New:
F/T Durability Testing:
CA - Maybee Pit # 58-4:
1986 Projects Requiring AWI's:
Light Weight Fill:
F/T - Original Sonic Modulous Readings:
Aggregates for Blending Bituminous Mixes:
Concrete Recycling - Crushed Concrete FA:
District Lab Inspection:
CA 26A - Davidson Pit # 12 - 44:
ID of Weathered Igneous and Metamorphic Particles:
Future F/T Durability Factors - Post 1983. M-21 Project:
LA Abrasion on OGDC Aggregate:

04/15/86: Minutes by Gallup.
Unconfined Aggregate F/T Field Survey:
AWI Determination MTM -112:
Aggregate Source Inventory - New:
F/T Durability Testing:
CA - Maybee Pit # 58-4:
1986 Projects Requiring AWI's:
Lightweight Fill:
Aggregate for Blending Bituminous Mixes:
Concrete Recycling - Crushed Concrete FA:
District Lab Inspections:
ID of Weathered Igneous and Metamorphic Particles:
Future F/T Durability Factors - Post 1983:
LA Abrasion for OGDC Aggregates:
CA for Pre-stressed Concrete Beams:
Future Wear Track Testing:
Deleterious Particle Save Samples:
OGDC 8G Uniformity Coefficient:

SP for Clay Ironstone:
35AA Aggregates:
Chlorides in Aggregates:

06/10/86: Minutes by Gallup (unsigned copy).
Unconfined Aggregate F/T Field Survey:
MTM-112 - AWI Determination:
CA - Maybee Pit # 58-4:
Lightweight Fill:
Clay Ironstone:
Aggregate Samples:
District Lab Inspections:
Inspection of Weathered Igneous and Metamorphic Rock:
F/T Durability Factors:
LA Abrasion for OGDC Aggregates:
SS for Pre-stressed Concrete Beams:
Future Wear Track Testing:
35AA Aggregates:
Chlorides in Aggregates:
Crushed Carbonates - Test Results:
Dissemination of Information Without Test Reports:
F/T Dilation verses Durability:
Coarse Aggregate 17A for F/T Durability:
F/T Restrictions:

Continued on 06/16/86: Minutes were included with those of 06/10/86.
F/T Durability Plus 40 Durability Factor:
LA Abrasion - Expanded Test Frequency:
OGDC:
Sources Approved to Certify Aggregates:
Pit Numbers - Out of State Sources:
Friable Sandstone:

07/15/86:
Unconfined Aggregate F/T Field Survey:
MTM - 112 AWI Determination:
CA - Maybee Pit # 58-4:
Lightweight Fill:
Clay Ironstones:
Aggregates:
District Lab Inspection:
Weathered Igneous and Metamorphic Rocks:
F/T Durability Factors:
Supplemental Specification - Pre-stressed Concrete Beams:
Future Wear Track Testing:
OGDC 8G Uniformity Coefficient:

Chloride in Aggregates:
F/T Dilation verses Durability:
F/T Restrictions:
F/T Durability - Plus 40 Durability Factor:
LA Abrasion - Expanded Test Frequency:
Sources Approved to Certify Aggregates:
Friable Sandstone:
Physical Properties of F/T Samples Compared to Subsequent Production:
Contamination of Salvaged Concrete for Recycling:

08/12/86: Minutes by Gallup:
Unconfined Aggregate F/T Field Survey:
CA - Maybee Pit # 58-4:
Lightweight Fill:
Clay Ironstones:
Aggregates:
District Lab Inspections:
Weathered Igneous and Metamorphic Rocks:
F/T Durability Factors:
Future Wear Track testing:
OGDC 8G Uniformity Coefficient:
F/T Dilation verses Durability:
F/T Durability - Plus 40 Durability Factor:
Sources Approved to Certify Aggregates:
Friable Sandstone:
Physical Properties of F/T Samples Compared to Subsequent Production:
LA Abrasion - Expanded Test Frequency:
Dense Graded 20AA and 20AAA:
Dense Graded 20 Series Deleterious Particles:

09/15/86: Minutes by Gallup.
Unconfined Aggregate F/T Field Survey:
CA Maybee Pit # 58-4:
Lightweight Fill:
Clay Ironstones:
Evaluation of Sandstone Particles in Top Courses:
District Lab Inspection:
Weathered Igneous and Metamorphic Rocks:
F/T Durability Factors:
Future Wear Track Testing:
OGDC 8G Uniformity Coefficient:
F/T Dilation verses Durability Factor:
F/T Dur. - Plus 40 Durability Factor:
Friable Sandstone:
LA Abrasion - Expanded Test Frequency:
Dense Graded 20AA and 20AAA:

Aggregate Acceptance Criteria Committee (AACC) Notes:

Descriptors of FA - Physical Properties:
Supplemental Specification for Dense Graded produced by crushing PCC:
Concrete Recycling:
Crushed Carbonate Aggregates:
Pea Gravel for PCC Pavement:
Foundry Sand for Backfill:

Note: Certain topics from 1986 were numbered after the fact, while later year topic numbers were not assigned. Consistency was not the long suite during this phase.

10/14/86: Minutes by Gallup.
Unconfined Aggregate F/T Field Survey:
CA Maybee Pit # 58-4:
Lightweight Fill: (later given 86-3)
Clay Ironstones - Field Survey:
Evaluation of Sandstone Particles in Top Courses:
Dist. Lab Inspections:
Weathered Igneous and Metamorphic Rocks: (later given 86-7)
F/T Durability Factors:
Future Wear Track Testing: (later given 86-9)
OGDC 8G Uniformity Coefficient:
F/T Dilation verses Durability Factor:
F/T Dur. - Plus 40 Durability Factor: (later given 86-12)
Friable Sandstone:
LA Abrasion - Expanded Test Frequency:
Dense Graded 20AA and 20AAA:
Description of FA - Physical Properties:
SS for Dense Graded produced by crushing PCC:
Concrete Recycling:
Crushed Concrete Aggregates: (later given 86-19)
Pea Gravel for PCC Pavement:
F/T Testing of Aggregates:

11/13/86: Minutes by Gallup.
Unconfined Aggregate F/T Field Survey:
CA Maybee Pit # 58-4:
Lightweight Fill:
Clay Ironstones - Field Survey:
Evaluation of Sandstone Particles in Top Courses:
Dist. Lab Inspections:
Weathered Igneous and Metamorphic Rocks:
F/T Durability Factors:
Future Wear Track Testing:
OGDC 8G Uniformity Coefficient:
F/T Dilation verses Durability Factor:
Friable Sandstone:

LA Abrasion - Expanded Test Frequency:
Dense Graded 20AA and 20AAA:
Description of FA - Physical Properties:
SS for Dense Graded produced by crushing PCC:
Concrete Recycling:
Crushed Concrete Aggregates:
Pea Gravel for PCC Pavement:
F/T Testing of Aggregates:

01/20/87: Canceled.

02/17/87: Minutes by Gallup.
Note: Started using a numbering system for items discussed. Any topic still active plus all new topics received a number to aid in tracking its status. This number assignment for the ongoing items (Old Business) can be miss-leading since these subjects actually started prior to 1986. Just be careful in making references to the dates.
Note: A precautionary warning when referencing documents relative to aggregates having only the initials "GHG" on them, either George H. Gallup or Gail H. Grove may be the guilty party.

Old Business:
86-1 Unconfined Aggregate F/T Field Survey:
86-5 Evaluation of Sandstone Parts. in Top Courses:
86-8 F/T Durability Factors:
86-11 F/T Dilation verses Durability Factor: G H Grove's *"Summary of Correlation Results"* were attached.
86-14 LA Abrasion - Expanded Test Frequency:
86-18 Concrete Recycling:
New Business:
87-1 Size and Amount of Deleterious Particles Relative to F/T Durability:
87-2 Recycled PCC - Coring:
87-3 Two New F/T Machines:
87-4 F/T Tests - Various Gradations:
87-5 Pretreatment of CA in F/T Testing:
87-6 Certification Program - FHWA:
87-7 Recycled PCC - Scalping Screen:

03/24/87: Only Gallup's unsigned copy is in the files.
Old Business:
86-1 Unconfined Aggregate F/T Field Survey:
86-5 Evaluation of Sandstone Parts. in Top Courses:
86-8 F/T Durability Factors:
86-10 OGDC Uniformity Coefficient:
86-14 LA Abrasion - Expanded Test Frequency:
86-15 Gradation Changes - Dense Graded 20AA and 20AAA:
86-20 Pea Gravel for PCC:

Aggregate Acceptance Criteria Committee (AACC) Notes:

87-1 Size and Amount of Deleterious Particles Relative to F/T Durability:
87-3 Two New F/T Machines:
87-5 Pretreatment of CA in F/T Testing:

New Business:

87-8 Test Reporting System (TRS):
87-9 Identification of Deleterious Particles:
87-11 Aggregate Handling Procedures:

Notes: What happened to 87-10? Was it skipped?
Next Meeting was not scheduled.

06/02/87: Minutes by Gallup.

Old Business:

86-5 Evaluation of Sandstone Parts. in Top Courses:
86-7 Weathered Igneous and Metamorphic Rocks:
86-8 F/T Durability Factors:
& 86-12 F/T - Plus 40 Durability Factor:
86-10 OGDC Uniformity Coefficient:
86-14 LA Abrasion - Expanded Test Frequency:
86-20 Pea Gravel for PCC:
87-2 Recycled PCC - Coring:

07/23/87: Minutes by Gallup.

Old Business:

86-5 Evaluation of Sandstone Parts. in Top Courses:
86-8 F/T Durability Factors:
& 86-12 F/T - Plus 40 Durability Factor:
86-10 OGDC Uniformity Coefficient:
86-14 LA Abrasion - Expanded Test Frequency:
86-17 Dense Graded Aggregate from PCC:
86-18 Concrete Recycling:
87-3 Two New F/T Machines:
87-11 Aggregate Handling Procedures:

New Business:

87-12 Topsoil as Mineral Filler:
87-13 Calcite-Dolomite Ratio for Crushed Carbonates:
87-14 Permeability Requirements for Granular Materials - Class II:

08/25/87: Minutes by Gallup.

Old Business:

86-5 Evaluation of Sandstone Parts. in Top Courses:
86-8 F/T Durability Factors:
& 86-12 F/T - Plus 40 Durability Factor:
86-17 Dense Graded Aggregate from PCC:
87-3 Two New F/T Machines:

87-12 Topsoil as Mineral Filler:

New Business:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-17 Coarse Aggregate 26A - Gradation Modification:
87-18 Proposed SS for Aggregate Base - Concrete Modification:

09/24/87: Minutes by Gallup.
Old Business:
87-12 Topsoil as Mineral Filler:
87-15 Improving Drainability of Class II:
87-17 Coarse Aggregate 26A - Gradation Modification:
87-18 Proposed SS for Aggregate Base - Concrete Modification:
New Business:
87-19 More Representative Water Content for Slag in F/T:
87-20 SS for Durability of CA for PCC:
87-21 SS for CA including Crushed Concrete:
87-22 Conversion of F/T Sonic Modulous to Dilation:
87-23 SS for Testing Materials for Local Government Projects:
87-24 Modification of 20 Series Dense Graded Aggregates:

10/27/87: Minutes by Gallup.
Old Business:
87-12 Topsoil as Mineral Filler:
87-15 Improving Drainability of Class II:
87-18 Proposed SS for Aggregate Base - Concrete Modification:
87-19 More Representative Water Content for Slag in F/T:
87-20 SS for Durability of CA for PCC:
87-22 Conversion of F/T Sonic Modulous to Dilation:
87-24 Modification of 20 Series Dense Graded Aggregates:

12/17/87: Minutes by Gallup.
Old Business:
87-12 Topsoil as Mineral Filler:
87-15 Improving Drainability of Class II:
87-18 Proposed SS for Aggregate Base - Concrete Modification:
87-20 SS for Durability of CA for PCC:
87-21 SS for CA including Crushed Concrete:
87-22 GHGrove’s 11/4/87 (DF - d) Conversion Table attached. Closed.
87-24 Modification of 20 Series Dense Graded Aggregates:
New Business:
87-25 SS for 20AAA, 20AA and 20A in Top Course Bituminous Mixes:
87-26 Slag Testing Program:
87-27 Aggregates 21B and 23B:
87-28 Improved Gradation for Structural Patching and Overlays:

87-29 Deleterious Particles in Bituminous Aggregates:

01/21/88: Minutes by Kim M. Elias for Gallup.
<u>Old Business:</u>
87-12 Topsoil as Mineral Filler:
87-15 Improving Drainability of Class II:
87-20 SS for Durability of CA for PCC:
87-24 Modification of 20 Series Dense Graded Aggregates:
87-25 SS for 20AAA, 20AA and 20A in Top Course Bituminous Mixes:
87-26 Slag Testing Program:
87-28 Improved Gradation for Structural Patching and Overlays:
87-29 Deleterious Particles in Bituminous Aggregates:
<u>New Business:</u>
88-1 Slag used in Pre-stress Beams:
88-2 Selection of F/T Samples:

02/25/88: Minutes by DFMalott, Acting Chairman.
<u>Old Business:</u>
87-12 Topsoil as Mineral Filler:
87-15 Improving Drainability of Class II:
87-20 SS for Durability of CA for PCC:
87-24 Modification of 20 Series Dense Graded Aggregates:
87-26 Slag Testing Program:
87-28 Improved Gradation for Structural Patching and Overlays:
87-29 Deleterious Particles in Bituminous Aggregates:
88-1 Slag used in Pre-stress Beams:
88-2 Selection of F/T Samples:
<u>New Business:</u>
88-3 Calibration of F/T Machines:
88-4 Review of Standard Specifications 8.02 Aggregates:

04/21/88: Minutes by Gallup. (Forgot to use #'s for <u>New Business</u> topics.)
<u>Old Business:</u>
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-3 Two New F/T Machines:
87-12 Topsoil as Mineral Filler:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-24 Modification of 20 Series Dense Graded Aggregates:
87-27 Aggregates 21B and 23B:
87-29 Deleterious Particles in Bituminous Aggregates:
88-2 Selection of F/T Samples:
88-3 Calibration of F/T Machines:
88-4 Review of Standard Specifications 8.02 Aggregates:
<u>New Business:</u>
88-? SP for Aggregate Testing & Acceptance: (later given 88-5)

88-? Uses of BF Slag:
88-? Chloride Content of Crushed Carbonate CA:

05/24/88: Minutes by Gallup. (Forgot to use numbers on New Business topics again.)
Old Business:
87-3 Two New F/T Machines:
87-24 Modification of 20 Series Dense Graded Aggregates:
87-29 Deleterious Particles in Bituminous Aggregates:
88-4 Review of Standard Specifications 8.02 Aggregates:
New Business:
88-? Uses of Blast Furnace Slag for various Construction.
88-? F/T Durability Test Notification to Aggregate Suppliers

06/28/88: Minutes by Gallup.
Old Business:
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-2 Recycled PCC - Coring:
87-3 Two New F/T Machines:
87-27 Aggregates 21B and 23B:
87-29 Deleterious Particles in Bituminous Aggregates:
88-4 Review of Standard Specifications 8.02 Aggregates:
New Business:
Note: Numbering system appears to be getting screwed up!
88-5 (corrected to 88-6 later) SP for CA 6A for Type P-FS and P-MS Concrete:
88-? Crushed Particle Determination: (later given 88-7)

08/30/88: Minutes by Gallup.
Old Business:
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-2 Recycled PCC - Coring:
87-3 Two New F/T Machines:
87-29 Deleterious Particles in Bituminous Aggregates:
88-4 Review of Standard Specifications 8.02 Aggregates:
88-5 SP for Aggregate Testing & Acceptance:
88-6 SP for CA 6A for Type P-FS and P-MS Concrete:
New Business:
88-7 Crushed Particle Determinations:
88-8 SP for Testing Aggregates for Bituminous Mixes:

09/27/88: Minutes by Gallup. (numbering system again not used on New Business topics.)
Old Business:
87-3 Two New F/T Machines:
87-20 Supplemental Specification for Durability of CA for PCC:
87-29 Deleterious Particles in Bituminous Aggregates:
88-6 SP for CA 6A for Type P-FS and P-MS Concrete:

88-7 Crushed Particle Determinations:

<u>New Business:</u>

88-? Aggregate Approval Based on F/T Testing

88-? Radial Stacker - Prohibiting Use Of

Next meeting scheduled for 12/1/88.

11/22/88: Gallup rescheduled 11/1/88 meeting to 11/22/88. Minutes unsigned.

<u>Old Business:</u>

87-3 Two New F/T Machines:

87-20 Supplemental Specification for Durability of CA for PCC:

87-29 Deleterious Particles in Bituminous Aggregates:

88-7 Crushed Particle Determinations:

<u>New Business:</u>

88-? Radial Stackers:

88-? 1990 Standard Specifications:

88-9 Aggregate Source Identification:

Next meeting scheduled for 1/19/89.

01/19/89: Minutes by Gallup.

<u>Old Business:</u>

87-3 Two New F/T Machines:

88-6 SP for CA 6A for Type P-FS and P-MS Concrete:

88-9 Aggregate Source Identification:

<u>New Business:</u>

89-? OGDC: (later given 89-1)

Next meeting scheduled for 3/17/89.

03/17/89: Minutes by Gallup.

<u>Old Business:</u>

86-3 Lightweight Fill:

86-9 Future Wear Track Testing - Recycled Concrete:

86-19 Crushed Carbonate Aggregates - Frequency of Tests:

86-20 Pea Gravel for PCC:

86-18 Concrete Recycling: & 87-2 Recycled PCC - Coring:

87-15 Improving Drainability of Class II:

87-16 Mechanical Analysis of Sandstone Particles:

86-8 F/T Durability Factors:

& 86-12 F/T - Plus 40 Durability Factor:

& 87-1 Size and Amount of Deleterious Particles Relative to F/T Durability:

& 87-4 F/T Tests - Various Gradations:

& 87-20 SS for Durability of CA for PCC:

87-23 SS for Testing Materials for Local Government Projects:

87-24 Modification of 20 Series Dense Graded Aggregates:

87-19 More Representative Water Content for Slag in F/T:

& 87-26 Slag Testing Program:

87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-6 SP for CA 6A for Type P-FS and P-MS Concrete:
88-10 Effective Approval Date of Coarse Aggregate:
Next meeting not set. This is Gallup's last meeting due to retirement.

05/25/89: Minutes by Al Robords, new Chairman.
<u>Old Business:</u>
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
86-20 Pea Gravel for PCC:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-6 SP for CA 6A for Type P-FS and P-MS Concrete:
88-9 Aggregate Source Identification:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:

Next meeting scheduled for 07/20/89.
Special AACC Meeting 05/31/89:
Topic 1: Moisture Content in the Field and Effects in F/T.
Topic 2: Effects of Various Amounts of Deleterious Particles on F/T.
Topic 3: Various Aggregate Sizes in Big Beams.
Topic 4: Percent Crushed via Particle Index Test.
Topic 5: F/T Test Variations.

Special AACC Meeting 06/06/89: Same five Topics as in 05/31/89 but with more detail.

07/20/89: Minutes by Robords.
<u>Old Business:</u>
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
86-20 Pea Gravel for PCC:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
86-8 F/T Durability Factors:
& 86-12 F/T - Plus 40 Durability Factor:
& 87-1 Size and Amount of Deleterious Particles Relative to F/T Durability:
& 87-4 F/T Tests - Various Gradations:
& 87-20 SS for Durability of CA for PCC:

87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-6 SP for CA 6A for Type P-FS and P-MS Concrete:
88-9 Aggregate Source Identification:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:

<u>New Business:</u>
89-? Update on 1990 Standard Specifications (Aggregates Only):
89-? Update on Angularity of Sand Portion of Bituminous Mixes:
89-2 Method for Determining Wear Track Data on FA:

Next meeting scheduled for 09/21/89.

09/21/89: Minutes by Robords.

<u>Old Business:</u>
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
86-20 Pea Gravel for PCC:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-6 SP for CA 6A for Type P-FS and P-MS Concrete:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:
89-2 Method for Determining Wear Track Data on FA:

<u>New Business:</u>
89-? MTM Revision Procedure:
89-? OGDC LA Abrasion Change?:

Next meeting scheduled for 11/02/89.

11/02/89: Minutes by Robords.

<u>Old Business:</u>
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
86-20 Pea Gravel for PCC:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:

87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:
89-2 Method for Determining Wear Track Data on FA:

New Business:

89-? Tighten Gradation Band on 7.10 Mixes:
89-? OGDC Changes:
89-? Aggregate Certification Procedures:

Next meeting scheduled for 01/10/90.

01/10/90: Minutes by Robords.

Old Business:

86-19 Crushed Carbonate Aggregates - Frequency of Tests:
86-20 Pea Gravel for PCC:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:
89-2 Method for Determining Wear Track Data on FA:

New Business:

90-? LA Abrasion Concerns:
90-? AWI variability:
90-? Sampling and Testing in the Field:

Next meeting scheduled for 03/8/90.

03/08/90: Minutes by Robords.

Old Business:

86-19 Crushed Carbonate Aggregates - Frequency of Tests:
86-20 Pea Gravel for PCC:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-20 SS for Durability of CA for PCC:

87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:
89-2 Method for Determining Wear Track Data on FA:

New Business:

90-? Failing F/T of Recycled I 69 (Perry) concrete pavement:
90-? Pavement Performance verses F/T:
90-? Sampling Aggregate from the belt:
90-? Pit Numbers for crushed concrete samples:

Next meeting scheduled for 04/25/90.

04/25/90: Last meeting for DFM due to retirement. Minutes by Robords.

Old Business:

86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:
89-2 Method for Determining Wear Track Data on FA:

New Business:

Various informational items were discussed but not numbered in.

Next meeting scheduled for 07/11/90.

07/11/909: Minutes by Robords.

Old Business:

86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:

88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:
89-2 Method for Determining Wear Track Data on FA:
90-2 Recycled Crushed Concrete Identification System:
90-3 SS for Utility Trench Backfill:
90-4 2NS Gradation:
90-5 Radial Stackers:

New Business:

90-? End Result Testing:
90-? MDOT's AWI Program by Fred Copple:

Next meeting scheduled for 09/11/90.

09/11/90: Minutes by Robords.

Old Business:

86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:
89-2 Method for Determining Wear Track Data on FA:
90-2 Recycled Crushed Concrete Identification System:
90-3 SS for Utility Trench Backfill:
90-4 2NS Gradation:
90-5 Radial Stackers:

New Business:

None, since the EOC has taken over making all important aggregate decisions. Even though the AACC has lost much of its extensive technical expertise of the past, the politically motivated EOC does not appear to be the logical group required to make these engineering decisions. At this point in time the AACC can only make recommendations and meetings have become less frequent. Their primary task is the need to bring closure to existing open topics on its books. It seems that the AACC has lost all its important responsibilities and may soon cease to exist. Next meeting scheduled for 11/08/90.

11/08/90: Minutes by Robords.

Old Business:

86-19 Crushed Carbonate Aggregates - Frequency of Tests:

87-15 Improving Drainability of Class II:
87-16 Mechanical Analysis of Sandstone Particles:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
89-1 OGDC:
89-2 Method for Determining Wear Track Data on FA:
90-2 Recycled Crushed Concrete Identification System:
90-3 SS for Utility Trench Backfill:
90-4 2NS Gradation:
90-5 Radial Stackers:
<u>New Business:</u>
90-? MSU Load Transfer Results for 1st year.
90-? Various Test Roads in MI
Next meeting scheduled for 1/10/91.

01/10/91: Minutes by Robords. Four items from last meeting were corrected.
<u>Old Business:</u>
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-15 Improving Drainability of Class II:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
90-2 Recycled Crushed Concrete Identification System:
90-3 SS for Utility Trench Backfill:
90-4 2NS Gradation:
90-5 Radial Stackers:
<u>New Business:</u>
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:
Next meeting scheduled for 03/07/91.

03/07/91: Minutes by Robords.
<u>Old Business:</u>
86-19 Crushed Carbonate Aggregates - Frequency of Tests:

87-15 Improving Drainability of Class II:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
90-2 Recycled Crushed Concrete Identification System:
90-4 2NS Gradation:
90-5 Radial Stackers:
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:

<u>New Business:</u>

91-? Obtaining Samples:
91-? LA Abrasion Frequency of Testing:
91-? Sample Size of Large Aggregate Bituminous Mixes:

Next meeting scheduled for 05/09/91.

05/09/91: Minutes by Robords.

<u>Old Business:</u>

86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-15 Improving Drainability of Class II:
87-20 SS for Durability of CA for PCC:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
90-2 Recycled Crushed Concrete Identification System:
90-4 2NS Gradation:
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:

Memos were sent to the Districts requesting annual Specific Gravity & Absorption Samples.

<u>New Business:</u>

91-? Procedure Modification for Verifying Marginal LA Abrasion Test results:

Next meeting scheduled for 07/11/91.

Aggregate Acceptance Criteria Committee (AACC) Notes:

07/11/91: Minutes by Robords.
Old Business:
86-19 Crushed Carbonate Aggregates - Frequency of Tests:
87-15 Improving Drainability of Class II:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
87-17 Coarse Aggregate 26A - Gradation Modification:
& 87-28 Improved Gradation for Structural Patching and Overlays:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
90-4 2NS Gradation:
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:
New Business:
91-3 Minimum % CA in bituminous mixes before LA needed?:
91-? MTM -113 Moisture Conditioning of Crushed Concrete Aggregate:
91-? Error in Standard Specifications for 23A.
Next meeting scheduled for 09/12/91.

09/12/91: Minutes by Robords.
Old Business:
87-15 Improving Drainability of Class II:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:
& 87-26 Slag Testing Program:
88-3 Calibration of F/T Machines:
88-10 Effective Approval Date of Coarse Aggregate:
90-4 2NS Gradation:
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:
91-3 Minimum % CA in bituminous mixes before LA needed?:
91-4 LBW for Aggregate Surface Course & Class AA Shoulders:
New Business:
91-? SP for Premium Coarse Aggregate:
Next meeting scheduled for 10/24/91.

10/24/91: Minutes by Robords.
Old Business:
87-15 Improving Drainability of Class II:
87-23 SS for Testing Materials for Local Government Projects:
87-19 More Representative Water Content for Slag in F/T:

& 87-26 Slag Testing Program:

88-3 Calibration of F/T Machines:

88-10 Effective Approval Date of Coarse Aggregate:

90-4 2NS Gradation:

91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:

91-2 MDOT/CRREL/MTU Study:

91-3 Minimum % CA in bituminous mixes before LA needed?:

91-4 LBW for Aggregate Surface Course & Class AA Shoulders:

<u>New Business:</u>

92-1 R. Muethel's Draft: F/T Durability & Pore Characteristics - Glacial Gravel:

Next meeting scheduled for 01/22/92.

01/22/92: Minutes by Robords.

<u>Old Business:</u>

87-15 Improving Drainability of Class II:

87-23 SS for Testing Materials for Local Government Projects:

87-19 More Representative Water Content for Slag in F/T:

& 87-26 Slag Testing Program:

88-3 Calibration of F/T Machines:

88-10 Effective Approval Date of Coarse Aggregate:

90-4 2NS Gradation:

91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:

91-2 MDOT/CRREL/MTU Study:

91-3 Minimum % CA in bituminous mixes before LA needed?:

91-4 LBW for Aggregate Surface Course & Class AA Shoulders:`

92-1 R. Muethel's Draft: F/T Durability & Pore Characteristics - Glacial Gravel:

<u>New Business:</u>

Gib Foster's Research on Bulk Expansion of CA:

Minor Change in ASTM/AASHTO FA Sieve Analysis:

Next meeting scheduled for 03/19/92.

03/19/92: No minutes were found in the files, not sure if meeting was held.

06/10/93: Minutes by Robords.

<u>Old Business:</u>

87-15 Improving Drainability of Class II:

88-3 Calibration of F/T Machines:

91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:

91-2 MDOT/CRREL/MTU Study:

92-1 R. Muethel's Draft: F/T Durability & Pore Characteristics - Glacial Gravel:

92-2 Minimum Sample Size for FA:

92-3 Microwave Drying of Samples:

92-4 AWI Nomographs:

MTM 107

New Business:

93-? F/T pick verses Field Stockpile Pick Study: (later given 93-2)

93-? LA Test from F/T Sample:

93-? Mechanical Washers:

93-1 MCPA Request to Use Crushed Concrete as Bedding Material:

Next meeting scheduled for 08/05/93.

08/26/93: Minutes by Robords.

Old Business:

87-15 Improving Drainability of Class II:

88-3 Calibration of F/T Machines:

91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:

91-2 MDOT/CRREL/MTU Study:

92-1 R. Muethel's Draft: F/T Durability & Pore Characteristics - Glacial Gravel:

92-2 Minimum Sample Size for FA:

92-3 Microwave Drying of Samples:

92-4 AWI Nomographs:

93-1 MCPA Request to Use Crushed Concrete as Bedding Material:

93-2 F/T pick verses Field Stockpile Pick Study:

New Business:

93-? Concrete under yield for Pit # 71-3.

93-? Guidance Requirements on F/T Testing of Slag:

Next meeting scheduled for 10/14/93.

10/14/93: Minutes by Robords.

Old Business:

87-15 R. Muethel's Draft: F/T Durability & Pore Characteristics - Glacial Gravel:

88-3 Calibration of F/T Machines:

91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:

91-2 MDOT/CRREL/MTU Study:

92-1 R. Muethel's Draft: F/T Durability & Pore Characteristics - Glacial Gravel:

92-3 Microwave Drying of Samples:

92-4 AWI Nomographs:

93-1 MCPA Request to Use Crushed Concrete as Bedding Material:

93-2 F/T pick verses Field Stockpile Pick Study:

MTM 108 Loss By Wash:

New Business:

93-? Continue F/T on Slag; Discontinue LA on Slag.

Next meeting scheduled for 12/09/93.

12/09/93: Minutes by Robords.

Old Business:

87-15 R. Muethel's Draft: F/T Durability & Pore Characteristics - Glacial Gravel:

88-3 Calibration of F/T Machines:
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:
92-3 Microwave Drying of Samples:
93-1 MCPA Request to Use Crushed Concrete as Bedding Material:
93-2 F/T pick verses Field Stockpile Pick Study:
MTM 108

<u>New Business:</u>

MTM (later #'d 123) for Unit Weight Determinations

Next Meeting Scheduled for 03/09/94.

03/09/94: Minutes by Robords.

<u>Old Business:</u>

91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:
92-3 Microwave Drying of Samples:
93-1 MCPA Request to Use Crushed Concrete as Bedding Material:
93-2 F/T pick verses Field Stockpile Pick Study:
MTM 108
MTM 123

<u>New Business:</u>

94-1 Crushed particles in recycled concrete:
94-? Benefit of crushed aggregate in bituminous mixes:
94-? Standardized Aggregate Gradations: (later given 94-2)

Next meeting scheduled for 05/11/94.

05/11/94: Minutes by Robords.

<u>Old Business:</u>

91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:
92-3 Microwave Drying of Samples:
93-1 MCPA Request to Use Crushed Concrete as Bedding Material:
93-2 F/T pick verses Field Stockpile Pick Study:
MTM 108
MTM 123
94-1 Crushed particles in recycled concrete:
94-2 Standardized Aggregate Gradations:

<u>New Business:</u>

94-? Sampling Slag for Concrete Mix Designs:
94-? New Aggregate Section 902 in 1996 Book:

Next meeting scheduled for 07/13/94.

Aggregate Acceptance Criteria Committee (AACC) Notes:

07/13/94: Minutes by Robords.
Old Business:
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
91-2 MDOT/CRREL/MTU Study:
92-3 Microwave Drying of Samples:
93-1 MCPA Request to Use Crushed Concrete as Bedding Material:
MTM 108
MTM 123
94-1 Crushed particles in recycled concrete:
94-2 Standardized Aggregate Gradations:
94-? Sampling Slag for Concrete Mix Designs:
94-? New Aggregate Section 902 in 1996 Book:
New Business:
94-? New Aggregate Gradation for High Durability Concrete:
94-? No ¾ Material in Some 6A Sources:
Next meeting scheduled for 09/21/94.

09/21/94: Only pencil copy of the minutes were found in the files.
Old Business:
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
93-1 MCPA Request to Use Crushed Concrete as Bedding Material:
MTM 123
94-1 Crushed particles in recycled concrete:
94-2 Standardized Aggregate Gradations:
94-3 Gradation for Freeze-Thaw Tests:
94-? New Aggregate Gradation for High Durability Concrete:
94-? 1996 Section 902 Review:
Next meeting scheduled for 11/08/94.

11/08/94: Minutes by Robords.
Old Business:
91-1 Special Investigation on F/T Repeatability and Individual Aggregate Variability:
93-1 MCPA Request to Use Crushed Concrete as Bedding Material:
MTM 108
MTM 123
94-1 Crushed particles in recycled concrete:
94-3 Gradation for Freeze-Thaw Tests:
94-? 1996 Section 902 Review:
New Business:
94-? Crushed Content of 23A:
Next meeting scheduled for 03/16/95.

Aggregate Acceptance Criteria Committee (AACC) Notes:

03/16/95: Only a partial unsigned pencil copy of minutes found in the files. This appears to be the end of the AACC work. No further minutes could be found.

Engineering Operations Committee (EOC) Notes:

The Department's master copy of EOC minutes is located in the C & T Division's administration office area, in Room 101. This committee was originally called "The Pavement Selection Committee" and was later renamed "The Engineering Operations Committee (EOC)". Early records are available as paper copies housed in binders, followed by later meeting minutes saved on floppy disks/servers which can be easily searched for the desired topics. The EOC covers a wide range of topics of which aggregate issues are but a small part. Only aggregate or closely related pavement topics are of interest for the scope of this project and only those items have been itemized below.

Since the Pavement Selection Committee started in 1969, it appears that Volumes 1 and 2 probably have nothing to do with Pavement Selection or the EOC. Any documentation in the Design Division more than likely has been sent to the Records Center where retention is only about 3 years and are long gone. It is unclear if any records are missing, since the beginning memos from 1969 appear in Volume 3. Possibly the more logical explanation is that Volumes 1 and 2 pertained to other Division level record keeping.

Pavement Selection Committee:

Volume 3: This volume includes documentation on: Agendas, Meeting Minutes, and other related correspondence.

01/08/69: John Woodford was appointed as Chairman and Roy Greenman as Secretary.
The select sub base on the US 25 project near Port Austin will be 22A material.

02/05/69: On the US 25 project near Port Austin, the select sub base under the 8 inches of reinforced concrete will be 6 inches of 22AA.
It was decided that the use of limestone chips be eliminated in nearly all cases and definitely in all cases involving roadway resurfacing.

07/02/69: Minutes are incomplete. No aggregate information.

09/03/69: No aggregate information.

10/08/69: Minutes are incomplete. No aggregate information.

03/04/70: Gerry McCarthy replaced John Woodford as Chairman.
On the US 31 relocation project near Muskegon, that because of extremely limited availability of aggregates for 22AA (50% minimum crushed) within reasonable distance, the use of PCC was recommended.

09/02/70: American Aggregates Corporation requested that they be permitted to use their 21A crushed aggregate as an alternate for 22A as base course aggregate.

Engineering Operations Committee (EOC) Notes:

10/07/70: No aggregate information.

11/04/70: The Construction Division wants to try stabilization (with asphalt, sodium chloride, lime) of select sub base on slip-form jobs.

12/03/70: No aggregate information.

01/06/71: No aggregate information.

02/03/71: No aggregate information.

03/03/71: Max Clyde replaced Roy Greenman as Committee Secretary.

04/13/71: A black base alternate was proposed for several projects.

05/05/71: Stabilization of selected sub base for slip form paving will be tried on a project only if FHWA participates.

American Aggregates Corporation wants the department to compare 21AA base with black base.

Consideration is being given to recycling bituminous pavement to make new base material.

07/13/71: Bituminous aggregate gradations were modified as follows to better utilize available aggregates:

1. Develop a Type “C” 25A Modified which essentially utilizes 35% to 45% stone (retained on the # 8 sieve), and

2. Footnote “e” was deleted from Table 8.02-2 permitting limestone aggregates. Levy requested to use open-hearth slag as 22A base.

Levy Company requested to have open hearth slag reinstated for use as 22A.

09/01/71: Open hearth slag expands in confined areas. An I 75 project will incorporate a section using open hearth slag as the coarse aggregate and another using 22A for comparison. Shoulder and base applications will be monitored.

A test project will be set up to evaluate using 100% crushed 21AA as a substitute for black base based upon American Aggregates Corporation request.

10/15/71: Design was charged with finding a project somewhere in the southeast part of the state to try wet bottom slag (by-product of power plants) as an aggregate.

11/03/71: No aggregate information.

12/01/71: No aggregate information.

Engineering Operations Committee (EOC) Notes:

Volume 4: (Same arrangement as Volume 3)

01/05/72: No aggregate information.

02/02/72: No aggregate information.

02/29/72: No aggregate information.

04/05/72: No aggregate information.

05/03/72: No aggregate information.

06/07/72: No aggregate information.

07/05/72: No aggregate information.

09/08/72: No aggregate information.

10/04/72: No aggregate information.

Volume 5: (This is the same arrangement as Volumes 3 and 4)

01/03/73: No aggregate information.

02/09/73: No aggregate information.

04/06/73: Wet bottom slag was used as an aggregate in an I 94 resurfacing project near Pelham.

05/04/73: No aggregate information.

06/12/73: No aggregate information.

08/01/73: No aggregate information.

10/03/73: Kent Allemeier replaced Max Clyde as Committee Secretary.

Steel corrosion in CRCP is the result of using slag aggregate verses natural aggregate in the concrete pavement and is most pronounced in the Metro area.

11/07/73: No aggregate information.

12/05/73: No aggregate information.

02/06/74: No aggregate information.

Engineering Operations Committee (EOC) Notes:

03/06/74: Seven projects on I 96 were changed from CRCP to 40' jointed pavement.

04/03/74: The committee is very concerned and hesitant about using one course bituminous surface over an existing PCC pavement.

EOC Binder 1974-1980:

01/11/74: CRC pavements in the Metro area are showing excessive corrosion of the reinforcing steel due the high salt usage required. CRC out-state is performing well.

Because of industry reporting difficulty in production and availability of 31A aggregate, the department agreed to trial use of a modified specification requiring only 80% crushed and eliminates the minimum top size before crushing. Three 1974 projects using this modification will be monitored for both stability and skid resistance problems.

02/06/74: No aggregate information.

03/07/74: Seven projects on I 96 were changed from CRC to 40' jointed pavement.

04/03/74: The committee continues to believe that it is preferable to use asphalt instead of cement for in place stabilization of existing shoulder base because of the cement shrinkage cracks.

05/07/74: No aggregate information.

06/05/74: The pavement type for I 96 between I 75 and I 94 was changed from CRC pavement to 40' jointed concrete with stainless steel dowels.

09/04/74: The policy of using flexible pavement design for freeways was confirmed as sound in spite of extensive reflective cracking. The committee believed that they just needed to solve the cracking problem.

The annual field survey of bituminous base performance continues to show generally good results and the conclusion was that the current policy of using bituminous base course should continue.

10/02/74: One ingredient in the US 27 north of M 55 flexible pavement design was the use of unwashed 31A aggregate leveling course. Adjustment of the mix was required to compensate for leaving the dust in.

11/03/74: The possibility of using an unwashed 31A aggregate on future bituminous pavement projects.

Locally available pea stone will be considered for shoulder construction. The main drawback exists because of its uniform size, and thus lack of stability in a bituminous mixture.

Engineering Operations Committee (EOC) Notes:

12/11/74: Based upon recent reports on skid test results, it was concluded that the department needs to improve bituminous pavement designs. The most significant factor involves adjusting the proportions of coarse and fine aggregate to give a more open textured surface.

01/07/75: No aggregate information.

02/05/75: Concrete pavement design modifications were made to Road Deign Notes, IM 108-R.

03/05/75: The need for a more formal review procedure to implement research findings has been assigned to the Pavement Selection Committee and they reaffirmed its intention to change its name based upon the wider scope of responsibilities.

A minimum 95% density, as established by a control strip, was proposed for the control of bituminous pavement compaction.

04/02/75: The committee name was changed to "Engineering Operations Committee" as a result of Max Clyde's proposal and the members unanimous approval.

05/07/75: This was the first official "EOC Meeting".

With the adoption of full depth shoulders for freeways, the situation can arise where the bituminous shoulder depth is greater than the bituminous surface of the traveled way, as was the case for NB US 131 south of Cadillac.

The balance of the I 696 pavement design, previously decided to be 10 inch jointed pavement in place of CRCP, was questioned and confirmed.

06/04/75: Based upon a report of surplus pea gravel aggregate, consideration was given to using it in PCC mixtures. However, the pea gravel was surplus only in minor areas of Michigan, use was not recommended at this time.

07/22/75: Experimental use of 21AA as a base material was proposed and approved for half of an M 15 project.

FHWA concluded that none of the separation materials were completely effective in stopping reflection cracking in bituminous overlays.

09/03/75: Skid coefficients for open graded friction course (OGFC) for three intersections in Monroe County using slag resulted in values ranging from 0.48 to 0.58. These are not unusually high, but very acceptable.

10/01/75: No aggregate information.

11/04/75: Because of recent instability problems of 24AA aggregate on the US 31 relocation in Oceana County, the 24AA specification will be eliminated and 22A will be used for sub base stabilization on future projects. The 22A abrasion requirement will be no more strict than that required for the 24AA.

Engineering Operations Committee (EOC) Notes:

12/03/75: No aggregate information.

01/07/76: No aggregate information.

02/04/76: In reviewing MDSHT Report 249 on the 1974 test program for skid resistance, G. J. McCarthy was concerned about the high percentage of 1973 and 1974 projects having skid coefficients below 0.40. A 01/30/76 meeting recommended (1) a mix design change to increase the proportion of coarse aggregate and decrease the fine aggregate and (2) better monitoring of the construction process to prevent or correct problems immediately.

03/05/76: No aggregate information.

04/07/76: A contractor quality control (end result) specification was proposed for “selected sub base” aggregate production for an I 275 project.

05/05/76: R. Welke’s “Open Graded Asphalt Friction Courses - Performance Report” was reviewed and several problems were identified.

06/02/76: M 21 was approved for 9” CRC over 4” aggregate base for concrete over 10” sand sub base. Choice was made due to heavy soils encountered and the relative scarcity of extra sand sub base required for flexible pavement.

According to R-966, the I 75 joint performance was a function of the type of aggregate. Joint performance was much better for the section having limestone coarse aggregate than the section having natural glacial gravel. Research Laboratory was directed to investigate other variables affecting this difference and report back to EOC.

Research Project 62 F-70 final report was approved. It concluded that bituminous stabilized aggregate separation course results in less reflective cracking than either an untreated aggregate separation course or no separation course.

07/07/76: An end result specification for concrete pavement was directed to be written for a trial project .

07/27/76: 100% crushed untreated aggregate as an alternate for black base will be evaluated on the same project for comparison.

Wet bottom slag shoulder comments were reviewed.

Skid resistance of asphalt pavements appears to be the same for slag aggregate and natural aggregate, thus choice should be based on cost.

08/31/76: Recycling asphalt pavement (Research Project 75 D-30) covering conceptual status was discussed.

Steel furnace slag (formerly open hearth slag) currently allowed for selected sub base under concrete will be investigated to see if it will perform satisfactorily in bituminous pavement mixtures.

Sub base drainage criteria and field test method (Research Reports. R-991 and R-1001) will be evaluated for implementation practicality.

Engineering Operations Committee (EOC) Notes:

Deletion of “selected sub base” under concrete pavement serves more to facilitate construction than as a pavement strength factor and is not required for slip form paving.

10/06/76: Previous attempts to obtain Federal participation for repairs on I 96 CRC near Portland have been unsuccessful.

Experimental features such as short slabs with skewed joints and no load transfer devices plus bituminous stabilized shoulders were used on the US 10 relocation NW of Clare. Performance will be monitored and reported on.

Research Report R-979 on I 196 in Kent County concluded that the overall better performance was due to several factors including: favorable base support, lower carbonate content in the coarse aggregate, better quality concrete, shorter slabs and dissipation of compressive forces at numerous expansion joints. No conclusion appeared strong enough to warrant changes in pavement design yet.

11/02/76: Deletion of “selected sub base” under concrete pavement will be attempted on a suitable project.

The Bituminous Advisory Committee was asked to make a report to EOC in December on the current status of improving skid resistance of the department’s mix designs.

12/01/76: No aggregate information.

01/06/77: It is now policy that EOC review all research reports prior to printing and implementation.

EOC reviewed and approved “Aggregate Gradation Quality Control”, (R-1024).

02/02/77: Bituminous Pavement Design Guidelines modifications concerning stabilization of existing shoulders, black base for new shoulders and areas of the state where carbonate aggregates may be used in the wearing course.

03/10/77: Report R-1040, “Statistical Analysis of Aggregate Base Course Inspection Using an End Result Aggregate Specification” was reviewed and approved.

R-1044, “Construction of a Cold-Mix Emulsion Black Base” covering the department’s second trial application of this type was approved.

R-1025, “Thickness Equivalencies for Asphalt-Treated and Untreated Aggregate Base Course Layers”, was approved. Since this was considered part of the overall flexible design research with Michigan State University, implementation was withheld pending completion of the other aspects of the project.

04/06/77: Research Reports R-1041, 1046, 1048 on various aggregate issues were reviewed and approved.

05/04/77: Research Report R-1051, “Mixed-In-Place Stabilization of Highway Base Aggregates and Pulverized Bituminous Surfacing Using Asphalt Stabilizers” was reviewed and approved with slight revision.

Engineering Operations Committee (EOC) Notes:

Based upon R-1049, there is concern about some newly constructed bituminous surfaces which exhibit lower than desirable skid coefficients.

06/01/77: No aggregate information.

07/06/77: No aggregate information.

08/03/77: Due to reflective cracking, the use of thin bituminous overlays over concrete base course is discouraged.

Since it is easy to obtain a surface tolerance of 3/8 inch for bituminous aggregate base course stabilized in place, the specification will be changed from the present ¾ inch to 3/8 inch.

US 31 was approved for 8 inches of CRC pavement on 4 inches of aggregate base and 10 inches of sub base.

09/07/77: No aggregate information.

10/05/77: No aggregate information.

11/02/77: No aggregate information.

12/07/77: Due to favorable experience, several high speed locations will be selected for open graded friction courses.

01/04/78: No aggregate information.

02/01/78: No aggregate information.

03/01/78: Bituminous pavement compaction policy: it was proposed to change from number of roller passes to 95% of maximum density.

FHWA objected to the proposed 9" CRC design for M 21. The department indicated that they would pay for the materials to have the extra inch of pavement in order to obtain a longer maintenance free life.

I 94 rehabilitation in Berrien County will be recycled due to base deficiency.

04/05/78: MRBA requested to use a separation course in lieu of joint repairs for concrete overlays.

05/03/78: Based upon experience over the past winter, open graded friction courses should be limited to placement over flexible sections and not over concrete surfaces nor in urban areas with turning or braking movements.

Research Report R-1085 noted that concrete pavements constructed with Pit 63-7 fine aggregate showed much better skid values. The Research Lab was assigned the task of determining why.

Engineering Operations Committee (EOC) Notes:

06/07/78: Joint condition surveys indicate that due to limited and short-term experience with 40' joints, there is no evidence to suggest the department change the standard 71' 2" spacing for jointed pavements.

Experiences on I 75 using RAP in bituminous stabilized bases (R-1088) resulted in recommendation to use and monitor on future projects.

08/02/78: No aggregate information.

09/06/78: M 99 recycling project north of the Ohio line is to be reviewed to determine how to reduce the excess reprocessed material.

10/04/78: Recycling of last two projects on I 75 between Gaylord and Grayling stipulate that one use plant recycling with 50% virgin aggregate and the other is to use 60% crushed 20AA.

11/01/78: Proposed M 99 recycling project, M-113 and M-186 will incorporate stabilized bases.

12/06/78: The concept using sandstone in bituminous wearing course to improve friction levels needs information on alternatives such as texturing or grooving.

01/03/79: The use of sandstone was approved to improve friction levels of bituminous wearing courses for Saginaw and Oakland Streets and the Cedar and Larch intersections in Lansing.

02/07/79: The bituminous end result specification was approved for two projects in each District.

EOC approved the Research Lab's recommendation that a moratorium be placed on CRC. US 31 was changed to conventionally reinforced concrete pavement with 40' joints, I 69 and M 21 will be decided later.

03/08/79: Research Report R-1107, Evaluation of Sodium Chloride for Stabilizing an Aggregate Base Course was approved. It concluded that addition of sodium chloride to an aggregate base course high in "fines" does not appear to significantly alter its performance.

04/11/79: Concrete joint spacing was reduced from 71' 2" to 40', except ramps, as the standard by unanimous decision. US 31 and I 475 were the first contracts to be effected.

Preliminary results of wear track aggregate polishing were presented in R-1098, which was approved by EOC.

05/02/79: Changing to viscosity grading from penetration grading of asphalt was approved.

In spite of Research Report R-1115, "Performance Evaluation of Non-Reinforced Ramps", EOC held with their earlier decision to reinstate the use of reinforcing steel in all concrete ramp pavement.

06/06/79: Michigan's first batch plant bituminous recycling project last year on I 94, Berrien County was very successful from both an engineering and a cost standpoint.

07/03/79: EOC decided that 40' slab lengths was as short as they were comfortable with thus the recommendation of shorter slabs for I 69 near Lansing was rejected.

08/03/79: Levy Company's basic oxygen slag has expansive properties and has been used as selected sub base in the Metro area.

CRC pavement in Michigan is based upon a 20 year history (R-1120) and it was recommended that further use be discontinued.

Research Report R-1124 indicates that based upon preliminary information, bituminous wearing course containing sandy limestone had friction numbers between 0.42 and 0.53 after one year of use.

09/05/79: No aggregate information.

10/03/79: Based upon I 275 longitudinal cracking of the CRC pavement, caused by restricted drainage of the sand sub base and lack of permeability in the selected sub base (R-1126), use of a more permeable sub base was recommended.

11/07/79: The effect of aggregate in pavement joint deterioration was discussed. The Research Laboratory was assigned to consider adopting reduced coarse aggregate size and possibly restricting the use of certain aggregates on future projects.

The existing condition of the 1921 M-153 (Ford Road) is adequate to be left in place and overlaid with a bituminous surface.

12/05/79: Under the 5-year Research Needs list, "Effect of Recycled Concrete as Concrete Coarse Aggregate on Concrete Paving Quality" was listed and approved. A detailed write-up was included.

01/02/80: Research Report R-78 concluded that the stability of bituminous mixtures is more significantly affected by the angularity of the fine aggregate than the percentage of crushed coarse aggregate.

02/06/80: No aggregate information.

04/02/80: Research Report R-1132, "The Michigan Department of Transportation Circular Wear Track - Results of Supplemental Aggregate Polishing Tests", was approved. The prospects are good that numerous sources of highly polishing carbonates can be upgraded in friction resistance by blending with 30% sandstone.

Preliminary results (R-1134) indicate that sprinkle treatment is superior to conventional surfaces.

Engineering Operations Committee (EOC) Notes:

05/07/80: A supplemental specification for skid resistant bituminous coarse aggregates was authorized to allow the use of polishing susceptible aggregates in bituminous mixes by blending with a suitable percentage of skid resistant aggregate. This essentially provides for greater use of limestone aggregates by blending with sandstone aggregates.

06/04/80: Proposed Department Regulation (DR) for EOC was sent on for implementation.

Research Report R-113, "Precision of the Aggregate Sample Splitter and Testing Methods" was approved with the suggestion that the conclusions and recommendations be organized into an "executive summary".

07/02/80: Research Report R-1147, Evaluation of 22A Gradation Open Hearth Slag as a Base and Sub Base Construction Material was approved. The final report concluded that the 22A gradation of steel furnace slag (formerly referred to as open hearth) is frost susceptible, has poor drainability, and exhibits unpredictable expansive characteristics causing heaving of pavement surfaces. The department eliminated all use of steel furnace slag of the 22A gradation and started a study to determine if more coarse gradations of steel furnace slag can be used satisfactorily.

08/07/80: The EOC fully agreed with using the OGDC concept which involves changing the 4 inches of "selected sub base" from 22A to either 6A, 9A, or 17A. However, they were very concerned with using "edge of pavement under-drains" due to previous problems.

Approval was given for an HPR study, "The Development of Acceptance Sampling Plans Assuring the percentage of In-Place 22A Aggregate Within the Specification Limits".

10/01/80: J. Woodford continues to disfavor, as a general policy, overlaying concrete pavements with bituminous overlays because of reflective cracking problems. However, due to high cost and funding problems, concrete pavement recycling will not be done in the near future.

For reasons of possible economy and best use of all available materials, ground slag as a cement substitute will be tried on a project in the Metro area.

11/05/80: C. J. Arnold's invited paper on "Jointed Concrete Pavement in Michigan" was presented at the Second International Conference on Concrete Pavement Design (4/14-16/81) in Indianapolis.

12/04/80: No aggregate information.

<u>EOC Binder 1981- 1982:</u>

01/07/81: The final report recommendation to discontinue use of cold-mix emulsion black base was not acceptable to EOC. They directed that the conclusion be modified to recommend further work since greater use of emulsions is inevitable and we will have to learn how to use them.

02/04/81: Problems have caused most of the other seven states using OGDC to drop use of OGDC. Michigan will proceed slowly until longer term results confirms our acceptable experience to date.

Research Report (R-1158) describes concrete pavement “D” cracking problems as related to aggregate types and recommends possible changes in aggregate specifications and testing. AACC will review and report back to EOC.

Concern about slip-forming concrete on sand sub base resulted in the M 21 relocation being approved for 9 inches of reinforced concrete on top of 4 inches of OGDC over 8 inches of sand sub base. Drainage was accomplished by the standard concept of draining out to the slopes rather than the edge-of-pavement under-drains.

03/12/81: No aggregate information.

04/03/81: M 21 relocation will have 4 inches of OGDC over 8 inches of sand sub base. An open graded drain would be used for primary drainage and will be placed 2 feet off the edge, after placement of the concrete pavement.

M 50 will utilize concrete recycling for the coarse aggregate in the concrete overlay.

05/06/81: Stabilized-in-place shoulders have performed satisfactorily.

Special Provision for bituminous wearing course aggregate employs a new index identified as “Michigan Polish Number” for accepting aggregates based upon polishing characteristics. EOC requested a name change to improve clarity.

06/03/81: Research Report (R-1158), “The Relationship of Aggregate Durability to Concrete Pavement Performance and the Association Effects of Base Drainability” was approved and the following three recommendations were to be implemented:

1. Continued aggregate research,
2. Development and use of an improved method for evaluating the performance of concrete pavements, and
3. Greater use of open graded drainage layers with under-drains on new construction.

07/14/81: Base and sub base drainage properties are affecting longitudinal cracking of I 275 CRC pavement (R-1152). CRC is becoming recognized as being more sensitive to non-uniform support than conventional jointed pavement.

08/13/81: Research Report R-1171 concluded that the premature cracking of the third lane placed in 1976 is due to inadequate drainage of the base and sub base of the outside lane. Recommendations included placing edge drains just outside the concrete shoulder in the two worst sections.

09/11/81: Proposed supplemental specification for bituminous mixture classified by stability was approved and it requires a higher percentage of crushed material than the formerly used 20 series aggregates.

10/15/81: No aggregate information.

11/12/81: No aggregate information.

12/02/81: No aggregate information.

01/06/82: Open graded base as a standard specification alternate for 22A aggregate was recently adopted for interstate and high volume construction to improve sub base drainage. For other projects, the standard aggregate base for concrete (aggregate base course) continues to specify 22A. The contract specifications will state if the open graded concept is a contractor option.

02/03/82: A moratorium was placed on the use of open graded friction course.

03/02/82: Degradation of steel furnace slag as an open graded base course for concrete pavement (Research Report R-1188) was reviewed and approved. The study showed that steel furnace slag degrades more than either blast furnace slag or natural aggregate. Continued use will require that it be washed prior to use.

04/07/82: The continuation of the OGDC moratorium was discussed and monitoring will continue.

EOC recommended the preparation of a supplemental specification allowing the use of up to 25% by volume steel furnace slag in bituminous mixtures to increase the AWI.

05/05/82: Research Report R-1191 that early cracking of a bituminous section of US 2 was due to lack of consolidation of base materials along the centerline and slow draining base material and low penetration asphalt. Recycling was recommended for the pavement along with part of the base to serve as virgin aggregate in the recycling during the ‘83-’84 program.

FHWA and MDOT agreed upon the merits of constructing I 696 with premium pavement.

EOC requested that a specification be written allowing the use of crushed concrete from department projects to be used as 6A aggregate. Use as 6AA would not be allowed except by special authorization.

Due to national attention, the department will construct a trial project on US 23 of shattering the concrete pavement prior to placing a bituminous overlay.

06/02/82: A moratorium was placed on open graded friction course because of difficulties reported by the Maintenance Division.

EOC rejected MAPA’s flexible pavement cross sections and adopted a design consisting of 11 inch reinforced PCC over 4 inches of OGDC and 10 inches of sand sub base for I 696. Other aspects of a premium pavement will be considered later.

Engineering Operations Committee (EOC) Notes:

07/07/82: No aggregate information.

08/04/82: A proposal was adopted for a research study (82 D-43) titled “Predicting Bituminous Mixture Stability by Measuring Fine Aggregate Angularity”. This test on fine aggregate as it came from its source would benefit producers and the department equally in predicting which sources consistently produced high stability mixtures.

09/08/82: Research Report (R-1203), “Further Evaluation of Black Base and Aggregate Base Construction” concluded that 4 inch asphalt stabilized base under flexible pavement performed as well or slightly better than conventional 7 inch aggregate base.

10/14/82: The premium pavement design for the rest of the I 696, previously approved by EOC, is to be 11” reinforced PCC with 41’ joints while the question of the use of a premium aggregate was to be studied further by Testing & Research.

11/03/82: No aggregate information.

12/01/82: The specifications will be modified to allow the cement stabilized permeable base option to the asphalt stabilized permeable base design.

The I 696 project from Lasher to I 75 will have PCC ramps the same as the mainline while the service roads will be asphalt surfaced.

Based upon FHWA and recent MDOT thinking, better performance results when freeway shoulders are constructed with the same surface material as the travel lanes. Thus in the future a separate pay item for freeway shoulders will be discontinued.

EOC Binder 1983-1985:

01/19/83: EOC decided following C. J. Arnold’s presentation on D - cracking, that MDOT’s aggregate standard specifications would remain unchanged. However, a special provision for the upcoming M 21 projects would require that the minimum freeze-thaw durability limit be increased from 20 to 40 for 6A, with an alternate option of furnishing 17A gradation (in lieu of 6A) with a minimum durability of 30. A survey of existing local sources indicated that they either meet the 40 durability or can meet it via heavy media separation. Quarried sources available at the Port Huron docks all have durability factors well above 40, indicating that this specification modification will afford improved pavement life without increased cost.

The question of specifying premium pavement (including higher durability aggregate) for I 696 was assigned to further review before EOC could approve the request.

M-21 relocation was approved for 10 inch sand sub-base, 4 inch aggregate base for concrete, and reinforced PCC pavement.

Degradation of acid-treated and untreated steel furnace slag as open graded base for concrete pavement (R-1208) was approved. Steel furnace slag will continue to be allowed as OGDC for concrete pavement and the abrasion limit will remain at 50 and not be reduced to 40 as requested.

Engineering Operations Committee (EOC) Notes:

A report on trial projects using steel furnace slag in bituminous mixtures was approved. Since steel furnace slag is heavier than natural aggregate, a supplemental specification is required which covers the correction factor for weight payment.

02/09/83: Review of Research Report R-1210, “Evaluation of the Straight Line Gradation Chart and the Particle Index Test” was assigned to the Aggregate Acceptance Criteria Committee (AACC).

03/16/83: Infiltration of sub-base sand into OGDC bases (Research Report R-1211) was approved.

05/04/83: Steel furnace slag OGDC on I 69 (Research Report R-1216) was reviewed and approved, resulting in adopting a modified gradation for OGDC to be used on the M 21 projects. This will provide better stability with somewhat reduced but acceptable rate of drainage.

In-place 22A acceptance sampling procedures (Research Report R-1218) was reviewed and approved. The study proposes a method of sampling and acceptance by statistical methods which would result in reduced testing costs and is especially applicable to end-result specifications.

An “Asphalt Stabilized Crack Relief Layer-Arkansas Method” was approved for M 3 in Macomb County to inhibit reflective cracking at joints.

06/01/83: A recent MAPA report listed cost estimates for both bituminous and PCC overlays. MDOT will consider the information and continue to bid both options.

Sprinkle treatment evaluation (Research Report R-1223) was presented.

07/13/83: MDOT has been advised by FHWA that the use of steel furnace slag in bituminous mixes will be considered ”innovative” and therefore eligible for 5% additional federal aid. A trial project for next year will be M 85 in Riverview.

08/17/83: I-75 recycled concrete over new OGDC and under-drains was approved.

A minimum AWI, presently being specified for bituminous resurfacing aggregates, has been suggested for all bituminous aggregate including natural gravel. MMRA wants immediate approval while MAPA wants further review.

Supplemental Specification for 8G OGDC prompted a question whether the pavement core length be reduced by 0.25 inches for the loss of mortar into the OGDC. T & R will report back to EOC.

09/29/83: The earlier approval of the Supplemental Specification for sprinkle treatment using pre-coated aggregate for bituminous top course has been modified such that will be tied to the AWI implementation.

MAPA delays AWI implementation of the AWI specification until further review is complete.

11/09/83: After review, EOC decided that the specification should not be changed which provides for an additional 0.025 inch of core length without payment.

MDOT allows cross project usage of recycled concrete aggregates, however, the contractor must show evidence to assure that it came from an MDOT project.

12/09/83: A proposal was approved for studying the performance of reinforced concrete overlays with doweled joints at 41' spacing over old existing concrete pavement with a bituminous - sand bond breaker.

FHWA's field permeability testing device for open-graded bases will be evaluated by the Research Laboratory.

The John Lodge Expressway (US 10) reconstruction was approved for recycling the existing concrete pavement over OGDC with drains.

01/04/84: I-75 near Luna Pier was approved for JRCP using the existing concrete as recycled concrete aggregate over OGDC and drains after re-grading the existing sand sub-base.

US-12 reconstruction in Dearborn was approved for JRCP over OGDC and sand sub-base.

02/13/84: I-94 in Yipsilanti was approved for JRCP over OGDC with under-drains.

US-10 in Detroit was approved using recycled concrete pavement with OGDC and under-drains.

M-53 in Sterling Heights was approved using JRCP over OGDC and under-drains.

Research Report R-1228, "The MDOT Circular Wear Track - Results of Supplemental Aggregate Polishing Tests" was approved and includes AWI results for a number of Michigan sources.

Last meeting for Kent Allemeier as Secretary.

03/15/84: Experimental Work Plan 30, Evaluation of Lime, Fly Ash Base Course Mixtures was approved.

Pea stone OGDC as an alternate to bituminous separation course was approved for the I 94 overlay at Portland.

M. O'Toole is new Secretary.

04/04/84: The new AWI specification on bituminous wearing courses was acceptable to the MDOT, MRBA, MAPA, and MMRA representatives of the joint review committee. This year, The AWI specification was to be included on selected projects in the Metro area so that industry could get used to it.

Last meeting with G. J. McCarthy as Chairman.

05/09/84: Comparison of aggregate and bituminous treated bases (Research Report R-1238) was approved as written. Conclusion was that 4 inches of hot mixed asphalt base in lieu 8 inches of 22A aggregate base course performed essentially the same, however, variations can be expected with changes in soil conditions and quality of materials.

Don Orne was acting Chairman.

Engineering Operations Committee (EOC) Notes:

06/20/84: Research Report R-1210, ”Evaluation of the Straight Line Gradation Chart and the Particle Index Test had been approved by EOC in February, 1983, but referred to AACC for recommendations on implementation. Use in the laboratory was approved by AACC but further refinement was needed for field application.

EOC approved a special provision allowing the option of placing (sprinkling) bituminous pre-coated, high abrasive coarse aggregate behind the paver on a freshly laid bituminous mat where the subsequent rolling will incorporate it into the top surface.

W. MacCreary was acting Chairman.

07/26/84: No aggregate information.

09/05/84: EOC approved the Supplemental Specification for pre-stressed concrete beams. The 6AAA coarse aggregate requirements call for a natural quarried crushed stone having a minimum freeze-thaw durability factor of 80 (vacuum saturated). Such aggregates are considered premium and are called for because of the 50-plus year life expectancy of pre-stressed beams. Currently, there are 14 aggregate sources providing this premium type coarse aggregate to the Michigan market. Pre-stressed fabricators normally use this type of premium stone because of the early strength this concrete mixture provides to facilitate form turnover and the higher 28 day strengths required.

EOC rejected MCPA’s request to consider use of 10 inch non-reinforced concrete pavement with 20’ slab lengths and load transfer. L. T. Oehler, Engineer of Research, pointed out in his 08/28/84 letter, that there are no economies in using non-reinforced pavement. The savings of reinforcement mats are offset by the additional joints and their attendant load-transfer devices. The additional inch of slab thickness does not prevent transverse cracking, nor the faulting that will occur at a non-reinforced concrete slab crack. The purpose of the reinforcement is to keep the edges of the transverse crack in intimate contact to provide concrete interlock for load transfer, preventing opening and faulting of the crack. Shorter joint spacing will give a rougher ride and result in increased joint repairs. In 1974, MDOT constructed an experimental short slab non-reinforced pavement on US 10 in Clare County. Early indications are that it is not promising.

10/11/84: Investigation of sympathy cracking of new pavement on the I 94 recycling project in VanBuren County lead EOC to approve the reinforcing of the tied shoulders along with the pavement slab.

The decision on a pavement design life cycle cost analysis developed by Tom Coleman was delayed until details and assumptions are clarified before the next EOC meeting.

11/07/84: Research Report R-1251, “Field Trial of Foamed Asphalt Stabilization” showed that the foamed stabilization process can be effectively used along with mixed-in-place stabilization of granular base materials.

EOC approved a proposal to study strengths of various recycled concrete mixtures.

Engineering Operations Committee (EOC) Notes:

12/05/84: The committee discussed proposed changes to the special provision for producing crushed concrete coarse aggregate for use in Portland cement concrete.

Work Plan 96 (Research Project 84 C-20) concerning the use of steel furnace slag in bituminous mixtures was approved.

Work Plan 97 (Research Project 84 D-48) concerning experimental cement stabilized fly ash as a base under shoulders was approved. This is of interest to electrical utilities to help them alleviate their disposal problem.

01/09/85: A draft Pavement Selection Procedure based upon life cycle cost analysis was discussed.

Low stability bituminous base course (Research Report R-1254) was approved as written.

02/06/85: FHWA has indicated that OGDC 4" drain construction is not being installed according to MDOT's Standard Plans.

I 69 relocation from Charlotte to I 496 will be decided later.

US 131 in Kent County questions are to be resolved by special meeting. The committee approved recycled concrete for aggregate in a bituminous overlay.

03/06/85: Cross section of rigid pavements were discussed. No low fatigue failures have been found. Failures in concrete have been initiated by poor aggregates, base plates, poor drainage and incompressible materials in the transverse joints.

04/03/85: Cross section of rigid pavements was discussed based upon load carrying capacity. The 9 inch slab thickness should be maintained, not reduced, because of the low durability aggregates used from local sources throughout the state and other factors.

Cracking and seating of rigid pavements as a means to reduce reflective cracking in bituminous overlays has shown no apparent benefit on US 23.

05/01/85: Last meeting with Marty O'Toole as Secretary.

No aggregate information.

06/13/85: Paul Milliman Secretary

I 69 Charlotte to I 496 was approved for the concrete option with bituminous shoulders.

I 94 Battle Creek life cycle cost was discussed.

07/10/85: I 69 Charlotte to Lansing was approved for bituminous ramps.

Research report R-1262, "Performance Evaluation of Concrete Pavement Overlays (Construction Report)" was presented.

08/14/85: I 96 through Ionia County was approved for the concrete option.

US-12 in Canton Township was approved for reinforced concrete over OGDC and geotextile separator, under-drains and concrete shoulders.

Engineering Operations Committee (EOC) Notes:

09/20/85: No aggregate information.

10/25/85: Approval was given on a high priority status M&T proposal to study bituminous overlays of rigid pavements.

M-25 Bay City project was approved for reinforced concrete with 41 joints over aggregate base and sand sub base with 4 inch under-drains.

12/09/85: M & T was assigned the task of following up on where the department was as far as specifications allowing the use of fly ash in concrete.

<u>EOC Binder 1986 - 1991:</u> In the binder pocket are the following two Department Regulations:

DR 4410.02 (new) 04/07/78, Pavement Selection.

OI 3000.01 (New) 08/12/80, Engineering Operations Committee.

01/24/86: US-12 using reinforced concrete over OGDC was approved.

03/13/86: No aggregate information.

04/18/86: The committee reaffirmed its earlier position that the F/T durability requirement on the 6A CA be increased from 20 to 40 for the remaining I 696 projects in Oakland County. M & T is also to review the broader subject of F/T requirements for other roads and bridges and make recommendations.

05/23/86: Review of EOC membership and procedures was assigned to a subcommittee with action set for Paul Milliman.

US 10/31 reconstruction and widening was approved as a flexible pavement.

07/17/86: M-32 from Atlanta to Hillman was approved for flexible pavement.

The Bayport limestone polishing resistance report R-1273 was approved and accepted with the suggestion that M & T prepare a summary of high AWI materials for the contractors.

09/02/86: A research proposal: “Freeze-Thaw Durability and Pore Characteristics of the Major Rock Constituents in Glacial Gravel” was approved.

Performance of sandy-limestone bituminous wearing course research (R-1276) was accepted.

10/08/86: I-75 south of the Mackinaw Bridge was approved for bituminous pavement over the rubblized existing concrete.

12/03/86: M-24 in Lake Orion using a bituminous pavement was approved.

Engineering Operations Committee (EOC) Notes:

01/07/87: EOC requested additional cost and availability data for higher durability coarse aggregates from the M & T Division. The 40+ durability coarse aggregate will be required for freeways having at least 5,000 vehicles per day per lane.

02/19/87: No aggregate information.

03/20/87: Evaluation of lime, fly ash base course mixtures on M 29, Research Report (R-1281), was approved.

05/06/87: As a result of EOC's request for higher durability aggregates, AACC recommended four classes (N, M, F, and B) of durability based upon use and ADT volumes and the use of an easier to measure "dilation" measure for durability. This was all approved for beginning with the 1988 construction season.

06/23/87: No aggregate information.

07/24/87: Recycled fines are not allowed in future recycling of PCC pavements due to significantly lower concrete strengths.

Recycled fines are not to be used as backfill and/or base material under pavements due to leaching plugging the drains and filter cloth.

09/09/87: Specifications will be modified to prohibit recycled concrete in fine aggregates used in drainage layers and 8G OGDC. Coarser OGDC gradations will be permitted to contain recycled PCC pending further evidence from additional field evaluations.

A policy was approved for using OGDC under all pavements on future projects where full lane pavements extend for ½ mile or more, except tapers and ramps.

10/21/87: EOC decided that no recycled aggregates are to be used on the I-696 reconstruction project between I 275 and Telegraph Road.

12/18/87: Potential concrete recycling projects will be evaluated so that projects containing very low durability aggregate are not approved for recycling.

Rubblizing under bituminous overlays continues to be evaluated to determine effectiveness of this option.

01/26/88: New aggregate specifications will be delayed until the 1989 construction season due to delays in delivery and checkout of new freeze/thaw testing equipment. A project by project special provision based upon existing data will be used for specifying higher durability CA for high-volume road construction until new testing data is available.

US 41 was approved for bituminous pavement.

US 31 was approved for rigid pavement upgrading.

03/03/88: A request from MCPA to build a white-topping (Concrete surfacing over an existing bituminous pavement) demonstration project was nor approved.

US 31 rehabilitation was approved for flexible pavement options.

Engineering Operations Committee (EOC) Notes:

SB I 75 near Grayling was approved for rubblizing plus a bituminous overlay and base drains.

04/20/88: Metro CRC pavement review was discussed and referred for further study on how to finance repairs.

A 6 inch overlay was approved for SB I 75 from US 10 south.

05/26/88: No aggregate information.

07/01/88: M 68 rehabilitation was approved for experimental rubblization.

Early performance of recycled freeways was presented to the committee. Chairman W. J. MacCreery requested that additional evaluations be undertaken and also presented.

08/04/88: No aggregate information.

09/20/88: No aggregate information.

11/03/88: US 10 rehabilitation using rubblizing and a bituminous overlay was selected.

12/16/88: Relative to PCC recycling for the 1989 season, it was decided that virgin 6A coarse aggregate with a maximum dilation of 0.040%/100 cycles will be used for the mainline pavement while recycled concrete CA is to be allowed in the shoulders only. Open graded material is to be 100% crushed; slag and recycled concrete are not to be used. A prime coat of bituminous emulsion is to be applied on top of the sand after compaction. Drains are to be placed under each lane with greater emphasis on base compaction.

The durability specified for pavements, etc., by special provision, will continue to be 0.040%/100 cycles dilation.

01/20/89: Rutting over rubblized concrete was determined to be a result of the amount and shape of the fine aggregate particles and not the rubblized base. Rutting can be prevented by using increased angular and crushed content fine aggregate plus latex in the mix. More stable mixes are to be designed for heavily traveled routes.

I-75 reconstruction in Monroe County was modified including requiring natural 6A coarse aggregate with a maximum of 0.040%/100 cycles dilation for the pavement concrete with 27’ joints over 5G OGDC made from 100% crushed natural aggregate.

I 696 decided to upgrade the requirements for the OGDC and the coarse aggregate for the concrete pavement.

02/17/89: Several I-696 projects with differing aggregate specifications were discussed and a continuation meeting on 02/21 was scheduled.

It was decided that the 3G gradation in a 5 inch thickness with additional compaction requirements to provide sufficient stability and strength will be the standard OGDC specification.

Engineering Operations Committee (EOC) Notes:

03/21/89: M-9 interchange designs using concrete with bituminous shoulders were approved.

The Levy Company requested to blend steel furnace slag or limestone with blast furnace slag to meet the abrasion requirements for 3G, 5G, and 8G and requested that the abrasion limits be raised to 50 for 21, 22, and 23 Series aggregates. Specific reasons were noted for denying these changes to the aggregate specifications.

Crushed concrete showed significant leaching and calcium carbonate precipitates, especially in particles passing the No. 4 sieve (Research Report R-1297). There were no problems with gravel and limestone and minimal with blast furnace slag.

04/24/89: Proposed guidelines for preparing a deteriorated JRCP for a bituminous overlay were presented and modified for use by the Design Division.

Based upon the twelve (12) experimental rubblized projects, further experimentation should not be used on high commercial volume roadways.

05/26/89: Guidelines for submission of pavement designs to EOC were accepted.

Interim procedures for determination of recycling suitability of concrete pavement were sent out for review within the department and the concrete paving industry.

Approval was granted for M & T to clarify the use of crushed concrete aggregates in pavements in Supplemental Specification 8.02(4a).

08/01/89: No aggregate information.

09/11/89: Decision was made to retain 5G, 8G & 34G open graded aggregates in the Standard Specifications without OGDC designation. 34G will remain as backfill for drains.

The concept of fast track concrete and rut resistant bituminous retrofits will be considered for heavily traveled intersections.

11/14/89: The M-53 relocation project using concrete over OGDC was approved.

Recommendations were made for reconstruction of PCC pavements by changing the location of the drains to outside the traveled way. Several combinations of virgin and recycled aggregates for concrete pavements and various types of bases were referred back for further review.

Research Report (R-1301) on freeze/thaw evaluation of Michigan aggregate was approved for publication and distribution.

12/05/89: No aggregate information.

J. D. Culp replaced P. Milliman as Secretary.

01/16/90: MCPA issued a report by CTL that states that crushed concrete aggregates can be washed to eliminate the possibility of fines or carbonates being released. This is contrary to MDOT experience and requires further review.

02/06/90: Restrictions were outlined for use of crushed concrete pavement as aggregate for OGDC and concrete pavement.

Engineering Operations Committee (EOC) Notes:

03/06/90: Correction to the crushed concrete restrictions (02/06/90, Old Business, Item No. 2) was noted. The last sentence in the "Decision" paragraph should read: A mixture of an approximate proportion of 50% 6A recycled aggregate and 50% of a larger sized, higher quality aggregate with a minimum durability of 60 to 70, or all virgin material (no recycled) with a durability of at least 40 will be accepted.

04/03/90: Draft Operating Instructions for determination of suitability of recycled concrete pavement will be sent to the Districts for review.

Performance evaluation of concrete pavement overlays (R-1303 Draft) was reviewed. An Action Plan is to be prepared.

Maximum transverse joint spacing (27' verses 41") criteria are to be established and added to the Design Standards.

06/05/90: Continue using 27" joints when ADTT > 5,000 and 41' joints for AADT < 5,000 until all factors are better understood. Review results in a year.

R-1303 on performance evaluation of concrete overlays was approved along with the modified action plan.

It was recommended that AWI requirements be modified for Bituminous aggregates. More field study will be initiated.

08/14/90: M 59 widening from 4 to 6 lanes on the median side was to consist of repairing the existing 24' by patching and grinding and adding a concrete lane and a bituminous median shoulder.

10/02/90: Recycled concrete specification changes were proposed and were to be reviewed with the Districts.

US-23 rehabilitation north of OH line will include removal of the bituminous overlay and old concrete pavement and be replaced with new reinforced concrete with 27' joints over an improved base.

11/06/90: Experimental design plans for two SHRP Special Projects Studies (SPS) were approved.

12/04/90: No aggregate information.

01/08/91: US-27 relocation was approved as a bituminous design.

02/05/91: US-131 using a bituminous overlay on rubblized pavement was approved.

I-275 experimental bonded concrete overlay on CRC was approved for 1992.

Experimental SMA overlay concept was approved and design will locate a suitable location.

03/05/91: M-37 rehabilitation using bituminous resurfacing over rubblized concrete was approved.

US 23 rehabilitation using reinforced concrete was selected.

04/02/91: No aggregate information.

Engineering Operations Committee (EOC) Notes:

06/04/91: Flowable fill will be offered as an option to density controlled backfilling in open-cut utility trenches based upon successful field trials.

08/13/91:

Conclusions indicate that rubblizing has eliminated reflective cracking and no additional rutting or drainage problems result plus good ride quality is being maintained.

CA from recycling concrete pavements will be limited to non-mainline pavement due to poor load transfer capability across a reinforced crack even when large natural CA is blended in.

I-96 rehabilitation using bituminous overlay over rubblized concrete was selected as the preferred option.

Construction Division requested that cement stabilization of OGDC be developed.

EOC Binder Sept. 1991- Dec. 1998:

09/10/91: Cement stabilization of aggregate or crushed concrete OGDC was put on hold until the leaching problem can be solved.

I-96 SMA on Rubblizing project was approved.

10/08/91: Discontinue use of lime, fly ash base course mixtures as result of R-1310.

Research Report R-1311 recommended significant changes to the aggregate specifications.

R-1312 Wear Track Testing was accepted with fine aggregate limited to thin (typically 1/2") bonded overlays,

Cement/asphalt coating of crushed concrete pavement (5G OGDC) experiences was reviewed and conclusions on coating options were outlined.

11/05/91: US-27 south of Price Road premium experimental bituminous design was approved.

I-94 experimental Stone Mastic Asphalt (SMA) overlay was approved.

01/07/92: US-23 SHRP and Aggregate Durability Test Roads @ the OH line projects were approved. The southbound section with the aggregate durability research test sections is to be built in 1992 and the northbound SHRP sections in 1993.

US 27 relocation for 1993 was discussed and was referred back to Design.

02/04/92: US-27 relocation using reinforced concrete with 41' joints over OGDC was approved.

03/03/92: Davison Freeway reconstruction using reinforced concrete with 41' joints and reinforced shoulders was approved.

I 94 rehabilitation of experimental recycled concrete pavement will need reconstruction in 3-5 years.

Engineering Operations Committee (EOC) Notes:

04/07/92: Full Depth Asphalt Design was approved for I-96 section.
M-121 flexible pavement was selected.
QA special provision for furnishing PCC was approved for 5 trial projects.

05/05/92: R. A. Welke was appointed as new EOC Chairman.
I 94 rehabilitation using unbonded reinforced concrete overlay with 41' joints and tied concrete shoulders was selected.
Cement stabilized fly ash as base under bituminous shoulders is discontinued due to severe cracking and frost heaving.
Cement stabilized crushed concrete for OGDC final report (91 TI-1583) was accepted.

06/02/92: Pavement Life-Cycle Costing Report was presented and approved for use on future projects.
Freeze-Thaw Durability of 6A Coarse Aggregate by Ralph Vogler explained the historical basis for the department's freeze-thaw, aggregate durability testing program and specification requirements will be sent to MMRA under R. Welke's signature.
Two I 194 rehabilitation projects using bituminous over on rubblized pavement were approved.

07/07/92: No aggregate information.

08/04/92: Formation of a life-cycle costing Pavement Selection Committee, a subcommittee of EOC,was approved.
M-15 rehabilitation using a bituminous overlay on rubblized pavement was approved.
Experimental SMA rehabilitation of US-131 using bituminous overlay was approved.
Freeze/Thaw Durability report (R-1311) was approved.
European Concrete Pavement Design was discussed.
A target of 10/01/96 was set for the new 1996 Standard Specifications book.

09/01/92: Performance of rubblized pavements were reviewed, resulting in: "Rubblization for bituminous overlay is no longer considered experimental and can be used with out EOC approval.
Cement stabilized sub-grades were discussed.
US-27 N. of I-69 to Price relocation using reinforced concrete with 41' joints approved.

10/13/92: M-37 reconstruction (6.8 miles) using reinforced concrete pavement with 41' joints and shoulders over OGDC except for 1.9 miles of flexible pavement was approved.
Six projects were selected for concrete QA in 1993.
Six projects were selected for concrete QA in 1993.

Engineering Operations Committee (EOC) Notes:

11/03/92: Metric requirements and new Divisions were set for the new standard specifications book.

Report was made on the European Concrete Pavement Tour.

12/08/92: Report on the German/Austrian pavement tour was presented.

Thin bituminous overlay (75 lbs/sq yd) as an option to micro-surfacing for pavement preservation program was approved for several trial projects.

01/07/93: M & T proposed the use of premium aggregate for high performance asphalt mixtures.

The 1996 specifications book committees/individuals were approved.

02/04/93: MAPA full-depth bituminous trial project on I-96 was approved as an experimental project.

Industry objected to premium aggregate be used for bituminous pavement. Gary Taylor was selected as General Chairman for the 1996 Standard Specifications book.

I-94 reconstruction using reinforced concrete pavement with 27' joints over OGDC and reinforced concrete shoulders was selected.

I 75 reconstruction was approved using reinforced concrete with 27' joints over OGDC on the southbound roadway while northbound was to be the European design on the northern section (1 mile) and high freeze-thaw durability premium aggregate (low dilation) in the southern section (1.3 miles) for experimental comparison.

03/17/93: Design-Build-Warranty on I 275 CRC to be discussed with industry. Several I-75 projects in Monroe County using recycled coarse aggregate were discussed.

Proposed ultra-thin bituminous overlay (75 lbs.) for highway preservation was approved.

Fly ash was proposed for low strength sub base for pavements.

I-75 reconstruction using the reinforced concrete with 41' joints over OGDC and geotextile separator was selected.

04/08/93: Work Plan 135 on temperature monitoring for binder specifications in bituminous pavements was approved.

05/14/93: Recommendation was approved to establish Centers of Excellence through Michigan Transportation Research Consortium (MTRC).

08/05/93: An update on an ultra-thin bituminous overlay (75 lbs) for highway preservation project was reviewed.

10/07/93: Special provision to increase the minimum Voids in Mineral Aggregate (VMA) was authorized.

I-131 Cadillac Bypass using the bituminous alternate was approved.

Engineering Operations Committee (EOC) Notes:

I-94 reconstruction using reinforced concrete with 27' joints and reinforced concrete shoulders over stabilized OGDC was selected.

11/03/93: M-43 reconstruction and widening to 5 lanes using bituminous alternate was approved.

I-94 relocation and reconstruction using the bituminous alternate was approved.

12/02/93: Reconstruction of experimental recycled concrete pavement on I 94 was approved.

01/06/94: EOC subcommittees: Bituminous Advisory Committee and Pavement Selection Committee - Roles and Responsibilities of each were discussed.

Special Provision for 17 Concrete QC/QA trial projects was approved.

Joint spacing standard was set at 27' for ADT (trucks) > 5,000 and 41' for ADT (trucks) < 5,000. "Until aggregate durability is significantly increased (lower dilation number) above the current specification, it is not advisable to increase the number of pavement joints in general."

02/03/94: Concrete QC/QA to stay as special provision.

03/03/94: OI 3000.01-EOC guidelines were approved.

04/14/94: No aggregate information.

05/12/94: Status of concrete QC/QA specification, clarification on intent.

M-6 new construction using bituminous option was approved.

US-23 reconstruction using reinforced concrete with 27' joints over stabilized OGDC was selected.

07/07/94: No aggregate information.

08/04/94: Bituminous QC/QA (focusing on acceptance procedures for bituminous mixtures) was approved for 1996 book.

09/01/94: No aggregate information.

10/10/94: Statement of Authority and Responsibility of new Joint MDOT/MCPA Concrete Committee.

Bituminous Advisory Committee (BAC) Joint Industry Group to investigate asphalt segregation.

11/03/94: Request for two new Research Center of Excellence (RCE)'s: "Materials" at MTU & "Infrastructure" at UM are pending, however, no funding is available now.

Two I-275 projects using reinforced concrete, one with 27' joints and another with 41' joints were approved. Both had reinforced concrete shoulders.

Engineering Operations Committee (EOC) Notes:

12/09/94: Research Report R-1327: “Concrete Pavement Restoration” was approved as modified.

01/05/95 (revised minutes 02/03): I-94 reconstruction using reinforced concrete plus some experimental non-reinforced sections and 14 ft right lanes and bituminous shoulders was approved.

02/02/95: 1995 Conc. QC/QA Trial Projects were approved.

Concern that contractors will leave salvaged uncrushed concrete after finishing a project will be discussed with industry. Crushing/stockpiling or burying may be an option.

03/02/95: Research Report R-1334 using a modified bituminous base course (9A) as a separation course for reducing reflective cracking in bituminous overlays was approved.

Approval was granted for use of a separate budget item for QC/QA on bituminous projects instead of considering it as a pay adjustment.

04/06/95: No aggregate information.

05/04/95: No aggregate information.

06/01/95: More changes proposed to (OI 3000.01) covering the EOC.

07/06/95: Suggestions were made to OI 3000.01

08/03/95: Updated OI 3000.01 approved as presented.

09/07/95: No aggregate information.

10/05/95: MTU proposal: “Effectiveness of Materials and Procedures for Sealing Joints and Cracks” was approved for two year project. Final proposal to be developed with help from MDOT.

11/02/95: Twenty 1996 Concrete QA/QC trial projects were approved as presented.

I 94 interchange pavement approved for an experimental Design-Build option.

01/04/96: Concrete pavement designs were reviewed along with Illinois, Wisconsin, and Minnesota and recommendations concerning lowered costs were made.

03/14/96: MSU’s research report: “Factors Affecting the Deterioration of Transverse Cracks in JRCP” was accepted for distribution.

The Superpave Asphalt Binder Specification was approved as modified for Michigan temperature data starting with projects let after 01/01/97 or when The 1996 Standard Specifications are implemented.

Engineering Operations Committee (EOC) Notes:

05/02/96: I-275 reconstruction using a bituminous overlay on a rubblized concrete slab was approved.

1996 EOC Membership list was attached with Tom Coleman noted as new Chairman.

06/07/96: No aggregate information.

07/08/96: Silica Fume modified concrete approved as an option to latex modified concrete as deck overlay.

I-75 reconstruction using reinforced concrete with 40 HDP mixture was approved, however, the Design Division will check out other options.

08/02/96: Discussion on how user costs should affect life Cycle Cost Analysis in pavement selection.

09/05/96: Contract Research Report 94A-0031 "Adoption of a Rapid Test for Determining Aggregate Durability in Portland Cement Concrete" approved.

11/05/96: No aggregate information.

12/04/96: No aggregate information.

01/08/97: I-96/M-14 using non-reinforced concrete with bituminous shoulders was approved.

US-12 using non-reinforced concrete was approved.

02/19/97: Hot In-Place Recycle Asphalt being evaluated as part of preventative maintenance.

Northwestern Highway using bituminous pavement was approved.

03/13/97: No aggregate information.

04/03/97: No aggregate information.

05/01/97: No aggregate information.

06/05/97: No aggregate information.

08/07/97: Jon Reincke replaced Calvin Roberts as Secretary.

US-23 and US-31 projects using non-reinforced concrete overlay with bituminous shoulders was selected.

US-131 using non-reinforced concrete overlay was approved.

11/06/97: Life Cycle Cost Analysis (LCCA) procedure revised for pavement selection was modified to agree with new legislation (Senate Bill 303).

Engineering Operations Committee (EOC) Notes:

12/04/97: Research Report R-1353: Investigation of Calcium Hydroxide Depletion as a Cause of Concrete Pavement Deterioration was approved.

M-6 reviewed and an increase to 350 lane miles of JPCP with a state of the art warranty was approved.

Steve Bower replaced Glen Etelamaki as Chairman of the Pavement Selection Review Committee.

I-69 using bituminous overlay on rubblized concrete was approved.

US-23 using reconstruction with jointed plain concrete was selected.

M-60 using bituminous overlay on rubblized concrete was approved.

01/08/98: Concrete and bituminous 1998 warranty projects were proposed. Final Report: Test Method to Determine the Existence of Segregation in Bituminous Mixtures was accepted and approval given for phase II.

03/12/98: No aggregate information.

04/02/98: Final report titled: Mechanistic Design Implementation Plan for flexible Pavements and Overlays, was accepted.

Revised Draft Bituminous Mixture Selection Guidelines was submitted and approved.

05/07/98: I-75 reconstruction using plain concrete was selected.

I-696 reconstruction using reinforced concrete was approved.

06/04/98: JPCP was proposed as the standard for rigid pavement in Michigan but was not approved due to insufficient field data.

09/10/98: I-275 design build warranty using jointed plain concrete selected.

US-131 rehabilitation using rubblized concrete approved.

I-69 reconstruction using jointed plain concrete approved.

11/05/98: M 46 white-topping project proposed.

12/03/98: Stockpiled Bituminous Aggregates payment proposed by industry, not agreed upon.

<u>EOC Binder 02/09/99-05/01/03:</u>

02/03/99: EOC was not convinced of the merits of paying for stockpiled aggregates for Bituminous Mixtures and tabled the issue.

03/04/99: No aggregate information.

05/11/99: MDOT procedure for innovative pavement designs, construction, and materials was approved.

Engineering Operations Committee (EOC) Notes:

06/03/99: Two I-69 rehabilitation projects using an unbonded jointed plain concrete overlay were approved.

Approval to start the new Standard Specifications book for 2003 was granted.

07/01/99: 2005 Book will use dual metric/English units and active voice,

US-131 rehabilitation using an unbonded jointed plain concrete overlay was selected.

08/05/99: Old M-14 reconstruction using a flexible bituminous pavement was approved.

09/02/99: Another M-14 reconstruction using a jointed plain concrete pavement was selected.

I 96 reconstruction using a jointed plain concrete pavement was approved.

10/08/99: Ride Quality Committee was formed,

US-23 reconstruction using an unbonded jointed plain concrete overlay was approved.

11/09/99: Active voice - imperative mood will be done on the 2003 book under contract.,

The C & T Bituminous QC/QA Procedures Manual of Field Testing was approved for 2000 projects.

I-75 rehabilitation using a rubblize and bituminous overlay was approved.

US-24 reconstruction using a jointed reinforced concrete pavement was selected.

01/06/00: Combining EOC's two standing committees: Bituminous Advisory Committee and Pavement Selection Committee was discussed and details will follow in upcoming meetings.

03/02/00: Old Bituminous Advisory & Pavement Selection committees were combined into a new "Pavement Committee" reporting to EOC.,

Old M-14 reconstruction using a flexible bituminous pavement was approved.

US-131 reconstruction using a jointed plain concrete design was approved.

M-6 new construction using jointed plain concrete was approved.

US-24 reconstruction using jointed reinforced concrete was selected.

04/06/00: Southbound M-10 reconstruction using flexible bituminous was approved.

I 75 and US 12 reconstruction projects using jointed reinforced concrete were approved.

05/03/00: US 27 reconstruction using flexible bituminous and rehabilitation using rubblize and bituminous overlay was selected.

M 43 reconstruction using flexible bituminous was approved.

06/02/00: JRCP vs. JPCP designs were discussed,

Engineering Operations Committee (EOC) Notes:

Revised AWI for Bituminous surfaces approved,
US-131 reconstruction using JRCP was approved.
Tom Fort's last meeting due to upcoming retirement.

07/06/00: 2003 book updates include deletion of Bituminous QA/QC and inclusion of Concrete QA/QC and "hot mix asphalt (HMA)" will replace "bituminous".
I-96/M-14 reconstruction using JRCP approved.
M-39 reconstruction using JPCP selected.

08/03/00: I-496 reconstruction using JRCP was selected.
M-6/I-196 reconstruction using JPCP was approved.

09/06/00: Michigan Aggregate Association (MAA) requested specification revisions for (22A, 34R). Revised 22A was tabled since it would potentially allow more fines and a higher wash content resulting in impeded drainability and increased potential for frost heave in the base.

Allowing increased crushed content in 34R backfill further reduces the aggregate's ability to flow into the trench thus preventing it from achieving a compacted condition without being further manipulated or worked. Will be tried by SP on a couple of 2001 projects.

10/10/00: M-50 reconstruction using flexible bituminous was approved.
M 50 rehabilitation using rubblizing and bituminous overlay was approved.

11/07/00: The State Transportation Commission directed the department convert back to English units from metric for contract plans and specifications.
I 75 and M 84 reconstruction projects using flexible bituminous were approved.

12/06/00: US-127 reconstruction using JPCP was approved.

02/01/01: US-131 new construction using flexible bituminous was approved.

05/01/01: I-96 reconstruction using JRCP was selected.
I-69 reconstruction using JPCP was approved.

06/07/01: Improved aggregate quality for pavements is the department's goal.

Timely Availability of 4AA Concrete Aggregate for P1 Modified Concrete in Central Michigan was discussed.

M-10 and Capital Loop reconstruction projects using flexible bituminous were approved.

07/16/01: Improving Aggregate Quality in Concrete strategy was proposed.
NB US-24 recon.

08/09/01: I 75 reconstruction using JRCP was selected.

Engineering Operations Committee (EOC) Notes:

09/06/01: M 84 reconstruction bituminous pavement design was approved.

01/03/02: I 94 & US 12 reconstruction bituminous pavement designs were approved.

02/07/02: 2003 Standard Specifications being prepared in active voice, except for Division 1 and books should be available in early 2003.
M 53 new construction of bituminous pavement approved.

03/12/02: US 23 reconstruction using jointed plain concrete was selected.
M 59 using a HMA design was selected.

04/04/02: Six (6) research projects were reviewed by Pavement Committee as to final implementation.

05/07/02: M 53 reconstruction using bituminous pavement was selected.
I 75 rehabilitation using rubblize and HMA overlay was selected.
I 69 reconstruction using a jointed P1 modified concrete pavement was selected.

06/06/02: This was Paul Miller's last EOC meeting.
US 23 rehabilitation using rubblize and HMA overlay was selected.

07/11/02: Michigan and Ohio are still using jointed reinforced concrete pavements in some instances.

09/11/02: US 10 rehabilitation using a rubblize and HMA overlay was approved.
I 96 rehabilitation using an unbonded jointed plain concrete overlay was approved.
I 94 reconstruction/rehabilitation using a jointed plain P1 modified JPCP was selected.
I 375 business spur using bituminous pavement was approved.

11/06/02: I 69 reconstruction using a jointed plain P1 modified concrete pavement was approved.

12/05/02: I 96 reconstruction using a jointed plain P1 modified concrete pavement was approved.

02/06/03: A total of 36 supplemental specifications (SS's), 60 frequently used special provisions (FUSP's) and several non-FUSP's were incorporated into the 2003 book.
I 94 reconstruction using a P1 modified concrete mix was approved.

03/10/03: US 31 rehabilitation using an unbonded jointed plain concrete overlay was chosen.

04/07/03: The US 131 rehabilitation project was withdrawn.

Engineering Operations Committee (EOC) Notes:

05/01/03: This was Thom Davies last EOC meeting.
M 59/US 23 interchange reconstruction was approved.

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