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THE GEOLOGICAL DISTRIBUTION OF HIGHWAY BASE COURSE  
MATERIAL AND AGGREGATE IN FLORIDA

By

Robert O. Vernon<sup>1</sup>

INTRODUCTION

The Florida State Road Department's philosophy of road building includes the purpose of using any rock materials in the area through which the road passes, provided these materials will meet or can be made to meet the specifications of use. This general philosophy also includes planning to have the cuts balance the fills with hauls being made as short as possible.

Failure of the road bed as a result of freezing and thawing is not a particularly distressing problem in Florida, but, because of our heavy rainfall over short periods of time the saturation by water and resulting failures by flow does present some difficulty. Soft clays and organic muds, mucks and peats occupy shallow sinkhole depressions through the State, and are present in large numbers along the coastal lowlands. These soft sediment-filled sinks are excavated where they are intersected by roads and are refilled by sand, which is compacted. If the sinks are excessively deep, piling or bridging may be used.

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For state roads, a base course of several accepted materials is placed upon the grade and sections cut into the native sediments. The thickness of the base course varies from 6 to 10 inches when compacted, depending upon the amount of the road traffic. Upon this base course, pavements of concrete with silica gravel and sand, and with stone and sand as aggregates can be constructed. Bituminous mixes require a prime and a tack coat upon the base course followed by the bituminous pavement, which may consist of 1) various sand-asphalt mixes, both hot and cold, using silica sand, stone screening, slag screening, or shell; 2) asphaltic concrete binder course followed by a surface course, using both stone or slag and the fine aggregates above.

#### BASE COURSE MATERIALS

Several mineral materials have been used for base-course materials in Florida. These must be porous and permeable, uniform or easily made so by mixing with other sediments, and must be easily worked into a smooth, firm surface free of pits and pockets.

Base-course material should show no tendency to air slake or undergo rapid chemical change when weathered. Limestone must be uniformly graded from the largest pieces down to dust, and of a stated chemical content. Hard, lumpy, and flinty pieces are allowed up to a percentage where their presence prevents the forming of a smooth surface. The presence of trash and other foreign matter is not tolerated.

The plasticity index, the volume of water in percent necessary to change the rock from its plastic limit to where the crushed rock matrix will deform and flow, is closely controlled and is not allowed to exceed 10 percent.

Materials near the road right-of-way are desirable not only for the ease of handling, but also because of low cost. The widespread occurrence of soft, granular limestones in Florida (frontispiece) provide convenience pits along many roads. Centers of production near Ocala, Williston and Miami can ship these materials at low cost to most of the State. Only in the Panhandle area is a sand-clay base commonly used, elsewhere limestone, marl or shell is specified.

Limestone, the primary material for road-base courses, is sold for about a dollar per ton F. O. B. at the plant. More than 4 million tons are used annually for this purpose. Sand-clay base course is similar in price, but the deposits are limited and becoming increasingly hard to find.

Limestone, sand-clay mixes, shell, marl and, where the traffic load permits, local rock bases may be used. These are listed approximately in their order of preference. Of the limestones, the Ocala group is the best available material. It is, as mined, more than 95 percent carbonate and is clean, uniform, smooth working and easily handled. Dampness rarely disturbs the road bed because the Ocala has an excellent porosity and permeability. The granularity of the limestone

allows the diskings of the base course, and the soluble organic-calcite forms a smooth compacted upper surface with little wetting. The stone is clean, easily dressed and pavement materials can be easily and firmly placed upon it.

A group of limestones of upper Eocene age called the Ocala group and including the Crystal River, the Williston and Inglis formations, crops out along the crest of the Ocala uplift along the tier of counties of the western peninsula from Suwannee southward to Hernando. These limestones are extensively mined in the Ocala and Williston areas and elsewhere in adjacent counties, where paved roads cross the outcrop. These limestones also crop out in Holmes, Washington and Jackson counties, but no attempt to utilize these as base course has been successful. A reserve of some 3 trillion cubic yards is present in the Ocala-Williston district and 15 billion yards in Holmes, Washington and Jackson counties.

Younger Oligocene and Miocene sediments, the Suwannee limestone and the Tampa formation, have been utilized under the term "Ocala limerock," but the plasticity index is usually too high for these to be used except when mined and combined with the limestones of the Ocala group. The Oligocene and Miocene limestones lie generally around the outcrop of the Ocala group in counties that adjoin the Ocala area. A recent test of dolomitic limestone of the Tampa formation or Suwannee limestone, exposed in Jefferson County, indicates

that this rock might be utilized for base course.

Miami limestone as used by the State Road Department includes all limestone mined below the 28th degree parallel, but for the most part is Miami oolite of Pleistocene age. These limestones are allowed to have a minimum of carbonate of 85 percent, a plasticity index not greater than 6 percent and a liquid limit below 35 percent. Hard pieces offer some difficulty in obtaining a smooth upper surface. About 16 billion cubic yards of Miami limestone is present in the southern peninsula of which only a portion is available for mining. Because of large land developments the area available for mining is becoming increasingly smaller.

Shell base course must be clam or oyster shell, but steamed shell cannot be used. Admixtures of other mineral materials having a bearing weight of 30 pounds per square inch is permitted as a shell stabilized base. Oyster shells are dredged from deposits accumulated in bays, bars and occasionally from large Indian shell mounds. One difficulty in using shells for base course is the requirement to wet heavily, and more often than limestone, to secure a smooth, firm surface.

Broken and whole shells make up 80 to 90 percent of the beach ridge along the Atlantic coast and to a limited degree the beach and ridge sediments along the Manatee, Sarasota, and Charlotte County coast. These shells are loosely to firmly indurated and except for a limited local use as a base course or road surface, the material is

employed for other more valuable structural uses.

Marl base must be either a shell marl that is uncemented or so indurated that it can be blasted in the pit and crushed by rolling on the road. The plasticity index must not exceed eight percent. Marl occurs rather commonly along the coastal areas of the Peninsula at elevations generally below 25 feet and rather generally along the deep stream-cuts of Holmes, Washington, Walton and Okaloosa counties.

#### AGGREGATE

Course aggregate is a scarce item in Florida. The State Road Department permits the use of silica gravel, stone or furnace slag. For use in Florida roads, silica gravel must be clean, tough, durable, quartz. The loss in a Los Angeles abrasion test cannot exceed 45 percent and the dry-rodded weight per cubic foot must exceed 95 pounds. Stone must be clean, sound, durable rock that, when subjected to the Los Angeles abrasion test, the loss shall not exceed 40 percent. Slag must be clean, tough, durable pieces of air-cooled, blast furnace slag, reasonably uniform in density and quality, containing not more than 1.5 percent of sulphur. The dry-rodded weight shall exceed 70 pounds per cubic foot and abrasion loss shall not exceed 40 percent. Slag cannot be used for portland cement concrete.

Fine aggregate for concrete shall be hard, strong, durable, reasonably well-graded, uncoated grains of quartz, reasonably free of

extraneous substances. However, natural sand, stone screenings, slag screenings, or combinations of these, provided they meet the abrasion requirements and are clean, tough, angular grains free from clay, loam and other foreign matter, may be used in asphaltic concrete or binder course.

Hard, dense limestone is the only coarse aggregate produced in any abundance in Florida. Indurated thin-bedded limestone of the Miocene-Tampa formation and Oligocene-Suwannee limestone is mined in Suwannee, Hernando and Lee counties and more than 3 million tons are used annually at a cost of \$1.00 to \$3.25 per ton F. O. B. cars at the plant. The harder seams and beds of limestone mined along the outcrop in Broward and Dade counties are screened from that sold for base course and are used as aggregate. To a very minor percent this separation is also made from the Ocala limerock.

Slag is shipped into Florida from the Birmingham district at a cost of \$1.75 to \$1.95 per ton F. O. B. cars at the plant. The freight rate makes Florida stone competitive. About 1.2 million tons of silica gravel is produced from dredgings in the Flint River. Minor deposits are known to occur in northern Escambia and Santa Rosa counties and in southwest Jackson County, but most of the silica gravel used in portland cement concrete is produced from these limited resources.

Insofar as fine aggregates are concerned, fine to coarse quartz sand is widely distributed over the State. Almost any road built in

Florida crosses suitable quantities of clear, sharp sand. However, because stone and slag are required as coarse aggregates it is sometimes more convenient and cheaper to use slag and stone screenings as fine aggregate, or to combine these with locally produced quartz.

## PETROLOGY OF CONCRETE AGGREGATE

By

Bryant Mather<sup>1</sup>

It was my pleasure to participate in the program of the 1956 Symposium. On that occasion I remarked that the fact that it was then the 7th Symposium on Geology as Applied to Highway Engineering should signify that there was no longer any need to advocate as new the use of geological knowledge and techniques in connection with highway engineering. Much of what I had to say in 1956 concerned aggregates for portland-cement concrete and some of the things I said then will be repeated here.

For many years aggregates were defined as "the inert materials such as sand, crushed stone, and similar particles," which together with cement and water compose concrete. If one examines the still valuable Treatise on Concrete, Plain and Reinforced by F. W. Taylor and Sanford E. Thompson, which was in its third edition in 1916, or the fifth edition of Johnson's Materials of Construction, which appeared in 1919, one finds no reference either to the concept that aggregate is, can be, or should be other than inert, or to the suggestion that samples

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of materials proposed for use as aggregate should be examined by a geologist or petrographer. The first record that we have been able to locate of the employment of a petrographer in describing and classifying concrete aggregates is a report published in May 1915 in the Bulletin of the AIME by C. W. Tomlinson entitled "Method of Making Mineralogical Analysis of Sand." This report describes a method that he developed under the direction of Prof. M. O. Withey and Prof. A. N. Winchell at the University of Wisconsin. Tomlinson's procedure consisted of separating a sand sample weighing about 300 g into four size ranges by the use of sieves, separating each sieve fraction into four specific gravity classes by the use of heavy liquids, and then examining and counting the particles of each class in each size range using a hand lens or microscope and computing weighted average composition. We do not have information as to what, if any, specific engineering utilization was made of the information developed from Tomlinson's work.

The literature contains relatively few references prior to 1930 relating to specific geological and petrographic information on aggregates that was used directly in engineering. Taylor and Thompson's treatise cited the work by Feret published in France in 1897 on the effect of the presence of mica in sand on the tensile and compressive strengths of mortar. They also cite additional work by W. N. Willis in 1907 where weighed quantities of mica were added to standard Ottawa

sands that were then used in making mortars from which tensile-strength test specimens were molded. It was indicated that the tensile strength dropped off as the mica content increased but it was also shown that this was caused almost entirely by an increase in the amount of water required for mixing rather than due to any specific physical or chemical characteristic of the mica particles as such. The discussion concludes with the interesting and cryptic statement, "Black mica with a different crystalline form is not injurious to mortar." So far as I know, this question has not been subsequently examined.

In the 1920's G. F. Laughlin was called upon to participate in an investigation of the failure of certain concrete in service that was suspected of having resulted from the use as aggregate of material having constituents with undesirable properties. He found that the aggregate was altered anorthosite and found that it contained considerable quantities of the zeolite, laumontite, which characteristically loses water and disintegrates when exposed to air. He was able to establish a correlation between deterioration of concrete and the use therein of aggregates containing significant quantities of laumontite. He continued his interest in concrete aggregates and wrote on various aspects of the question. This work stimulated several engineers connected with highway departments and other concrete-using agencies to send to him samples of aggregates associated with unsatisfactory service from concrete or associated with suspicious test results. His study of these samples,

