PROCEEDINGS
OF THE
FIRST, SECOND, THIRD & FOURTH
HIGHWAY GEOLOGY SYMPOSIUM

VOL. I

Vol. I Sig. I

First Annual Symposium on

"GEOLOGY AS APPLIED TO HIGHWAY ENGINEERING"

April 14, 1950

Under the Sponsorship of

DEPARTMENT OF HIGHWAYS

RICHMOND, VIRGINIA

SYNOPSIS OF FIRST HIGHWAY GEOLOGY SYMPOSIUM

By

W. T. Parrott, Engineering Geologist

Virginia Department of Highways

To foster the exhange of ideas between highway engineers and geologists on problems relating to highway construction, the Virginia Department of Highways sponsored a symposium on "Geology as Applied to Highway Engineering" in Richmond on April 14, 1950.

Attending were representatives of the highway departments of Georgia, South Carolina, North Carolina, Virginia, Kentucky, West Virginia, Maryland and Pennsylvania. Other organizations represented included the United States Geological Survey, the Virginia Geological Survey, the North Carolina Commission of Conservation and Development, the United States Army Engineers, the National Park Service, the United States Department of Agriculture (Soils Engineers), the Bureau of Public Roads, the Engineer School at Fort Belvoir, and faculty members and students from the University of Virginia, Virginia Military Institute, Virginia Polytechnical Institute, and Washington and Lee University.

The meeting was opened with an address of welcome by C. S. Mullen, Chief Engineer of the Virginia Department of Highways. James A. Anderson, Commissioner, Virginia Department of Highways, then outlined the general purpose of the meeting.

The first paper was presented by A. Stinnott of the Ground Water Division, United States Geological Survey. He discussed the various methods of the control of ground water in unconsolidated settlements.

He briefly outlined the gological factors involving the collection and dispersion of ground water with various means of controlling the same in order to prevent damage to highways under construction as well as the elimination of costly maintenance work due to the action of ground water.

Mr. Stinnott's paper was followed by one by Dr. Jasper L. Stuckey, State Geologist of North Carolina. Dr. Stuckey discussed the importance of geological surveys in highway location and design. He gave a brief review of the principals of geology and the formation of various rocks. These rocks were treated from the standpoint of genesis, structure, and weathering, and their direct relationship to the importance in highway engineering. He discussed the importance of geological mapping, bringing out that this particular branch of mapping would enable the highway engineer to visualize the type of material over which his road would pass, enabling him to design the road in order to take care of unfavorable geologic conditions which might otherwise pass unnoticed. Dr. Stuckey emphasized the importance of soils, soil sampling, and soil mapping.

"Roads are founded on geologic materials and built of geologic materials," he concluded. "When the engineer has done his very best construction job, the road is no better than the foundation on which it is laid and the materials of which it is built."

Dr. Stuckey was followed by Mr. D. D. Woodson, Soils Engineer of the Virginia Department of Highways. Mr. Woodson spoke on soils as correlated with parent material. He discussed the various physiographic provinces of Virginia and the principal rock types from which the soils in each of these sections were derived. He gave a

brief account of the action of the resulting soil, its mineralogical content, and the engineering qualitites of each of the soils so encountered. He stressed the importance of geological maps which enable the soils engineer to better forecast or correlate the probable action of the soil which overlies its parent rock. He concluded by stating that a close liaison of the work done by the geologist and the soils engineer would go far toward the solution of many problems which confront the soils engineer.

In a lively discussion following Mr. Woodson's paper, the group considered the various aspects of how the types of behavior of the soils in other States reacted in comparison with similar soils found in Virginia.

Robert A. Laurence, Regional Geologist of the United States Geological Survey, presented a paper on geologic factors involving land slides and rock falls. Mr. Laurence classified types of land movement in accordance with the classification given by C. F. S. Sharpe: (1) slump, (2) debris fall, (3) debris slide, (4) rock slides, and (5) rock falls. Each type of land movement and geologic conditions which caused it was illustrated. He concluded that, while many slides and rock falls cannot be avoided, a thorough geologic study will often indicate either a way to prevent a slide by changing the location or alignment of the cut or will indicate a method of stabilizing the slide.

Dr. L. W. Currier of the United States Geological Survey gave a paper on Federal participation in geologic materials surveys. He outlined the various types of surveys in which the United States Geologica Survey is participating. These surveys, he said, had been

made in Kansas, Wyoming, and Montana. At the present time, he said his organization is cooperating with the Bureau of Public Works in Massachusetts in publishing a geologic map of this State. He emphasized that while the survey is not in the business to map for individuals or consultants, it quite often sends out field parties to work with various State agencies in publishing geologic construction material maps. The various types of maps ranging from the simple spot map to a complete geologic map of an area were illustrated and the value of each shown.

J. C. Stevens of the Virginia Council of Highway Investigation and Research gave a paper on the use of aerial photographs in engineering geology. He pointed out that various land forms could be recognized by their different characteristics. He added that various soil patterns could be interpreted due to their drainage characteristics. In addition to the above mentioned guides, it was pointed out that highway location could be speeded up by the use of these photographs in laying out preliminary base lines. The drainage pattern of the various streams which to some degree give the types of land forms were also discussed. All of the points mentioned in Mr. Stevens' paper were illustrated by slides.

Dr. R. W. Moore of the United States Bureau of Public Roads presented the subject of geophysical methods for subsurface exploration in highway construction. He explained the basic differences between the seismic method and the resistivity method. Each of these methods will give an accurate profile of any proposed road down to solid rock if they are used in a country which is

subjected to leaching such as limestone and dolomite; they will not pick out cavities or solution channels, thus they do not take the place of borings for structures such as dams and bridges.

The final paper was written by Mr. S. E. Horner, chief geologist of the State Highway Commission of Kansas, on "Engineering Geology as Applied to Kansas Highway Problems." Mr. Horner was unable to be present and his paper was read by Dr. Raymond S. Edmundson of the University of Virginia. Subjects discussed by previous speakers were covered and the paper served as an excellent resume of the entire meeting.

Before adjournment, a tour of the Virginia Department of Highways laboratories was conducted.

# # #

PROGRAM

Symposium on Geology as Applied to Highway Engineering

Department of Highways - Auditorium

Richmond, Virginia - April 14, 1950

9:00 A.M. Registration - Lobby - Central Office Virginia Department of Highways

Presiding - Mr. W. T. Parrott, Engineering Geologist

9:30 A.M. Address of Welcome - C. S. Mullen, Chief Engineer - Virginia Department of Highways

9:40 A.M. Purpose of the Meeting - Gen. James A. Anderson, Commissioner Virginia Department of Highways

9:50 A.M. Groundwater Control as Applied to Consolidated Rocks - William M. McGill, Virginia State Geologist

10:20 A.M. Groundwater Control as Applied to Unconsolidated Sediments - A. Sinnot, United States Geological Survey, Groundwater Division

10:50 A.M. The Importance of Geological Surveys in Highway Location and Design - Dr. Jasper A. Stuckey, North Carolina State Geologist

11:20 A.M. The Correlation of Soils and Their Parent Material - D. D. Woodson, Soils Engineer - Virginia Department of Highways

11:50 A.M. Adjournment for Lunch

1:00 P.M. Geologic Conditions Affecting Landslides and Rockfalls - Robert A. Laurence - Regional Geologist - United States Geological Survey

1:30 P.M. Federal Participation in Geologic Material Surveys - Dr. L. W. Currier, United States Geological Survey

2:00 P.M. The Use of Aerial Photographs in Engineering Geology - J. C. Stevens, Virginia Council of Highway Investigation and Research

2:30 P.M. Geophysical Methods for Sub-Surface Exploration in Highway Construction- R. W. Moore, United States Bureau of Public Roads

3:00 P.M. Engineering Geology as Applied to Kansas Highway Problems - S. E. Horner, Chief Geologist, State Highway Commission of Kansas - to be presented by Dr. R. S. Edmundson, University of Virginia

3:30 P.M. Business Meeting

4:00 P.M. Tour of Laboratories

4:45 P.M. Adjournment

Proceedings
Second Symposium of

"GEOLOGY AS APPLIED TO HIGHWAY ENGINEERING"

February 16, 1951

Sponsored by
VIRGINIA DEPARTMENT OF HIGHWAYS
RICHMOND, VIRGINIA

SYMPOSIUM ON GEOLOGY AS APPLIED TO HIGHWAY ENGINEERING

Department of Highways - Auditorium

Richmond, Virginia - February 16, 1951

The Adhesion of Bituminous Materials to Highway Aggregates - A. B. Cornthwaite, Assistant Testing Engineer, Virginia Department of Highways

Geological Enterprise in Virginia - Present and Future - Dr. B. N. Cooper, Professor of Geology - Virginia Polytechnic Institute

The Importance of Geology in Military Highway Construction - Frank C. Whitmore, Jr. Chief, Military Geology Section, United States Geological Survey

Injurious Minerals in Highway Aggregate Dr. Duncan McConnell - Professor of Mineralogy Ohio State University

What Does the Engineer Expect of the Geologist Professor A. T. Granger - Professor of Civil Engineering - University of Tennessee

The Use of Plate Bearing Tests in the Thickness Design of Flexible Pavements - L. D. Hicks, Assistant Engineer Materials and Tests North Carolina Department of Highways and Public Works

The Control of Groundwater in Consolidated Sediments - George D. DeBuchananne - Geologist in Charge - United States Geological Survey Groundwater Division

The Identification of Rock Types - D. O. Woolf Senior Materials Engineer - Bureau of Public Roads

The Construction of Highway Bridges and Separation Structures in Unconsolidated Sediments - Professor Frank W. Wheeler Professor of Civil Engineering University of Virginia

THE ADHESION OF BITUMINOUS FILMS TO HIGHWAY AGGREGATES

BY
A. B. CORNTHWAITE

It is needless, perhaps, to mention the part that mineral aggregates play in the building of our highways. When it is remembered, however, that in our bituminous or black-top roads, aggregates comprise approximately 95% by weight of the system, and that in plain portland cement concrete roads they account for approximately 80% by weight of the structure, it is readily seen that for the tens of thousands of miles of highways in the United States the quantities involved runs into astronomical figures. Added to this amount should be the thousands of tons used in the stabilizing and building up of thousands of miles of unsurfaced county or secondary roads.

For our discussion today, we are not so much interested in the quantity of the mineral aggregate used, but in the relationship of these aggregates to the bituminous materials.

Virginia is geologically blessed by having so many different aggregates of such good quality and quantity for use in building highways. Our aggregates vary from sand and gravel in the Tidewater and Piedmont areas to granites, limestones, gneisses, trap rocks, etc., in the Piedmont and mountainous regions. For each of the different types of aggregates you geologists recognize that there are many different geological formations of different ages which identify rocks of the same general classification.

In our laboratories we classify them by their hardness, or resistance to abrasion, their soundness, or resistance to freezing and thawing, and by their behavior with bituminous materials.

The behavior of these aggregates in highways sometimes leads the highway engineer to believe that they have not been classified into a sufficient number of catagories since it often seems that each individual particle behaves differently from the one next to it.

In combining aggregates and bituminous materials to build road surfaces, use is made of three different phases of the bituminous material: solid, semi-solid, and liquid. The solid and semi-solid materials require the use of considerable heat for their proper manipulation, and for that reason they are not readily adaptable to field conditions. They are, however, widely used in central mixing plants where both the aggregate and the bituminous material can be heated to the proper mixing temperatures, mixed, and the resultant mixture then applied to the prepared roadway, rolled into place and the job is complete.

The liquid materials naturally lend themselves to a much easier application and manipulation in the field than either the semi-solid or solid materials and for that reason are more widely used.

It has long been recognized that the presence of water in and around bituminous pavement structures causes more damage than perhaps any other one factor. This is the reason highway

departments build such elaborate drainage structures, and periodically clean and maintain their drainage ditches.

This damage from water may exhibit itself in a number of different ways but of primary interest to us is the fact that the water causes a definite lack of adhesion of the bituminous film to the aggregate surface. Ultimately this loss of adhesion means that under traffic the aggregate particles will be displaced and the pavement begin to deteriorate.

All of you know how difficult it is to wet an oily surface with water - it is practically impossible. This same condition is encountered when trying to coat a wet aggregate surface with bituminous material. Without using a material that has been especially treated, this can't be done either. On the other hand, aggregates which have been coated with bituminous materials and later subjected to excessive moisture will in time tend to lose their bituminous coating which then permits the rapid destruction of the pavememt. It is not only the adhesion of the bituminous material to the aggregates that is affected, but the mechanical stability of the road surfaces is also weakened by the loss of cohesion between particles and under traffic the surface is destroyed.

The seriousness of this adhesion problem to highway departments was well demonstrated in Virginia about fifteen years ago when approximately fifty miles of road surfaces were lost due to the entrance of moisture into the pavement structure. This was rather a severe blow and very careful attention has been paid to the problem since that time in order to prevent its

recurrence or to keep this type of damage to a minimum.

It is not intended to give you the impression that Virginia is the only state in the nation faced with the problem of obtaining satisfactory adhesion of bituminous materials to mineral aggregates under all possible climatic conditions. The problem has received nation-wide attention in recent years and has also been studied in many road research laboratories in Great Britain and Europe. The American Society for Testing Materials and the Highway Research Board both have committees actively working on the problem attempting to determine methods of evaluating the resistance of bituminous films to the effect of water, and the relationship between the bituminous films and the aggregate whether it be a question of surface tension, interfacial tension, or a combination of the two. The Bureau of Public Roads has also contributed very materially to this study.

Among highway engineers it is common to express this lack of adhesion by the word "stripping" and the degree of stripping in laboratory studies is considered to be a measure of the adhesive qualities existing between the bitumen and the aggregate.

To improve the adhesion of bituminous films to aggregates certain chemicals have been developed which we call additives and which chemically are closely related in action to the detergents in common use today. By their use the surface tension of the bituminous materials is altered to the extent that it is possible to not only cover and coat wet aggregates but also to enable them to retain that coating under adverse weather conditions. With the liquid bitumens being most widely used, it

is in this field that the use of additives has been most pronounced.

As mentioned before, in order to secure proper coating of the aggregate when using solid or semi-solid bitumens it is generally necessary to heat not only the bituminous material to such a temperature that it will flow readily, but also to heat and dry the mineral aggregate. Both of these conditions are conducive to good adherence of the bituminous film and proper wetting of the aggregate surfaces. This does not mean that the solid materials are immune to the detrimental effects of water but their performance in this respect is generally superior to the liquid bitumens. Since the additives used to improve adhesion are organic compounds and as many are readily decomposed at the mixing temperatures required, the use of these additives in this class of products has been rather limited.

Not to slight the aggregate side of the story, it is also possible to improve the characteristics of the mineral aggregates by treating them with certain chemicals so that better adhesion is obtained. It may be somewhat surprising to the geologist to learn that any material that has existed some few millions of years could possibly be improved, but a great many patents have been issued for these processes.

However, the treatment of aggregates has always seemed to be doing things in the hard way for the reason that we would be treating 95% of the road structure, whereas by the use of additives in the bituminous material it is necessary to treat only 5% of the structure. Also, economically it has been found to be more feasible to treat the bituminous material than to treat