PROCEEDINGS OF THE 17th ANNUAL HIGHWAY GEOLOGY SYMPOSIUM

Iowa State University

April 21-23, 1966

Department of Earth Science Publication No. 1
Iowa State University
July 1968

PROCEEDINGS OF THE 17th ANNUAL HIGHWAY GEOLOGY SYMPOSIUM

Iowa State University

Ames, Iowa

April 21-23, 1966

CO-HOSTS

Iowa State University

Iowa State Highway Commission

CO-EDITORS

Dr. John Lemish, Iowa State University

Mr. Theodore L. Welp, Iowa State Highway Commission

July, 1968

PROCEEDINGS OF THE 17th ANNUAL HIGHWAY GEOLOGY SYMPOSIUM

Iowa State University

Ames, Iowa

April 21-23, 1966

CO-HOSTS

Iowa State University

Iowa State Highway Commission

CO-EDITORS

Dr. John Lemish, Iowa State University

Mr. Theodore L. Welp, Iowa State Highway Commission

July, 1968

TABLE OF CONTENTS

PREFACE

The 17th Annual Highway Geology Symposium held at Iowa State University was organized to include a Concrete Durability Field Trip on the first day, a program consisting of papers presented on various aspects of highway geology on the second day, and a panel discussion on the chemical and physical reactions of carbonate aggregates in concrete on the morning of the third day.

Part I consists of ten papers which were presented during the technical sessions of the Symposium. All of these papers are included in these proceedings except Chemical Stabilization of an Active Landslide, by W. W. Williams and R. L. Handy. This paper was published by the American Society of Civil Engineers in volume 37 of "Civil Engineering" in the August 1967 issue on pages 62-65.

Part II is the panel discussion which covered various aspects of carbonate aggregate behavior presented by persons with research experience in this area. The panel discussion represents the first of its kind held for a geologically trained audience. For this reason the editors have transcribed the panel discussion for publication as Part II of the Proceedings. We feel it is a valuable addition to the literature and thank all the panelists for their co-operation in getting the discussion published. Dr. Chalmer J. Roy, Dean of Sciences and Humanities at Iowa State University is especially thanked for the support which made publication of the Proceedings possible.

At the Friday evening banquet Mr. Milo D. Nordyke of the Lawrence Radiation Laboratory in Livermore, California, spoke on the application of nuclear explosives to excavation and aggregate production.

The Co-chairmen wish to express their gratitude to the people and organizations who assisted us in so many ways. Joan Stock, Diana Kneller, Lola Nelson, L. M. Clauson, George C. Christensen, Chalmer J. Roy, H. G. Hershey, A. C. Dodson, T. E. McElherne, James Elwell, David Simon, The W. H. Kessel Company, Geophysical Specialties Company, Soiltest Incorporated, Acker Drill Company, all the authors and panel members for their very fine contributions to the program. Mrs. Lola Nelson, James Elwell and David Simon transcribed the panel discussion. Marvin Gould, and the Staff of the Engineering Extension and the Memorial Union at Iowa State University helped with arrangements for the symposium.

Supporting agencies contributing to the success of the Symposium were the Iowa Limestone Producers Association, the Geological Society of Iowa, Iowa Geological Survey and the Engineering Extension Service at Iowa State University.

The Co-chairmen also wish to express their thanks to those who attended the meeting and have been so very patient in waiting for the publication of these proceedings.

T. L. Welp, Chief Materials Geologist
Iowa State Highway Commission

John Lemish, Professor of Geology
Iowa State University

PART I. TECHNICAL SESSION

ENGINEERING GEOLOGY IN KANSAS HIGHWAY CONSTRUCTION

By

Virgil A. Burgat, Chief Geologist
State Highway Commission of Kansas

First of all I would like to give you a little history of our Geology Section and acquaint you with the staff.

Kansas employed the first Highway Geologist in 1936. Prior to this time bridge foundation and rock information was obtained by driving sounding rods and drilling with hand augers. No correlation of strata was attempted between individual soundings. It soon became apparent, however, that correlation of strata needed to be made between test holes to expand the information of the tests and that this correlation could be done properly only by the Geologist. When highway design was changed from that of terrain grades to the long radius curves and ruling grades, it resulted in marked deepening of road cuts and increased height of the fill sections.

These improved design and construction practices increased the need for Engineering Geologists as the Engineer was becoming more dependent upon the Geologist for many design and construction details. We presently have a sectional staff of 25 geologists. Five geologists are serving in other departments of the Highway, namely, two geologists in Research, 2 geologists in the Photo-Interpretation Section and one geologist in the Materials Department. Nearly all studied Geology in our own State Universities. The Section is administered under the Design Department yet works rather directly with each of the approximately seven other Headquarters Departments and also with the Division Engineers. This organizational structure allows for the efficient use of geologic service throughout the whole of the Highway Department. Within the intricate organizational structures the section is divided into three regions. The regions are supervised by a regional geologist. Close coordination of the three regions is carried out through the office of the Chief Geologist to make the most effective use of both personnel and equipment. Each region is staffed with two surface parties composed of two or more geologists and engineering aides and a core drill party composed of a geologist, a core driller and two or more engineering aides. Surface parties work out the geology for grading plans and administer to the construction problems. The core drill party is used primarily on bridge foundation studies. The duties performed by either party are interchangeable as the need arises.

As you can see this is a rather sizable organization and like any other governmental organization we are required to take inventory occasionally at the demands of those who hold the purse strings to see what is really being bought with the money spent for geologic services. So far we have been lucky enough to show on the ledger sheet that our geologic service is giving the State of Kansas a good bargain. And for more reasons than one we hope the balance remains favorable on our side.

When we consider the present-day Highway Construction program we are aware of the tremendous resources and the combined knowledge and skill of many disciplines to build good highways rapidly. The earthwork and bridge foundation aspects of highway construction are the responsibilities of the Engineering Geologist. Each year's program requires many millions of yards of classified excavation and the construction of several hundred bridges. The traveling public demands highways of high standards and quality and to build highways having high quality in a limited number of working days requires much advanced planning before earthwork is begun and bridges are erected. The plans of how to properly construct the highway are placed on a few blueprints.

I wish to acquaint you with the materials which which we work in Geology.

Our highways are constructed making use of various geologic materials which are under the following categories: Loesses, silts, clays and sands and conglomerates of the Pleistocene and tertiary age; the chalk beds; the alternating shales, limestone and sandstone members of the Cretaceous, Permian, Pennsylvanian and Mississippian Periods.

The Engineering Geologist has the responsibility of identifying the various geologic materials which will support the overall road structure, determine what geologic problems exist and prescribe a solution for these problems.

HIGHWAY ALIGNMENT

The assistance which the geologist gives begins with the highway alignment. The alignment is usually located along a direct route from the point of origin to point of destination. Streams, cross road highways and railroads are the major vertical control points. Unnecessary right of way costs, the movement of historical landmarks, churches, and cemeteries are of course avoided. In general our highway alignment is chosen regardless of the geology except where geological conditions become critical. In very rough terrain the Location Engineer will discuss the geologic conditions and on recommendation from the geologist he will try to minimize, if possible, heavy rock excavation, avoid large areas of landslides and unstable shale strata springs, seeps, and swampy ground and unique water supplies to prevent costly construction and legal involvement. The major alignment problems based on geology are areas where alignments cross unstable shale formations. Several miles of Interstate highway location survey had to be realigned in two locations after it was discovered during the geology survey that the highway, if following the original alignment, would have to be built on several thousand feet of old Graneros Shale slides. The original line would have required costly corrective measures including such measures as removal and wasting of several hundred thousand cubic yards of unstable slide material, construction of benches into shale below the slide plane, backfilling to grade with a stable material and the construction of underdrains to prevent resaturation of the area. Occasionally there are seepy and wet land areas which must be avoided by the alignment if at all possible. Photo-interpretation and reconnaissance field investigation by the geologist often proves to be helpful in the advanced planning of the Highway route. Large savings have resulted by avoiding adverse geological conditions through the proper choice of highway alignment.

GEOLOGY FIELD DATA

With the alignment established, the problems of design which are of geologic nature are resolved in the final plans through the cooperative efforts of the Geologist and the Design Engineer. The field data are obtained by the Geology Field Party. It includes measured stratigraphic sections, description of strata elevation of strata, test hole data and other information. A description of the kinds of material and the conditions in which it will be encountered are presented in a geology report. This report also gives basic information that will enable the engineer to evaluate such factors as: classification of excavation, steepness of backslopes, groundwater problems, unstable subgrades, balance factor of the rock and common excavation and other special specific geologic problems. The report will indicate where the contractor may observe similar geologic units to those on the project in open cut sections, thus giving information to him whereby he can make a more intelligent bid on the excavation materials.

Geologic data must be graphically portrayed to be usable. Detailed Geologic profile and cross sections are developed parallel to and across the roadway throughout the alignment. This portrayal of data on the plans and in the geology report requires the certain detailing procedures and symboling. It requires the use of basic geologic data and nomenclature made available through the publications of the State Geological Survey. These data and nomenclature are incorporated in both the graphic plans presentation and in the written report. Names of geologic strata and their physical characteristics must become common knowledge of both the geologist and the engineer. In some cases this information even becomes common knowledge to the contractor familiar with a certain area. The methods of portraying the geology in the report and on the plans and the engineering usage made of it develops with experience and improved understanding.

CLASSIFICATION OF EXCAVATION

All earthwork is classified as either rock or common excavation on the basis of geologic characteristics. Present specifications are based on geologic terms and definitions of the materials of excavation. Prior specifications which were based upon the methods and type of equipment used to make the excavation rather than the nature of the material led only to many arguments and lawsuits. Specifications now based on geologic characteristics give uniformity of classification regardless of the Contractor's equipment or methods. A successful system of classification can only result by calling the same material the same today, tomorrow and from project to project whenever it is encountered.

Rock excavation includes limestone, sandstone, unweathered sandy and calcareous shale and other materials that have the characteristics of rock, whereas common excavation includes soils, soft weathered shales and other materials which do not geologically have rock characteristics. By classifying excavation as rock or common on the basis of Geology, Kansas has long enjoyed low bid prices by Contractors. The cost of rock excavation per cubic yard is presently only 4 to 5 times, that of common excavation. Common excavation is bid at 15 to 25 cents per cubic yard on normal grading projects. Very few disputes over classification have arisen. The Contractor has been able to plan his work and make better use of his equipment because the geology is plotted accurately on the cross sections showing the boundary lines between the rock and common excavation. This boundary line in excavation is determined by test hole and other pertinent field data to determine classification.

It has become a common practice for Contractors to bid excavation unclassified on classified material. This practice would indicate his trust in the accuracy of the classification. At the same time this creates a saving to the State by the decreased cost of engineering needed to determine the classification for final payment. The Contractor may stand to lose heavily on this unclassified bid if the excavation is not accurately classified.

GRADE LINE

A tentative grade line is plotted showing its relationship to the strata portrayed on the cross section and profile in the cut and fill sections. At this stage the grade line may be adjusted upward or downward to avoid cutting the roadway into undesirable strata requiring a more costly design. Minor realignments by office relocation may be required to avoid potential slide or otherwise unstable areas, unique water supplies and other problems.

After the road designer determines the best desirable vertical and horizontal alignment the work of design proceeds. Templates of the roadway are placed over corresponding geologic sections to show in cross section, the graphic relationship between the roadway template and the strata. The sections will show the depth of the cut and the quantities of soil, limestone, sandstone, or other to rock that will need to be moved. Also they will indicate what is common and what is rock excavation.

BALANCE FACTOR

The adjustment factor for the earthwork balance is the volume expressed in percentage that results when material is broken up in the process of excavation and is moved from a cut to a fill section. The volume of the excavated material may be either greater or less than the original volume. Adjustment factors to compensate for this change must be accurately determined if a satisfactory earthwork balance is to be obtained. Limestone strata taken from the cut section and placed in the embankment will increase in volume from 35 to 50 percent depending upon the physical characteristics of the strata. The volume changes of shales and sandstones vary with their cementation and physical structure.

A clayey soil mantle has a higher shrinkage volume than does a granular or gravelly soil. The proper earthwork balance adjustment factor for the geologic units must be supplied to the road designer, otherwise the volume of fill material will be either too great or too little. An excess is wasteful and a shortage will require additional borrow pits. This can cause a critical problem in construction either in requiring a waste area for excess material or purchasing a borrow pit to obtain the extra material needed.

Problems of overruns are created when the contractor bids unclassified on classified materials and unreliable adjustment factors have been supplied to the road designer. This type of error can be very costly to the State.

To show an example consider a circumstance which would be very favorable to the contractor. A grading project has a million cubic yards of classified excavation. The Contractors bid the job unclassified, his bid being based on the quantities of classified material shown on the plans. The unclassified bid price is basically the average of the rock and common bid price. In this example the total million yards of excavation is divided equally. Thus, $\frac{1}{2}$ million yards of rock at 75 cents and $\frac{1}{2}$ million yards of common at 25 cents would average 50 cents per cubic yard for the unclassified bid price. If the earthwork balance adjustment factors used were 10% too high on the swell of the rock and 10% too low on the shrinkage of the common excavation it would require an additional 100,000 cubic yards of excavation to make up the difference in quantity to complete the grade as shown on the plans. Additional borrow material must be acquired. The contractor receives the unclassified bid price of 50 cents per cubic yard for the 100,000 yards of material needed from the borrow to bring the roadway up to finished grade, thus creating a 50 thousand dollar overrun on the contract. Had the contractor made the classified bids of 25 cents common and 75 cents rock, the additional yardage of common excavation needed, due to the error, would have cost only half as much or a reduction of $25,000.00 on the overrun. Thus, the error in adjustment factor became very favorable to the contractor and vice versa a considerable loss to the State.

On the other hand, if the earthwork balance adjustment factors used were 10% too low on the swell of the rock and 10% too high on the shrinkage of the common the project cost on excavation would not overrun in dollars, but at the same time 100,000 cubic yards of material at 50 cents per yard will be needlessly wasted and again this waste would be no loss to the contractor but likewise another heavy unnecessary loss to the state.