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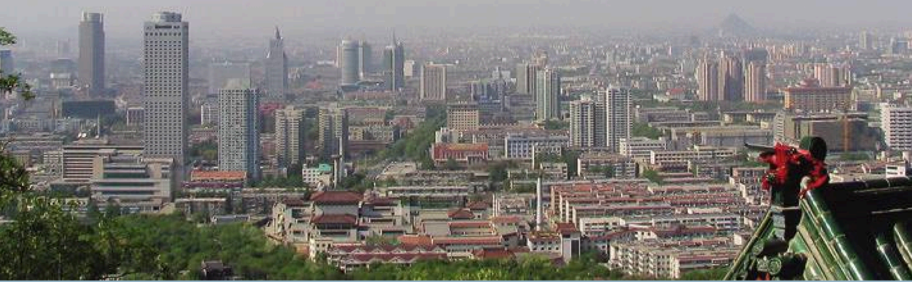

In Situ and Laboratory Test Methods for Site Characterization, Design, and Quality Control

Edited by
Chao Wang, Ph.D.
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Preface

This Geotechnical Special Publication (GSP) contains 35 papers that were accepted and presented at the GeoChina International Conference on sustainable civil infrastructures: innovative technologies for severe weathers and climate changes, held in Jinan, China on July 25-27, 2016. Major topics covered are in-situ test methods for site characterization, design and quality control of earth structures and subgrades, design and quality control of earth structures and subgrades, soil behavior and laboratory testing, and bridge approach embankment. The overall theme of the GSP is in-situ and laboratory test methods for site characterization, design and quality control and all papers address different research findings of this theme. It provides an effective means of shearing recent technological advances, engineering applications and research results among scientists, researchers and engineering practitioners.

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Contents

Construction Issues Associated with the Cold Weather Construction of a Highway Embankment Fill in Alberta, Canada

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Abstract: There is very little information available in the literature directly related to the compaction of clay type materials in highway embankment construction during cold weather in seasonal frost areas, although every construction season some work is done during the winter on account of the short construction season normally available in seasonal frost areas. This paper addresses a case study of a low highway embankment fill (less than 3 m in height) constructed during freezing temperatures. This case study embraces compaction behaviour during winter, observations made during spring thaw, embankment remedial works following spring thaw, and the subsequent performance of this roadway.

INTRODUCTION

With the exception of construction in muskeg areas and areas with very soft ground the construction of highway embankments in freezing weather is traditionally not desirable. However, on numerous occasions, construction works in seasonal frost areas do extend into this weather. This is not often intended but occur as a result of (a) the desire to finish a project nearing completion, and (b) to expedite construction works, thus allowing the Contractor freedom to undertake new projects early the following year.

According to Clark (1970), the advantage of cold weather construction for the Contractor is the length of time during which he can keep his crews occupied. A major disadvantage, however, is the difficulty in achieving a good quality end product. It is perhaps for this latter reason, more than any other, why cold weather construction of highway embankment fill is undertaken with much skepticism.

Except for reports by Yoakum (1962), Lovell and Osborne (1968), Clark (1970), Alkire, Hass and Botz (1976) and Burwash and Clark (1981) there is very little information available in the literature to date directly related to compaction of clay type materials in highway embankment construction during winter periods. The lack of sufficient case studies in the literature is perhaps a main hindrance in deciding on whether or not construction should be allowed during freezing temperatures.

SITE LOCATION AND DESCRIPTION

The study site was a 13 km stretch of roadway situated in northeast Alberta, Canada along Secondary road (S.R.) 831:08 (km 12 to km 25) between the County of Thorhild Boundary and S.R. 661:02. This stretch of roadway was to be upgraded to meet Alberta Transportation's design designation - RAU-209-100 which depicts a finished roadway of 9 m top width, 4:1 sideslopes in fill sections and a 3.5 m wide ditch.

PROJECT BACKGROUND

Upgrading of S.R. 831:08 was awarded as an Alberta Transportation (Province of Alberta Department of Highways) Contract on August 26, 1982. Actual roadway operations commenced on September 17, 1982 and was terminated by the Contractor on October 29, 1982 on account of financial problems after only 4 km of roadway (km 21 to 25) had been constructed. The remaining 9 km between km 12 and km 21 was negotiated with another Contractor. This stretch of roadway was constructed during the winter months and forms the subject of this paper. Prior to construction, the roadway design gradeline was revised to allow for a minimum of 300 mm of fill over the existing road top. This revision placed most of the roadway cross-section in fill.

SOILS ALONG ALIGNMENT

Prior to the design of the roadway a soils survey investigation was undertaken and completed on February 11, 1982 to determine the characteristics of the subsoils along the roadway alignment and prospective borrow areas. Fifty (50) boreholes were drilled along the alignment to a maximum depth of 2m and approximately 2m right of the existing roadway centerline. The soil profile deduced from these borings consisted of 0.10 to 0.15 m of low-cost oil bound wearing surface overlying glacial till containing mainly gravel size particles. According to the modified Unified Soil Classification System, the fill was predominantly of the CI and CI-CL soil types (low to medium plasticity soils. In comparing the field moisture contents with the plastic limits, the soils were generally 1 to 4% above the plastic limits with the majority of values about 2% greater.

BORROW PIT SOILS

Ten prospective dugout borrow areas and two landscape borrows were investigated adjacent to the alignment. Boreholes were drilled to a maximum depth of 3m. During the course of construction, some of these borrow locations were shifted on account of poor ground conditions or at the landowner's request. Borrow pits were distributed about one per kilometer and were generally within 200 m left or right of the roadway centerline. Pits were located in treed areas in the case of dugout borrows and on cultivated land in the case of landscape borrows. Nine dugout borrow pits were used for the winter construction with grain size analyses of the soils shown in Fig.1.

Standard Proctor compaction tests were carried out on the soils during working of the pits to facilitate quality control of the embankment construction. Pits were generally stripped one ahead of completion of working the previous pit. Since test results could not always be attained before moving material to site, estimates of the optimum moisture content and maximum dry density were used to judge the field compaction. These estimates were determined using the Alberta Family of Curves (MEB2, 1982). All field results were finally related to Proctor values determined from actual testing **(**Fig. 2).

EMBANKMENT CONSTRUCTION - WINTER OF 1982

Air Temperatures during Construction

Roadway construction operations by the new contractor recommenced on November 7, 1982 with earthmoving beginning from km 22 proceeding southwards to km 12. The daily temperature variation throughout the month of November showed that there was a general steady decline in temperature from the start of construction to November 25, 1982, when the Contractor ceased operations. The lowest temperature recorded was -25^{o}C on November 20, 1982.

Earthmoving Operations

A total of 100,000 cubic meters of borrow material was placed between km 22 and km 15 during the period November 7, 1982 and November 25, 1982 when construction operations were shut down by the Contractor due to unfavorable temperatures and wet borrow material. Actual construction operations began with the clearing of borrow pit No. 4. This pit was worked between November 7 and 11, 1982. Soil wetter than optimum moisture was encountered at a depth of about 2m. In an attempt to overcome this situation, the pit was made wider. However, the use of wet borrow was not completely unavoidable. The method used in dealing with the wet borrow was to place this material along the sideslopes working from the toe of the slope towards the shoulders. Drier borrow was then placed over the wetter material as the roadway approached grade. Drier fill was also reserved for the central portion of the roadway overlying the existing oil bound surface. It was originally intended to roughen this surface prior to the placement of fill by walking the compactor over the surface - an operation which was successfully used during the first 4 km of construction. However, this was not found to be feasible on account of the prevailing cold temperatures which made the wearing surface very resistant to indentation. Ripping of the surface as an alternative could only be accomplished with much difficulty with a Cat D9 bulldozer with ripper attachment. A trial section produced large chunks of oil bound material which could not be readily broken down into smaller workable chunks. In addition, it was felt that the grooves of gouges produced in the existing roadbed by this operation would create weak areas in the grade since it would be difficult, if not impossible, to ensure good compaction.