VARIAIIBITY OF THE COEFFICIENT OF CONSOLIDATION OF THE MEXICO CITY CLAYEY SEDIMENTS ON SPATIAL AND TIME SCALES

INTRODUCTION

Mexico City is built on highly compressible fine-grained lacustrine sediments which are referred to in the geotechnical community as the Mexico City clay. The Basin of Mexico, where Mexico City is located, is delimited by volcanic mountains (Fig. 1) and it was a closed basin from approximately 700,000 years ago until the XVIIIth century when it was artificially drained towards the north. During hundreds of thousands of years sediments washed out into hundreds of thousands of sediments washed out into hundreds of thousands of sediments washed out into leaves of volcanic materials which have been eroded and transported by the wind to form a large plateau. The lacustrine sediments which are referred to in the geotechnical literature and overlie a regional productive aquifer which provides about 50 m³/s of water for the city.

Consolidation settlement of the lacustrine sediments in Mexico City is due mainly to pumping of this regional aquifer and by construction of buildings. Although the coefficient of consolidation has much geotechnical importance, little is known about its magnitude or geological controls at various spatial and time scales relevant to consolidation settlement. Different methods are used to evaluate the coefficient of consolidation at four different scale volumes of sediment: the traditional oedometer tests, piezometer response tests, surface loading tests and modelling of long-term transient land subsidence due to aquifer pumping in an area where the present subsidence rate is 0.40 m/year. The spatial scale of the measurements range between 0.02 m to 300 m and the time scale between 24 hours to 30 years. Results showed that the coefficient of consolidation depends on the spatial and time scale encompassed by each type of measurement. As the scale of the test increases the coefficient of consolidation also increases, showing the increasing effect of discontinuities within the lacustrine sequence.

When laboratory values are used in larger scale subsidence models, results are unrealistic. The bulk coefficient of consolidation is two orders of magnitude higher than the upper limit of the laboratory measurements. Therefore, the bulk coefficient of consolidation cannot be approximated from oedometer tests and a range of this coefficient has to be obtained based on the scale of application.

This study pertains to the two of the six main lacustrine plains of the Basin of Mexico within which Mexico City is situated. These lacustrine sediments are referred to as the Mexico City clay in the geotechnical literature and overlie a regional productive aquifer which provides about 50 m³/s of water for the city. Consolidation settlement of the lacustrine sediments in Mexico City is due mainly to pumping of this regional aquifer and by construction of buildings. Although the coefficient of consolidation has much geotechnical importance, little is known about its magnitude or geological controls at various spatial and time scales relevant to consolidation settlement. Different methods are used to evaluate the coefficient of consolidation at four different scale volumes of sediment: the traditional oedometer tests, piezometer response tests, surface loading tests and modelling of long-term transient land subsidence due to aquifer pumping in an area where the present subsidence rate is 0.40 m/year. The spatial scale of the measurements range between 0.02 m to 300 m and the time scale between 24 hours to 30 years. Results showed that the coefficient of consolidation depends on the spatial and time scale encompassed by each type of measurement. As the scale of the test increases the coefficient of consolidation also increases, showing the increasing effect of discontinuities within the lacustrine sequence.

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Abstract

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Résumé

Cette étude concerne les deux plaines lacustres, parmi les six du Bassin de Mexico, où est située la ville de Mexico. Ces sédiments lacustres sont appelés dans la littérature géotechnique argile de Mexico et ils recouvrent un aquifère qui produit environ 50 m³ d'eau par seconde pour la ville. La consolidation par tassement des sédiments lacustres à Mexico est essentiellement due aux pompages dans cet aquifère et à la construction d'immeubles. Bien que le coefficient de consolidation ait une grande importance sur le plan géotechnique, on sait peu de choses sur les facteurs géologiques qui dans l'espace et dans le temps influent sur la consolidation par tassement. Différentes méthodes sont utilisées pour évaluer le coefficient de consolidation à quatre échelles différentes de volume de sédiment : les essais traditionnels à l'œdometre, les essais piézométriques, les essais de chargement en surface et enfin la modélisation du tassement à long terme dû au pompage de l'aquifère dans un secteur où la vitesse d'enfoncement du sol est actuellement de 0,40 m par an. L'échelle spatiale des mesures s'étale de 0,02 m à 300 m et l'échelle de temps de 24 heures à 30 ans. Les résultats montrent que le coefficient de consolidation dépend du volume et du temps pris en compte dans chaque type de mesure. Quand le volume concerné par l'essai augmente, le coefficient de consolidation augmente également, montrant ainsi l'effet croissant des discontinuités de la séquence lacustre. Quand les valeurs obtenues en laboratoire sont utilisées dans les modèles d'affaissement à plus grande échelle, les résultats ne sont pas réalisistes. Le coefficient de consolidation apparent est supérieur de deux ordres de grandeur à la limite supérieure des mesures de laboratoire. Donc, le coefficient de consolidation apparent ne peut pas être approché à partir des essais oedométriques et il doit être caractérisé par une série de valeurs dépendant de l'échelle d'application.

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City in the past half century, and currently the Chalco area has subsided about 7 m in the last ten years at a current subsidence rate of 0.40 m per year (Ortega et al., 1993) (Fig. 2).

The coefficient of consolidation ($C_v$) of the lacustrine sediments is important in many geotechnical aspects of the Metropolitan Mexico City, because it governs the consolidation settlement. Although the coefficient of consolidation has much geotechnical and hydrogeological importance, little is known of its magnitude or geological controls at various spatial scales, depth range and time encompassed by the test. Nearly all of the published information on this parameter derives from laboratory consolidation tests on core samples, which provide no insight into the influence of fractures, bedding or other features that could influence the coefficient of consolidation of the lacustrine sediments at the scale most relevant to consolidation settlement.

This paper focuses on two of the main lacustrine plains near Mexico City: the Chalco and Texcoco plains (Fig. 3), and examines the coefficient of consolidation of the lacustrine sediments at several scales and time of measurement, including: (1) the small scale of conventional laboratory consolidation tests from core samples to a depth of 132 m, which take between a few hours to two days to be accomplished; (2) field bailing tests in about 150 drive-point piezometers installed between 2 and 85 m; this test takes between a few weeks to two months of field measurements; (3) dissipation of excess pore pressure due to solid waste fill on the aquitard in the Texcoco plain, during almost one