Engineering Geology 122 (2011) 146–159

Contents lists available at ScienceDirect

Engineering Geology

journal homepage: www.elsevier.com/locate/enggeo

Changes in late Pleistocene–Holocene sedimentary facies of the Mekong River Delta and the influence of sedimentary environment on geotechnical engineering properties

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A R T I C L E   I N F O

Article history:
Received 30 March 2010
Received in revised form 28 May 2011
Accepted 31 May 2011
Available online 31 July 2011

Keywords:
Holocene
Mekong River Delta
Facies
Geotechnical properties
Sedimentary environment

A B S T R A C T

The aim of the study was to characterize a variety of sedimentary facies from the Mekong River delta (MRD) and to determine their geotechnical properties. The paper furthermore discusses the influences of sedimentary environment and conditions on geotechnical properties of the sedimentary facies. A core at the Vinhlong province, MRD, sufficiently presented the sedimentary facies of the area. Eight successive facies were identified based upon sedimentary properties. Characteristics of the unit showed development of sedimentary facies. Each sedimentary facies was formed under a different environment and revealed typical geotechnical properties. Estuarine channel, estuarine marine, delta front-mouth bar, and sub- to inter-tidal flat facies were formed under strong hydrodynamic conditions. The sediments are from clay to coarse sand and even pebbles, and the sedimentary structures are plentiful, such as intercalated clay, silt beddings and fine to coarse sand beddings with very different thicknesses. Strengths of these sedimentary facies vary significantly, which can be observed by cone penetration test (CPTU) results, but not by standard penetration test (SPT). The normalized values from CPTU show saw–tooth graphs with large variations, especially delta front-mouth bar and sub- to inter-tidal flat facies at shallower depth. The soil-behavior-types determined from the normalized values are plentiful from cohesionless to cohesive soils. As an example, an estuarine channel facies experiencing a large consolidation pressure, in relatively long-time (over 9920 yr BP) has geotechnical properties with heavily overconsolidated conditions and high strength. On the other hand, marsh, open bay, pro-delta and March/flood plain facies, which formed under relatively low hydrodynamic conditions, have simple and homogenous sedimentary properties. The sediments are commonly silt and clay, and sedimentary structures are very faint interbedded clay and silt laminae, and rarely very fine sand laminae. Strengths of these sedimentary facies increase linearly with depth, the normalized values are all rather constant with depth, and their soil behavior-type is only normally consolidated clays from CPTU results. It could be said that the particular sedimentary conditions in the late Pleistocene–Holocene deposits of MRD can be reasonably estimated by the CPTU test.

Contents

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0013-7952/$ – see front matter
doi:10.1016/j.enggeo.2011.05.012

1. Introduction

The Mekong River delta (MRD), the largest delta in Vietnam, is located in southern Vietnam between 8° 30′ and 11° 00′N and 104° 30′ and 106° 50′E (Figure 1). A great flat plain of 62,520 km^2 has been created by the progradation of the delta during high stand and regression over the last 4550 yr BP (Nguyen et al., 2000). During this time period, the landforms, sedimentary structures, thickness and material composition of sedimentary facies in the late Pleistocene–Holocene deltaic sediments have undergone complex changes (Ta et al., 2002a, 2002b; Umitsu et al., 2003).

Several studies have been conducted about specific geotechnical engineering problems in the MRD. Dornbusch et al. (1969) studied the distribution of construction materials according to grain size and Atterberg limit from the ground surface to a depth of −10 m. Takemura et al. (2007) studied the characterization of alluvial deposits in the region.

The structures of post-glacial natural soils depend on both the depositional conditions and post-depositional processes. Research has also been carried out on normally consolidated natural argillaceous sediments deposited at many places in the world during the post-glacial period. Studying the compression curves of various natural clays, Burland (1990) proposed a method of describing the level of structure of natural clay using the sedimentation compression line (SCL) and the intrinsic compression line (ICL). The micro- and macro-structure of natural soils causes them to differ from reconstituted soils in a number of important ways. In this respect, following Mitchell (1976), the term “structure” implies a combination of “fabric” (arrangement of particles) and interparticle “bonding”. Studying sedimentation compression curves, Burland (1990) found a difference between British post-glacial clays present at Shellhaven (Skempton and Henkel, 1953) and Gosport (Skempton, 1970) and showed that their structures depend both on the depositional conditions and on the post-depositional processes. Wu (1958) also found that the sedimentary materials and post-depositional processes affect the geotechnical properties of sediments. The late Pleistocene–Holocene sediments that have accumulated during the post-glacial period consist of several sedimentary facies, each of which was formed in a different sedimentary environment and has typical sedimentary structures and materials. Given the importance of sedimentary

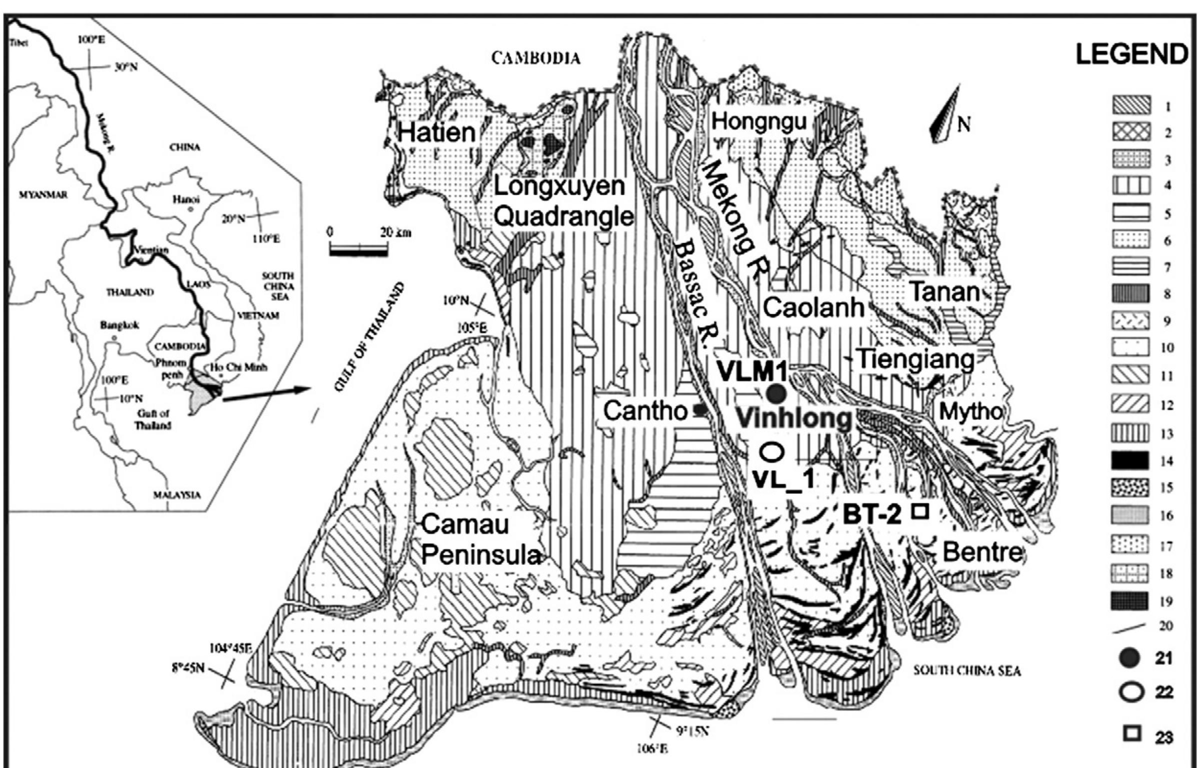

Fig. 1. Environmental sedimentary map of the Mekong River Delta (Nguyen et al. 2000), location of the VLM1 borehole (filled circle) and the VL1 (Ta et al., 2002b) and BT2 boreholes (Ta et al., 2001, 2002a) (open circle and square, respectively): 1. Channel bar, 2. Point bar, 3. Bank, 4. Flood basin, 5. Back swamp, 6. Swamp, 7. Flood plain, 8. Abandoned channel, 9. Alluvial apron, 10. Coastal plain, 11. Marsh, 12. Salt marsh, 13. Mangrove marsh, 14. Relict beach ridge or sand dune, 15. Sand spit, 16. Tidal flat, 17. Undivided deposits of late Pleistocene age, 18. Weathered land, 19. Basement rock, 20. Line of profile, 21. VLM1 borehole, 22. VL1 borehole, 23. BT2 borehole.