

INTERNATIONAL SOCIETY FOR SOIL MECHANICS AND GEOTECHNICAL ENGINEERING



This paper was downloaded from the Online Library of the International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE). The library is available here:

<https://www.issmge.org/publications/online-library>

This is an open-access database that archives thousands of papers published under the Auspices of the ISSMGE and maintained by the Innovation and Development Committee of ISSMGE.



LOWLANDS AND THEIR CHARACTERISTICS

LES PLAINES ET LEURS CARACTERISTIQUES

Norihiko Miura¹ Madhira R. Madhav²

¹Professor and Director, Institute of Lowland Technology
Saga University, Saga, Japan

²Professor, Indian Institute of Technology, Kanpur, India and
Saga University, Saga, Japan

SYNOPSIS: Lands affected by fluctuating surface water levels are defined as lowlands (Madhav et al., 1992). They are categorized as natural lowlands, lowlands created by human activities such as withdrawal of groundwater, extraction of oil, gas, coal, etc, and manmade coastal islands created out of the sea. Tidal flats, bays, lagoons, marshes, mangrove forests, deltaic deposits, etc. in the tropical and subtropical regions, constitute the natural lowlands. Marine clays are formed in tidal flats, organic soils in the marshes, silty clays and clays in lagoons. The groundwater level is close to the surface and often rises above the ground due to tides and floods. The pore fluid can be fresh water, brackish, normal to hypersaline. These lowlands are spread all over the world. The soils are characterized by high liquidity index, compressibility, and sensitivity and low strength. Subsidence due to groundwater withdrawal from the aquifers below, large settlements, disruption of water courses, drainage, etc., are some of the major problems. Difficulties encountered in their development are particularly with reference to the environment, water management and the geotechnical aspects.

Large tracts of coastal lands which are very near or below mean sea level exist all over the world, (Fig.1) notably in the United States, Netherlands, Japan, Bangladesh, India, Indonesia, Thailand, etc. Flood plains of major rivers which are inundated periodically, have problems similar to coastal lowlands. Lowlands are created by human activity as a consequence of withdrawal or removal of natural resources. Pumping of groundwater, oil, or natural gas from aquifers below soft clay deposits is the most common source of subsidence of ground creating lowlands. Japan, Mexico, United States, Italy and Thailand are countries with prime examples of such phenomenon. Many areas from beneath which coal is extracted subside. If they get flooded periodically or otherwise, these regions also would qualify as lowlands. In some of the developed countries, due to paucity of land, the same is being reclaimed from the sea as in Japan and Singapore.

These manmade coastal islands founded usually on soft marine deposits are subjected to tides and storm surges. To compound the problems, global warming is a major threat and the human society should be prepared to face it. Even one meter rise in sea level could submerge large land areas.

TYPES OF LOWLANDS

Tidal flats are depositional environment along flat coasts which are subject to significant tides. Much of the area gets exposed during low tide and flooded during the high tide. This zone is sometimes termed as a marsh and in the tropics as mangrove forests. The subtidal zone is perennially below water level. The intertidal zone is an intermediate area between supratidal and subtidal zones. Most marine clays formed in tidal flats, form parts of large deltas particularly in the tropical and subtropical regions. In the marshes, the sediments are trapped by vegetation and hence are organic.

A bay is a recess in a coastline that is well protected from the near-shore currents while a lagoon is a shallow water body that is connected by one or more inlets. They have similar characteristics from sedimentological and geomorphological considerations, and may contain brackish, normal to hypersaline waters. Fine grained soils predominate in deep bays while silty clays and clays are found in extensive lagoons. Deltaic deposits may extend deep into the sea or the ocean, and grade themselves from coarse to fine grained soils towards the continental slope. The depositional processes in deltaic deposits are governed by (i) river regime; (ii) coastal processes; (iii) currents; and (iv) climatic factors. The intertidal flats and



Fig.1 Lowlands of the world

shallow bays constitute the subaqueous zone. Swamps and marshes consisting of highly organic deposits, constitute the subaerial zone of the delta. Major deposits of soft marine clays, encompass flat deltaic lowlands of North America, South and Southeast Asia, Japan, etc., at the mouths of rivers such as Mississippi, Ganges, Irrawaddy, Chao Phraya, Mekong, Kelantan, Pahang, etc. Deltaic areas can be subdivided into alluvial fans, composed of terrestrial deposits, natural levees, usually 1m to 4m above the surrounding plains with terrestrial deposits on the surface, swamps between levees, the underlying sediments being finer and organic, and lower deltaic area, which is at nearly sea level, flat and with marine deposits. The salinity of the soils is highest at the coastline and decreases with distance inland. The groundwater level is close to the surface and often rises above the ground due to floods and tides.

The soils of the lower deltaic plains can be categorized as coastal saline clays, soft and slightly acidic, often flooded at spring tide; fresh clays, slightly alkaline and soft whose strength and profile development is controlled by the leaching of salt water by flood waters; organic soils, found in swamps, marshes and localized basins where the water table is high and drainage poor. If the organic content exceeds 30%, they are termed as peat soils; and acidic clays, with pH values less than 4.5 found in backswamps.

Lacustrine lowland deposits are controlled by the hydrodynamic conditions of the lake, topography and the depth of the lake, relief of and of material from the surroundings, etc. Clays get deposited towards the center of the lake. Flood plain soils grade from coarse to fine grained as the river traverses to the sea. Silt, silty clay and clay layers found in the lower reaches of the river, are subject to alternate cycles of wetting and drying, desiccation, weathering, shrinkage, etc. Flood plain deposits are much stronger and stiffer than those in the deltas and the tidal flats.

Erosive and depositional types of lowlands can be distinguished. Erosive lowlands are associated with marine and glacial activities and are less common than the depositional ones. They are normally found in regions of tectonic uplift. The depositional type of lowlands are composed of material produced by weathering and erosion of soils and rocks from the higher terrains in the uplands. Rainfall, temperature, the seasonal distribution of precipitation and evaporation influence the weathering processes. The rivers transport the products of erosion on to the depositional lowlands.

TIDAL LOWLANDS

Distribution of the sediments at or along the coast and the formation of the tidal lowlands, are strongly dependent the waves, the tides and the currents. The sediments are swept ashore or carried along the coast to form beach ridges, dunes, estuaries and lagoons. High wave energy conditions favor the transport of the material to the deep ocean floor while the low energy environment is particularly favorable for the

formation of deltas. The coastal lowland is a dynamic system where sedimentation and erosion alternate and are influenced by fluvial, coastal and marine systems. The lowlands, presently known, are formed as a result of the geologically the most recent sea level rise over a height of 120m. Lowlands can also be classified as natural lowlands, lowlands created by human activity such as groundwater withdrawal, extraction of oil and gas, reclaimed ground and manmade coastal islands.

Characteristics of a Typical Lowland

Vast lowland (230 sq.km. at spring tide and 110 sq.km. at neap tide) exposed some 5 to 7 km offshore at low tide of Ariake sea forms part of the Saga plain with an area of about 400 sq.km. The plain is underlain by the soft sensitive Ariake clay, 5-30 m thick. The natural water content ranges between 50% and 200%, the liquidity index between 0.5 and 2.5 and sensitivity from 8 to 100. Below the clay layer, water bearing sand strata exist. Excessive pumping (Miura et al. 1988) of groundwater resulted in subsidence in the range of 30 to 80 cm and intrusion of salt water into the aquifers. Kinds of damage resulting from subsidence, flooding, poor drainage, reclamation of land in coastal regions can be loss in production in farming and agriculture due to increased wetness of soil; decrease in the safety of dikes; decrease in the quality of subsurface water; ecological damage; and disruption of water courses and drainage channels.

PROBLEMS OF LOWLAND DEVELOPMENT

Development of lowlands involves consideration of their ecology, engineering aspects of design, construction and management, and assessment of environmental impact (Miura et al., 1993). Coastal lowlands are often underlain by marine sediments which are soft, highly compressible, and very sensitive. The determination of the in situ properties of the soils, design and construction of structures on them, and if required, the improvement or modification of the original ground is a challenging task (Nakase, 1991).

REFERENCES

- Madhav, M.R., Miura, N. and Araki, H. (1992). Lowlands of the world and problems in their development. Proc. ILT Seminar on Problems of Lowland Development, Saga, pp.45-56.
- Miura, N., Taesiri, Y., Sakai, A. and Tanaka, M. (1988). Land subsidence and its influence to geotechnical aspects in Saga Plain, Proc. ISSL, Saga, pp.151-158.
- Miura, N., Madhav, M.R. and Koga, K. (1993). Lowlands - Development and Management. Under publication.
- Nakase, A. 1991. The importance of geotechnical engineering in coastal development. GEO-COAST '91, Vol.2, pp.867-876.