A review of the stabilization of tropical lowland peats

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Peats, as we now know, are formed by the limited decomposition and accumulation of organic soil materials. These organic materials can further consist of undecomposed, partially decomposed and highly decomposed plant remains. Tropical lowland peats usually contain undecomposed and partly decomposed branches, logs and twigs (Fig. 1). Due to their domed shape, tropical lowland peats form a fragile ecosystem and are almost purely organic (Paramananthan 1998, 2010). Tropical lowland soils, which typically have mean annual soil temperatures greater than 22 _C with monthly variations of less than 5 _C, have an isohyperthermic or a warm soil temperature regime and a common elevation of less than 750 m (2,500 feet) (Paramananthan 2010). According to Paramananthan (2010), lowland organic soils are soils in which the thickness of the organic soil layers makes up more than half the soil to a depth of 100 cm (or shallower if rocks or parent materials occur at less than 100 cm depth). Lowland organic soils are subdivided based on the thickness of their organic soil layers. Lowland organic soils, including peat and histosol soils, are subdivided into ombrogambists or deep organic soils that are more than 150 cm thick and topogambists or moderately deep and shallow organic soils that are 50 to 150 cm thick.

Soil improvement in peat

Peat is an extreme form of soft soil and is subject to instability and massive primary and long-term settlement when subjected to load increases during construction work (Huat 2004). Access to peat sites can be difficult and sometimes impossible, especially in swampy, waterlogged peat areas, leading to difficulties in sampling peat for laboratory tests. Tests involving peat also often result in large variations in peat index properties.

Although buildings constructed on peat are usually suspended on piles driven into underlying mineral soil and bedrock, the soft ground around such buildings may still settle, resulting in cracks in pavement and driveways and broken drains around the building structure. Settling of roads built on peat ground may result in bulging and tilting of houses situated near or alongside the roads (Huat 2004). Due to problems with settlement, the difficulty of construction on peat ground and the inevitable high building and maintenance costs involved, engineers and developers tend to avoid building on problematic peat ground. However, due to the scarcity and sometimes the unavailability of suitable construction ground, this is not always possible, especially in coastal lowland areas where there is often high pressure for land development. Hence, peat land development is becoming more and more unavoidable. Because of this problem, ground improvement methods are now being developed for tropical lowland peats.

According to Edil (2003), and Kazemian et al. (2011), the following current construction methods are suitable for use on peat ground:

1. Avoidance: consider avoidance of peat lands, if possible.
2. Excavation-displacement/replacement: practical in peats that are up to 5 meters in peat depth.

3. Ground improvement and/or reinforcement for

enhancement of soil strength and stiffness:
(a) Stage construction and preloading: This method is used to overcome problems of instability in fills

constructed over weak deposits such as peat ground. Although it is time-consuming, it can be accelerated by the construction and use of vertical wick drains, and geosynthetic reinforcement can be used to enhance stability. Placement of loads on the surface or vacuum consolidation can be used to achieve loading.

(b) Deep in situ mixing (lime-cement columns): This method involves forced mixing of lime, cement, or both with soft mineral soil deposits to form stabilized soil columns. This method of peat stabilization is still being developed.

(c) Stone columns: Compacted gravel is used to fill water-jetted holes in soft ground.

(d) Piles: Piling is an expensive but reliable solution for building foundations with suspended floors and for creating embankment supports.

(e) Thermal precompression: In this method, the ground is moderately heated (15–25 _C) to accelerate settlement and reduce long-term compression upon cooling. This method has been field-tested but has not yet been applied commercially.

(f) Preload piers (Geopiers): This method, which is currently being developed, involves packing stones in dense layers in a hole to allow radial pre-compression in the ground.

4. Reduction of driving forces by the use of light-weight fill: Light but sufficiently strong and stiff materials such as woodchips, sawdust, tire chips, geofoam and expanded shale are used as fill.

The deep in situ mixing (lime-cement columns) method is a deep stabilization technique that has been popularly used in Sweden and Finland to strengthen soft soils such as silt and clay using cement or lime mixes or pure cement. The increase in strength obtained using this method was reported to be as high as 30-fold. However, strength gain in peats may not be as high due to the high water content and low strength of peat soils, and it is further inhibited by the high organic content of peats (Huat 2004). With the addition of sufficient stabilizers and the use of appropriate binders, soil stabilization by suitable chemical admixture results in increments in shear strength and bearing capacity, reductions in permeability and compressibility, and improvement in the swelling characteristics of soft soils. The Deep Mixing Method (DMM) is suitable for deep peat stabilization (Axelsson et al. 2002; Janz and Johansson 2002; Wong 2010). In DMM, columnar soil reinforcement is used in the form of in situ stabilized peat columns constructed by a deep mixing rig. The rig mixes the injected binder with peat soil, dispersing the binder into the soil to provide conditions that permit the binder's chemical reaction to take place (Larsson 2003). The DMM technique involves mechanically mixing binder and soil or peat with a mixing head equipped with a nozzle for binder feeding. The mixing tool is connected to the rotating Kelly of the rig (EuroSoilStab 2002). The formation of stabilized peat columns by the dry method of deep peat stabilization usually begins by driving the rotating shaft and mixing tool to the desired depth and is followed by simultaneous lifting of the mixing tool while feeding the binder into the peat ground.

For shallow peat deposits, the mass stabilization technique is often used to stabilize the soil instead of the removal and replacement method, which is costly and problematic in terms of transportation and disposal of the replaced unsuitable soil (Axelsson et al. 2002). The mass stabilization method is a soil reinforcement technique in which the entire soil layer is blended with stabilizing binders, resulting in a stabilized ''block'' of the shallow peat layer (Axelsson et al. 2002). The machines used for mass stabilization are essentially excavators that are installed and modified using mass stabilization mixers. The binder is fed into the mixing head while the mixer simultaneously

rotates and moves vertically and horizontally
(EuroSoilStab 2002).

The concept of soil-cement stabilization involves the addition of water to cement, resulting in a chemical process known as cement hydration. This process occurs when the pore water or ground water in soil interacts with ordinary Portland cement to form a cement paste containing primary cementation products that harden to create a system of interlocking crystals that bind the material together, thus stabilizing the peat soil.

Stabilization of peat by cement results in a significant increase in the strength of the cement-stabilized peat/ organic soil. Peat stabilization by cement is attributed largely to physicochemical reactions, which include cement hydration, hardening of the resulting cement paste and interactions between soil substances and primary and secondary cementation hydration products.

Full text available at :

http://download.springer.com/static/pdf/385/art%253A10.1007%252Fs10064-013-0549-5.pdf?auth66=1387434656_10b02e17014c5f7e0ae8e2e0e7658f46&ext=.pdf