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MASS STABILISATION MACHINERY

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Abstract. Mass stabilisation method, a soil stabilisation technique using cement, lime or other reactive binders like fly ash or furnace slag, was developed in Finland in 1990s. The development work was utilizing the experiences from deep mixing resulting a soil mixing method with wide application window. The first mass stabilisation projects were for improving very soft soils in situ. The demand for applications with more difficult soil conditions has been increased. To meet this, the machinery was developed to meet the project and operator´s needs. Today the method is used for both geotechnical and environmental applications. Part of the quality chain is the machinery and the way it is being used. This paper presents a State of the Art machinery for shallow mixing.

Keywords: mass stabilisation, mass stabilisation machinery, soil mixer, binder feeder, soil improvement, shallow mixing

1. Introduction

Mass stabilisation is a ground improvement method, where soft soils like clay, peat and dredged sludge are strengthened to a certain depth by feeding and mixing suitable binder into the soil.

Ground improvement by stabilising is today accepted world-wide in order to improve permeability and strengthen the deformation properties of soils. The experiences have been very positive. Many executed projects have proven that soft organic soils can be stabilised. Organic clay and peat have given good results. Dredged sediments can be stabilised either in situ where the stabilised material can be part of the sub structure or ex situ in barges or in temporary built lagoons from where the stabilised material is taken into further use.

Typical mass stabilisation machinery can stabilise down to seven meters. Technically it would be possible to have longer mixers but in practice they would require very heavy excavators for operating. For deeper treatment the structure can be floating or combined technologies can be used resulting economically more feasible solution. See Fig 1 for different construction possibilities.

2. History

Column stabilisation development started in 1960´s in Sweden and Japan. It became more common in 1970´s. In 1980´s it was established as a normal ground improvement method. Mass stabilisation method was developed in Finland in the early 1990´s and in the development work the experiences from column stabilisation were utilized. First mass stabilisation test site was executed in 1993 in Finland. The machinery

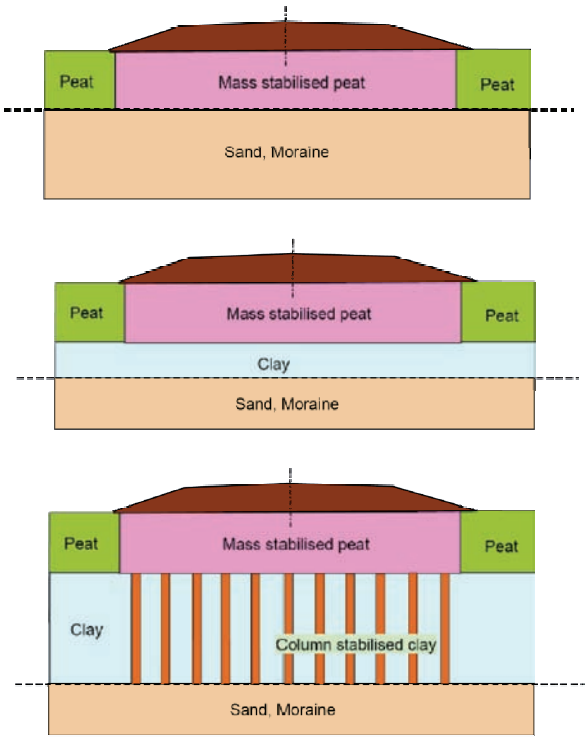

Fig 1. Construction principles

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designed and dedicated only for mass stabilisation was developed in Finland in the early 2000´s. Today there are many project executed globally with a sound history. Typical application areas are: roads, streets, railroads, pipelines, parking areas, sport fields, commercial, residential and industrial areas, harbor storage areas, river embankments, vibration preventing walls, soil solidification and remediation.

3. In-situ mixing

The method employs mechanical mixing which consists of horizontal rotary drums with mixing blades. The blades on the drums create threads which are driving the soil to the middle of the drums where the binder is injected. This ensures a thorough mixing. The operating principle can be seen in Fig 2.

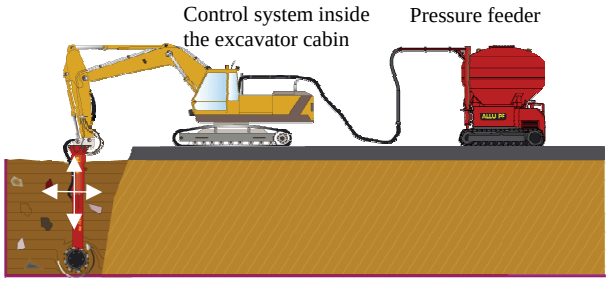

Fig 2. In-situ mixing process

The pressure feeder is feeding the binder through the feeding hose to the mixer end between the mixing drums. Feeding is done by using compressed air. The rotating drums mix the binder into the soil homogenizing it simultaneously. The mixing work is carried out in blocks by moving the mixer in vertical and horizontal directions. The block dimensions depend on the excavator´s operating distance, typically being 5 x 5 m. After finishing the feeding and mixing a geotextile and 0,3…1 m high load embankment are installed.

In many sites soil improvement is one of the first operations. The sooner the construction work can continue, the better it is. The excavator can drive on the stabilised area next day and the required strength can be achieved within 1…3 months.

4. Mass Stabilisation Machinery

The machinery consists of

1.) Power mixer
2.) Pressure feeder and
3.) DAC control system.

Options include 3D positioning system.

4.1. Power Mixer

Power mixer is a versatile hydraulic operated mixing unit for 30 – 40 t excavators. When it is attached to an excavator the combination converts to an easily movable and effective mixing plant. The mixer can be mounted on an excavator with pin mounting or with quick hitch adapter plate. The hydraulic power is taken from the excavator.

Technical details:

Working depth:	PMX 300 3 m
	PMX 500 5 m
Hydraulics:	230 – 420 bar
	200 – 300 l/min
	Max power 160 kW
Weight:	PMX 300 2100 kg
	PMX 500 2500 kg
Option:	2 m extension tube with hydraulic connections

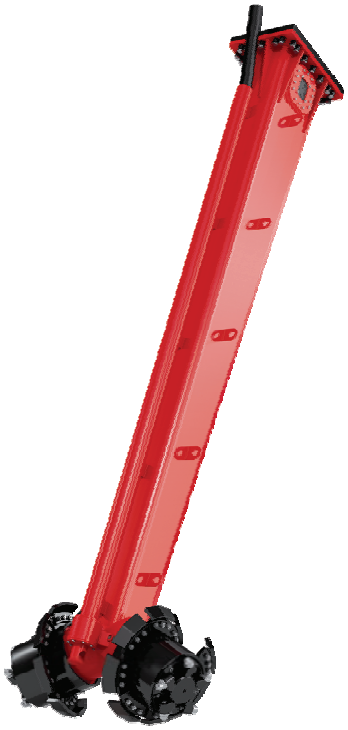

Fig 3. Hydraulically operated rotary mixer

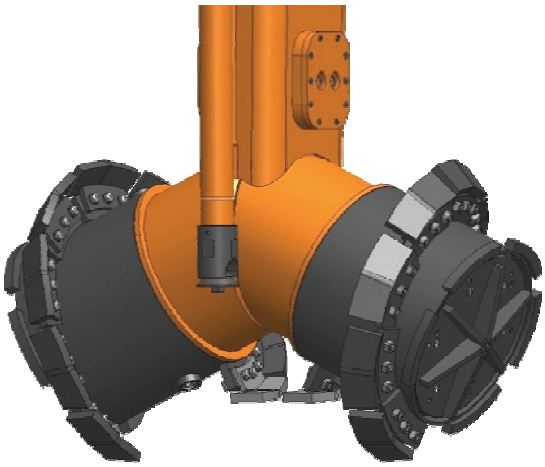

Fig 4. Mixing head with replaceable blades and binder feeding nozzle

Fig 5. Pressure feeder with one binder tank

Fig 6. Pressure feeder with two binder tanks and automatic filter

4.2. Pressure Feeder

The Pressure Feeder injects the binding agent into the soil through a feeding pipe by using compressed air. The unit is mounted on a tracked chassis and is remotely controlled. The feeders can be as a single binder tank version or a dual binder tank version .

Technical details:

Engine:	74,5 kW diesel engine
Compressor:	Working pressure max 8 bar
	Capacity 6,5 m^3/min
Tank:	Max working pressure 8 bar
	Volume 6,5 m^3
Feeding capacity:	
	Adjustable, up to 5 kg/s
	Max feeding distance 50 m
Weight (empty):	
	PF 7 7900 kg
	PF 7+7 13500 kg

4.3. DAC control system

DAC (Data Acquisition Control) system measures, controls and reports the feeding operation and parameters. It enables control of the whole stabilisation system making the system user friendly and it provides the facility to transfer data onto other computers for further processing. The work is documented for quality control purposes. The system saves the data during the stabilisation work and it can be transferred into a normal computer via an USB port. The control panel is mounted into the excavator cabin and the operator can manage the entire system.

4.4. 3D positioning system

The excavator operator controls the vertical and horizontal movement of the mixing tool. The mixing result and binder dosing depends on the operator´s skill and experience. The 3D positioning system informs the driver the position of the mixing head at the accuracy of +/- 2 cm. The system guides the driver to feed right amount of binder and to mix adequately each cell of the block. It eases the mixing , ensures homogenous mixing and accurate binder feeding for the entire block. The system has advanced data logging and reporting system, which is becoming more and more as a requirement from the project owner.

The system consists of four modules: computer unit with dedicated software for mass stabilisation purposes, touch screen operating panel, base station sending correction signal to the system and GPS sensors which are mounted on the mixer.

Fig 7. DAC control panel

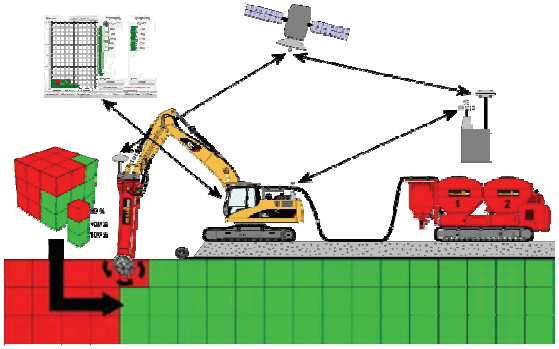

Fig 8. 3D positioning system

5. Conclusions

Mass stabilisation as dry soil mixing method is an excellent soil improvement method for many soft soil problems providing both technical and economic advantages. It does not compete directly with other soil improving methods, but complements them being another method in designer´s and contractor´s toolbox.

The dry soil mixing method can give the following advantages:

- Allows development of otherwise unusable (cost/time-prohibitive) sites
- Economical system, can be combined with other ground improvement systems
- Generally more economical than remove-and-replace options
- Accelerates construction schedule
- Low vibration and noise during execution
- Dewatering is not required
- Rapid mobilization
- No spoil for disposal

In most cases, dry soil mixing works well in high moisture content (>50% from dry weight) silty and clayey soils. Organic soil and peats can often be stabilized, but laboratory testing is always recommended prior to design

Most of the cost in a mass stabilisation project comes from the binder, which can represent 50-70 % of the total project cost. The key elements to reducing this cost factor are binder optimization by the laboratory and accurate binder feeding system. When pneumatic conveying system is being used there should be enough pressure to overcome the backpressure caused by the soil. The mixer should provide enough shear and mixing energy for thorough mixing. Attempts using excavator bucket for mixing do not lead to a homogenous mixing result.

The first project using mass stabilisation was executed more than 20 year ago. The method can be used in various in-situ and ex-situ projects. For treating contaminated sediments there are many projects carried out, for example Vuosaari and Kokkola harbor cases in Finland. Today it is well established method and in the near future it will surely be used more for solving challenges with soft soils.

Fig 9. Railway embankment support by mass stabilising. Stabilisation work in progress at -20^{o}C temperature.

References

EuroSoilStab 2002. “Development of design and construction methods to stabilize soft organic soils.” Design Guide Soft Soil Stabilisation. CT97-0351. Project No.: BE 96-3177. Available online: < http://spsi-sro.ru/files/stab.pdf>

Havukainen, J. 2010. Mass stabilisation principles and geotechnical aspects. *Mass Stabilisation Conference. Nieuwegein Holland*