A Review of Advantages and Methods of Soil Stabilization

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Abstract : Some of the 'green technologies' are: enzymes, surfactants, biopolymers, synthetic polymers, co-polymer based products, cross-linking styrene acrylic polymers, tree resins, ionic stabilizers, fiber reinforcement, calcium chloride, calcite, sodium chloride, magnesium chloride and more. Some of these new stabilizing techniques create hydrophobic surfaces and mass that prevent prevents road failure from water penetration or heavy frosts by inhibiting the ingress of water into the treated layer.
However, recent technology has increased the number of traditional additives used for soil stabilization purposes. Such non-traditional stabilizers include: Polymer based products (e.g. cross-linking water-based styrene acrylic polymers that significantly improves the load-bearing capacity and tensile strength of treated soils), Copolymer Based Products, fiber reinforcement, calcium chloride, and Sodium Chloride.

Key Words : soil, Stabilization, cementation, argillization, bituminization, silicification, resinification,

Introduction : Traditionally and widely accepted types of soil stabilization techniques use products such as bitumen emulsions which can be used as a binding agents for producing a road base. However, bitumen is not environmentally friendly and becomes brittle when it dries out. Portland cement has been used as an alternative to soil stabilization. However, this can often be expensive and is not a very good "green" alternative. Cement fly ash, lime fly ash (separately, or with cement or lime), bitumen, tar, cement kiln dust (CKD), tree resin and ionic stabilizers are all commonly used stabilizing agents.

ADVANTAGES

Treatment of soils offers technical, economic, ecological and environmental advantages.

Technical advantage

Treatment with lime and/or cement or cementitious road binders allows production and use of homogeneous, long-lasting and stable materials with mechanical characteristics comparable to those of graded aggregate with cementitious binders.

In addition, these materials are characterised by great stiffness and excellent fatigue strength. They show good performance in hot weather, with no deformation or rutting, and good performance on exposure to freeze-thaw cycles due to the stiffness of the material and the slab-side effect.

Economic advantage

Field recycling is a significant savings factor as this reduces to a minimum stripping cuts, landfill, provision of aggregates and thus the cost of their transport. The absence of transport of aggregates and of cuts to the landfill contributes to preserving the road network in the vicinity of the building site.

Also, these are very economical techniques, especially on account of the shorter duration of the works: compared to a conventional solution, the savings are of the order of 30%.

Ecological and environmental advantage

Cold treatment reduces pollution and discharge of fumes into the atmosphere. Moreover this technique allows significant global energy savings by reducing the transport of materials, the quantity of materials for landfill (thus limiting indirect effects - nuisance to users and residents) and fatigue of the road network adjacent to the site.

Field recycling minimises exploitation of aggregates deposits (quarries and gravel pits), non-renewable natural resources. This contributes to preserving the environment.

METHODS OF SOIL STABILIZATION

Soil Stabilization artificially changing soil properties for construction purposes (by physical or chemical methods) at the natural site. As a result of soil stabilization, the bearing capacity of the foundation of the structure is increased and its strength, water tightness, resistance to washout, and other properties are improved. Soil stabilization is widely used in the construction on sagging soils of industrial and civil buildings; for strengthening the banks adjoining highways in a hollow or the walls of a ditch, where the ground is saturated with water; for preventing landslides; in sinking shafts and in creating filtration-proof barriers in the foundations of hydraulic structures; for protecting concrete structures (foundations) from aggressive industrial effluents; and for improving the bearing capacity of piles and of large-diameter supports. Soil stabilization is achieved by injecting cementing materials or chemical solutions into the ground and also by applying electric currents to the ground or heating or cooling it.

The basic methods of soil stabilization are

1. cementation,
2. argillization,
3. bituminization,
4. silicification,
5. resinification,

methods using electrochemical or thermal action, and artificial freezing.

Cementation consists in injecting a cement suspension into the soil to be stabilized (such as fissured, rocky soil or soil containing sand and gravel) through a system of boreholes drilled in the soil. The suspension has a mass ratio of cement to water in the range of 0.1 to 2. To increase the mobility of dense cement solutions and cement-sand solutions a sulfitealcohol vinasse can be added, in the amount of 0.01–0.25 percent of the quantity of cement. Additions of calcium chloride, in the amount of 1–5 percent of the quantity of cement, can be used to regulate the acceleration of setting of the solution and increasing the initial strength of cement stones. The stability of the soil and its watertightness increase significantly after cementation.

Hot bituminization, as well as cementation, is used in cavernous rocky strata where subsurface flow attains a high speed. The purpose of hot bituminization is to seal those larger cavities that can not be sealed off by cementation because of the high speed of subsurface flow. Hot bitumen is injected into the cavities and fissures of cavernous rock through boreholes equipped with injectors. In cold bituminization a finely dispersed bitumen emulsion is injected into the ground. This method is used for very narrow fissures in rocky soil and for stabilization of sandy soils.

Argillization is used to reduce filtration capacity of fissured, rocky cavernous strata and of gravelly soils. In this method a clay suspension, with a small amount of a coagulant added, is inserted under high pressure into the fissures of the stratum. The solidification method is based on the use of silicate solutions. To stabilize medium-grained sands the so-called two-solutions method is used. It consists of successively injecting into the ground solutions of sodium silicate and of calcium chloride. As a result of the reaction, silica gel is obtained. This gel imparts to the soil considerable strength and watertightness. Fine-grained sands are stabilized using the one-solution method of silicification, that is, using a solution of sodium silicate with phosphoric acid added (Figure 1).

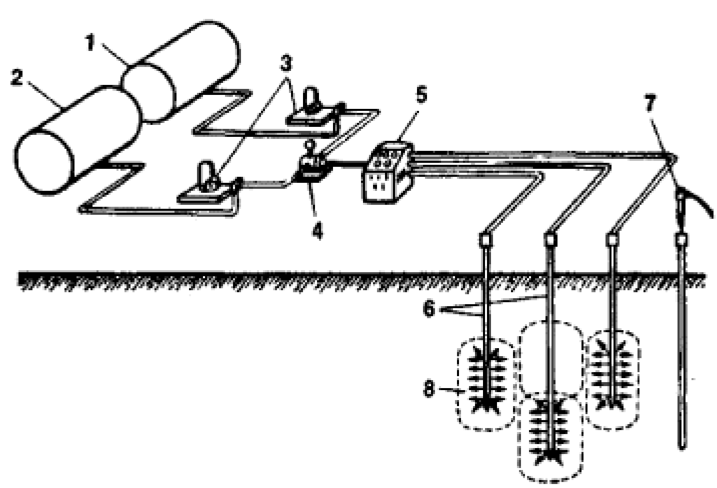

Fig 1.1 equipment used in solidification of soils: (1) tank containing binder r, (2) tank containing acid, (3) pump “ND,” (4) mixer, (5) control console with recording instruments, (6) injector, (7) pneumatic drill used to sink injectors into the soil, (8) stabilization contour

Resinification consists in injecting into the ground an aqueous solution of carbamide resin, with additions of hydrochloric acid, oxalic acid, or ammonium chloride. This method is used to stabilize and to improve the strength and watertightness of fine-grained sandy soils.

In argillaceous soils, where injection of solutions into the soil is not feasible, an electrochemical stabilization method is used. This method is based on passing a direct electric current through the soil, into which a solution of calcium chloride has been introduced. As a result, the soil is dehydrated and packed. Exchange reactions occurring in the regions adjacent to electrodes are also conducive to the packing and stabilization of the soil. Electrochemical stabilization can be subdivided into electrodrying, electropacking and electrostabilization.

Thermal stabilization is used to strengthen sagging loess soils. In this method the soil to be stabilized is sintered by gaseous products of fuel combustion, having a temperature of 700° to 1000°C. Combustion is most effective if conducted within the stratum of the soil to be stabilized (Figure 2). Stabilization of unstable water-bearing soils can be achieved by artificially freezing the soil.

In the USSR all-Union symposia on stabilization and packing

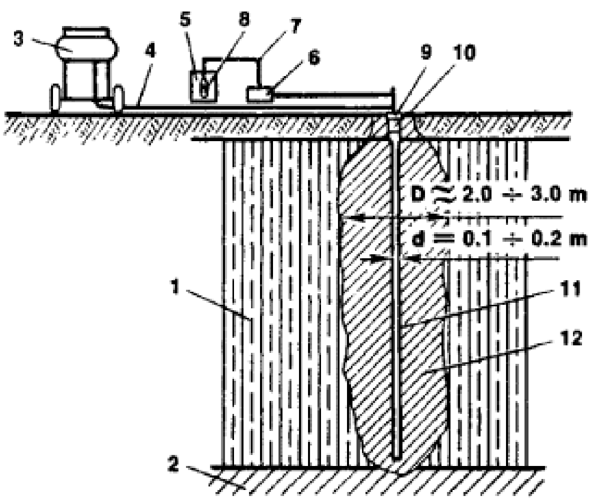

Fig 1.2 equipment used in thermal stabilization of sagging loess soils by combustion of fuel directly within a borehole: (1) sagging soil, (2) nonsagging soil, (3) compressor, (4) pipeline for cold air, (5) container for liquid fuel, (6) pump feeding fuel into the borehole, (7) fuel feed pipeline, (8) filter, (9) nozzle, (10) gate and combustion chamber, (11) borehole, (12) region of

thermal soil stabilization of soils are conducted periodically. Records of such symposia are published in special collections.

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