1-1-2007

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DOI: 10.5703/1288284315790

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Recommended Citation

ECT Team, Purdue, "Plasma Arc Torch Technology Stabilization and Ground Improvement" (2007). *ECT Fact Sheets*. Paper 81.
<http://dx.doi.org/10.5703/1288284315790>

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PLASMA ARC TORCH TECHNOLOGY: STABILIZATION AND GROUND IMPROVEMENT

THE NEED

This technology represents an additional alternative for stabilizing weak foundation soils upon which buildings, bridges, roads or other structures are to be constructed. In-situ thermal stabilization and improvement of foundation soils has been pursued for over a century. It is well recognized that heating soil results in increased strength and decreased compressibility. Consequently, thermal treatment methods have been used as a means of soil improvement in construction operations to stabilize weak foundation soils, and for the stabilization of landslides and slopes subject to failure.

Previous efforts have involved the use of conventional heating methods on surface applications or boreholes filled with fossil fuels or mechanical burner units. However, the high cost of treatment, low burning temperatures, complexity of the process, and uncertainty of the results have limited the use of this technique to relatively few construction applications.

FIGURE 1 HIGH-HEAT TORCH OPERATES AT UP TO 7,000 C

THE TECHNOLOGY

A plasma is a gas that has been ionized by the electric arc of a plasma torch and can therefore respond to electrical and magnetic fields. Plasma arc technology can create plasma using almost any type of gas (oxygen, nitrogen, carbon monoxide, air, etc.) and in a wide range of pressures (vacuum to 20 atmospheres). The flame of the plasma torch is actually an energized arc, similar to lighting.

The plasma arc has a wide spectrum of temperatures ranging from 1500°C to over 7000°C, or approximately 1000°C hotter than the surface of the sun. The plasma arc torch uses copper electrodes to create a non-transferred arc. The plasma torch and electrodes are water-cooled and the average life of the electrodes ranges between 200 to 500 hours of operation. A DC power supply unit provides the electrical requirements of the torch and commercial units are available in power levels ranging from about 100 kW to 10 MW capacity.

The plasma torch is lowered to the bottom of a small diameter, cased borehole. By raising and operating the torch at progressively higher levels the borehole casing is rapidly melted opposite the plasma flame, and a column of soil is heated and converted into a stabilized vertical mass. Successive or simultaneous operations in adjacent boreholes, properly spaced, could similarly stabilize an entire foundation.

At approximately 200°C soil plasticity begins decreasing until it is reduced to zero at around 500°C. Swelling is reduced to zero at temperatures above 750°C and shear strength rises continuously throughout this range of temperatures. At temperatures above 900°C the soil begins to fuse into brick-like material. Finally, the soil melts and later hardens in a rock-like material (similar to obsidian) at temperatures above 1,100°C.

FIGURE 2 PLASMA ARCH TORCH

Plasma torches have the capability to readily create temperatures which produce these irreversible changes in the soil properties, such as decrease in sensitivity, swelling and compressibility and increase in shear strength and stiffness. These changes allow to achieve different soil stabilization stages and significantly improve the engineering properties of a soil. Weathered or weak rock formations can be also stabilized in a similar manner.

THE BENEFITS

Plasma arc technology appears to overcome most of the limitations present with thermal stabilization techniques using fossil fuels and electric heat sources. The much higher temperatures, greater flexibility,

simplicity and the high efficiency of the plasma torch makes it a much more attractive alternative for the stabilization of weak and unstable foundation soils (excessive settlement, liquefaction, excess seepage), slopes and landslides subject to failure and vertical or steep cuts in soil.

The plasma torch offers two to three times the heating value of fossil fuels. According to research testing, the torch melts and vitrifies two foundation soils (clay and silty sand) into rock-like glassy materials, virtually can turn these soils into a rock that it is 5 to 10 times stronger than unreinforced concrete. The process is about 90 percent efficient in energy usage. Plasma heating systems can be placed on flatbed trucks for a mobile configuration. While plasma torch may not be advisable in every case at this moment, it may salvage sites that would otherwise be unbuildable.

STATUS

Even though the technology has begun to emerge as a commercial tool in several industries such as steelmaking, precious metal recovery, and waste disposal, it is a prototypical technology in the stabilization and ground improvement field. Further research in the U.S. is being done in the use of plasma torches at higher power levels with different types of soils, varying moisture content, and at different depths. Major research programs for the study of the basic science of plasma heating and development and implementation of models and prototypes for different applications are being conducted around the world (U.S., Japan, Canada, Russia, France, Switzerland, Australia and South Africa).

BARRIERS

Promising results in the laboratory have been achieved with only two types of soil clay and silty sand. It is difficult to forecast the cost of the technology. Further, the economies of this in-situ thermal stabilization concept will be highly dependent on several variables relating to site location, geological conditions, and the type of plasma torch system used for the process. Even though the plasma torch makes soils very stable, the technology reduces volume by about half.

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REFERENCES

1. Circeo, L. J., Jr. and Mayne, P. W., In-Situ Thermal Stabilization of Road and Airfield Foundation Soils using Plasma Arc Technology, Forth International Conference on Bearing Capacity of Roads and Airfields - Proceedings., July 17-21 1994, Minneapolis, Minnesota. Vol. 2, pp. 899-916.
2. Spinoff. (NASA) 1994 pp. 104-105.
3. Engineering Design and Construction., Civil Engineering News. (ASCE) Apr. 1994.
4. Circeo, L. J., Jr. and Mayne, P. W., Plasma Torch Holds Promise for Strengthening, Stabilizing Weak Foundation Soils In-Situ, Georgia Tech Research News, Oct. 1993.
5. Camacho, S. L., Harnessing Artificial Lightning, The World & I., Dec. 1991, pp. 310- 317.

REVIEWERS

Peer reviewed as an emerging construction technology

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PUBLISHER

Emerging Construction Technologies, Division of Construction Engineering and Management, Purdue University, West Lafayette, Indiana