CIGMAT

CENTER FOR INNOVATIVE GROUTING MATERIALS AND TECHNOLOGY, UNIVERSITY OF HOUSTON

November 1995 Issue
Vol. 1, No. 3

NEWS AND LITERATURE REVIEW

Cellular grouts: A View Point

Slipping a new pipe inside an old pipe and grouting the annular space with a cellular grout is a cost effective method of repairing storm drains, industrial drains and sanitary sewers. The process known as sliplining, eliminates cut and cover operations that disrupt day to day life. Cellular or foam grout is lightweight with densities in the range of 30-80 pcf and uniaxial compressive strength in the range of 80-400 psi. Foamed cement was first developed in Sweden and Germany in the 1920's as an alternative to timber in the construction industry and it was introduced to the U.S in 1950. Cellular cement grouts have a unique set of properties, such as moderate thermal insulation, high heat capacity, high stiffness and low cost relative to polymer foams which makes it attractive as a sliplining material. In sliplining, cellular grout also helps in slowing down or stopping the corrosion to the existing pipe, provides support to the new pipe and controls infiltration. It usually costs around 5-10% of the sliplining contract and is very low when compared to the cost of redoing a failed pipe installation. In the Houston area alone, sliplining accounted for 1.3 million feet of rehabilitated sanitary sewer lines (ENR, Oct 16, 1995).

When done correctly, grouting can ensure a permanent pipe repair, but incorrect grouting can cause many problems. For example, the new pipe might collapse as a result of the grouting operation, or it might get selectively floated during grouting. The flotation forces during the grouting operation and the condition of the existing pipe may also cause unacceptable strain on the liner pipe and might damage the liner pipe.

At the CIGMAT Research Laboratory, we are developing and characterizing various cellular grouts as part of a project funded by the National Science Founadation. ACI Committees 211 and 213 are involved in the development of specifications and tests for lightweight concrete. The various ASTM, RILEM and ACI test methods and specifications which have been recommended for the quality control of the cellular grouts/concrete are listed below:

Standard Number	Scope of the Test	Committee and Subcommittee
C796-87a	Standard test method for foe use in producing cellular concrete using preformed foam.	C-9 on Cement and Concrete Aggregates and C09.23 on chemical admixtures.
C 495-91a	Standard test method for compressive strength of lighweight insulating concrete	C-9 on Cement and Concrete Aggregates and C09.23 on chemical admixtures
C567-91	Test method for unitweight of structural lighweight concrete.	C-9 on Cement and Concrete Aggregates and C09.21 on lightweight aggregates.
C 157-91	Standard test method for length change of hardened cement mortar and concrete.	C-9 on Cement and Concrete Aggregates and C09.68 on volume changes of concrete and aggregates.
C 496-90	Standard test method for splitting tensile strength of cylindrical concrete specimens.	C-9 on Cement and Concrete Aggregates and C09.61 on testing of concrete for strength.
ACI - 211.2.81	Standard practice for selecting proportions for structural lightweight concrete.	ACI Committee 211
ACI 213R-79	Guide for structural lightweight aggregate concrete.	ACI Committee 213
RILEM 5.1	Volume changes caused by temperature, moisture and loads.	RILEM Technical Committees-78 MCA and 51 ALC.

In this issue....

Announcements

(i) CIGMAT is on the World Wide Web (WWW). The web site is at http://www.cigmat.uh.edu (or gem1.cive.uh.edu)

(ii) CIGMAT/GIS Database is expanding. If you are interested, please sign up.

(iii) CIGMAT Conference: March 8, 1995, Houston, Texas.

(iv) Comments from various people on the article, "Shrinkage: A View Point", (CIGMAT, News and Literature Review, Vol. 1, No. 2) is very much appreciated.

I. SOIL GROUTING

(i) Vertical cutoffs and bottom sealing by jet grouting; *Welsh, J.P and Burke, G.K., Geotechnical Special Publication, No. 46/2, 1995, ASCE, pp. 1207-1221.*

Since its introduction into the United States in the 1980's, jet grouting has been utilized mainly for excavation support and underpinning. In the late 1980's, jet grouting began to be utilized as a vertical and horizontal barrier to prevent groundwater migration. Sixteen case histories are cited where this grouting technique has been successfully utilized to control both contaminated and uncontaminated groundwater flow. It is hoped by documenting this number of diverse jet grouting projects that the engineering communities will recognize another proven tool is available for control of contaminants and groundwater .

Keywords: *groundwater migration, jet grouting, vertical cutoffs, bottom sealing.*

(ii) Jacking of a railroad overpass with soil stabilization and water proofing by ground freezing; *Orth, W., Proceedings of the 7th International Symposium on Ground Freezing, 1994, A.A.Balkema, pp. 411-412.*

For an underpass below a highly frequented railroad line ground freezing using liquid nitrogen was used both for stabilizing the embankment and waterproofing the soil. This paper describes the waterproofing by ground freezing, which was used to avoid groundwater pollution by chemical grouting and stability problems in the railroad embankment by jet grouting. Stabilization of the embankment by ground freezing is described in an earlier paper about a former project by the same author.

Keywords: *freezing, embankments, liquefied gases, jet grouting.*

(iii) Remote monitoring electro-levels for the new St. Clair rail tunnel; *Drooff, E.R., Geotechnical News, Vol. 13, No. 1, Mar. 1995, pp. 38-41.*

The new St. Clair River Tunnel currently under construction passes underneath the Imperial Oil Refinery building at approximately 10 m below the foundations, hence it has the potential to cause significant differential movement and damage to the building. This indicates that the level of the building should be maintained in order to prevent damage to the building. In view of this, the Soilfrac grouting method which is controlled by real-time remote monitoring electro-levels, is used to increase bearing capacity and shearing resistance of soils and to induce heave to compensate against settlement. In particular two types of electro-levels are used. Experience gained from the use of electro-levels indicates room for an improved electro-level system and the consideration of other monitoring systems.

Keywords: *fracture grouting, electro-levels, construction monitoring, telemetering.*

CIGMAT CONFERENCE!!!

Conference on "Construction and Rehabilitation Activities in The Greater Houston Area; A Model City", will be held in Houston, Texas, on March 8th 1996.

(iv) Lifting of structures using soilfrac: Application of an active foundation method; *Falk, E., Proceedings of the 10th European Conference on Soil Mechanics and Foundation Engineering, Vol. 4, 1994, A.A.Balkema, pp. 1349-1350.*

During the load increase of free cantilevering, bridge pier No. 8 of the Winkl-highway bridge in Austria began to settle unevenly. The increase of the stability factor of a moving foundation requires a geotechnical method which disturbs the present graound conditions as little as possible. It was decided to try relevelling and underpinning using the Keller Soilfrac technique. The primary grouting resulted in a strengthened soil area around and below the existing foundation. During this phase of soil strengthening, the success of the method is documented by an decrease in settlement rate and an increase in the grouting pressure.

Keywords: *foundations, soil structure interactions, Keller Soilfrac technique.*

II. ENVIRONMENTAL GROUTING

(i) Grouting gasoline-contaminated sand with microfine cement; *Schwarz, L.G and Krizek, R.J., Geotechnical Special Technical Publlication, No. 46/2, 1995, ASCE, New York, NY, pp. 1366-1380.*

The effectiveness in using microfine cement grout injected into three different gasoline-contaminated sands was evaluated. Experiments were conducted to determine the bleed capacity and microstructure of neat grouts containing various percentages of gasoline, and it was found that the presence of a small amount of gasoline significantly reduces the bleed capacity of the grout and that the discrete entities of gasoline were encapsulated within the grout microstructure. Six grouting scenarios were investigated: four involved gasoline-contamination to model the effect of water table fluctuations on the residual saturation of the gasoline, and two involved no contamination to establish reference conditions.

Keywords: *soil pollution, microfine cement grout, gasoline contamination, grout microstructure.*

(ii) Performance of cement-based seal system components in a waste disposal environment; *Malone, P.G., Wakeley, L.D., Pete, J and McDaniel, E.W., Microstructure of Cement-Based Systems/Bonding and Interfaces in Cementitious Materials, Materials Research Society Symposium Proceedings, PA, Vol. 370, pp. 191-198, 1995.*

The effectivity of a closure grout developed as a part of hollow subsurface structures for disposal of low-activity radioactive wastes to maintain adequate volume stability and other required physical properties in the internal environment of the disposal structure was studied by monitoring the heat output, volume change and compressive strength of the sealing grout. Cured specimens were immersed in a liquid waste simulant to determine if contact with an alkaline liquid waste would cause chemical deterioration of the sealing grout. Lastly, the results obtained were discussed.

Keywords: *alkaline liquid waste, chemical deterioration, bentonite clay.*

III. SEWER GROUTING

(i) Rehabilitation of masonry combined sewers in the city of St. Louis; *Collins, M.A and, Stude, C.T., International Conference on Advances in Underground Pipeline Engineering, ASCE, NY, 1995, pp. 709-20.*

A rehabilitation program is being conducted to minimize the potential for structural failure of Metropolitan St. Louis Sewer District's sewers as a result of hydrostatic pressure and increased infiltration. This paper addresses the rehabilitation of sewers made of brick and other types of masonry. The salient features of three rehabilitation techniques considered (reinforced shotcrete, cured-in-place, sliplining), as they apply to man-entry sized sewers, are described.

Keywords: *pipe linings, sliplining, masonry combined sewers.*

(ii) In-situ nondestructive testing of buried precast concrete pipe; *Sack, D.A and Olsen, L.D., Infrastructure: New Materials and Methods of Repair Proceedings of the Materials Engineering Conference 804, Oct. 1995, ASCE, NY, pp. 499-507.*

This paper presents a summary of research work to develop an in-situ nondestructive testing system to evaluate the integrity of precast, post-tensioned concrete pipe from it's interior without excavation. The results of the research show that relatively high-speed Impact Echo scanning (up to 6 m (20 feet) / 5 min. or more) of this type of pipe is feasible. This type of concrete integrity scanning of pipes has not been done prior to this, and will potentially allow economical testing of many miles of pipe. This paper includes a brief description of the patent-pending pipe scanning unit, which uses the Impact Echo method to scan the inside pipe wall for defects throughout the pipe wall thickness. This new scanning system is designed particularly to look for delaminations of the outer grout covering over the post-tensioning wires. Also included in this paper are actual data scans collected from buried pipe sections. Finally, potential applications of the Impact Echo scanning method are presented.

Keywords: *in-situ nondestructive testing, concrete pipes.*

IV. STRUCTURAL GROUTING

(i) Three-leaf stone masonry strengthened by injecting cement grouts; *Vintzileou, E., Tassios, T.P., Journal of Structural Engineering, Vol. 121, No. 5, May 1995, pp. 848-856.*

In a large number of monuments and buildings belonging to urban nuclei, the walls are made of the so-called three-leaf stone masonry (i.e., two mortar and small pieces of stone). In this paper, The effect of injecting cement-based grouts in such walls is experimentally investigated on wallets subjected to vertical or to diagonal compression. A drastic improvement of mechanical characteristics is observed thanks to the homogenization of the three-leaf masonry after the injection of the grout.

Keywords: *cement grout, stone masonry.*

(ii) Post-tensioned concrete bridges: the UK debate; *Raiss, M., Concrete (London), Vol. 29, No. 2, Mar-Apr. 1995, pp. 23-26.*

The Working Party was set up in 1992 by the Concrete Society and the Concrete Bridge Development Group to study the problem regarding post-tensioned concrete bridges. The Working Party aims to generate confidence in the industry's ability to design and build durable post-tensioned concrete structures. This party has six subject areas and these are as follows; (a) grouting specifications and prestressing systems, (b) unbonded construction, (c) design and detailing, (d) vacuum grouting, (e) testing and (f) grout materials. In general, the party has made considerable preogress towards improving design, detailing, specification, materials, construction methods and testing since its introduction.

Keywords: *concrete bridges, unbonded tendons, grouting techniques.*

(iii) Reliable corrosion protection for bridge stay cables; *Funahashi, M., Concrete International, Vol. 17, No. 2, Feb. 1995, pp. 33-37.*

Cable-stayed bridges have become popular due to advancements in prestressed concrete structures technology and economic advantages over other types of structures. With

the increasing popularity of these bridge types, of equal importance is the effect of corrosion protection systems of the stay cables and anchorages. Corrosion if not properly monitored and most importantly prevented, may lead to progressive structural failure. A number of corrosion prevention methods are being impemented for this purpose, however, not one can be considered permenant. Most of these last only for a few years. As efforts continue to be exerted in this area, it is hoped that more reliable prevention methods will evolve.

Keywords: *cementitious grout, corrossion protection systems.*

(iv) 'Stressed arch' roofing; *Riley,E., Construction Specifier, Vol. 47, No. 2, Feb. 1994, pp. 43-50.*

This article presents an innovative engineering process known as STRACH or 'stressed arch' structure. It is a flat system composed of multiple two-legged trusses assembled no more 9m off the ground and covered by metal decking. This flat structure is then forced into an arched position by stressing cables that slide the trusses legs closer together. The roofing system and interior electrical, mechanical and sprinkler systems are installed while the structure is in the flat position. The arch is formed by a series of large, multi-strand jacks that pull the cables that run through the bottom chord of each truss. As the tension on each cable increases, the truss legs across from the jacks are drawn towards the stationary legs of the trusses on greased tracks. Once the roof reaches the proper height, the mobile legs are bolted into place, and the bottom chords are filled with grout to bond the cables to the pipe.

Keywords: *prestressing cables, stresses arch roofing.*

Industrial Contacts and Sponsoring Members :

Berry, R., Rembco Engineering, Knoxville, Tennessee.
Cook, D., Cook Construction, Albuquerque, New Mexico.
Fiest, G., 3M Construction, St. Paul, Minnesota.
Magill, D., Avanti International, Webster, Texas.
Odell, K., Gelco Services, Salem, Oregon.

For more information on CIGMAT or Comments on this issue of CIGMAT News And Literature Review, contact;

Dr. C. Vipulanandan, P.E.,
Director of CIGMAT,
Department of Civil and Environmental Engineering,
University of Houston,
Houston, Texas 77204-4791
Ph. No. 713-743-4278; Fax No. 713-743-4260.

Journals Reviewed

The articles for inclusion in the CIGMAT News and Literature Review are selected on the basis of their usefulness and applicability in the field of grouting technology, and are geared towards practicing professionals in the field. Recent issues of the following publications were reviewed.

1. American City and County
2. American Concrete Institute
3. Civil Engineering (ASCE)
4. Civil Engineering (London, England)
5. Concrete Construction
6. Concrete International (ACI)
7. Civil and Structural Engineering Abstracts
8. Engineering News Record
9. Environmental Geology
10. Electrical World
11. Geotechnique
12. Indian Geotechnical Journal
13. Canadian Geotechnical Journal
14. Ocean Engineering
15. Soil Dynamics and Earthquake Engineering
16. Foundation Facts
17. Geodex Retrieval System for Geotechnical Abstracts
18. Geotechnical Abstracts
19. Journal of Geotechnical Engineering (ASCE)
20. Journal of Structural Engineering (ASCE)
21. Soils and Foundations
22. Soil Technology
23. Series on Rock and Soil Mechanics
24. Public Works
25. New Scientist
26. Military Engineer
27. Oceanus
28. Pipelines and Utilities Construction
29. Pipes and Pipelines Manual
30. Pipes and Pipelines International
31. Tile and Brick International
32. Composite Materials Series
33. Mexican Society for Soil Mechanics Meeting
34. Tunnels and Tunnelling