CIGMAT

http://cigmat.cive.uh.edu/

November, 1999

Vol. 5, No. 1

CENTER FOR INNOVATIVE GROUTING MATERIALS AND TECHNOLOGY, UNIVERSITY OF HOUSTON.

News and Literature Review

Is CLSM a Grout?

The versatility of Control low strength material (CLSM) or flowable fill makes it useful in a wide variety of applications. CLSM is gaining acceptance as a backfill material, particularly for work around pipes and other utility trench applications and as a void filling material for abandoned underground facilities. CLSM has inherited many different names throughout the industry including liquid dirt, controlled density fill, flowable mortar, and lean backfill. General constituents of CLSM are sand, cement, fly ash and water with flowing consistency and relatively easy pumpability. This clearly qualifies CLSM as a grout, although the ready mix suppliers or the ACI 229 committee doesn't refer to it as a grout.

The key to CLSM's (a self leveling material) success has been the ease of placement, no required compaction, reduced trench excavation, use of locally available material, less labor and safer operations. Because of the nature of application the component materials need not meet the standards required for concrete production, typically 28th day unconfined compressive strength of 100 psi is specified for excavatable fill. The National Ready Mixed Concrete Association has defined excavatable CLSM as having an unconfined compressive strength of 150 psi in one year. Higher strengths are used for applications where future excavation is not required.

Performance tests may be required before placement to establish the rate of strength gain and the potential ultimate strength of the mixture. Besides compressive strength, flowable fill has many other physical properties that have to be specified and evaluated before placing the material. Flowability is a measure of the flowable fill mixtures' fluid characteristics. Highly flowable mixtures often contain more water so hydrostatic pressure during backfill placement must be considered; placing them in lifts will reduce the hydrostatic pressure. When using CLSM, buoyancy is a common concern because the pipes can be lifted off the foundation/bedding. CLSM unit weight varies from 70 to 145 pcf.

The permeability of CLSM can range from sand to clay or even lower, this will also help in selecting the material for different applications. ASTM has approved a few standards for measuring the properties of CLSM and these are listed below. CIGMAT researchers are currently working on developing and characterizing various CLSM mixes using foundry sand, clay and fly ash.

Standard Number	Scope of the Test	Committee and Subcommittee
D 4832-95	Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders	D-18 on Soil and Rock and D18.15 on Stabilization with Admixtures
D 5971-96	Standard Test for Sampling Freshly Mixed Controlled Low Strength Material	D-18 on Soil and Rock and D18.15 on Stabilization with Admixtures
D 6023-96	Standard Test Method for Unit Weight, Yield, Cement Content, and Air Content (Gravimetric) Controlled Low Strength Material	D-18 on Soil and Rock and D18.15 on Stabilization with Admixtures
D 6024-96	Standard Test Method for Ball Drop on Controlled Low Strength Material (CLSM) to Determine Suitability for Load Application	D-18 on Soil and Rock and D18.15 on Stabilization with Admixtures
D 6103-97	Standard Test Method for Flow Consistency of Controlled Low Strength Material (CLSM)	D-18 on Soil and Rock and D18.15 on Stabilization with Admixtures

In this issue.....

Announcements

(i). CIGMAT-2000 Conference will be on March 3, 2000 University of Houston, Texas.

http://cigmat.cive.uh.edu/

Literature Review

(I) Geotechnical Grouting

(i) Cementing the future, *Berti, D.J.; Koutsoftas, D.C.; Lindquist, E.S., Civil Engineering, Vol. 68, No. 12, 1998 ASCE, pp. 46-48.*

The reconstruction of the Cypress Freeway in Oakland, Calif., required some of the most extensive and innovative uses of soil-cement mixing in the U.S. The following problems are discussed in the paper: dewatering, soil-cement solutions, soil-cement piles, BART underpinning and a novel solution. The success of the Cypress Contract B project shows the versatility of in situ soil-cement mixing for diverse temporary and permanent construction applications. Future advances, such as the development of jet-grouting techniques for constructing even larger columns, will probably reduce costs even further and expand the uses of soil mixing in difficult geotechnical applications.

Key words: *Soil-cement, Jet grouting, Dewatering*

(ii) Geotechnical challenges faced on Line 2 of the Greater Cairo Metro System, *Campo, D. W. and Richards, D. P., Proceedings of the Geo-Congress, Big Digs Around the World, GSP No. 86, ASCE, 1998, pp. 358-379.*

This paper describes the geotechnical challenges faced during the design and construction of Line 2 of the Greater Cairo Metro System. The line is 19 km long, 13 km was constructed underground within the waterbearing Nile valley alluvium. The underground works included construction of cut-and-cover tunnels and stations using diaphragm walls, top-down methods, and state-of-the-art computerized injection grouting. General aspects of the bored tunneling are discussed, along with an innovative new method successful in minimizing surface settlements. Finally, construction of special hand-mined connections to the bored tunnels, TBM entry and exits methods from underground stations, and a major building underpinning effort is discussed.

Key words: *Subways Construction, Tunneling*

(iii) Jet grout stabilized excavation beneath an existing building, *Ho, C. E. , Proceedings, Geotechnical Special Publication No.80, 1998, ASCE pp. 1-15.*

A new single basement was constructed as part of a building refurbishment project in Singapore. The excavation was carried out within the tight confines of the existing building. The sides and bottom of the excavation were stabilized by jet grout columns installed using the triple-tube technique. The excavation was carried out without shoring. The installation of the jet grouting works and subsequent excavation was monitored by geotechnical instruments. This paper presents the monitoring data obtained and discusses the influence of the jet grouting and construction activities on the surrounding ground and structures.

(iv) Behaviour of ground anchorages under cyclic loading, *Merrifield, C.M. and Carey, J.M, Proceedings of the Institution of Civil Engineers, Geotechnical Engineering, Vol. 131, No. 3 1998, pp. 133-140.*

In the design of grouted ground anchorages the greatest uncertainty in the prediction of anchorage behaviour resides in the interaction between the grouted fixed length and the surrounding soil or rock. While there are generally accepted international practices for in situ anchorage tests, both at time of installation and at some time during the working life of the anchorage, at no time is the anchorage subjected to a test which involves a large number of repeated or cyclic loads, even when the predicted working load pattern suggests that it is appropriate. This paper investigates the behaviour, under repeated loading, of stiff right cylindrical model anchors installed vertically in the ground. All tests undertaken on the geotechnical centrifuge ensured that the anchors were correctly subjected to field-scale stresses.

Key words: *Anchors, Cyclic loading*

(v) Compaction grouting to reduce seismic risk and collapse potential for freeway storm drain system, *Reed, John W.; Hourihan, Daniel T.; Thornton, G. J. Proceedings, Geotechnical Earthquake Engineering and Soil Dynamics III, Vol. 1, 1998, pp. 666-677.*

The deep storm drain system for the Century freeway in Los Angeles began to show signs of significant distress within a few years of original construction. Several sinkholes and open depressions developed at on-ramps, off-ramps, overcrossings, slopes, and around a new pumping plant. Geotechnical analyses revealed erosion and piping of significant quantities of granular backfill soils into the deep storm drain system, primarily at unsealed pipe joints. The result was collapsible voids around and above the storm drains, low-density bedding and backfill soils subject to differential settlement, and seismic risk due to liquefiable fine sands below a very shallow groundwater table. Compaction grouting was used to help restore the overall integrity and stability of 5.1 kilometers (3.2 miles) of the storm drain system by reducing liquefaction and settlement potential of coarse-grained and fine-grained foundation soils, respectively, as well as filling any macroscopic subsurface voids that might exist. Cone Penetration Testing (CPT) established the condition of soils around the storm drains prior to compaction grouting. A true low-mobility grout mixture was then injected to fill voids and improve soil properties from a depth of 1.5 m (5 ft) below the freeway, to a depth of 1.5 m (5 ft) below the bottom of the storm drain. Post-grouting CPT data established that the design performance criteria for the compaction grouting program had been achieved, including a marked decrease in the liquefaction potential of sandy soils in areas of groundwater table as shallow as 1.5 m (5 ft).

Key words: *Compaction grouting, Cone penetration tests*

(vi) Should grouted anchors have short tendon bond length? *Briaud, Jean-Louis, Powers, W. F. III and Weatherby, D. E., Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 2 , 1998 ASCE, pp. 110-119.*

Field measurements associated with the behavior of ten low-pressure grouted anchors installed with a hollow stem auger at the National Geotechnical Experimentation Site at Texas A&M University are presented. The anchors were 0.3 m in diameter and embedded 13.8 m in a stiff to very stiff clay. Six anchors had a tendon bond length of 4.6 m and four had a tendon bond length of 9.2 m. All anchors were load tested to near failure, some were subjected to creep tests, and some to long-term relaxation tests. This study evaluates the load distribution in the soil, grout, and steel tendon; the shear strength of the soil-grout interface compared to engineering soil properties; the relationships between the ultimate load, the creep failure load, the creep threshold load, and the design load; the creep movement rate under load; and the load loss as a function of time. The results show that anchors with shorter tendon bond lengths have higher ultimate capacities and lower creep rates, and transfer the load further away from the supported structure.

Key words: *Grouted anchors, Load testing*

(II) Tunnel Grouting

(i) Controlling subsidence with grout injection, *Donnaes, P., Concrete International, Vol. 20, No. 11, 1998 American Concrete Institute, pp. 47*

As part of the construction of the Jubilee subway line extension, one of Europe's largest underground railway projects, an immense, existing railway viaduct into the Waterloo station was shadowed by running the tunnel for the new line 65 ft. below. To preserve the existing viaduct, it was imperative to keep subsidence levels below 1 in. This specification was met by injecting 10 ft. thick bentonite cement blocks under each viaduct column and under the foundations of sensitive buildings in the vicinity. All the structures were then raised to levels corresponding to the degree of subsidence above by injecting a special grout under the blocks through tubes in carefully marked locations.

Key words: *Tunnel, Settlement, Bentonite-cement*

(ii) Grouting of TBM rock tunnels for the Los Angeles subway, *Kramer, G., Roach, M., Townsend, J., and Warren, S., Proceedings, Grouts and Grouting, GSP No. 80, ASCE, 1998, pp. 100-110.*

Twin subway tunnels, each 4 km (2.5 miles) in length were TBM mined in urban Los Angeles through extremely varied geologic conditions. Ground consisted of alluvial soil, shale, sandstone, basalt and granodiorite rock and varied from massive to blocky, shattered to completely decomposed to fault gouge material. TBM advance was possible by the implementation of various grouting methods for ground improvement, water inflow control, environmental issues and settlement limitation.

(iii) Back-fill grouting model test for shield tunnel, *Koyama, Y., Okano, N., Sato, Y., and Shimizu, M., Quarterly Report of RTRI (Railway Technical Research Institute) (Japan), Vol. 39, No. 1, 1998, pp. 35-39.*

Back-fill grouting of a shield-driven tunnel is significant not only for its effect of stabilizing the surrounding ground but also for that of acting as a load on tunnel. Back-fill grouting model tests have been carried out and the behavior of tunnel and the surrounding ground is discussed in this paper. Ground displacement and acting load on the model tunnel were measured during the grouting. As a result of the model testing, it is found that injection pressure and ground densities significantly influence pressure of the tunnel and ground displacement.

Key words: *Railroad tunnel grouting, Model structures, Backfill grout*

(III) Grouting Materials

(i) Experience with waterproofness of basements constructed of concrete diaphragm walls in Singapore, *Wong, I.H., Tunnelling and Underground Space Technology, Vol. 12, No. 4, Oct-Dec 1997, Elsevier Sci Ltd Exeter, England, pp. 491-495.*

Diaphragm walls 600 to 1200 mm thick are increasingly used as both temporary and permanent supports for excavations as deep as 20 m in congested urban areas in Singapore. Spaces enclosed by diaphragm walls include basements used for shops, offices, car park, underground mass rapid transit train stations, depressed roadways and civil defense centers. Diaphragm walls are effective as a water barrier during the construction phase in keeping the excavation dry and in reducing the lowering of the water table outside the excavation. However, experience in Singapore indicates that, during their service life, it is difficult to make the diaphragm walls dry enough for habitable or utilitarian uses without extensive grouting or the installation of a false wall.

Key words: *Underground structures walls, Waterproofing*

(ii) Microstructural changes due to elevated temperature in cement based grouts, *Palardy, D., Onofrei, M. and Ballivy, G. Advanced Cement Based Materials, Vol. 8, No. 3-4, Oct-Nov 1998, Elsevier Science Inc New York NY, pp. 132-138.*

The durability of type K and H cement based grouts under conditions potentially found to be in high level nuclear waste repositories was studied. Tests have been carried out to determine the effects of temperature on the hydraulic conductivity and the leaching resistance of the grouts. Measurements of mercury intrusion porosimetry and scanning electron microscopy with energy dispersive X-ray analysis have been used to investigate the changes in the pore structures of both grouts as function of leaching and permeating time. Type K and type H cement based grouts, made with low water to cementitious materials ratio, silica fume, and superplasticizer, were exposed to high temperature and pressure. Preliminary results indicate that both hydraulic

Key words: *Railroad tunnels, Settlement*

properties and leaching behavior of the grouts investigated are

affected by the increase in temperature. However, data show that leaching rate and hydraulic conductivity of the grouts decrease with time. The results showed clearly that chemical reactions, presumably accelerated by the elevated temperatures (100 °C), led to the formation of a precipitate in the microcracks and on the surface of the leached specimens. This precipitate is likely the cause of the observed decrease in the hydraulic conductivity and leaching rate.

Key words: *Microstructure, temperature effects, Cements*

(iii) Study of a new cheap grouting material: clay-hardening grout, *Xinghua, W. and Gao, Q., Tunnelling and Underground Space Technology Vol. 12, No. 4, Oct-Dec 1997 Elsevier Sci Ltd, Exeter England, pp. 497-502.*

The paper discusses factors that affect gel time and strength of a new, cheap grouting material: clay-hardening grouts (CHG). A special quality of these grouts is that they may be grouted repeatedly. The concept of a 'groutable period' (GP) is introduced in connection with this quality. Results of a comparison of a CHG with an ordinary cement grout are presented, and an example of a practical engineering application of a CHG is discussed.

Key words: *Underground structures, Clay hardening grout, Rheology*

(IV) Mine Grouting

(i) Grouting to control coal mine subsidence, *Stump, D. E. Jr., Proceedings, Grouts and Grouting, GSP No. 80, ASCE, 1998, pp. 128-138.*

Abandoned underground coal mines are located throughout the coal fields in the United States. The mines are anywhere from a few meters to several hundred meters below the ground surface. In many of these mines coal pillars and/or wooden supports were left in the mine to keep the roof from collapsing during operations. After abandonment these roof supports deteriorate and eventually collapse causing subsidence. To protect the public from subsidence and other adverse effects of coal mining an Abandoned Mine Lands Reclamation Fund was established under Public Law 95-87. This fund is used to finance subsidence control projects. Grout is frequently used to stabilize areas in the mines by filling the mine voids and providing the support needed to minimize future subsidence. However, the placement of the grout may require unique equipment or customized grout materials since abandoned mines are generally inaccessible, the areas requiring stabilization are beneath surface structures, the voids may be flooded, and methane gas may be present. In addition to special considerations in grout placement the areas requiring roof support may be extensive and filling the voids in the entire mine are cost prohibitive. Special grout placement techniques have been evaluated including controlled grout columns or synthetic bags filled with grout and chemical additives to control grout set-up.

Key words: *Abandoned mines, Subsidence*

(V) Enviornmental Grouting

(i) Autogenous healing properties of cement-based grouts, Onofrei, M., Roe, L. and Shenton, B., *Atomic Energy of Cananda Limited, AECL (Report), No.11753, May 1997, 38p.*

Cement-based grouts have been identified as likely candidate sealing materials by nuclear waste management programs investigating the deep burial of nuclear waste as a disposal strategy. Laboratory, field and modelling studies are under way to gather fundamental data, practical experience and estimates of the longevity of cement-based materials. Cracks in cement-based sealants within a radioactive waste repository could provide fast transport pathways and as such could impair the performance of the cement-based sealants as barriers to radionuclide migration. It has been reported that cracks in concrete can self-seal and this phenomenon is generally accepted to occur in civil engineering practice. Experimental work is required to improve understanding of the self-sealing process, particularly for concrete and grout mixes that contain mineral and chemical admixtures and under the likely chemical conditions within an underground repository. This report presents the results of a study conducted to provide information on the ability of cement-based grouts to self-seal. Autogenous sealing was investigated both on bulk grouts and in thin films of grouts. In both cases, the self-sealing capabilities of the cement-based grouts were investigated with water flowing through the grout. Autogenous sealing was studied through changes in pore structure (decrease in pore radius and volume of pores) and changes in the rate of water flow through the cement-based grouts. Analyses showed that the hydraulic conductivity (k) of the cement-based grouts with imposed porosity decreased with time, but only within limits that depended on the grout's initial porosity and composition. In some cases, k decreased from 10^{-7} m/s to 10^{-10} m/s. The observed decrease in the hydraulic conductivity was found to depend on the pore-size distribution in the grout, and more importantly, on the chemical reactivity of the grout. Changes in hydraulic conductivity were related mainly to changes in porosity caused by changes in the volume of the solids. The changes in the volume are caused by the formation of new hydration products resulting from the increase in the degree of hydration and associated reactions. The material observed to form in the available pore space and to bond the grout grains in the compacted hardened grout specimens exposed to percolating water was identified as ettringite ($3CaO.Al_2O_3.3CaSO_4.32H_2O$). The results indicate that self-sealing also occurs in thin films of hardened grouts. The infilling material formed in cracks was identified as a mix of calcium silicate hydrate (CSH), calcium hydroxide ($Ca(OH)_2$ and traces of calcite ($CaCO_3$). Self-sealing occurs in both thin-film and bulk-hardened grouts when they are in contact with water. More than one mechanism may be responsible for promoting self-sealing. These include the formation of ettringite and portlandite as well as calcite in the permeable connected porosity. It is concluded that high-performance cement-based grouts have the potential to self-seal and maintain their performance for a very long time. Further experimental work is

required to improve understanding of the self-sealing process, particularly for high performance grouts that have been cured for very long times (curing time longer than 2 years). Uncertainty also rests with mature concretes or concretes containing large quantities of silicious materials (i.e., silica fume, silica flour, sand) such as the low-heat, high-performance concrete (LHHPC), where the equilibrium concentration of calcium in its pore water is low compared with standard high-performance concrete (SHPC).

Key words: *Nuclear waste, Mechanism, Cement*

(ii) Study on the permeability of engineered barriers for the enhancement of a radioactive waste repository system, *Tashiro, S., Fujiwara, A. and Senoo, M., Nuclear Technology, Vol.121, No. 1 Jan 1998, pp. 14-23.*

To develop engineered barriers and construction methods for an enhanced radioactive waste repository, an advanced application of cement/concrete and bentonite was studied. On the basis of the tests on fundamental properties of the materials, model structures were prepared by actual construction methods, and then the permeability was evaluated. For cement/concrete, two model silos were constructed by different methods and then the reduction in permeability was evaluated. One was constructed by an ordinary method and then grouted with cement milk containing fine cement and silica fume. The whole permeability of the silo after grouting decreased to one-sixteenth of the value before grouting. The other was constructed by a crack-controlling method. This method could make the whole permeability of the silo as low as one-tenth of that of the cracked silo. For bentonite, a compaction method and a spraying method were examined with a mixture of sodium-type bentonite and sand. To demonstrate these methods, model structures were constructed using full-scale machines. Then the relationship between the dry density and the permeability was examined. For a 20 to 30% bentonite mixture, the permeability was almost equally low for both methods, while the density was lower for the spraying method than for the compaction method. In contrast, for a 10% bentonite content, low permeability could only be obtained with the high-density structure. The permeability of both the concrete structures and the bentonite-sand structures was significantly low as engineered barriers, showing some differences with the structures and their construction methods. Referring to the test results, an engineered barrier system proving low permeability was suggested by a combination of the structures and the construction methods.

Key words: *Radioactive wastes, Crack control, Cements, Permeability*

(iii) Pilot in situ auger mixing treatment of a contaminated site. Part 1: Treatability study, *Al-Tabbaa, A and Evans, C. W., Proceedings of the Institution of Civil Engineers, Geotechnical Engineering, Vol. 131, No. 1 1998, pp. 52-59.*

methodology using auger mixing for a contaminated site at West Drayton. This paper, Part 1, contains the introduction, site details and results of the laboratory treatability study and Part 2 details the prototype auger development, site trial and assessment of the in situ treatment. The objective of the treatability study was to develop soil-grout mixes appropriate for the site soils and in situ application process with emphasis on low cement and grout content. The site investigation work revealed two distinct soil types-made ground and sand and gravel-and a wide range of contaminants. Cement-based soil-grout mixes were developed based on available strength, durability, permeability, compressibility and leachate pH design criteria. Constituents of the soil-groutmixes, which included cement, pulverized fuel ash and lime, and their ratios were varied. Contradicting requirements for satisfying some of the criteria meant that the developed mixes had to be a compromise. The applicability for stabilized contaminated ground of the permeability and freeze-thaw durability criteria considered was questioned. The work resulted in the selection of seven mixes for the site trial, detailed in Tables 3 and 8.

Key words: *Cement, Treatability*

(vi) Pilot in situ auger mixing treatment of a contaminated site. Part 2: Site, *Al-Tabbaa, A., Evans, C. W. and Wallace, C.J., Proceedings of the Institution of Civil Engineers, Geotechnical Engineering Vol. 131 n 2 Apr 1998, pp. 89-95.*

This paper, Part 2 of a publication, presents details of the auger development, site trial and assessment of the in situ treatment of a pilot in situ auger mixing treatment of a contaminated site. A prototype auger, 0.6 m in diameter and 2.4 m long, consisting of cutting flights and mixing rods, was designed and manufactured to produce homogeneous mixing of the soil and grout with minimal exposure of contaminated material. In the site trial, the seven soil-grout mix formulations proposed at the end of the treatability study, detailed in Part 1, were applied. A total of 23 overlapping soil-grout columns were constructed with minimal problems treating around 14 m^3 of contaminated ground and resulting in a small overall volume increase of around 7%. The work presented in this two-part publication demonstrates the importance of the initial laboratory treatability study in identifying suitable soil-grout mixes and suggesting modifications to the in situ application process. The pilot study demonstrated that combined treatability study and in situ trials are an essential part of full-scale treatment methodology.

Key words: *Augers Grouting, Contaminated site*

(VI) Structural Grouting

(i) Control of settlement by compensation grouting - Jubilee Line in London, *Essler, R. D., Proceedings, Big Digs Around the World, GSP No. 80, ASCE, 1998, pp. 398-417.*

The paper describes the development of Compensation grouting in the United Kingdom during the construction of the Jubilee Line extension (JLE). The merits of various injection

The work presented in this two-part publication covers certain findings of a research contract and related studies to develop an in situ stabilization/solidification treatment

systems used for Compensation grouting are discussed and it is shown that close to tunnels a fluid grouting system is more favourable. The development work carried out during the construction of Contract 104 of the JLE is described and some

of the results presented together with an explanation of the mechanism of fluid hydro-fracture grouting. The actual Compensation grouting design of Contract 104 is described and some results presented.

Key words: *Fracture grouting, Compensation grouting, Settlement of structures*

(ii) Performance of full-depth shear keys in adjacent prestressed box beam bridges, *Lall, J., Alampalli, S. and DiCocco, E. F., PCI Journal, Vol. 43, No. 2,1998, pp. 72-79.*

Bridge decks supported by adjacent precast, prestressed concrete beams have become increasingly popular in recent years due to their ease of construction, shallow superstructure, and aesthetic appeal. In New York State prior to 1992, such structures were built by placing a number of precast beams alongside one another and connecting them through 12 in. (0.305 m) deep grouted keyways called shear keys to transfer shear forces across the structure. After the grout hardens, the beams are transversely post-tensioned and a composite, cast-in-place deck is poured over them. Prompted by the frequent appearance of longitudinal deck cracking over these partial-depth shear keys soon after construction, full-depth shear keys with more transverse tendons were adopted in 1992. A follow-up study evaluated the performance of this new full-depth shear key/transverse tie system. Results indicate that this method has reduced the frequency of shear key related deck cracking.

Key words: *Shear keys, Deck cracking*

(VII) Sewer Grouting

(i) Chemical grout stops leaks, *Anon, Public Works Journal, Vol. 129, No. 8, 1998, pp. 38-40.*

Since its development in the early 1950s, chemical grout has been used to stop water movement through soils in mines, earthen dams, tunnels, and excavation sites. It is also effective in stopping leaks into buried structures. This paper presents case studies illustrating chemical grout's effectiveness in stopping leaks into or out of concrete structures, whether above or below grade.

Key words: *Grouting leakage, Chemical grout*

For More information on CIGMAT or comments on this issue of CIGMAT News and Literature Review, Contact;

Dr. C. Vipulanandan (Vipu), P.E.,
Director of CIGMAT,

Department of Civil and Environmental Eng.
University of Houston,
Houston, Texas 77204-4791

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, other related topics and are geared towards practicing professionals in the field. Recent issues of the following publications were reviewed.

1. American Concrete Institute
2. Canadian Geotechnical Journal
3. Civil Engineering Magazine (ASCE)
4. Civil Engineering (London, England)
5. Civil and Structural Engineering Abstracts
6. Composite Materials Series
7. Concrete Construction
8. Concrete International (ACI)
9. Engineering News Record
10. Engineering and Mining Journal
11. Foundation Facts
12. Geodex Retrieval System for Geotechnical Abstracts
13. Geotechnical Abstracts
14.Geotechnique
15. International Journal of Rock Mechanics and Mining Sciences and Geomechanics Abstracts.
16. Japan Society of Civil Engineers.
17. Journal of Geotechnical Engineering and Geoenvironmental(ASCE)
18. Journal of Structural Engineering (ASCE)
19. Journal of Protective Coatings and Linings.
20. Materials Performance
21. New Scientist
22. Pipes and Pipelines Manual
23. Pipes and Pipelines International
24. Pipelines and Utilities Construction
25. Rock Mechanics and Rock Engineering
26. Series on Rock and Soil Mechanics
27. Soils and Foundations
28. Soil Technology
29. Trenchless Technology Magazine
30. Tunnelling and Underground Space Technology
31. Waste Management

Industrial Contacts and Sponsoring Members:

Berry, R., Rembco Engineering, Knoxville, Tennessee.
Bandimere, S., Denver Grouts, Denver, Colorado.
Fiest, G., 3M Construction, St. Paul, Minnesota.
Spero, M., Gulf Coast Trenchless Association (GCTA).
Magill, D., Avanti International, Webster, Texas.
Moore, B., InsituformTechnologies, Chesterfield, Missouri.

Houston, Texas 77024-4791
Ph. No. 713-743-4278; Fax No. 713-743-4260.
Email: cvipulanandan@uh.edu

If you have any questions, please contact **Dr.C.Vipulanandan**