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

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News and Literature Review

Flow Properties of Grouts: A View Point

Flow property makes the grout a unique material as compared to other construction and rehabilitation materials. Flow property in many applications is the determining factor in selecting the grout. It should be noted that there are exceptions to this rule such as the compaction grout were very low flowable grout is desired for application. Flowability of a grout is very much related to the viscosity of the grout and determining this property becomes a challenge with various grouting materials that are being introduced into the market to solve multitude of engineering problems.

Testing methods are needed to determine the initial and changing viscosity of a grout. Viscosity of a solution grout can be determined using spindle type, falling needle viscometer. These tests are mainly laboratory tests. The viscosity of suspension grouts are determined using rheometer (Fann Viscometer). Will there be segregation of particles during this test due to differences in particle and liquid specific gravities ? When the sand content in the grouts are increased none of the spindle type equipment can be used to determine the viscosity. This is further complicated by the need for field equipment to control the quality of the grout. A popular field test that is generally used is the ASTM C 939-94, Flow Cone Test. This test is used for routine quality control in the field. It is a static type instrument indirectly measuring the viscosity of the grout. The variable measured is the time, in seconds, required for a given quantity of grout to pass through the orifice of a standardized funnel. The measurement obtained is influenced considerably by the rate of gellation and by the density which varies the hydrostatic head of the column of the grout in the funnel. The Flow Cone also gives a measure of the fluidity of the grout by virtue of the "time of efflux" through the orifice.

Flow properties of grouts used for auger cast piles (about 60% sand) and cellular grouts (unit weights less than water) used for sliplinning are being characterized in the CIGMAT Research laboratory. Studies indicate that Flow Cone can be used for these grouts. The cellular grout should be designed to be flowable through annular space in the pipes (50 mm or less) for a distance of 300 m (1,000 ft) with a maximum allowable pressure at the point of placement of 34.5 kPa (5 psi). Simulation of the prototype conditions in the laboratory was done by using coiled tubes. The length and time scales (ratio of model to prototype) adopted are 1/16 and 1/8 respectively. This model is used to quantify the pumpability of cellular grouts in annular space.

Standard	Scope of the Test	Committe and Subcommittee
C 230-90	Flow table for use in tests of hydraulic cement.	ASTM Committee C-1 on Cement. Subcommittee C01.22 on Workability.
C 939-94	Flow of grout for preplaced-aggregate concrete (flow cone method)	ASTM Committee C9 on Concrete and Concrete Subcommittee C09.41 on Concrete for Radiation Sheilding.
D 5225-92	Solution viscocity of polymers with a differential viscometer.	ASTM Committee D-20 on Plastics. Sobcommittee D20.70 on Analytical Methods.
D 4016-93	Viscocity of chemical grouts by Brookfield viscometer.	ASTM Committee D-18 on Soil and Rock. Subcommittee D18.16 on grouting.
D 5478-93	Viscocity of materials by a falling needle viscometer.	ASTM Committee D-1 on Paints and Related Coatings, Materials and Applications. Subcommittee D01.24 on Physical Properties of Liquid Paints and Paint Materials.
D 4684-92	Yield stress and apparent viscocity of engine oils at low temperature.	ASTM Committee D-2 on Petroleum Products and Lubricants. Subcommittee D02.07.0C on Low Temperature Rheology of Non-Newtonian Fluids.

In this issue.....

Announcements

(i) New ASCE publication on Grouting; Compaction, Rehabilitation and Test Methods, GSP No. 66.
(ii) Call for abstracts on Tunnel and Structural Grouting. Contact Dr. Roy Borden Ph: (919)515-7630.

Literature Review

(I) Soil Grouting

i) Landslide of Litigation, *Crampton, W. F., Civil Engineering, Vol. 66, No. 10, October 1996, pp. 61-63.*

Tasked with stabilizing a reactivated landslide downslope of an expensive Southern California residential development, design engineers had to avoid getting sued while doing their jobs. The contractor, Group Delta Consultants, Inc. (GDC) designed a system to stabilize the landslide with five horizontal rows of post-grouted tiebacks, using bundled strand anchors with a double corrosion protection system. Construction started in December 1992. With the initiation of the construction, additional analyses were conducted to further clarify the basis of design and to increase the city's comfort level regarding the proposed stabilization of the landslide. As a result of pressure placed in the slope from the tied-back slope-stabilized system, the inclinometer moved backward as much as 0.35 in., 800 days after completion of the project.

Key words: *Landslides, Legal Aspects, Tiebacks,*

ii) Base and Shaft Grouted Piles, *Troughton, V. M., and Stocker, M., Proceedings of the Institution of Civil Engineers, Geotechnical Engineering, Vol. 119, No. 3, July 1996, pp. 186-192.*

This paper describes experiences with base grouting piles. One reason for using this system is that the undisturbed ultimate bearing capacity can be approached for piles in very dense sand deposits. Higher working loads can be adopted as the contribution of the base can be reelied upon. They are economically better than conventional piles founded in sands. They provide quality assurance that is vital where high loads are to be carried on a single pile per column. They are suitable for sands and gravel at depth. Results of four pile tests from Canary Wharf are discussed to demonstrate the advantages and limitations for base grouting.

Key words: *Models, Piles, Settlement*

iii) In-situ Slurry Wall Formation with the Soilsaw Barrier System, *Carter, E. E., ASTM Special Technical Publication, Vol. 1240, March 1996, pp. 596-608.*

This new technology was designed to form high-quality 'formed-in-place' barrier walls in soil in a more continuous and uniform manner that the two-step, excavate and replace, processes of conventional slurry trenching. Soils in the path of the device are pulverized in-situ and liquified by high-energy jets of a permeability modifying grout. The hardware then passes through the liquified soil under the pull of gravity. The soil/grout mixture hardenss to form a plastic diaphragm wall. Walls can be formed from a variety of materials. The bulk of the energy to cut and mix the soil is transferred to the soil work face hydraulically by the sslurry media itself. Massive energy transfer of over 2000 hydraulic horsepower (1500 kilowatts) supplied by oil field cement slurry pumps allows dramatic productivity rates. The produation rate of the process is significantly reduced in highly cohesive soils. This paper presents an introductory look at a potentially useful new method of cconstruction of large subsurface barriers and contrasts it with conventional methods.

Key words: *Barrier Walls, Containment, Soil Saw, Trenching Soils.*

(II) Tunnel Grouting

i) Prediction of Groutability from Grout Properties and Hydrogeological Data, *Gustafson, G., and Stille, H., Tunnelling and Underground Space Technology, Vol. 11, No. 3, July 1996, pp. 325-332.*

Sealing tunnels and caverns in fractured crystalline rocks has been considered notoriously unpredictable and possible to manage only through experience and intutive knowlwdge. Words such as witchcraft and black art have been used ironically in Sweden to describe the state of the art. In this paper, initially grout penetration and grout take in parallel planar fractures are discussed. General expressions for these entities are also derived for fractures with varying width. In this paper, the grout take of a system of inhomogeneous channels in a fracture plane is studiedfurther and grout takes of such systems are modeled numerically. Grout takes are calculated for increased variability of the fracture aperture and the influence of this is assessed. In normal Swedish grouting procedures, the grouting boreholes are tested by water pressure tests (WPT). The hydrogeological information from these tests can be transferred to grouting apertures, and thus yield design information for grouting of the access tunnel of the Aspo Hard Rock Laboratory, Sweden.

Key words: *Construction Sealing, Fracture Plane, Models.*

ii) Construction of a Piperoofed Underpass Below Groundwater Table, *Liao, H. J., and Cheng, M., Proceedings of the Institution of Civil Engineers Geotechnical Engineering, Vol. 119, No. 4, October 1996, pp. 202-210.*

An underpass constructed under a busy road of Taipei city is studied herein with emphasis on the geotechnical engineering aspect. A watertight piperoof structure which was formed by several interlocked, horizontally jacked pipes was adopted as the temporary retaining structure for the underpass excavation. To facilitate the pipe jacking processand thesubsequent underpass excavation in the sandy layer below the groundwater table, an intensive soil grouting programme was carried out prior to the construction of the piperoof. Meanwhile, the ground settlement was constantly monitored throughtout the entire construction process. In general, this project was completed successfully without causing any ground loss problem around the underpass. Problems encountered and experience gained from this project are discussed in this paper.

Key words: *Pipe Jacking, Settlement.*

iii) Seepage Stoppers, *Hebert, V. J., Lelito, J., and Naudts, A., Civil Engineering, Vol. 66, No. 10, October 1996, pp. 68-70.*

The 40 ft deep Detroit-Windsor tunnel has been operating continuously for the past 65 years without any major rehabilitation. However, just recently, the tunnel sprung a few leaks. Engineers used elasticized grout to stop the seepage. The elasticized grout is a material flexible enough to withstand the vicissitudes of freeze-thaw cycles.

Key words: *Cracks, Freeze-Thaw Cycles, Microfine Cement Grout.*

(III) Mine Grouting

i) Investigation of One-Pass Grouted Support Systems for Use in a High Stress Mining Environment, *Langille, C. C., Tannant, D. D., Galbraith, J., CIM Bulletin, Vol. 89, No. 1001, June 1996, pp. 111-116.*

This work investigates the expected convergence in deep development headings at plus 2200 (plus 7200 ft) through the use of direct measurements using both flex rod extensometers and five-point tape extensometer stations. Measured results are compared with simple 2-D numerical analysis to evaluate the anticipated convergence expected to be absorbed by the bolting system. Furthermore, the required convergence is compared with load deformation response of several support configurations.
Key words: *Mining, Model.*

ii) Innovation in Roofbolted Development Roadways - the Voest Alpine ABM 20 Continuous Miner Bolter, *Baldwin, J., CIM Bulletin, Vol. 89, No. 1000, May 1996, pp. 40-45.*

Increasing mine depth and panel length combined with faster longwall retreat rates necessitated a change from the passive support of steel sets to roofbolts at the Phalen Colliery in the Sydney Coalfeild. Development drivage rates achieved with roadheaders installing steel sets would not support the retreat rates of the longwall panels. Also, front abutment pressures from the longwall retreat were seriously deforming the steel sets. In 1991, full column resin grouted roofbolts were introduced by the Cape Breton Development Corporation to the Phalen Colliery as a means of primary roof support for in-seam retreat longwall entries. Continuous miners, complimented by roofbolt support were chosen to facilitate the increased production rates and roof support capacity required. The roofbolting system evolved from a hydraulic mobile rubber tired machine to hand held pneumatic rotary drill to a continuous mine-bolter - ABM 20. This paper discusses the evolution from the startup of roofbolting at Phalen Colliery to the latest technology in continuous miner-bolters.
Key words: *Longwall, Mine Bolters.*

iii) Recent Mine Safety R&D Projects of the U.S. Bureau of Mines, *Anon,Engineering and Mining Journal, Vol. 196, No. 11, November 1995, pp. 26-28.*

A summary is presented of some of the projects that the US Bureau of Mines was working on, or had recently completed, when the US Secretary of the Interior scrapped the agency in September, 1995. One of the most important activities was research and development in the area of mine safety: systems, equipment, and hardware. In this article, described are monitoring hoists and elevators, new synthetic rope designs, switch point-closure indicator, grouted roof bolt load evaluation, unique water spray system, and bag and belt cleaner.
Key words: *Coal Mines, Roof Bolt.*

(IV) Environmental Grouting

Blast Furnace Slag-Modified Grouts for In-Situ Stabilization of Chromium Contaminated Soil, *Allan, M. L., and Kukacka, L. E.,Waste Management, Vol. 15, No. 3, 1995, pp. 193-202.*

Blast furnace slag-modified grouts were used to stabilize soils contaminated with trivalent and hexavalent chromium. Slag content, grout/soil ratio and water/cementitious material ratio were varied to determine the effects on leachability of chromium,permeability and compressive strength. Slag modified grouts successfully stabilized Cr(VI) contaminated soil to give low leacheability, thereby allowing omission of the pretreatment stage to reduce Cr(VI) to Cr(III) necessary with lime and ordinary Portland cement stabilization procedures. Leacheability of both Cr(III) and Cr(VI) decreased with increasing slag content. The permanence of leach resistance is enhanced by higher slag levels in grout. Compressive strength of grout treated soil ranges from 6 to 36 MPa and permeability is of the order of 10^{-11} to 10^{-7} cm/s, depending on mix proportions. Slag modified grouts have potential for in situ stabilization of Cr(III)- or Cr(VI)-contaminated landfills.
Key words: *Cement, Chromium, Permeability, Stabilization.*

(V) Structural Grouting

i) Precast Bridge Decks: Keyway Grouting Data, *Gulyas, R. J., Concrete International, Vol. 18, No. 8, August 1996, pp. 45-48.*

There are design and construction conditions, along with material selection requirements, which should be followed to achieve properly functioning grouted precast bridge shear keyways in side-by-side members. In areas where concrete is exposed to chloride deicing salts or salt-laden sea sprays, laboratory data on tensile bond strength of composite keyways should be part of the project specifications to ensure durability of the shear keyway grout. Composite shear and composite tensile bond testing should be used to screen materials using surface preparation techniques to improve bonding.
Key words: *Bridges, Chloride, Strength, Test Methods.*

ii) Bond Strength of Cement Grouted Glass Fibre Reinforced Plastic (GFRP), *Benmokrane, B., Xu, H., and Bellavance, E., International Journal of Rock Mechanics and Mining Sciences & Geomechanics Abstracts, Vol. 33, No. 5, July 1996, pp. 455-465.*

Fibre reinforced plastic (FRP) has recently been introduced in the market in the form of bars for grouted anchor bolts. The resistance to corrosion and chemical attacks, high strength-to -weight ratio, low electromagnetic properties, and ease in handling of these bars make them a better alternative to steel in some applications of grouted anchor bolts. However, to fully utilize FRP bars as tendons for cemented grouted anchors, some aspects of their behavior have to be determined, including load carrying capacity, bond strength in cement grout, long-term strength and durability in alkaline environments. In this paper, the load carrying capacity and bond strength of cement grouted glass fibre reinforced plastic (GFRP) anchor bolts are discussed in comparison with steel anchor bolts. The results of laboratory and field pull out tests of GFRP and steel bars anchored with cement grout are presented. The pull out tests were conducted on four types of GFRP bars and two types of steel bars installed in concrete blocks and rock mass. The experimental results have shown that the bond strength of GFRP bar anchor bolts is close to that of steel bar anchor bolts. The slip at failure of GFRP bars relative to the cement grout is greater than that of steel bars, mainly due to their low modulus of elasticity.
Key words: *Bond Strength, Cement.*

iii) Strain Concentration Factors and Load Capacity of Innovative Tubular Joints, *Ure, A., Grundy, P., and Eadie, I., Proceedings of the International Offshore and Polar Engineering Conference, Vol. 4, 1996, pp. 74-77.*

This paper examines strain concentration factors

(SNCF's) and ultimate strength of four YT joints: one profile cut, one flattened-end, one profile cut grouted and one flattened-end grouted. The joints were tested in a specially designed rig with load applied to the inclined brace using a hydraulic actuator. SCNF's were derived at crown and saddle locations. The SCNF's calculated using laboratory testing were compared with finite element results obtained using Lusas 11.0. The joints were loaded, at a constant displacement rate until failure was reached. A description of the failure mechaniam and load capacity of each joint is provided. The load capacity of each joint is compared with standard profile cut joints.
Key words: *Finite Element Method, Joint Strength.*

(VI) Sewer Grouting

Grouting Combination Repairs Sewer Pipe, *McGovern, M. S., Aberdeen's Concrete Repair Digest, Vol. 7, No. 2, April-May 1996, 6p.*

In January 1991, a comprehensive investigation was conducted to determine the cause of pipe failure that caused the collapse of a section of Almeda road in southern Houston and to specify the appropriate remedial action. The result was the City of Houston's first full scale use of polyurethane and compaction grouting to repair a deteriorated sewer pipe. The properties and use of these two groutings are described.
Key words: *Polyurethane, Sewer Pipe.*

Honolulu's Street Relief, *Raines, G. I., and Honke, J. K., Civil Engineering, Vol. 66, No. 9, September 1996, pp. 70-72.*

The Nimitz Highway is one of the Honolulu's main throughfares. Beneath the Nimitz's media, a 54 in. interceptor sewer stretches along the freeway near the harbor and Kapalama basin. The sewer had to be relieved before it reached capacity. In July, a new dollar 15 million pipeline, which runs for approximately 3,000 ft parellel to the existing line, was completed. Faced with trenching problems, engineers posed a microtunneling alternative through weak lagoonal deposits and coral reef formations.
Key words: *Jet Grouting, Microtunneling.*

(VII) Masonry Grouting

i) Behavior and Design of a Single Wythe Concrete Masonry Residence in a Southern Humid Climate, *Stokoe, M. L., ASTM Special Technical Publication, No. 1246, July, 1996, pp. 7-20.*

An objective recanting of the construction practices, materials, and wall design of a 3300 sq. ft. concrete masonry structure built with standard gray units. Over 20 years in which this residence has been lived in and monitored give a good look at how total masonry homes might perform in a southern humid climate, using vertical grouted cells, internal bond beams and horizontal joint reinforcement. The study shows how a total masonry residence has performed successfully in a hot humid climate, what the problems have been and suggested solutions.
Key words: *Cements, Joints, Masonry.*

ii) Flexural Behavior of Reinforced Concrete Masonry Walls Under Out-of-Plane Monotonic Loads, *Abboud, B. E., Hamid, A. A., and Harris, H. G., ACI Structural Journal, Vol. 93, No. 3, May-June 1996, pp. 327-335.*

This paper presents the test results of an investigation carried out to study the behavior and flexural strength of vertically spanned reinforced concrete block masonry walls under out-of-plane monotonic loading. The study presented in this paper, which is part of the U.S.-Japan Coordinated Program on Masonry Building Research, addresses the elastic and inelastic behavior of reinforced block masonry walls. Six walls were tested to determine the effects of percentage and location of vertical reinforcement, block size, and extent of grouting. The behavior included cracking patterns and cracking moments, load-deflection curves up to and beyond the peak load, and displacement ductility. Test results showed that the percentage and location of vertical steel (centrally located versus staggered) had a significant effect on wall load-deflection curves, strength, and ductility. The extent of grouting (partially versus fully grouted) affected cracking load and consequently, flexural rigidity and deflection under service loads. The extent of grouting, however, did not show an adverse effect on wall stability in the inelastic range. The specified value of the modulus of rupture in the UBC-94 code is much lower than the experimental values of maximum tensile stress at first crack obtained for fully grouted walls. The theoritical analysis for the ultimate strength based on the Whitney stress block method that is included in the UBC-94 code showed a good correlation with the experimental results. Displacement ductility ratios ranged from 1.79 for the wall with 0.44 percent vertical steel to 16 for wall with 0.19 percent steel. As explained, the displacement ductility of the wall panels decreased as the percentage of vertical reinforcement increased.
Key words: *Flexural Rigidity, Masonry Wallls.*

(VIII) Dam Grouting

i) Current Use of Asphalt in Dams, *Anon, Asphalt - Concrete Water Barriers for Embankment Dams, 1996, pp. 59-76.*

Historically, the use of asphalt in dams has been for the reduction of seepage past the dam. Seepage can be through the foundations; along the contact between the dam and its foundations; along the contact between the dam and an outlet conduit; constructed in the foundation throughth edam; or in the case of embankment dams, through the embankment itself. There are four types of subsurface treatment of the foundations of a dam that can be beneficial. They are grouting; sealing; filling; and cutoff. The last three have used asphalt concrete successfully, and the first shows some potential for its use.
Key words: *Asphalt, Dams.*

ii) Accidents at Installations of the Kolymskaya Hydroelectric Plant During Construction and Temporary Operation, *Frishter, Y. I., and Kogodovskij, Y. A., Gidrotekhnicheskoe Stroitel'stvo, No. 12, December 1995, pp. 16-26.*

Emergency situations, arising during the construction and temporary operation of the Kolymskaya hydroelectric power plant, are described and analysed. The following cases are considered: the formation of a crack in the vault of the machine hall of the Kolymskaya hydroelectric power plant; floating up of the gate of a temporary board room; overdamming of the support inclusions of the dam; destruction of protective coating of some hydrological installations. Several conclusions are made. In particular, it is pointed, out that it is desirable to avoid the creation of a grouted block under the dam. Grouting of the foundation should be carried out either before the erection of the dam or after its completion.
Key words: *Accidents, Hydroelectric Power Plants.*

(IX) Rock Grouting

i) Load Distribution along Fully Grouted Bolts, with Emphasis on Cable Bolt Reinforcement, *Hyett, A. J., Moosavi, M., and Bawden, W. F., International Journal of Numerical and Analytical Methods in Geomechanics, Vol. 20, No. 7, July 1996, pp.517-544.*

Explanation for the widely reported observation that fully grouted reinforcement is more effective in hard rock that behaves as a discontinuum than in soft rock is presented. Analytical solutions are presented for the distribution of displacement and load along an untensioned fully grouted elastic bolt, of specified bond stiffness, which is activated during excavation by either a continuous or discontinuous distribution of rock displacement. The results indicate that significantly higher axial loads are developed for the discontinuous case. Since the mechanics of bond failure depend on the type of bolt and grout used, in the second part of the paper a finite difference formulation is introduced and combined with a nonlinear model for the bond behavior of a cement grouted seven wire strand cable bolt. The results of a parametric study indicate that, because the bond is frictional and depends on confinement at the borehole wall, for the same profile of rock mass displacement lower loads are developed in soft rock. Furthermore, in soft rock, excavation induced stress changes can cause a dramatic reducction in bond strength, so that, even after significant rock mass displacement, the axial load developed is significantly less than the tensile strength of the cable. A combination of these effects can explain why failures of cable bolted groune involve debonding at the cable grout interface in soft rock, and why instances of cable rupture are confined to hard, blocky rock masses.

Key words: *Bond Strength, Model, Rock Bolting.*

ii) Analytical Model for the Mechanical Behavior of Bolted Rock Joints Subjected to Shearing, *Pellet, F., and Egger, P., Rock Mechanics and Rock Engineering, Vol. 29, No. 2, April-June 1996, pp. 73-97.*

This study proposes a new analytical model for the prediction of the shear strength of a rock joint. The main characteristics of the model are the accounts for the interaction of the axial and the shear forces mobilized in the bolt, as well as the large plastic displacements of the bolt occuring during the loading process. The complete curve of the bolt contribution as a function of the displacement along the joint can be computed, and the maximum bolt contribution is obtained by dissociating the bolt cohesion and the confinement effects. The comparison of the performances of this analytical model with test results shows its capacity to describe the observed phenomena. The effects of the most important parameters such as bolt inclination, mechanical properties of the bolt material, rock strength and joint friction angle are clearly established and discussed.

Key words: *Bolted Rock Joints, Failure Analysis, Models.*

(X) Coatings

i) Understanding Standard Tests for Pipeline Coatings, *Senkowski, E. B., Journal of Protective Coatimgs and Linings, Vol. 11, No. 2, February 1994, pp. 76-84.*

Throughout 30 years ASTM Subcommittee G.03.06 on the Deterioration of Pipeline Coatings and Linings has been responsible for identifying, evaluating, and documenting test methods suitable for pipeline coatings. Each method has been standardized after a period of inter-laboratory round robin testing. This article gives a description of these methods, along with guidance regarding their significance in the evaluation of pipeline coatings.

Key words: *Coatings, Standard Tests.*

ii) Evaluating Coatings for Concrete in Wastewater Facilities. An Update, *Render, J. A., Hsi, R. P., and Esfandi, E. J., Journal of Protective Coatings and Linings, Vol. 11, No. 12, December 1994, pp. 50-61.*

Unless adequately protected, concrete structures in wastewater treatment facilities deteriorate quickly when subjected to sulfuric acid that is formed by the aerobic microbial oxidation of hydrogen sulfide. The authors update information on research to evaluate performance of protective coatings in waste water service. The article reviews earlier work and reports on the performance of new products.

Key words: *Concrete, Microbial Oxidation, Sulfuric Acid.*

iii) Cracks in Concrete and Their Effect on Coatings and Linings, *Dively, R. W, Materials Performance, Vol. 33, No. 2, February 1994, pp. 44-45.*

Cracked concrete creates a complex problem for coating system designers. The extent to which joint design is efficient and t which the coating system design takes into account natural stresses such as settling largely determines how well the coating or lining performs. To attain a successful system, the coating engineer must consider all aspects of each job before determining the best approach.

Key words: *Concrete cracks, Joint.*

iv) Coating film Thickness in Concrete Sanitary Sewers. How Much is Enough? *Steele, J., Materials Performance, Vol. 33, No. 9, September 1994, pp. 39-41.*

To be effective, a coating system must form a continuous protective barrier over the concrete surface, which would otherwise deteriorate rapidly under these hostile conditions. A key factor in achieving a continuous barrier is the applied thickness of the coating. This is particularly true for concrete surfaces, which typically are rough and irregular. This article examines the role of coating film thickness in establishing a continuous barrier coating for long-term protection of concrete..

Key words: *Defects, pH Effects, Sanitary Sewers.*

v) Specifying Coatings for Concrete Surfaces, *Greenfield, T. K., Materials Performance, Vol. 33, no. 7, July 1994, pp. 37-41.*

The requirements for coating concrete surfaces vary significantly from one project to the next and even within the same structure. Success depends on careful evaluation and specification of the requirements peculiar to each project. This article summarizes the cnsiderations for developing coating specifications for concrete surfaces.

Key words: *Concrete, Inspectipon.*

vi) Epoxies for Concrete, *Stavinoha, R., Journal of Protective Coatings and Linings, Vol. 13, No. 8, August 1996, pp. 76-86.*

Epoxy coatings used for concrete floors and lining systems are similar in basic chemistry to epoxy coatings used for steel. The wide variety of epoxy resins and hardeners allows formulation of products with a wide range of performance properties and application characteristics. Coatings for concrete must recognize the unique properties of the substrate in addition to the performance characteristics of the installed system. The variables and uses encountered in coating concrete are greater than those encountered in coating steel. A wide variety of epoxy coatings is available for concrete, but selection is more critical for a particular end use.

Key words: *Concrete, Curing, Epoxy Resins, Molecular Structure.*

vii) Tips on Improving Application of Plural Component Polyurethane Linings to Pipelines, *Soebbing, J. B., Journal of Protective Coatings and Linings, Vol. 11, No. 5, May 1994, pp. 148-155.*

Plural component polyurethane linings were applied to 3 sections of replacement pipeline over a five year period. The pipeline carries an aggressive wastewater effluent. The present article offers tips for successfully applying plural component polyurethanes based on experience gained in the project. An overview of plural component polyurethanes, their advantages, equipment and lining application requirements, and specific application problems and their resolution is also provided.

Key words: *Linings, Polyurethanes.*

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