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A Research Method for Design of Below Grade Waterproofing Systems

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Phil Haisley, AIA Arch 600: Fall, 2001

INTRODUCTION:

Research can inform architectural design on a variety of levels. Cultural expression, social interaction, and the safety, comfort, utility and enjoyment of our built environment are all important goals for the design of created spaces, and each might benefit from research. Sometimes the benefit is visible or obvious. In other cases, building occupants may never become aware of the result of research or design effort. Below grade waterproofing is one such case; a design element which is critical to achieving one of the basic goals of shelter, yet invisible to building occupants, unless it fails. Second chances at waterproofing below grade surfaces are severely limited once a structure is set in the ground, and are costly, if possible. It is far better to do it right than do it over.

The risk of waterproofing failure might be greatly reduced through appropriate research. A systematic method can help assure the selection and design of a successful waterproofing installation. This paper proposes one such method, briefly examines the history of products presently available, discusses a range of appropriate research activities, and describes some of the available systems.

BACKGROUND:

Early cave dwellers probably didn't concern themselves much with modifying their environments, though they were likely to have preferred dry caves over damp caves for habitation. With the advance of civilization and the pressures of an increasing population, the built environment began to replace the "found" environment as people created habitable spaces. Thermal and moisture protection were devised for above grade spaces. Increasing population pressures eventually led to optimization of land resources by terracing buildings, construction of spaces below grade, and the advent of below grade waterproofing.

Approximately 2500 years ago, people were using bitumen and lead to keep water out of occupied spaces beneath the hanging gardens of Babylon. Coal tar pitch with fabric reinforcing came into use about 200 years ago, followed by hot-mopped bitumen in the mid-nineteenth century and cementitious waterproofing around the turn of the last century. The past 50 years has seen an acceleration of available products, with the introduction of Crystalline coatings, rubberized asphalt sheets, single ply butyl & PVC sheets, liquid applied membranes, and the use of bentonite clay. During the past 10 years, regulation of volatile organic compounds (VOCs) has influenced the introduction of cold applied, two component, and water based systems. (Henshell, 2000)

RESEARCH METHOD:

Given the variety of waterproofing systems presently available, the promises and claims offered by manufacturers and the assumption of significant risk by the designer must be carefully weighed. The cost of investigation should also be balanced with the risk of failure. Research for design of a small residence in a simple setting might be less comprehensive than for a large commercial building in a difficult location, but the elements requiring research are similar. A cautious and methodical approach to selection and detailing of waterproofing systems should include:

1. Familiarity with the site: site surveys, soil borings & client requirements

Keeping water away from building foundations is a primary goal of every waterproofing effort. A visual observation, and perhaps a survey of the site should be undertaken to identify existing surface slopes and the potential for improving slope by grading surfaces away from building foundations. Site slope will determine if drainage can be provided at underground building foundations, as foundation drains must eventually daylight downslope of below grade footings to provide effective drainage. Soil permeability also affects drainage, both at the surface and at below grade walls.

If the slope of the site does not permit a drainage outlet below the elevation of building foundations, or if soil permeability is poor, both walls and waterproofing must be designed to resist static pressure of water at the anticipated depth.

Soil borings may be required to identify the water table and soil contaminants. "Shelved" water tables result from water flowing over non-porous sub-surface strata, and may result in water tables that are elevated above other surrounding locations. Care must be taken to evaluate the likelihood of fluctuations when interpreting soil boring data. If borings are taken after dry periods, they may not accurately reflect the level of the water table after a rainy period. Borings can also identify soil contaminants. The presence of acids or alkalis, hydroxyls, sulfates, salts, and petroleum products will affect the choice of waterproofing materials.

An interview with the building owner is essential to identify specific project requirements. The owner's expectations for a parking structure will likely differ from their expectations for an office space, or computer room, or archival storage of important documents. Identify and document these expectations.

2. Review of existing documents: historical climatological data, borings at neighboring properties, geological data

An understanding of local building codes and ordinances is essential to ensure compliance with the law and identify requirements and restrictions that might govern the choice of materials. For example, regulation of VOC emissions may preclude the application of some asphaltic and solvent based materials, particularly in urban areas.

Research of local climatological data may influence conclusions about the water table elevation if rainfall patterns suggest that more extreme conditions can be expected. Local climate conditions may also influence selection, as temperature and moisture conditions affect the application and choice of materials. Borings from neighboring properties are often available in public records or the records of engineering firms, and can augment the information gained from the site investigation. Geological records of surrounding areas may be useful in determining the nature and layers of sub-grade strata, to evaluate the quality of drainage materials and possibility of intermittent underground streams. A geotechnical engineer can help find and interpret these records.

3. Local information sources: strengths and experience of the local work force, neighbors' experience with products and contractors

An interview of property owners in the community might reveal unusual conditions that would otherwise be missed by less personal research, and is invaluable in evaluating the success (or failure) of waterproofing systems and applicators. References of contractors should be checked to identify the strengths and weaknesses of the local work force, and their level of experience with various systems.

4. Research material data: product properties and performance

After site conditions, owner requirements and local limitations are understood, the choice of system types may be narrowed. Manufacturers of appropriate types should be consulted to determine if any specific chemicals or petroleum products present in the soil will damage their materials. Other contaminants, such as acids, sulfates, or salts may damage the building structure, and require a waterproofing that will resist these contaminants and provide protection without degradation. Manufacturers should be consulted on details, compatibility with adjacent systems and surfaces to which they will be applied, requirements for curing, application temperatures, and surface preparation.

5. Comparison with conditions elsewhere: evaluate manufacturer's claims
Before final selection of a specific system, manufacturer's claims of product performance should be evaluated. If local experience with the material has not already been determined, ask manufacturers for references for installations elsewhere in the country with similar water table elevations, soil contaminants, drainage conditions, and occupant requirements, and call building owners to confirm that performance was satisfactory. Manufacturer's support capability may vary with locale. Find out if technical representatives will be available to visit the site, and if they will provide inspection services and reports during installation. Warranties must also be considered and compared. Warranties may indicate confidence of the manufacturer in performance of the material, but should not be the determining factor in system selection. Usually, by the time a warranty is needed, there will be fingers pointing in several directions. Language must be carefully reviewed to identify whose interests the warranty protects; the manufacturer or the owner.

6. Identification of remaining questions: other considerations
Before specifying and detailing the selected system, the requirements of other consultants (structural, mechanical electrical) must be evaluated to identify how their work will impact the building envelope. The anticipated structural deflection, creep, cracking, and post-application loading must be compared with the product's ability to withstand movement. All penetrations, edge conditions and transitions must be carefully considered and detailed. 90% of water intrusion problems occur within 1% of surface area (Kubal, 2000), so attention must be focused on any discontinuities in the waterproofing, no mater how small.

Consideration must also be given to anticipated construction sequences, to identify whether the waterproofing will be compatible with the construction activities and resulting surfaces. The maximum height of the backfilling operation will affect protection of the waterproofing. The time needed for concrete to cure will affect product selection. The length of time and nature of traffic on surfaces may affect surface preparation, application, or subsequent protection.

DISCUSSION:
Knowledge of site specific conditions, client requirements, the local environment, manufacturer's claims, and special requirements of design elements must be evaluated together with the properties of materials to guide the designer toward appropriate choices. A basic understanding of system properties is important. Systems are generally classified as “positive side” or “negative side”, and further classified as “waterproof” or “dampproof”.

Dampproofing retards vapor migration; waterproofing is needed to resist standing or flowing water. Dampproofing may be acceptable if no hydrostatic head of water can be expected, but only if the owner is willing to tolerate some leaks or moisture. If the occupancy requires complete moisture and humidity control, waterproofing should be considered regardless of anticipated hydrostatic pressures. If the space is under a horizontal slab, waterproofing is always required, because all horizontal slabs are subject to some hydrostatic pressure when they become wet.

It is generally considered desirable to place moisture protection on the wet side, or "positive side" of surfaces whenever possible, to protect the building structure as well as occupants, and to allow a continuous application which is protected from interior construction activity. Negative side membranes are placed on the interior (dry) face of surfaces. Easy access to interior surfaces makes negative side systems an obvious choice for remedial waterproofing projects, or when access to the positive side is difficult or impossible.

Positive side systems: Coal tar pitch and bituminous systems are the traditional systems and are still available, though VOC regulations have limited their use in some locations. They are fluid applied while hot, and are built-up in layers over reinforcing fabrics. The petroleum products provide the moisture resistance, while reinforcing fabrics provide tensile strength. One or two layers can provide dampproofing protection. Three or more layers is considered waterproof, with additional layers recommended for higher static pressures.

Waterproofing sheets have come into common use. They eliminate release of volatile compounds, assure a uniform thickness of material, provide flexibility and allow labor savings for application. Sheets might be loose laid, mechanically fastened, or fully adhered. Fully adhered sheets prevent water migration behind the membrane which would make finding a leak difficult, but full adhesion also makes seams and membranes susceptible to splitting if the substrate develops a crack. Rubber modified asphalt (modified bitumen) sheets are the most common of the adhered sheets. They can be applied in two layers with seams staggered to minimize the risk of splitting in critical applications. Other membranes that can be loose laid or mechanically fastened include butyl and polyvinylchloride (PVC) sheets. Butyl sheets are joined by adhesives, resulting in seams which are weaker than the surrounding sheet. PVC seams can be heat welded, matching the strength of the material. Loose or partially adhered sheets will accommodate slight cracking and movement, as stresses are not directly transferred to the membrane. In all cases, seams must be carefully sealed and inspected.

Liquid cold applied "positive side" systems are available which allow seamless application. Lack of seams is particularly important where the geometry of surfaces makes it difficult to apply sheet materials or layers of reinforcing fabrics. Coatings conform easily to surface irregularities and penetrations, and minimize the need for flashings, but most high quality coatings tend to be expensive. Relatively inexpensive asphalt based coatings have been developed which are suspended in a water based emulsion to eliminate VOC concerns, though their flexibility is somewhat limited. More costly fluid applied urethane coatings provide a durable, flexible, and seamless moisture and vapor barrier, but they must be built up in several thin layers, cannot be applied to damp substrates, and special formulations may be required where VOCs are a concern. Some urethane coatings may be extended with asphalt to reduce costs. Others might be modified with epoxy to enhance adhesion.

Bentonite clay is an environmentally benign product that is mined from natural deposits, and swells to many times it's dry volume when it becomes wet. It can be applied by spray, or may be factory adhered to sheet products or encased in cardboard panels. Bentonite reacts with water and expands when encountering potential leaks, so is self-healing to some extent. High sulphate or salt contamination may interfere with performance, and fluctuating water tables can result in washing away material and loss of mass. It is most reliable under continuous submersion in fresh water. Bentonite is not effective as a vapor barrier.

Negative side systems: Systems consist of a dense cementitious coating, or a crystalline coating. Density of cementitious systems is achieved by using a finely ground cement, or by adding iron or aluminum filings which oxidize and expand in the cement paste during hydration. Crystalline coatings chemically react with water to fill concrete pores. Being applied to the interior, these offer no protection to the structure from soil contaminants which may be corrosive to concrete, masonry, or reinforcing steel. Interior partitions and structure may cause discontinuities in waterproofed surfaces, and occupant activities (attaching shelving, picture hanging, etc) may penetrate the barrier. Negative side systems are more suited to retro-fit applications. They are generally vapor permeable, and should be limited to occupancies which can tolerate high relative humidity. They may be installed as a positive (wet) side membrane before backfill, but they are inflexible and prone to leaks if there is any continued movement or cracking. Negative side systems should not be considered if the structure is exposed to corrosive chemicals, if surfaces are exposed to freeze-thaw cycling, or if indoor relative humidity must be controlled.

In remedial applications where leaks have occurred, it may be possible to inject epoxy or chemical foams and gels into cracks and joints from the interior. Epoxy injection is required if a structural bond is needed, but epoxies are relatively inflexible and will not resist building movement. Injected polyurethane or acrylate foams and gels will not provide a structural repair, but form a flexible gasket that can stop leaks. When leaks are stopped at one location, it is not unusual for water to find another point of entry. Multiple applications may be required.

In situations where construction is below the water table, special consideration must be given to waterproofing caissons, pilings, tie-backs and lagging, and to casting water stops into concrete joints. Water stops are flexible strips or gaskets which seal joints between concrete pours, installed at the time of concrete placement. They are not typically relied on as a sole source of waterproofing, but form a secondary barrier against water infiltration at these vulnerable locations. They are commonly made of PVC, or another durable and flexible material, with edges anchored into each pour of concrete. They might also be of polyurethane foam, or a sealant or rubberized material which is formulated to expand when in contact with water.

Traditionally, gravel and filter fabric drainage courses are placed against the waterproofed surface during backfilling, assuming foundations are above the water table and footings can be drained. A number of drainage mat products have been developed that incorporate both drainage course and filter fabric, that can provide dual service as drainage and protection board to prevent damage to waterproofing during backfill operations.

CONCLUSION:

An appropriate research method can organize the process of system selection, supplement the designer's knowledge of site and project requirements, and maximize the chances for a successful project. The designer's checklist should include a review of local codes and restrictions, identification of occupancy requirements, consideration of anticipated hydrostatic pressures and water table elevations, soil characteristics, substrate stability, construction sequence, product track record, ease of application, and comparison of risk vs. cost of installation. Because of the difficulty in repairing a failed waterproofing system, cost should never be the governing factor in selection.

An increasing awareness of the health risks related to building moisture is being developed. Moisture in buildings has been associated with asthma, allergies, and more serious illness, particularly when moisture results in microbial growth. Building designers must consider an enormous number of factors during the design process, but the comfort, health and safety of building occupants is the primary purpose of shelter and must be the designer's primary goal. Any tools that can be developed to ensure achievement of that goal should be considered. A systematic research method for the design of below grade waterproofing systems is one such tool.

APPENDICES:
The overview of system types discussed above is not comprehensive. New products and materials are continually being introduced. Manufacturers are a good source of information for details on existing products and new product development, and discussion with them is an essential phase in the research effort. A list of several waterproofing manufacturers is attached for future reference as Appendix A. A very systematic framework for system selection was developed by the U.S. Navy, and flowcharts describing a selection procedure are attached as Appendix B.

ACKNOWLEDGEMENTS:
An introduction to, and concise metholodogy for design of below grade waterproofing systems is well presented in Justin Henshell's *The Manual of Below-Grade Waterproofing Systems*. Mr. Henshell has kindly provided copies of the (now out of print) Navy Design Manual selection procedure flowcharts which are appended. More comprehensive building envelope design considerations and a detailed discussion of waterstops are offered in the below-grade chapters in Michael Kubal's *Construction Waterproofing Handbook*. This reference provided the basis for the appended list of manufacturers, which has been modified and extended for the appendix. Excellent examples of below grade waterproofing details can be found in the referenced ORNL *Building Foundation Design Handbook*. The *NRCA Roofing and Waterproofing Manual* also includes standard waterproofing details, and is a good general reference.

REFERENCES:

Henshell, Justin *The Manual of Below-Grade Waterproofing Systems*
John Wiley & Sons, New York, NY, 2000

Kubal, Michael T., *Construction Waterproofing Handbook*, McGraw Hill, New York, NY, 2000

Kenneth Labs, John Carmody, Raymond Sterling, Lester Shen, Yu Joe Huang, Danny Parker. ORNL/Sub/86-72143/1: *Building Foundation Design Handbook* (May 1988).

National Roofing Contractors Association *NRCA Roofing and Waterproofing Manual*, Fourth Edition, 1996, Rosemont, IL

US Navy NAVFAC DM-1.4, "Earth Sheltered Buildings" Design Manual 1.4 (no longer in print)

APPENDIX A. - Manufacturer List & Contact Information
Reseacth Method for Design of Below Grade Waterproofing Systems

The following is a list of below-grade material manufacturers, to be used as resource for acquiring information on many of the waterproofing systems, materials, components and processes.

The manufacturers are listed for information purposes only, and the list is not intended as a recommendation for companies or materials. Most manufacturers will provide information on their products, and may be excellent sources of information on termination and transition details and compatibility of adjacent products.

Waterstops

Cetco Building Materials Group
1500 W. Shure Drive
Arlington Heights, IL 60004
847/392-5800 Fax: 847/577-5571
Web site: www.cetco.com
E-mail: sbyrd@cetco.com

EarthShield
551 Birch Street
Lake Elsinore, CA 92530
888/836-5778
Fax: 909/674-1315
Web Site: www.earthshield.com
E-mail; davidp@earthshield.com

Greenstreak, Inc.
3400 Tree Court Industrial Boulevard
St. Louis, MO 63122
314/225-9400
Fax: 314/225-9854
Web site: www.greenstreak.com
E-mail: info@greenstreak.com

J P Specialties, Inc.
551 Birch Street
Lake Elsinore, CA 92530
800/821-3859
Fax: 909-674-1315
Web site: www.jpspecialties.com

Tamms Industries
3835 State Route 72
Kirkland, IL 60146
815/522-3394
Fax: 815/522-3257
Web site; www.tamms.com
E-mail: sales@-tamms.com

Vandex
PO Box 1440
Columbia, MD 20144
410/964-1410
Web site: www.vandexus.com
E-mail: info@vandexus.com

Vinylex Corporation
PO Box 7187
2636 Byington-Solway Road
Knoxville, TN 37921-0087
423/690-2211
Fax: 423/691-6273
Web site: www.vinylex.com
E-mail: centr@vinylex.com

Webtec, Inc.
PO Box 241166
Charlotte, NC 28224
704/398-0954
Fax: 704/394-7946
E-mail: info@webtecgeos.com

W.R. Meadows, Inc.
PO box 338
Hampshire, IL 60140-0338
847/683-4500
Fax: 847/683-4544
Web site: www.wrmeadows.com
E-mail: wrmil@wrmeadows.com

Drainage Protection Courses

American Hydrotech, Inc.
303 East. Ohio Street
Chicago, IL 60611-3387
312/337-4998
Fax: 312/661-0731
Web site: www.hydrotechusa.com

American Wick Drain Corporation
1209 Airport Road
Monroe, NC 28110
704/238-9200, 800/242-9425
Fax; 704/296-0690
Web site: www.americanwick.com
E-mail: mobermeyer0-americanwick. com

Carlisle Coatings & Waterproofing
8810 West 100th Street South
Sapulpa, OK 74060
800/338-8701
Fax: 918/227-0603
Web site: www.carlisle-ccw.com
E-mail: info@carsile-ccw.com

Cetco Building Materials Group
1500 W. Shure Drive
Arlington, Heights, IL 60004
847/392-580
Fax: 847/577-5571
Web site: www.cetco.com
E-mail: sbyrd@cetco.com

Cosella-Dorken Products, Inc.
4655 Delta Way
Beamsville, ON, Canada LOR 1B4
905/563-3255
Fax: 905/563-5582
Web site: www.deltams.com
E-mail: cdsales@niagara.com

Schluter Systems Inc.
28 Hymus
Pointe Claire, QC H9R 1C9
800/667-8746
Fax: 514/630-0983
Web site: www.schluter.com
E-mail: info@schluter.com

TC MiraDRI
2170 Satellite Blvd., Ste. 350
DuLuth, GA 30097-4074
770/689-2627, 888/464-7234
Fax: 770/689-2628
E-mail: W.Harvie@miradri.com
Web site: www.miradri.com

W R Grace
Construction Products Division
62 Whittemore Ave.
Cambridge, MA 02140-1692
617/876-1400
Web site: www.gcp-grace.com
E-mail: info@gcp-grace.com

Cementitious positive and negative system

Anti Hydro International, Inc 45 River Road
Flemington, New Jersey 08822
908/284-9000, 800/777/1773
Fax: 908/284-9464
Web site: www.anti-hydro.com
E-mail: sales@anti-hydro.com

Bonsal
PO Box 241148
Charlotte, NC 28224-1148
704/525-7621
Fax: 704/529-5261
Web site: www.bonsal.com
E-mail: commercialproducts&bonsal.com

Tamms Industries
3835 State Route 72
Kirkland, IL 60146
815/522-3394
Fax: 815/522-3257
Web site: www.tamms.com
E-mail: sales@-tamms.com

Vandex
PO Box 1440
Columbia, MD 20144
410/964-1410
Web site: www.vandexus.com
E-mail: info@vandexus.com

APPENDIX A. - Manufacturer List & Contact Information
Reseacth Method for Design of Below Grade Waterproofing Systems

Fluid-applied systems

American Hydrotech, Inc.
303 East. Ohio Street
Chicago, IL 60611-3387
312/337-4998
Fax: 312/661-0731
Web site: www.hydrotechusa.com

Anti Hydro International, Inc
45 River Road
Flemington, New Jersey 08822
908/284-9000, 800/777-1773
Fax: 908/284-9464
Web site: www.anti-hydro.com
E-mail: sales@anti-hydro.com

Basement Systems
60 Silvermine Road
Seymour, CT 06483
800/638-7048
Fax: 203/881-5095
Web site: www.basementsystems,com
E-mail: mailbox@basementsystems.com

Carlisle Coatings & Waterproofing
8810 West 100th Street South
Sapulpa, OK 74060
800/338-8701
Fax: 918/227-0603
Web site: www.carlisle-ccw.com
E-mail: info@carsile-ccw.com

Karnak
330 Central Avenue
Clark, NJ 07066
732/388-0300
Fax: 732/388-9422
Web site: www.karnakcorp.com
E-mail: info@karnakcorp.com

Kemper Systems
550 S. Michigan Street
Seattle, WA 98108
206/767-9505
Fax: 206/767-9531
Web site: www.kempersystem-us.com
E-mail: alldry@kempersystem-us.com

LBI Technologies, Inc.
3873 East Eagle Drive
Anaheim, CA 92807-1722
714/575-9200
Fax: 714/575-9229
Web site: www.liquidboot.com
E-mail: lbi@liquidboot.com

Mer-Kote Products, Inc.
501 South Van Ness Avenue Torrance,
California 90501
310/775-2461
Fax: 310/320-4938
Web site: www.merkote.com
E-mail: info@-merkote.com

Mar-Flex Systems, Inc.
6866 Chrisman Lane
Middletown, Ohio 45042
513/422-7285
Fax: 513/422-7282
Web site: www.mar-flex.com
E-mail: keepdry@mar-flex.com

Nox-crete/Kinsman Corporation
PO box 8102
Omaha. NE 68108
402/341-9752
Fax: 402/341-9752
Web site: www.nox-crete.com
E-mail: kinsman@-nox-crete.com

Pacific Polymers
12271 Monarch Street
Garden Grove, CA 92841
714/898-0025
Fax: 714/898-5687
Web site: www.pacpoly.com
E-mail: pacpoly@-aoLcom

Polymer Plastics Corp.
65 Davids Drive
Hauppauge, NY 11788
516/231-1300
Fax: 516/231-1329

Fluid-applied systems (continued)

Rubber Polymer Corporation
1135 West Portage Trail Ext.
Akron, OH 44313
330/945-7721
Fax; 330/945-9416
Web site: www.rpclink.com
E-mail: rpclink@)worldnet.att.net

Terry Industries
8600 Berck Boulevard
Hamilton, Ohio 45015
513/874-6859
Fax: 513/874-6870
Web site: www.houseguard.com
E-mail: kim@fuse.net

TC MiraDRI
2170 Satellite Blvd., Ste. 350
DuLuth, GA 30097-4074
770/689-2627, 888/464-7234
Fax: 770/689-2628
E-mail: W.Harvie@-miradri.com
Web Site: www.miradri.com

W R Grace
Construction Products Division
62 Whittemore Ave.
Cambridge, MA 02140-1692
617/876-1400
Web site: www.gcp-grace.com
E-mail: info@grp-grace.com

W.R. Meadows, Inc.
PO box 338
Hampshire, IL 60140-0338
847/683-4500
Fax: 847/683-4544
Web site: www.wrmeadows.com
E-mail: wrmil@wrmeadows.com

Hot-applied systems

American Hydrotech, Inc.
303 East. Ohio Street
Chicago, IL 60611-3387
312/337-4998
Fax: 312/661-0731
Web site: www.hydrotechusa.com

Carlisle Coating R Waterproofing
8810 West 100th Street South
Sapulpa, OK 74060
800/338-8701
Fax: 918/227-0603
Web site: www.carlisle-ccw.com
E-mail: info@carsile-ccw.com

TC MiraDRI
2170 Satellite Blvd., Ste. 350
DuLuth, GA 30097-4074
770/689-2627, 888/464-7234
Fax: 770/689-2628
E-mail: W.Harvie@-miradri.com
Web site: www.miradri.com

Texas Refinery Corp.
One Refinery Place
PO Box 711
Fort Worth, TX 76101
817/332-1161

APPENDIX A. - Manufacturer List & Contact Information
Reseacth Method for Design of Below Grade Waterproofing Systems

Sheet systems

Carlisle Coating R Waterproofing
8810 West 100th Street South
Sapulpa, OK 74060
800/338-8701
Fax: 918/227-0603
Web site: www.cariisle-ccw.com
E-mail: info@carsile-ccw.com

Compotite Corporation
355 Glendale Boulevard
Los Angeles, CA 90026
213/483-4444, 800/221-1056
Fax: 213/483-4445
E-mail: Anna@compotite.com

NEI Advanced Composite Technology
50 Pine Road
Brentwood, NH 03833
603/778-8899
603/778-7455
Web site: www.nei-act.com
E-mail: nei@nei-act.com

The Noble Company
614 Monroe Street
Grand Haven, Michigan 49417
618/842-7844
Fax: 800/272-1519
Web site: www.noblecompany.com
E-mail: sales@noblecompany.com

Poly-Wall International, Inc.
Minneapolis, MN
800/846-3020
Fax: 612/780-0170
Web site: www.poly-wall.com
E-mail: info@poly-wall.com

Protecto Wrap Company
2255 South Delaware Street
Denver, CO 80223
303/777-3001
Fax: 303/777-9273
Web site: www.protectowrap.com
E-mail: info@protectowrap.com

Tamko Waterproofing
220 West 4th Street
Joplin. MO 64801
800/841-1923
Fax: 417/624-8935
Web site: www.tamko.com
E-mail: info@tamko.com

TC MiraDRI
2170 Satellite Blvd., Ste. 350
DuLuth, GA 30097-4074
770/689-2627, 888/464-7234
Fax: 770/689-2628
Web site: www.miradri.com
E-mail: W.Harvie@-miradri.com

W R Grace
Construction Products Division
62 Whittemore Ave.
Cambridge, MA 02140-1692
617/876-1400
Web site: www.gcp-grace.com
E-mail: info@gcp-grace.com

W.R. Meadows, Inc.
PO Box 338
Hampshire, IL 60140-0338
847/683-4500
Fax: 847/683-4544
Web site: www.wrmeadows.com
E-mail: wrmil@-wrmeadows.com

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Reseacth Method for Design of Below Grade Waterproofing Systems

Clay systems

Cetco Building Materials Group
1500 W. Shure Drive
Arlington Heights, IL 60004
847/392-5800
Fax: 847/577-5571
Web site: www.cetco.com
E-mail: sbyrd@cetco.com

Paramount Technical Products, Inc
2600 Paramount Drive
Spearfish, SD 57783
216/752-4400, 800/658-5500
Fax: 216/752-5005

TC MiraDRI
2170 Satellite Blvd., Ste. 350
DuLuth, GA 30097-4074
770/689-2627, 888/464-7234
Fax: 770/689-2628
Web site: www.miradri.com
E-mail: W.Harvie@-miradri.com

Injection Foams & Gels

Deneef Construction Chemicals
PO Box 1219, 18314 Mathis Road
Waller, TX 77484-1219
800/732-0166, 936/372-9185
Fax: 936-372-9897
Web site: www.deneef.com
E-mail: info@deneef.com

Strata-Tech
3601 104th Street
Des Moines, IA 50322
515/251-7770
Fax: 515/251-7705
Web site: www.strata-tech.com
E-mail: wjaques@strata-tech.com

3M Construction Products
800-328-5949
tech (St Paul) Tom Galush - 651-736-8228
Customer Service: 800-480-1704
(5600 & 5610 Scotch-Seal)
Web site:
www.3M.com/US/arch_construct/index.htm
l
Avanti uses 3M products, and has info on their web site at
http://www.avantigrout.com/5600.htm

Master Builders, Inc.
23700 Chargrin Blvd.
Cleveland, OH 44122
800-628-9990
Web site: www.masterbuilders.com
(Concresive 1210, 1230, 1250)

bbZ USA, Inc.
P.O. Box 2111
Bristol, CT 06011-2111
800-814-4498
Fax: 860-583-3434
e-mail: bbzusa@aol.com
(acrylate and polyurethane resins)