BBM USA, Inc.

PROJECT: Yonkers/Tully/Pegno Port Authority
PATH TRAIN RESTORATION
TUNNELS E AND F

Objective: **To propose and gain approval for the grouting techniques and waterproofing barrier criteria required to stop the leakage through the tunnel sections of the E & F inverts at the downtown PATH Restoration Program located in the Manhattan area previous World Trade Center of New York City.**

Requirements of the Grout Material:

- **penetrate as extensively as possible**
- **displace any water present**
- **gel or otherwise consolidate to cease and/or divert flow**
- **harden to form a strong solid waterproofing barrier that remains in place for the life of the repair**
- **maintain hydrophilic characteristics - reversible swelling process**
- **remain flexible in the grouted medium while providing an active seal**
- **durable (no aging)**
- **stabilize the leakage through the typical metal structure and concrete interface areas and to create a waterproofing barrier to provide a contiguous shield against the intrusion of water**

Requirements of Grout Performance:

The properties of the selected grout material that relate specifically to their ease of application within the confides of the site conditions, penetrability (i.e., viscosity), strength, and gel time control.

The division between working time and set (gel) time are based on values that will be calculated through jobsite demonstration, laboratory testing, and physical test results by hand-mixing prepared samples at predetermined mixing ratios.

"*Gel time control*" is the degree to which the gel time can be set in advance by properly proportioning the ingredients (e.g., by adding accelerators or retarders (water) to the grout mix). Gel time is important as it defines (together with the pumping rate and pressure) how far the grout will travel into the designated medium (i.e., into the cracks in the tunnel invert metal ring sections and interface areas between the concrete and adjacent metal rings.

Selection of the Proper Grout and Grouting Techniques:

This material is specially formulated resin designed specifically to seal soil covered areas. Due to its low viscosity and low resistance to flow, a homogenous gel membrane is created at the concrete and soil interface void areas.

Duro Soil has been successfully injected into voids in projects such as a 100 year old brick arch tunnel where a zero leak tolerance had to be obtained and guaranteed to the owner.

Also, in the case of dynamic vibrations inherent to the structure, the consistency of the waterproofing barrier will be guaranteed by the swelling and re-swelling characteristics of the material.

Application Steps :

The tunnel is comprised of a series of 2'ft. metal rings, which are gasketed and attached. The areas of concern are modifications to the typical metal structure as follows:

1. **There is a concrete invert approximately 8'ft. long that runs from position 4 o'clock to 8 o'clock on the circumference of the tunnel. The leaks inthis area are cracks isn the concrete and typical crack injection technique will be applied.**
2. **As the tunnel was constructed from both sides (i.e. New York on one side and New Jersey on the other), the closure was not exactly 2'-0"feet. Therefore, a concrete ring was placed as an alternate to a metal closure ring. This area is leaking and may either be cracks in the concrete or at the interface between the concrete and adjacent metal rings.**
3. **There is a concrete adit/tunnel connection for maintenance to the metal rings. Again, this area is leaking and can either be due to cracks in the concrete or at the interface between the concrete and adjacent metal rings.**

- **The drilling pattern is based on a scheme of injection port holes spaced as jobsite conditions dictate depending on the condition of the bolted area, concrete interface and flow of water leakage.**

- **Injection port holes shall be drilled with ½" diameter drill bits. All holes will be protected following drilling and filled with a rapid cement after the injection process has been completed.**

- **Prior to injecting any material all open joints shall be closed with mortar or rapid cement in order to ensure that injection material does not flow out of the structure during the initial injection process.**

- **The injection material shall be Duro Soil, acrylate-ester resin, which will provide an impermeable waterproofing barrier in the cracks and voids in the typical areas decribed herein.**

Note: **This Method Statement applies to the conditions viewed at the jobsite inspection and as described by the Project Engineer. All other areas requiring crack and leak repair shall be individually addressed by a separate specification.**

Grouting Techniques:

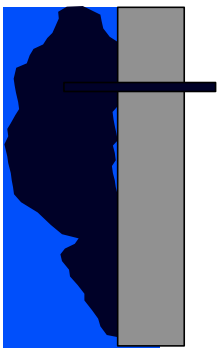
The requirements for the grouting operation process were based precisely on the confines of the jobsite criteria, the capabilities of the materials, and the extremely sensitive safety issues relative to the potential for a hazardous situation in the traffic controlled repair area. The selection of the grout material for the next injection process required a necessity for material characteristics which included; insensitivity to water in its uncured state, ability to allow the injection process to take place without fear of uncontrolled expansion or subsequent formation of negative by-products such as gases (CO_2), bubbles or foam layers and the ability of the material to cure into a solid mass which would be able to withstand high hydrostatic pressure for a long time.

Injection Grout Material: DURO SOIL:

The low flow resistance of *Duro Soil* guarantees that even the smallest of voids can be filled completely and reliably with the injection material. The use of hydrophilic acrylates in the development of *Duro Soil* means that absolutely no solvents are needed. It is, therefore, possible to do without the use of solvents on the jobsite completely because all equipment can be cleaned by simply using soap and water, including the jobsite area or residue left on or near the injection site surface.

DURO SOIL PRINCIPLES

Filling of large cracks and voids utilizing a method of systematic drilling with actual test performances.



APPLICATION

Soil stabilization - below grade civil engineering projects

- Mixing ratio
  - 1 : 1 for Sealing and filling voids
  - 1 : 0.2 for high compressive strengths

Duro Soil's **excellent water displacing properties come into play when injecting the material into water-bearing soil or stone formations. The hydrophilicity of *Duro Soil* means that the material can incorporate water that has not been displaced into its polymer matrix. This is what differentiates *Duro Soil* from other hydrophobic properties, such as epoxy. The incorporation of water is a physical process and guarantees that the structure of the solidified material is homogeneous. The formation of voids and/or honeycombs resulting from trapped water which effect the structure of the material is eliminated. Unlike polyurethane products, there is no chemical reaction with water, therefore, there is no formation of gaseous reaction or by-products resulting from uncontrollable build up of pressure. *The user during the entire injection process can control Duro Soil's reaction and pressure*, therefore, "self-injection" never occurs.**

Duro Soil's **slight swelling capabilities (up to 10%) provides an additional benefit. Disturbances, which occur in the injected area, can be brought under control by the swelling at the edges. *Duro Soil* only swells in the layers which come into contact with water; water is not transported within the material.**
As well as the ability to adjust the reaction time to suit the various jobsite conditions, there is also the possibility of changing the toughness of stabilization. To achieve this, the proportions of Component B must simply be reduced.

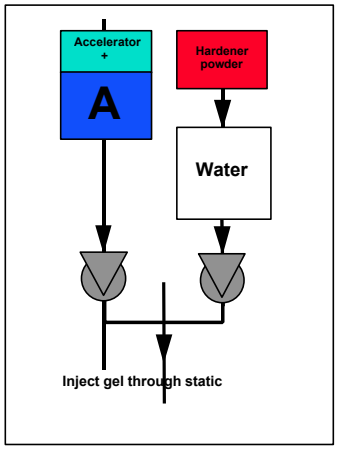
DURO SOIL INJECTION GROUT & SOIL STABILIZER

DURO SOIL

Mixing Procedure

2 component pump, mixing ratio 1:1:

- put accelerator into component A and dissolve approx. 16 hrs)
- dissolve hardener powder into 4.5 liters of water approx. 16 hrs)
- **Two component pump required**



Duro Soil Component A is activated with the supplied accelerator. The reaction time is adjusted by choosing the amount (percentage) of accelerator added.

Duro Soil Component B is produced by dissolving the hardener powder in water.
The concentration of the hardener powder likewise influences the reaction time.

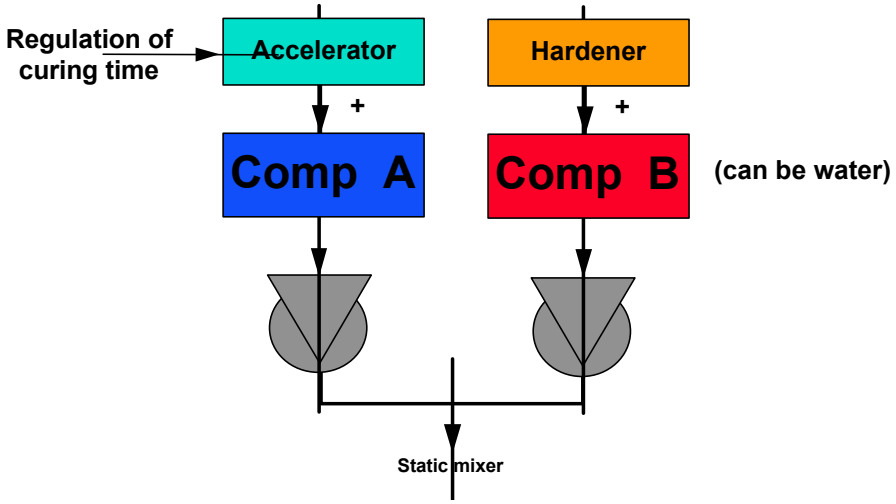
EQUIPMENT - TWO COMPONENT INJECTION PUMP:

Two component injection pumps are utilized to inject highly reactive grout materials. Materials that have reaction times within the range of seconds now become possible to work with. Duro Soil, Duroseal Inject 2000, and Drainseal are typical materials that are injected with the use of a two-component pump. Injecting highly reactive materials with a two-component pump is the only suitable technique to seal a crack with hydrostatic pressure.

Another benefit of two-component pumps is the probability to constantly inject large quantities of grout over a long period of time.

Two component pumps eliminate the need of pre-mixing material. The material is mixed in the "head" by the static mixer prior to injection into the injection packer. The cleaning of the static mixer will run automatically when injection is stopped, therefore, making it possible to inject resins and gels with very short reaction (cure) times.

TECHNOLOGY OF TWO-COMPONENT INJECTION GROUTS



Applications for two component materials would be sealing of the entire defective areas of the structure against water pressure, moisture (dampness/weeping) at active and non-active cracks. Packer injection of systematically set drillings to permanently seal medium-to-high water pressure. Filling of large cracks and voids utilizing a method of systematic drilling with distances calculated in accordance with actual test performances and materials mixing with ratios that reflect actual test results for cured material.