Injection of Large Joints

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Abstract

Use of chemical grouts to seal cracks and joints has traditionally been limited to small openings with other products being used for larger voids. This limitation being primarily due to the standard application procedures of placing the grout through injection ports and using an additive to accelerate the reaction time of the material. However, the physical properties of a chemical grout are desirable in same large void applications. This paper discusses how, working with the materials manufacturers, modification to the material and method of installation can lead to successful application to areas where it has not traditionally been used.

Introduction:

Chemical grouts have been used for some time now in the sealing of small voids due to cracks and small openings in joints by injection. Typically, the injection is performed with an accelerator to start the set up immediately upon contact with water. The sealing of large joints has not used this procedure as the set up time of the material is such that it blocks off the flow path before the injection can be completed. Recently, a large joint in a highway tunnel was sealed using a chemical grout by single point injection. The result was the largest single point injection of a single-component chemical grout ever undertaken successfully.

The joint in questions was a movement joint between two sections of cut and cover concrete box tunnel. The joint was designed as a movement joint in the range of ½" to 2 ½", so injection with a cementitious grout or a rigid chemical grout could not be done. The joint was initially designed to be a 1 ½ inches open and protected from leakage with two bulb-type water stops located approximately 8 inches apart running completely around the 40 foot deep by 90 foot wide tunnel section (See Figure 1). 1 1/4" pipes were installed at six locations, two locations in the tunnel roof, two locations in the supply air duct beneath the roadway surface, and two locations at the roadway surface to pressure test the space between the water stops (See Figure 2).

Upon completion of the construction, the joint was to be tested by pressurizing using water; however, the specified test pressure of 52 pounds per square inch could not be attained. A maximum of 40 pounds was achieved at which point the water flow was shut off. After about 15 minutes the gauge reading reduced to zero, indicating that the joint had lost pressure and was not tight. Shortly thereafter, the joint started leaking with the rate of inflow of 1.7 gallons per minute. This rate fluctuated, reaching a maximum rate of 2.5 gallons per minute during periods of heavy rain with the correspondingly high ground water table.

Investigation

Due to concern for the proper functioning of the joint and the need to eliminate the intrusion of ground water, a study was undertaken to identify potential solutions. Meetings were held with tunnel repair experts and manufacturers of injection systems. Suggestions ranged

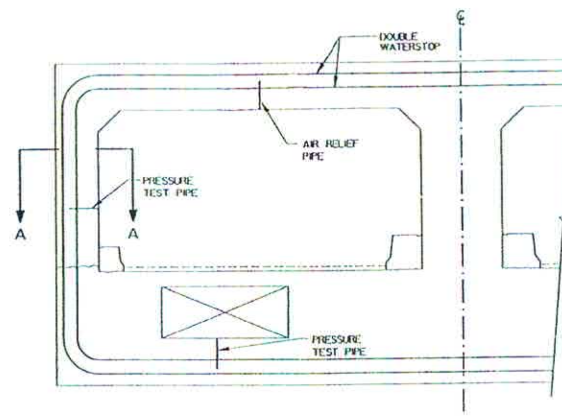

Figure 1

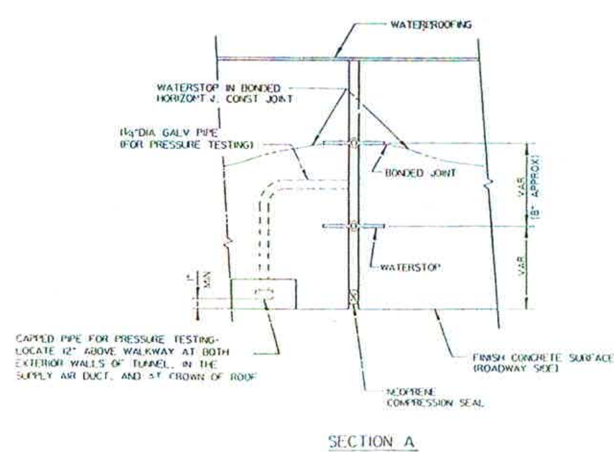

Figure 2

Continued page 16

***Joints** (continued)*

from the traditional stitch and pump repair to an elaborate recommendation to drill into the joint and penetrate the water stops and then use a two product injection system to seal the leak. The types of materials considered included polyurathanes, acrylates, acrylics and epoxies. A review of these recommendations revealed that they were all very costly and would require a long time to implement.

A further review of the design of the joint and subsequent field inspection of the joint revealed that the test pipes originally installed during the construction of the joint were still in place, operational, and accessible. The optimum solution would make use of these points to access the joint rather than an expensive and time consuming drilling process since they were installed with a clear path which would allow injection of grout into the area between the waterstops.

The first step in determining the suitability of these pipes was to test for connectivity through the joint. If successful, the results of the connectivity test would provide information on the volume of grout required and the length of time needed to fill the joint.

A Vactor Jet Rodder truck with a high capacity pressure pump and a 5000 gallon tank was used to pump water into the joint through one of the test ports in the tunnel roof. The Jet Rodder was connected to the test port with an adapter and an equivolume valve located in the exhaust air plenum above the roadway (See Figure 3). The

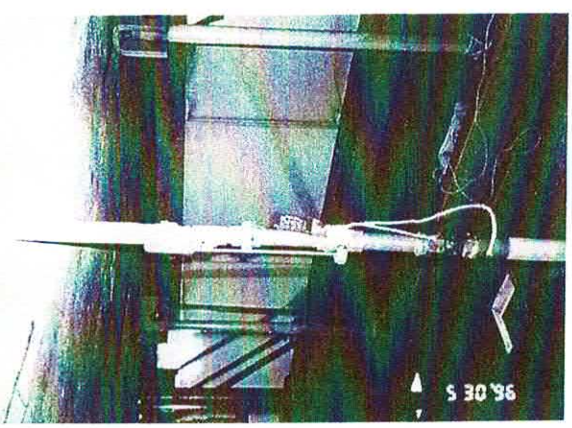

Figure 3

equivolume valve was used to control the pressure so as not to fracture the concrete lining of the tunnel. An aniline green dye was used to identify the presence of pumped water in the joint. After the pumping began, the pressure was slowly increased to 750 psi at the pump, the actual pressure at the joint was significantly less due to pressure loss in the 500 feet of hose between the pump and the test port. The calculated pressure of the water in the joint was approximately 100 psi.

All of the valves on the test ports were opened and immediately after the pumping commenced, very black, organic smelling water began to flow out of the test pipes in the invert of the tunnel. After 10 minutes, green dye was observed across the roof joint in the tunnel, and after 25 minutes, green dye was observed flowing out of the test ports in the invert of the tunnel, the furthest point from the

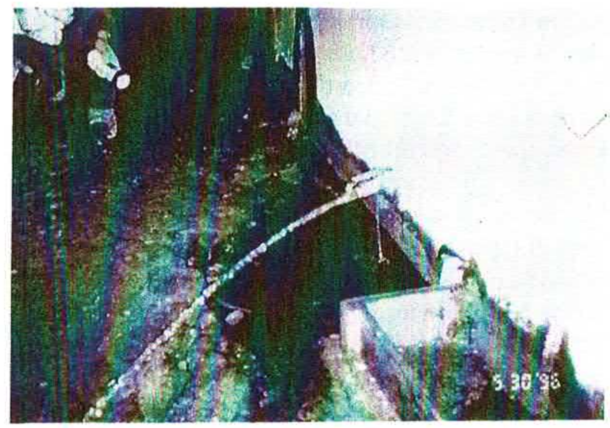

Figure 4

injection port (See Figure 4). The volume of water pumped during the 25 minute period was approximately 500 gallons.

The conclusions from the test were that the joint did have sufficient connectivity to make the use of the test ports a viable repair option. Also, the volume of chemical grout required to fill the joint would be approximately 500-600 gallons.

Observations of the environmental conditions during the connectivity test provided further information for the chemical grout. The set time for the grout must be retarded more than 30-40 minutes at a temperature of 45 degrees F to ensure complete filling of the joint. The grout should have a centipoise of less than 600 to ensure pumpability and that the volume could be pumped within the timeframe stipulated previously. And, lastly, as this joint is a movement joint, the grout must be flexible, have the capability to develop a strong bond with concrete surfaces, and be capable of sufficient elongation to move with the joint.

Based on this grout criteria, available chemical grouts were researched and discussions were held with several manufacturers. Unfortunately, as mentioned previously in this paper, most chemical grouts are designed for extremely quick set times and rapid, non-extended pump times. Based on previous work, the research turned to a product that was pumped in large volume at extended times, deNeef Flex LV. The manufacturer was contacted and the joint problem

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discussed. The manufacturer agreed to conduct a series of tests at their facilities in Belgium and in the United States to determine set times and viscosities under various conditions. The purpose of these tests was to provide a single component polyurathane grout that was sufficiently retarded to ensure full filling of the movement joint. The results of the tests were encouraging, as can be seen in the following table.

	TEST 1	TEST 2	TEST 3
FLEX LV TEMP. DegF	58	50	45
ROOM TEMP. DegF	60	64	64
WATER TEMP. DegF	60	50	45
VISCOSITY cps	700	850	1100
GEL TIME min	50	57	58

Based on these results, a program was developed to proceed with the repair to the joint.

The program was transmitted to the contractor along with the volume of product required and the specifications for the pump. The program consisted of three basic steps. First, the joint would be flushed by pumping fresh water into the ports at the tunnel roof and allowing it to flow out of the ports installed in the supply air duct beneath the roadway. The flushing would last for a period of 45 minutes to ensure that all loose, foreign and deleterious material was cleaned from the joint and to provide clean, potable water to act as a catalyst for the grout. Second, the first injection would commence from the bottom pushing all water in the joint out of the ports in the top of the joint. This step would last until the material was observed flowing out of the ports in the tunnel roof. The third step would be undertaken only if, after most of the material had been pumped no flow of the material was observed at the ports in the tunnel roof. The third step would be to inject from one of these ports and to check the other tunnel roof port for material flow.

Resolution

On the day selected for the repair, the contractor arrived on site with a new spiralflow pump capable of pumping 5 gallons per minute at 500 psi, 750 gallons of deNeef Flex LV, and the necessary adapters to connect the pump to the ports. Because of the large volume of product to be pumped, the pump suction was placed in a new 30 gallon galvanized barrel which was kept full so as not to interrupt the process once the pumping started Also, the Vactor Jet Rodder truck used in the connectivity testing was on site to do the flushing of the joint. The Vactor Jet Rodder was connected to one of the ports in the roof of the tunnel, the remaining ports were opened and the flushing was started. The pressure was increased to 700 psi to ensure complete flushing of the joint. Unlike the observations made during the connectivity test, no dirty water or foreign matter was observed coming out of the ports at the bottom of the tunnel. Because of the cleanliness of the water flowing out of the joint, the flushing was terminated after 30 minutes.

After the Vactor was disconnected from the port, the pump was connected to one of the bottom ports, all ports were left open and the pumping began. Shortly after the pumping was started, the flow of water observed from the open port in the bottom of tunnel diminished substantially to a point where it was not longer noticeable. The pumping continued until there was 625 gallons of grout was injected. Since no product was observed flowing out, step three was undertaken. The valve on the port through which the injection had been done was closed and the pump disconnected. The pump was connected to one of the ports in the tunnel roof and the injection was re-started pumping the remaining 125 gallons of grout. Within a few minutes of re-starting the injection, product was observed flowing out of the other port in the roof of the tunnel, that port was then closed. While no flow observed from the one port in the bottom of the tunnel which remained open, that port was also closed. The remaining product was pumped into the joint through the last open port and then that port was closed and the pump disconnected. The total injection time was four hours and all of the 750 gallons of product was pumped.

Based on the results of the laboratory tests and the environmental conditions on site at the time of the repair and the volume of product pumped, a gel time of the repair and the volume of product pumped, a gel time of approximately four hours was expected. After seven hours, the site was inspected and no flow was detected. In opening the ports at the top of the tunnel, some flow of product was observed. The product flow observed had begun to react as evidenced by entrained air bubbles and increased viscosity. No water flow was observed at any port. The valves were closed and the handles bent over to prevent them from being inadvertently opened until the product cured completely. Since the repair over a year ago, the joint has been inspected monthly and no visible flow has occurred. The joint has been successfully sealed.

Conclusion

Single component polyurathane chemical grouts can be successfully used to seal large movement joints. The work is site specific and requires modification of the grout to provide set times that will totally fill the joint. Cooperation is required of the owner, engineer, contractor, and manufacturer to allow for the use of specialized equipment and site access for a successful project. The authors would like to thank Bert Krickermans and Brian Iske of deNeef America for their cooperation in the modification of Flex LV and their continued support in the R and D effort.