NATIONAL BUREAU OF STANDARDS REPORT

6682

Freezing and Thawing Tests of Grout Pocket Assemblies
as Used at Welded Joints of Precast Concrete Panels

by

Leopold F. Skoda

Report to
Bureau of Yards and Docks
Department of the Navy

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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FREEZING AND THAWING TESTS OF GROUT POCKET ASSEMBLIES AS USED AT WELDED JOINTS OF PRECAST CONCRETE PANELS

Leopold F. Skoda

Five specimens representing grout pocket assemblies used to protect welded joints in precast concrete panels were subjected to 250 cycles of freezing and thawing in order to determine the effectiveness of epoxy/Thiokol adhesives when applied to the surfaces of grout pockets prior to grouting. The specimens of plain concrete were cast in two halves and were 14- by 14- by 2 5/8 in. in size when placed together. The resulting grout pocket was 8 1/4 in. square at the top surface and 1 5/8 in. deep. The sides of the pockets were cast at an angle of 45° with the horizontal so that the bottom of the pocket was a 5 in. square. The sides and bottom of four of the specimens were coated with various epoxy/Thiokol adhesive compounds just prior to grouting. The fifth specimen was used as a control specimen and was not coated. The specimens were frozen in air at a temperature of 2 ± 1°F, and were thawed in a water bath at a temperature of 77 ± 1°F. The control specimen failed after 96 cycles of freezing and thawing while no visible damage was apparent in the coated specimens after 250 cycles. These results clearly indicate that the use of epoxy/Thiokol adhesive mixtures significantly increases the durability of grout pocket assemblies by improving the bond between the grout and the hardened concrete.

1. INTRODUCTION

The object of these tests was to observe the effect of adhesive coatings on the freezing and thawing properties of grout pocket assemblies as used in the 16- by 30-ft panel frame structure. The grout pockets that enclosed the welded knee joint connections did not provide adequate protection against water penetration when subjected to weathering. It was felt that the application of adhesive coatings to the grout pockets just prior to filling them with grout would increase their resistance to freezing and thawing thereby improving the watertightness of the assembly. A number of simulated grout pockets were cast of concrete and coated with various adhesives prior to grouting. These specimens were then subjected to 250 cycles of freezing and thawing in order to determine the effectiveness of the various adhesive coatings.

2. DESCRIPTION OF TEST SPECIMENS AND PROCEDURES

The simulated grout pocket assemblies were cast of plain concrete in two pieces. When placed together the dimensions of the grout pocket duplicated precisely those used in the panel frame structure. A recess was also cast into each half so that upon assembly, a 1/2- by 1/2-in. calking joint was formed at the mid-plane of each specimen, as shown in figure 1. Five such specimens were prepared for the test. Four were used to evaluate the adhesive coatings and the fifth was used as a control specimen.

The adhesives chosen for this test were epoxy/Thiokol formulations. Past experience and knowledge of the mechanical and physical properties of epoxy/Thiokol adhesives indicated that desirable results could be obtained. The four major ingredients used in the epoxy/Thiokol adhesive compounds were: (a) liquid epoxy resin (Epon 828, Shell Chemical Company), (b) liquid polymer (Thiokol LP-3, Thiokol Chemical Company), (c) amine catalyst (diethylene-triamine, Carbide & Carbon Chemical Company), and (d) an inert filler (Cab-O-Sil, Godfrey L. Cabot, Inc.). The proportions of epoxy to Thiokol used were 1:1, 1.5:1, 2:1, and 1:0, by weight. The inert filler was proportioned 1:20, by weight, of epoxy and the amine catalyst was proportioned to 8 percent by weight of epoxy. These particular ratios of epoxy to Thiokol were used because the workability and pot life of each was suitable for this kind of application.

The procedure used for preparing and filling the grout pockets was the same for all specimens. The pockets were first wire brushed in order to remove any loose cementitious material with no attempt being made to roughen the surfaces. An adhesive mixture was then brushed on to each pocket. A single batch of grout had been mixed and was used to fill the pockets just after they were coated with adhesive. The grout used had a sand to cement ratio of 3:1, by weight, with the cement being of Type III. The specimens were then allowed to cure under damp burlap for 7 days. The 7-day compressive strength of 2 in. control cubes that had been cast at the time of grouting averaged 10,540 psi.

To complete the specimens a Thiokol base calking compound was applied to the 1/2- by 1/2-in. recess that had been formed at the center section of each specimen. The calking was allowed to cure for two weeks before the freezing and thawing tests were initiated.

A malfunction of the automatic testing equipment necessitated the first 113 cycles of freezing and thawing to be a manual operation. The specimens were first soaked in water at room temperature for 48 hours. They were then placed in a refrigerated chamber maintained at 3 ± 1°F for 7 hours. Upon removal from the freezing chamber they were carefully inspected and

then placed in a water bath and allowed to thaw overnight at a temperature of 73 ± 2°F. This procedure yielded only 5 cycles of freezing and thawing per work week.

The remaining 137 cycles were completed in automatically controlled equipment that was capable of subjecting the specimens to two cycles of freezing and thawing per day. The equipment was allowed to run continuously, thus yielding 14 cycles per week.

Changing the freezing and thawing operation from a manual to an automatic method altered the procedure somewhat. In the automatic method, both freezing and thawing was accomplished with the specimens remaining undisturbed in the equipment. To begin a freezing cycle one hour's time was required to reach a temperature of 2 ± 1°F. This temperature was maintained for 4 hours. The thawing cycle then began with heated water being pumped into the chamber that contained the specimens. Five hours were required for the heated, circulating water to elevate the temperature to 77 ± 1°F. This temperature was maintained for 2 hours after which the chamber was pumped dry in preparation for another freezing cycle. Under these conditions only a weekly inspection of the specimens was practical. The tests were terminated after the specimens had been subjected to 250 cycles of freezing and thawing.

3. RESULTS

Figure 2 is a photograph of the top and bottom of the specimens before and after testing. The Roman numerals on the specimens indicate the epoxy/Thiokol ratios used to coat the pockets prior to grouting and are as follows: I - 1:1, II - 1.5:1, III - 2:1, IV - 1:0, and V - control. No visible effects can be seen in specimens I through IV with the exception of separation of the calking compound from the sides of the joints. As the study of the behavior of the calking compound was not the main objective of these tests, this observed separation was disregarded when considering the grout pocket behavior. The control specimen, No. V, which was not coated prior to grouting failed after 96 cycles. The first indication of failure was observed after the 92nd cycle when hairline cracks formed about the periphery of the grout pocket. After the 96th cycle the grout was completely dislodged from the pocket. When this happened the calked joint was the only thing that held the specimen together. The specimen broke in two at the calked joint as a result of subsequent handling and not as a result of freezing and thawing.

The results of these tests indicate that an adhesive coating applied to the cast surface of a grout pocket prior to grouting increases significantly the durability of the assembly. Its resistance to freezing and thawing increases by at least 2 1/2 times, as measured by the number of freeze-thaw cycles. However, this figure cannot be projected into a prediction

of service life in the field because of the lack of confirming field trial data, and the fact that no laboratory failures of coated specimens occurred. As none of the coated specimens failed, no conclusion can be drawn with regard to the relative merits of any of the epoxy/Thiokol compounds used. The selection of a particular mixture would have to be based on other factors such as cost, workability, pot life, and mechanical properties.

A summary of the conclusions resulting from this investigation are as follows:

1. All of the epoxy/Thiokol adhesive mixtures tested increased significantly the durability of the grouted pockets. The resistance to freezing and thawing of the grout pocket assemblies increased by at least 2 1/2 times as compared with an untreated grout pocket.

2. The four epoxy/Thiokol mixtures tested displayed no differences after being subjected to 250 cycles of freezing and thawing.

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NOTE: ASSEMBLY OF TWO PIECES

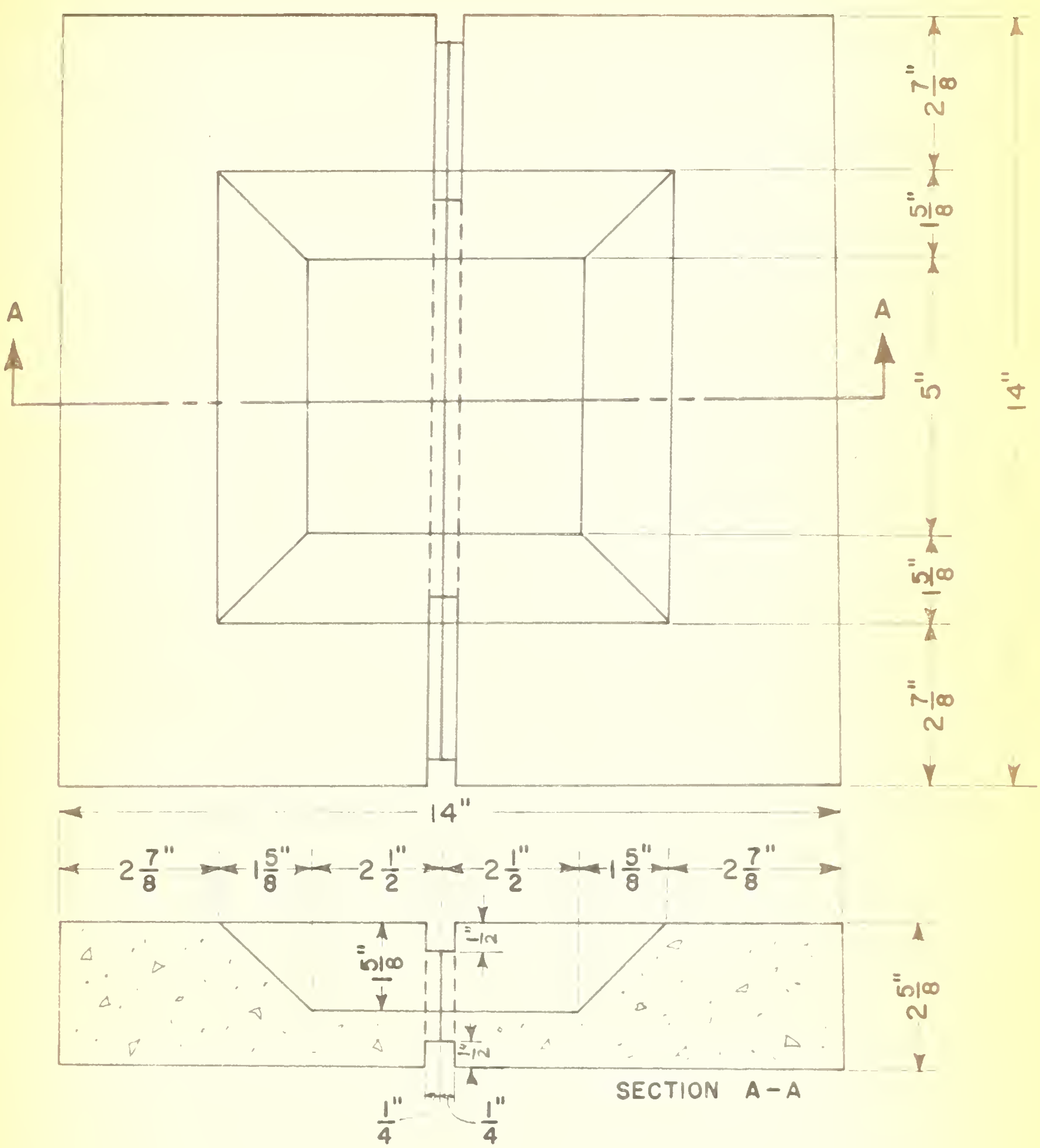
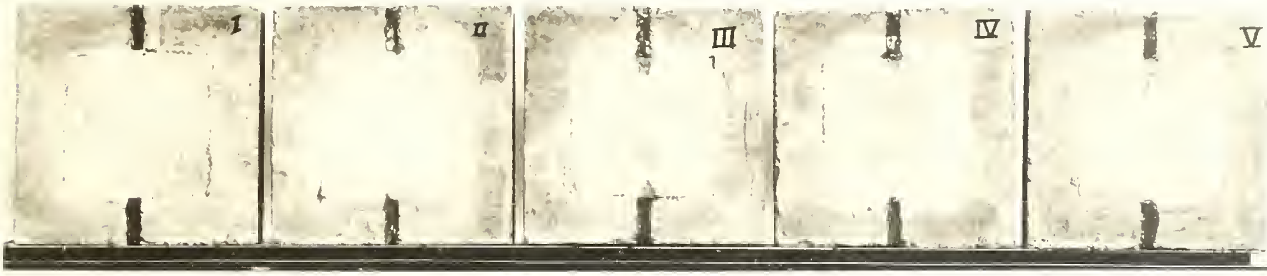
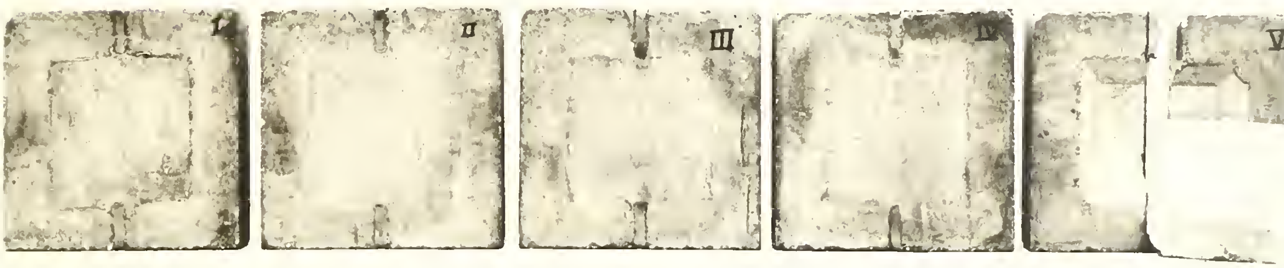


FIGURE I. FREEZING & THAWING SPECIMEN OF GROUT POCKET

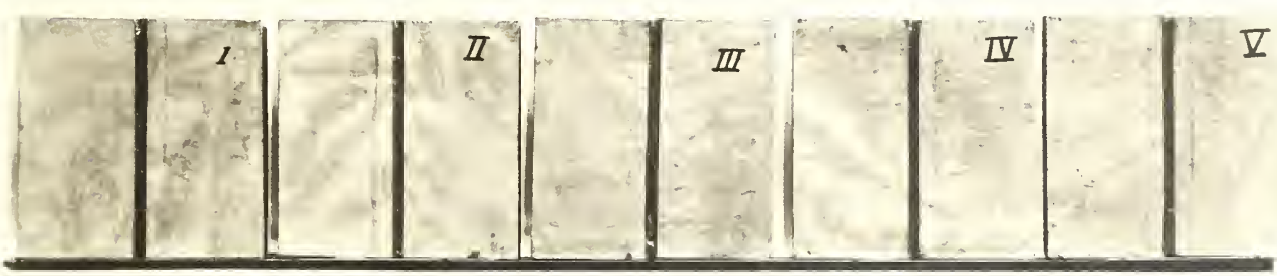
VIEW OF TOP OF SPECIMENS BEFORE TEST



VIEW OF TOP OF SPECIMENS AFTER TEST



VIEW OF BOTTOM OF SPECIMENS BEFORE TEST



VIEW OF BOTTOM OF SPECIMENS AFTER TEST

FIGURE 2. SPECIMENS SUBJECTED TO FREEZING & THAWING TESTS

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Frederick H. Mueller, *Secretary*

NATIONAL BUREAU OF STANDARDS
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THE NATIONAL BUREAU OF STANDARDS

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Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

- Office of Basic Instrumentation.
- Office of Weights and Measures.

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

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Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

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