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# Geopolymer Coating Demonstration Project for Route I-295 Scenic Overlook

FINAL REPORT

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And

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16. Abstract

This report presents the background information, application procedure, and final outcome of a demonstration project carried out to prove the viability of coating an existing 300 ft. parapet wall with inorganic (Geopolymer) coating. This wall, located at the Scenic Overlook on I-295 South near Trenton, N.J. (mile post 58.5), was coated with Geopolymer tinted with pigments. The wall surface was pressure washed before applying the coating. This was the only surface preparation that was needed before the application.

Before the coating was applied, a number of "small patch" applications on the backside of the wall were made to gain approval by NJDOT. The oldest patch was more than 18 months old when the wall was coated. Self cleaning and de-polluting characteristics of the coating are being investigated under a project funded by the National Science Foundation.

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## INTRODUCTION

Surface deterioration of concrete is becoming one of the major problems for durability of concrete structures. The surface deteriorations could develop into structural problems, especially in reinforced concrete structural elements. The most efficient way to reduce this deterioration is to prevent liquid ingress into concrete, thus preventing the ingress of chemicals such as chloride from salts and subsequent deterioration. The coating used to protect the surface should allow the concrete to breath. Otherwise, the coating will delaminate due to liquid collection at the interface. Therefore, a strong need exists for the development of an inorganic coating, which is less permeable than concrete and will allow the concrete to breath.

Graffiti is a common occurrence, especially in cities, and transportation structures are primary targets because of their easy accessibility. Graffiti is unsightly and in some cases is offensive and has to be removed. The removal of graffiti is both expensive and time consuming. Therefore, a strong need exists to reduce the problem by developing a coating to which organic materials, especially spray paints, will not stick.

The results of the previous research have shown that an inorganic polymer coating is a viable alternative to organic polymer and polymer modified cement coatings.[1] The primary difference is the compatibility of the new coating with common construction materials such as concrete, concrete bricks (including hollow core blocks), clay bricks, steel and timber. The constituent materials of the coating chemically react with the concrete because Portland cement used in concrete is a calcium alumino-silicate system where as the cement in the coating is potassium alumino-silicate. Any free hydroxide in concrete will react with silica in the coating and vice versa{2]. Since the coating contains submicron and nano particles they penetrate both timber and clay-brick surfaces. Small amounts of rust present in steel act as activators for the coating, thus improving the bond.

Absence of bond failure between the matrix and the parent surface in a large number of tests involving both strengthening and coating confirms the compatibility and excellent bond. Since the coating allows for release of any vapor pressure from the parent surface, blistering is eliminated. The long term durability of both the coating and the interface provides the primary motivation for this demonstration project. The self cleaning property of the coating system will provide a giant step forward for this relatively new material. The fact that the coating can withstand up to 1000˚C provides the motivation for creating systems that can be used in critical locations such as staircase pier caps and tunnels.[3]

## BACKGROUND INFORMATION

Rutgers, The State University of New Jersey in cooperation with the New Jersey Department of Transportation (NJDOT) have developed an inorganic coating material that can be used as a protective coating. This coating material is about two orders of magnitude less permeable than concrete but allows for release of vapor pressure; that is, allows concrete to breath. The coating also provides a glassy surface to which organic paints do not stick. The basic features of this material are as follows.

- The cementing part of the coating to be used, called Geopolymer, was developed for aircraft structures and subsequently modified for use as a coating material. The cementing part is a potassium alumina-silicate, or polysialate-silox with the general chemical structure:

  $$K_n \{- ( SiO_{2\,z} - AlO_2 )_n \} \bullet wH_2O \quad \text{,where } Z>>n. \qquad (1)$$

- The research conducted so far has focused on the mechanical, thermal, and durability properties of composites and durability of strengthening systems for concrete structural elements. [1-5]
- The pot life varies from 30 minutes to 3 hours for compositions that cure at room temperature.
- Common application procedures such as brushing and spraying can be used to apply the Geopolymer coating. Using brush, roller, and sprayer, the product was successfully used to coat bridge substructures and secondary structures in Rhode Island. In New Jersey, the product was successfully used to coat NJ traffic barriers with brush and roller.
- The matrix can withstand temperatures up to $1000^0$C, and is not affected by UV radiation. Fire tests show that the flame-spread index is zero.
- The base coating material is white and hence other color schemes can be easily formulated using pigments. Various color schemes, including concrete and brick color coatings have been successfully developed.
- The coating is expected to have self cleaning properties because zinc oxide is one of the constituent materials. [4,5]

The coating formulation, generically called an inorganic matrix, is a polymer like material that is being evaluated for applications in aircrafts and civil infrastructure. Originally it was developed for use in aircraft structures and modified for use as a coating material and adhesive for brick, concrete, wood, and steel. The resin is prepared by mixing a liquid component with silica powder. Fillers and hardening agents can be added to the powder component. The two components can be mixed to the consistency of paint. The matrix is water based; consequently tools and spills can be cleaned with water. All of the components are nontoxic and no fumes are emitted during mixing or curing. The matrix bonds well with carbon and glass fiber reinforcements.

Durability of the coating system is central to the proposed research and hence a short summary of the durability results are presented in the following section.

## DURABILITY OF THE PROPOSED COATING SYSTEM

The effectiveness and durability of the coating was evaluated using strength tests of flexural concrete prisms strengthened with carbon reinforcement and the inorganic polymer to be used for the coating. The tests were conducted before and after exposure to wet-dry and scaling conditions. Strengthening of prisms was done by bonding carbon toes or fabrics to the tension side of the prisms using the inorganic polymer. This strengthened face was subjected to wet-dry and scaling conditions[2].

The test samples consisted of the following: two control samples, two samples strengthened with both two and four percent discrete carbon fibers; two samples strengthened with one, two, and three carbon tows and two samples strengthened with one and two layers of carbon fabrics. Note that carbon fibers do not corrode and therefore failure has to occur due to the deterioration of the matrix or the interface. The test results, summarized in Figure 1 and Figure 2, show that the system is durable both under wet-dry and scaling (freeze-thaw cycle) conditions. The decrease in peak loads did not exceed 10% for either condition.

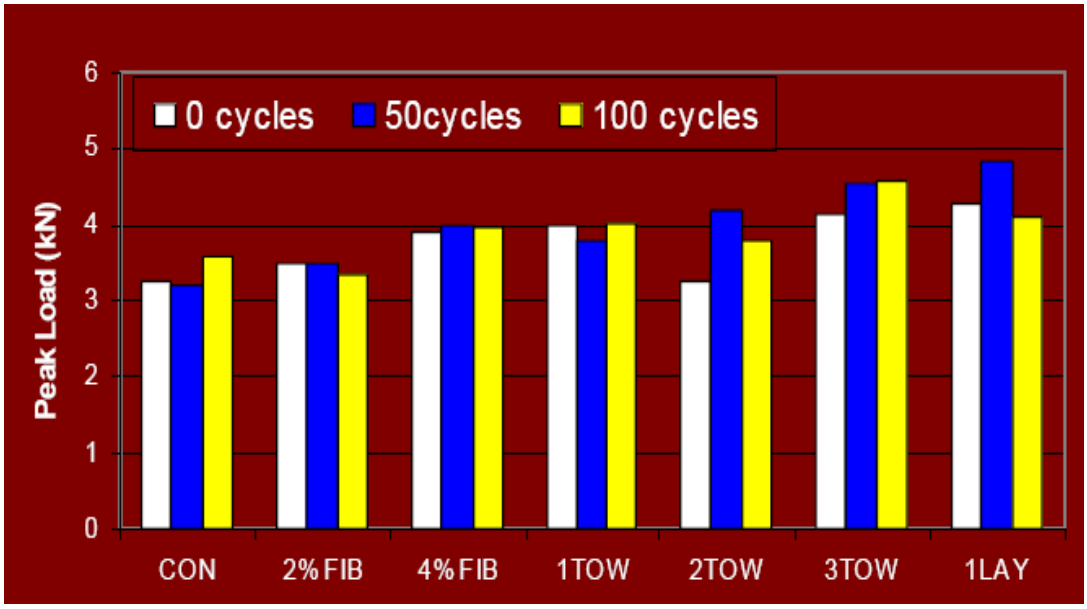


**Figure 1. Peak Loads after Wet-Dry Exposure [2]**

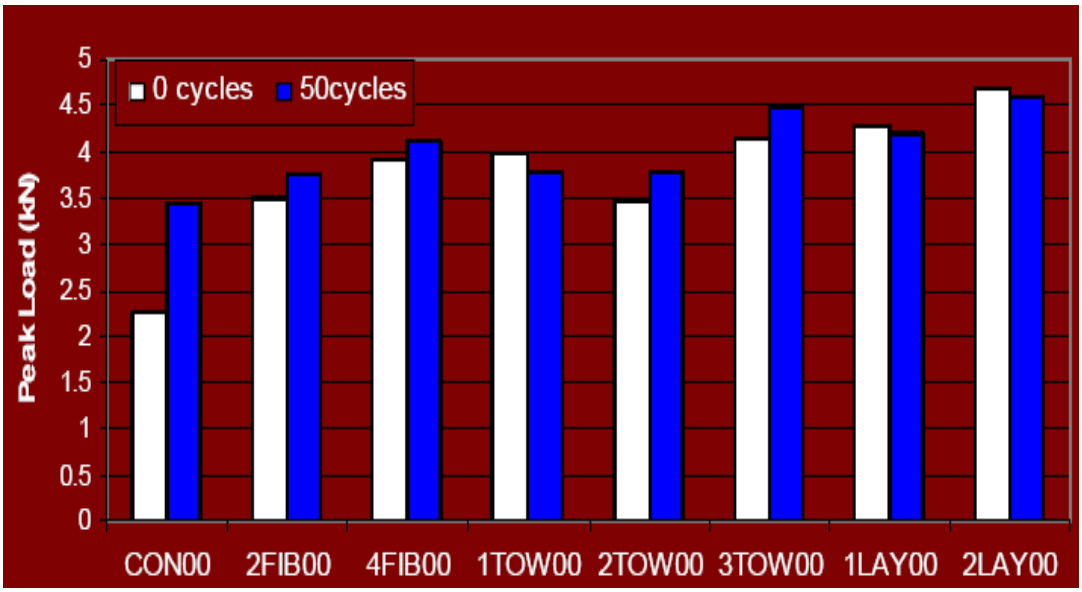


**Figure 2. Peak Loads after Scaling Exposure [2]**

Subsequently, a study conducted under the sponsorship of NJDOT led to the following conclusions:

- Geopolymer coating can be applied to smooth or rough concrete surfaces with minimal surface preparation.
- Only excess dirt and standing water need to be removed before the application.
- The Geopolymer coating cures in 24 hours if the ambient temperature is more than 10 degrees C. The coated surface has to be protected for 24 hours from direct rain or running water.
- Basalt, glass and carbon fibers can be added to the matrix to improve the performance.
- Four different sets of students were able to apply the coatings without any problems. Therefore the field crew can be easily trained.

These conclusions were based on more than 30 applications in walls and curbs on the Rutgers University campus and demonstration applications on New Jersey Barriers and walls near Douglass College.

## DEMONSTRATION APPLICATION: PROTECTIVE COATING

This application was aimed at demonstrating the viability of the new coating for relatively large surfaces encountered in transportation structures. The structure chosen was a parapet wall located at the Scenic Overlook along I-295 South near Trenton, New Jersey. The surface to be coated consists of sixteen blocks with a total surface area of about 1100 sq. ft. The surface is in good condition except for six sections that have some minor spalling on the surface. The work schedule is described in the following sections.

**Develop the Formulation for NJDOT Approval**

The existing Geopolymer formulation with 1% discrete carbon fibers was modified using pigments to obtain a white concrete color. Small slabs coated with the modified matrix (Figure 3) and small patch applications at the back of the structure were used to obtain NJDOT approval. A typical trial patch is shown Figure 4. The approved color for the coated surface looks closer to a white concrete surface.

**Figure 3. Various Color Schemes to Match the Color of Parent Concrete Surface**

**Figure 4. Test Patch (More Than Two Years Old)**

### Cleaning

A few weeds were present at the base of the blocks. These weeds were removed and the wall was pressure washed by NJDOT. Washing of the wall was needed to obtain as uniform a finish as possible.

### Application

In the summer of 2005, the Rutgers team, under the supervision of Professor Balaguru, applied the coating with paint rollers and brushes. Care was taken to prevent spills on the concrete slab next to the wall and on metal posts attached to the wall on the top. The safety railing posts and adjacent floor slabs were taped to protect these areas from any drips or spills. A time slot that provides two dry days was chosen for the application. However, for one application it rained heavily starting 3 hours after the application, but the coating was not damaged. The uncoated concrete surface and coated surface are shown in Figure 5. A close-up view of uncoated and coated surfaces is shown in Figure 6. Another close-up view of the coated surface is shown in Figure 7.

**Figure 5. Uncoated Concrete Surface (on the left) and Coated Surface (on the right)**

**Figure 6. Uncoated Concrete Block Next to a Coated One**

**Figure 7. Close-up View of Coated Surface**

## Monitoring

The performance of the Geopolymer coating will be monitored as part of a research project supported by the National Science Foundation. The main features to be evaluated are durability, aesthetics, and the self cleaning and de-polluting properties of the coating.

## SUMMARY AND CONCLUSIONS

The field demonstration project presented in this report shows that the inorganic-polymer coating can be easily applied to large surfaces. The application system was easy to work with and the Geopolymer coating was applied using paint rollers and brushes.

Extensive surface preparations are not needed prior to the application of the coating. For this field demonstration, only pressure washing was done prior to the application of the coating.

Finished surfaces provide an aesthetically pleasing appearance as shown in the photographs.

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