

# **Shimonoseki Fishing Park Pier**

## **Mighty Coat CF-CP Application and its Progress over 24 years**

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### **1. Introduction**

Mighty Coat CF-CP is inorganic anti-corrosion material containing Carbon Fiber. At the outset, Mighty Coat CF-CP's target use was as an anti-corrosion application for marine vessel exhaust pipes. For this reason, Mighty Coat CF-CP was developed with the capabilities of high-temperature endurance, long term weather resistance, and heavy duty anti-corrosion protection.

With the first stage of development, the plan was to conduct several small test applications. However, because Mighty Coat CF-CP was an unknown and newly-developed material, only one test was conducted. Shimonoseki City was fortunate to be chosen to apply Mighty Coat CF-CP to the newly constructed Shimonoseki Fishing Park Steel Pier. In the 24 years since its construction no major repairs have been performed. At present, rust is still minimal and major repair work is not still required. This has proven Mighty Coat CF-CP's long term weather resistance, and heavy duty anti-corrosion nature. With this 24 year history, it is important to follow the progress of the 24 years from the construction of Shimonoseki Fishing Park pier and to update that progress. This brief report provides an account of the 24 year progress of Mighty Coat CF-CP.

### **2. What is Mighty Coat CF-CP?**

As described above, Mighty Coat CF-CP is inorganic anti-corrosion material containing Carbon Fiber. Mighty Coat CF-CP is supplied in two separated parts: a compound which is made mainly of cement components and a water-based emulsion to bind the cement particles and adhere it to the steel plate.

The compound consists essentially of White Cement, Silica Sand and Carbon Fiber, to achieve a high compression strength and high elongation. Some Alkaline Calcium is added to this compound mixture to improve the alkaline property which creates better anti-corrosion properties. With this high alkaline nature, red powder rust will be changed to stable black rust for a long period of time. The black rust forms a passive layer on the steel surface to maintain a stable state which protects

the steel from corrosion.

The emulsion works to bind the compound particles and to adhere it to the steel surface. Because Mighty Coat CF-CP has such long-term anti-corrosive properties, it is important that the emulsion is also able to withstand the elements for a long period of time. For this reason, the co-polymer of Acrylic Acid Ester resin was selected as the main polymer which has a very high adhesive strength with steel. This co-polymer resin also has a very high temperature resistance, up to 180 °C, over a prolonged period of time.

The following Table identifies the composition and properties of the compound and the emulsion:

<b>Compound</b>	White Cement	Alkaline Nature	Compressive Strength
	Fine Silica sand	Fine Layer	Prevention of Cracks
	Carbon Fiber	Membrane Strength	Prevention of Cracks
	Alkaline Calcium Compou	Higher Alkaline	Stabilizes Rust Membrane
<b>Emulsion</b>	Co-polymer of Acrylic Acid-Ester	Higher Adhesive	Higher Particle Binding Strength
	Higher Adhesion	Higher Adhesive Strength	
	High Temperature Resistance	Up to 180 °C for several years	

Table 1 Mighty Coat CF-CP Components and their Properties

### 3. What is the Shimonoseki Fishing Park?

Shimonoseki Fishing Park was constructed by Shimonoseki City for recreational fishing in 1984. This park has very long steel pier, approximately 300m, (Photo 1) which extends into the ocean, built specially for anglers.



Photo 1 Shimonoseki Fishing Park Steel Pier

Shimonoseki Fishing Park is located in northwest Shimonoseki City. The City charges users for access to the pier. Because this pier gives citizens easy access to ocean fishing and the ability to land large fish, many people throughout the region utilize it. At the Fishing Park, there is a gift shop and tool shop, which are conveniently located in the Park. In front of these Shops, there is large parking lot and people can drive to this park and can fish all day. Young and old can safely walk on pier and enjoy its amenities. At this Fishing Park, Black Porgy, Rockfish, Flounder, Mackerel, Mullet, Balloon Fish and other varieties can be caught.



Photo 2 Shops at Shimonoseki Fishing Park

In 1984 The Port Authority of Shimonoseki City requested that Mighty Corporation apply Mighty Coat CF-CP on the Pier, to protect the Pier from corrosion. For this purpose, 1.5Kg/m<sup>2</sup> of Mighty Coat CF-CP with a chlorinated rubber top coating was applied, at up to 300µm of thickness. An expanded metal mesh fencing and guardrail on the Pier slab were coated first coated with zinc. As shown in Photo 2, the Shops are also steel structures. The steel walls of the Shops were first painted only with a standard resin coating. However, within several years the Shops' structures corroded severely and were repainted with Mighty Coat CF-CP.

#### 4. **Actual Application of Mighty Coat CF-CP to New Construction, 1984**

Using photographs from the new construction in 1984 as illustration, this section will show how Mighty Coat CF-CP was applied to the Pier for anti-corrosion. Mighty Coat CF-CP was applied to the structural elements while they were on land, at a staging area near the coast. during September 1984. Mighty Coat CF-CP was

applied to the surface of the steel structure, even if red rust was present. After a simple cleaning procedure, Mighty Coat CF-CP was sprayed on the surface. Two coats were applied; each coat was 0.5Kg/m<sup>2</sup> of Mighty Coat CF-CP, for a total of 1.0Kg of Mighty Coat CF-CP per square meter, as shown on Photos 3, 4, and 5.



Photo 3 Coating over red rust



Photo 4 Beam structure of Pier

When the Mighty Coat CF-CP was applied over the on the red rust, the color appears whitish-red because the mixture of the white Mighty Coat CF-CP and red rust. The spray application procedure of Mighty Coat CF-CP can be seen in Photo 5.



Photo 5 Spraying of Mighty Coat CF-CP

In this procedure, the Mighty Coat CF-CP mixture was one part emulsion to 2.3 parts compound, and was applied with an air spray gun with a 4.5 mm diameter nozzle. The spraying pressure was controlled at about 6 atmos. Before applying the second coat, the first coat was dry to the touch. As it was normal summer weather, the drying time of the first layer was approximately half hour. Additionally, after confirmation that the two coats of Mighty Coat CF-CP were completely dry, a Chlorinated Rubber top coat was applied as the final coating.

## 5. 24 Year Progress since Construction

Shimonoseki Fishing Park was built in a very severe environment. There has been no major repair work done over the 24 years since it was constructed in September 1984, due to the rust prevention performance of Mighty Coat CF-CP. However, some problems have been found, and those were taken care.

The first repair work occurred just under the leading edge of the fishing pier deck. Some floating materials collided against the pier under-deck and the coated layer was damaged 4 years later during new construction. Rust was observed on this part, so Mighty Coat CF-CP was reapplied at this location. A similar accident occurred in 1990 as well.

The second repair work was in 1991 on the hollow steel piles. These pier piles were originally coated with epoxy resin paint, but after 6 to 7 years exposure in severe conditions, they were completely corroded. Where this corrosion damage occurred, the area of the pile surface up to 60cm below from the deck was repainted with Mighty Coat CF-CP instead of epoxy resin paint. After cleaning the remaining epoxy resin paint, Mighty Coat CF-CP was applied. In total, 120 of the piers were re-coated with Mighty Coat CF-CP between 1992 and 1994.

The third repair work was on guardrail on the pier. It was painted with normal resin paint, but was corroded by wind and salt. The guardrail was also re-coated by Mighty Coat CF-CP. In 2002, deterioration of the top coating was observed and it was re-painted with urethane paint for aesthetic purposes.

As mentioned above, three major repairs have been performed in the 24 year history. However, the majority of repairs were in areas where Mighty Coat CF-CP was not originally applied or where something collided with the structure and damaged the coatings. This is evidence that Mighty Coat CF-CP has very good durability and anti-corrosion performance even under severe conditions.

In order to confirm that Mighty Coat CF-CP has the ability to change red rust to black, some objective tests were conducted at the top head of the steel piles in September 2006 by COSMO Engineering Co. Photo 6 indicates the top of the steel pile used for this exploratory testing.

At first, the top coat was lightly sanded down using a sander disk, to check the condition underneath. Photo 7 shows the pile after the first layer was removed. Photo 8 is a close-up of the sanded portion. It was confirmed that the condition of Mighty Coat CF-CP is still healthy, and the bonding strength testing measured 1.4N, even 24 years after construction. After the measuring the adhesive strength, another layer of Mighty Coat CF-CP was removed, to check the rust conditions, as shown on Photo 9.

Photo 9 shows the top coat removed further to expose the steel surface of the pillar. According to this test, it shows the red rust shown had changed to a stable black rust. This is evidence that the red rust will be changed to the black stable rust through the high alkaline nature of Mighty Coat CF-CP. At present, Shimonoseki Fishing Park Pier appears to have corrosion on about 2 to 3 % of the total area, but this Pier is still in good condition and will not require major repair work, even after 24 years. Given these results, we anticipate that the Pier can go at least 30 years with no major maintenance.



Photo 6 Top of steel pile



Photo 7 After grinding top coat

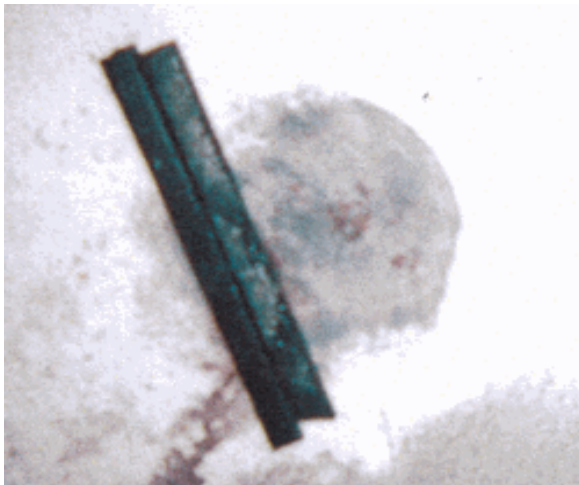


Photo 8 Close-up of sanded portion

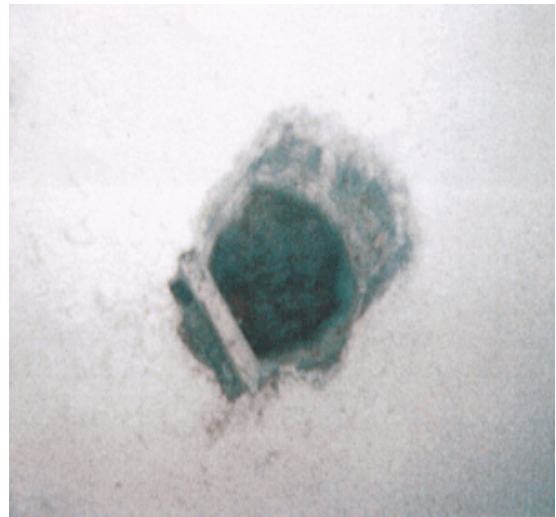


Photo – 9 Black rust on steel surface

## 6. Official Test Results from the Japanese MLIT and a Private Company

During the 24 year history, many tests have been conducted, both standard and specialized, funded by the government as well as by private companies. Two of the important test results will be outlined in this section. The first analysis tested long term exposure in severe, corrosive environments, organized by the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT). This test has been conducted since September 2000 at Araiso Beach in Akita Prefecture. The report was published after five years of exposure; the test will continue to be conducted for a total of 10 years. In this exposure test, 6 different specifications of Mighty Coat CF-CP are being analyzed. Because this was a good opportunity, Mighty Corporation chose to have as many variations as possible tested, even if some of them are not normally utilized in such severe conditions. The specifications tested are:

Specification 1: Mighty Coat CF-CP 0.5Kg/m<sup>2</sup>

Specification 2: Mighty Coat CF-CP 1.0Kg/m<sup>2</sup>

Specification 3: Mighty Coat CF-CP 1.0Kg/m<sup>2</sup> + Acrylic resin top coating

Specification 4: Mighty Coat CF-CP 1.5Kg/m<sup>2</sup>

Specification 5: Mighty Coat CF-CP 1.5Kg/m<sup>2</sup> + Acrylic resin top coating

Specification 6: Mighty Coat CF-CP 1.5Kg/m<sup>2</sup> + Polysiloxane resin top coating

After 5 years of exposure, the samples coated with specification 1 and 2 started to corrode, which is conceivable given that these are not normally specified for heavy duty corrosion protection. In the case of specification 6, the durability of Polysiloxane resin is shortened because it generated many cracks on the surface of sample. However specification 3, 4 and 5 had no issues and no corrosion occurred within the 5 years exposure timeframe as shown on Photos 10, 11 and 12. As is clear in these Photos, there is no observable corrosion on any of the samples.



Photo 10 Specification 3 after 5 years



Photo 11 Specification 4 after 5 years



Photo 12 Specification 5 after 5 years

The second important test was to check the adhesion and shear strength of Mighty Coat CF-CP. These tests were conducted by Sumitomo Metal Industries Ltd., to test Mighty Coat CF-CP's properties for use on a steel slab, on which an asphalt finisher machine would be driven after construction. The asphalt finisher machine has caterpillar tracks made of hard rubber (as shown on Photos 13 and 14) and would be driven on the steel slab coated with Mighty Coat CF-CP. The coated surface of the slab would experience very strong shear stress and would be expected to sustain heavy damage.



Photo 13 Asphalt finisher



Photo 14 Caterpillar tracks

To replicate the actual driving patterns of the asphalt finisher under normal circumstances, the finisher was driven in a zigzag pattern on the coated steel slab for the test. The asphalt finisher was loaded with 1.5 tons of freight for a total of 3.0 tons of deadweight. The vehicle was driven back and forth on the slab 10 times. In addition, a 9 mm thick steel plate was welded on a part of steel slab, and Mighty Coat CF-CP was coated on the plate and the edge of the plate. The asphalt finisher was driven in a zigzag pattern across the edge of this plate twice, after which the damage

to Mighty Coat CF-CP was inspected, as shown on Photos 15 and 16. The inspection showed that the 1.0 and 1.5Kg/m<sup>2</sup> of coating had no damage at all. This test proves the very strong shear strength of Mighty Coat CF-CP and the very high adhesive strength between Mighty Coat CF-CP and steel.



Photo 15 Inspection after the zigzag driving test



Photo 16 Details of plate edge

## 7. Brief Review of Recent Applications

As demonstrated, the performance of Shimonoseki Fishing Park Pier and the various test programs have proven Mighty Coat CF-CP's superior characteristics, not only for anti-corrosion resistance but also its heavy duty weather durability. Additionally, Mighty Coat CF-CP has been used in many large, important projects, including highway bridges and a bridge for the Shinkansen (Bullet Train) Railway.

Mighty Coat CF-CP was applied to the Kurigaya Viaduct for the brand new Tokai-Hokuriku Highway, of the Japan Highway Public Corporation, built constructed August 2003 by Sumitomo Metal Industries Ltd. Mighty Coat CF-CP was coated on the under surface of the Kurigaya Viaduct steel slab, as shown in Photos 17 and 18. For this project, approximately 3,000m<sup>2</sup> of steel slab was coated with Mighty Coat CF-CP, in which more than 5 tons of Mighty Coat CF-CP was used. Mighty Coat CF-CP was chosen for this Viaduct project, because the Viaduct has very high piers and will be difficult to repaint the under-surface of steel slab.



Photo 17 Birds eye view of the Kurigaya Viaduct



Photo 18 Mighty Coat CF-CP coating of Kurigaya Viaduct under slab

As shown in Photos 19 and 20, Mighty Coat CF-CP was also applied to the Nishinaka Bridge across the Shinkansen railway located on National Highway Route 23, managed by the Japanese MLIT, Chubu Region. Mighty Coat CF-CP was applied in November 2003. The Nishinaka Bridge across the Shinkansen railway can only accommodate repair work at intervals of more than 10 years. Mighty Coat CF-CP was chosen for this project because it has such long durability, which was demonstrated with the Shimonoseki Fishing Park Pier. For the Nishinaka Bridge project, approximately 8,000m<sup>2</sup> of the structure was coated with Mighty Coat CF-CP, which is largest application Mighty Coat CF-CP on record to date. The location of Nishinaka Bridge is not close to coast; however, the specification of 1.5Kg/m<sup>2</sup> of Mighty Coat CF-CP with a top coat of Chlorinated Rubber was selected for its durability.



Photo 19 Nishinaka Bridge across the Shinkansen



Photo 20 Mighty Coat CF-CP coating

## 8. Summary

As of December 2008, 24 years and 3 months after the construction passed of the Shimonoseki Fishing Park Pier, the Pier is in outstanding condition with only minimal corrosion of 2 to 3 % of the structure, even under the severe corrosive environmental conditions of that location. This is an excellent example of the long durability of Mighty Coat CF-CP. Not only does Mighty Corporation take pride in this accomplishment, but it is important in expanding the use of Mighty Coat CF-CP for large projects. Mighty Corporation would like to express its appreciation and gratitude to the employees of the Japanese MTIL, Highway Companies, local governments and other who assisted in accomplishing these important projects.

Mighty Coat CF-CP was reported and registered to NETIS (New Technology Information System) of the MLIT. The environmental exposure test by the Akita office of MLIT is continuing until 2010. This brief is published in order to acknowledge the importance of the 24 year history of the Shimonoseki Fishing Park Pier and Mighty Coat CF-CP's the long durability without major repair work.

In 2002, the report "Fundamental Policy of Future Road Management" published by "Road Fundamental Policy Committee of MLIT Social Capital Improvement" was revised in 2006. This report indicated that in Japan it is very important in the near future to develop a Strategic Road Maintenance Policy regarding the aging road infrastructure. The existing road infrastructure which was constructed between 1900 and the end of WWII, and between the 1950's and the period of high economic growth of the 1960's, will reach the replacement age at the same time. This will mean an enormous amount of public investment will be required for road repair and replacement at the same time. To avoid this situation, it will be more important to utilize existing road infrastructure for as long as possible and to maintain and repair this infrastructure with the most advanced technology. Additionally, it will be important to select the maintenance technology with the lowest Life Cycle Cost (LCC). The LCC is the sum of the initial investment cost, maintenance costs and reconstruction costs. In general, reconstruction costs require a large investment, because it includes the construction of temporary structures and roads, removal of old structures, reconstruction of new structures, and removal of temporary structures. The total amount of investment for reconstruction is approximately 3 times more than for new construction. Considering these factors, long-term durability free from major maintenance and repair will be very desirable. Mighty Coat CF-CP is very pleased to have proven its outstanding anti-corrosive durability through 24 years in a severely corrosive environment.