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The Research and Application of Protective Coating for PCCP

Lin Zhu†, Xu Cuizhu, Zhang Li, Fan Yunpeng, and Zhang Qibin

CNPC Research Institute of Engineering Technology

Prestressed Concrete Cylinder Pipe(PCCP) had became one of the dominating kinds of pipes substituting for steel pipes because of its unique feature (high intensity, high pressure and high leakproofness). PCCP was produced firstly by Bonna company in France. By the end of 20th century, there were over 19000 km of this product installed in America. PCCP was introduced from Ameron company by Shandong Eletric Power Pipeline Engineering Company in 1988. As the statistical data in 2002, 700 km of PCCP had been applied in China, and the application trended towards rapid increase.Since prestressing wire would be corroded in environment, Several accidents due to the breakdown of pipe had happened. Consequently the external wall of pipe should be covered with protective coatings. There was a lack of technical study in corrosion and control of PCCP, because PCCP had been applied for a short time in China. in order to ensure the service life of PCCP, we have developed a kind of protective coating for concrete pipe, which had high intensity and anti-corrosive property with convenient applicability. The physical and chemical properties, painting technology and field application of this coating was introduced in the paper, at the same time, the future of external protective coating for PCCP was looked into.

Keywords *: protective coating PCCP concret*

1. Foreword

Prestressed Concrete Cylinder Pipe (PCCP) was a kind of compound pipe. Cylinder was first Welded by thin steel plate and socket, then concrete was poured inside and outside the Cylinder, finally High Strength Steel Wire was wound on the Cylindrical Core and mortar protective layer was sprayed.

PCCP took on high intensity, high working pressure, good watertightness, impermeability and abrasive resistance. It had the advantage of both steel pipe and concrete pipe. PCCP was a high quality and low cost pipe. The service life of PCCP was more than twice as long as steel pipe. In use the body and socket would not burst like the iron pipe and reinforced concrete pipe.

PCCP was best suited to the production of large-diameter pipe which met the requirements of the city water diversion works, water supply systems, circulating water pipe in large thermal power plants and nuclear power stations, large sewage drainage pipes project. It could be used in the high water pressure, Large-caliber, long conduit project.

As a kind of new and high quality pipe, PCCP had been applied over half a century, it was first successfully developed in Bonna France. By the end of 20th century, the laying length of PCCP had been more than 29000 km only in the United States. PCCP was introduced to China from Ameron company USA by Shandong Eletric Power Pipeline Engineering Company in 1988. soon after other pipeline companies in Wuxi, Shenzhen and etc. set up factories with America equipment, and a Hohhot company also produced PCCP by domestic equipment. PCCP has been applied in some large water transfer and supply project in China. According to the statistical data in 2002, 700 km of PCCP had been applied in China, and the trend has rapidly increased.

According to the information, many incidents had occurred in the laying PCCP pipeline of U.S. in the recent 50 years. A 17 km PCCP pipeline with DN 1600 was reported Cracking after a few years running in the United States "Materials Performance" 1992/5. American Concrete Pressure Pipe Association (ACPPA) attaches great importance to the cause and mechanism of destruction of PCCP pipeline. In the technical report they said that most of the damage was ascribe to the corrosion of prestressed steel caused by the external environment in the 118 reported incidents.

At present, the anticorrosion measures and techniques for PCCP were less dealed with in domestic industries, and there was no report on the practical application. In

† Corresponding author: lz7058@163.com

this case, we developed a kind of protective coating which had high strength, good impermeability and anticorrosion, convenient applicability for concrete pipe.

2. Research on coating

The paint film forming material is very important. There were a large number of polar groups such as hydroxyl and ether in the epoxy resin molecular structure. In the curing process strong chemical bonds formed by reactions of lively epoxy groups with interface metal atoms. There was excellent adhesion between the substrate and coating. The coating was hard, flexible and corrosion-resistant as strong polar aliphatic hydroxyl groups and anti-hydrolytic ether bond in structure. coating. The resins suitable for the preparation of solvent-free coating were generally low-molecular-weight liquid epoxy resins, such as E-44, E-42, E-51, of which E-51 had the lowest viscosity.

Due to the high viscosity, liquid epoxy was hard to construction, and reactive diluents were required in use to reduce the viscosity. Reactive diluents contained epoxy groups which participated in the curing reaction and became an integral part of the curing coating.

The coal tar pitch had very complex components, with extremely stable chemical nature, excellent water resistance, humidity resistance, chemical resistance, anti-microbial corrosion, and comprehensive performance better than asphalt. In addition, epoxy had better compatibility with aromatic polymer than with aliphatic polymer. Therefore we chose coal tar pitch.

Common epoxy curing agent include aliphatic amine adduct, polyamide resin, phenolic amine, etc. Suitable curing agent was identified by the study on several different types of curing agent from different manufacturers as the spot requirements.

It could be seen from Table 5 that the coating showed good performance when the ratio of E51 and T1+K1 was between 100: 40 ~ 45, and specific ratio could be adjusted according to spot temperature.

Generally, the impact of inorganic filler on the coating

Table. 1. Impact of the proportions of E51 and T1+K1 on coating properties

No.	E51: (T1:K1 = 8:2)	Tack-free time, min	Hard drying time, h	Hardness, H	Evaluation
1	100 : 35	50	8	4H	Common
2	100 : 40	40	5	5H	Good
3	100 : 45	30	3	5H	Good
4	100 : 50	40	8	3H	Common
5	100 : 55	60	10	2H	Bad

Table. 2 Impact of Filler ratios on anti-corrosion properties of coating

Formula No / properties	1#	2#	3#	4#
sericite content, %	8	16	24	32
talc content, %	32	24	16	8
Salt fog resistance	2000h	4000h	4000h	4000h
Adhesion, MPa	5	8	8	6
abrasive resistance (1000g, 1000r), mg	88	76	72	84

strength and permeability was associated with the physical shape of the fossil. General decreasing order as follows: flake 〉 ibrous 〉 columnar 〉 granular. We chose sericite and talc as two different shapes filler for the trial.

It was showed that the salt fog resistance could be greatly improved when sericite was added to the coating. It was because that the sericite crystal took on 2D sheet, no matter thin to what extent. Sericite laid parallel in the coating, thereby prolonging water vapor infiltration trails; Additionally there were active hydroxyl groups in sericite, which were easy to combine and wrap with the molecular chain of reactive diluents, then paralleled and overlapped in the coatings. So a dense layer network structure was

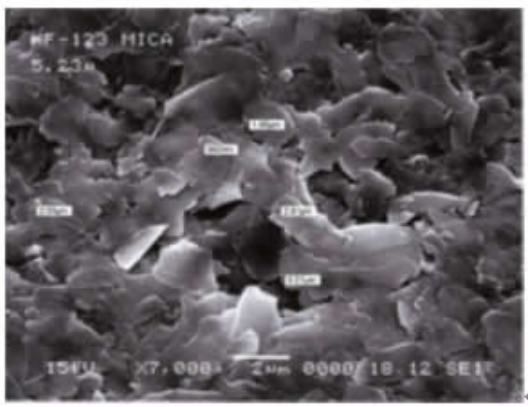

Fig. 1. Electron microscope photograph of sericite

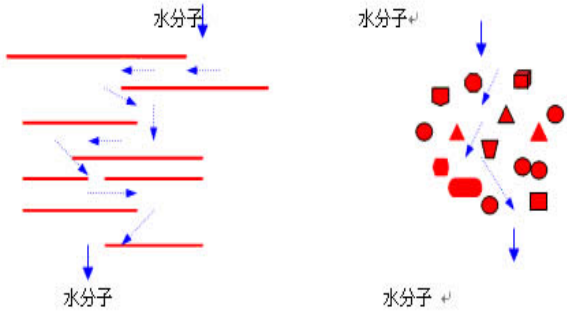

Fig. 2. Water penetrating way in different coatings

Table. 3. properties of solvent-free epoxy coal tar coating and coatings

No.	Items	Indexes
1	Apperance	no blister, crack and breaking off
2	Tack-free time (h, 3℃±2℃)	0.5
3	Hard drying time (h, 23℃±2℃)	1.5
4	Desity, g/ml	1.375
5	Solid content	96.2%
6	Adhesion, MPa	6.8
7	Resistanceto impact, J	4.1
8	DFT, μm	≧900
9	Pencil hardness, H	5
10	Salt fog resistance	4000h no blister, crack and breaking off
11	Corrosion resistance	90d no blister, crack and breaking off
		30d no blister, crack and breaking off
		30d no blister, crack and breaking off
12	Abrasive resistance, g (750g, 1000r)	0.089
13	Cl-permeability coefficient, $mg/cm^2.d$ (30d)	3.06×10^{-3}
14	Volume resistance, Ω·m	2.0×10^{14}
15	dielectrical strength, MV/m	26.4

formed in the coating, thereby the mechanical properties, anti-permeability and anti-corrosion of coating were greatly enhanced.

The physical and chemical properties of paint and coatings developed were showed in Table 3.

3. Field detection methods

There was no standard on epoxy coal tar coating for PCCP pipeline in China. And conventional field detection methods for anti-corrosion coating including magnetic seizure thick and EDM detection methods could not apply to the PCCP pipeline because of the substrate specificity. Therefore, we propose the following field detection methods.

3.1 Inspection on anticorrosion pipe

Anticorrosion pipes were visual inspected one by one, and the coating should be smooth, uniform thickness, no pinholes, no holidays and free from cracks.

3.2 Dry film thickness inspection

The coating thickness was inspected by ultrasonic thickness gauge after coating completely cured. Selective check should be given in every 10 pipes and no be less than 20 points of each pipe.

3.3 Anticorrosion coating adhesion inspection

After the coating cured, adhesion of the sampling anti-corrosion pipes was measured by GB/T5210 "Determination of adhesion of coats- Pull-off".

3.4 Anticorrosion pipe resistivity inspection

resistivity of curing coating was measured by rhometer, the wet sponge drip with 5% saline used as measuring head, another grounding. resistance of coated pipe should be 100 times more than exposed concrete pipes, Inspection should be given in every 10 pipes and no be less than 10 points of each pipe.

4. Application of coating

The solvent-free epoxy coal tar coating developed was used on the DN4600 mmPCCP Pipeline in Nan Shui Bei Diao water supply project (Beijing). By the end of November 2006, about 1800 m PCCP had been coated,

Fig. 3. Spray operation

Fig. 4. Coated PCCP pipeline

and the coating quality met the requirements of the relevant standards for Nan Shui Bei Diao. Through field detection testing, the coatings which met all the technical requirements of the contract, were praised by the owners and supervision. At present field application is still underway.

5. Conclusion

For the advantage of PCCP, the application took on increasing trend at home and abroad. However the anti-corrosion coating and coating technology of PCCP was immature due to the lack of systemic research. Therefore, the outer anti-corrosion coating technology we developed had broad application prospects.