Study on Water Based Ultra-thin Fire Resistive Coating for Steel Structure and the Fire Resistance Test

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Abstract. A water based ultra-thin fire resistive coating for steel structure was researched. The coating was coated on I40b I-beam with APP as the main flame retardant and titanium dioxide as filler. The full-scale fire resistance test was carried out according to the China standard GB 14907-2002. The results shows that the resistive of the water based steel structure fire resistive coating can reach 1.2h when the thickness is about 2mm. Related research shows that water based steel structure fire resistive coating can be used as an effective fire-resistant material for steel structure.

1. Introduction
Water based ultra-thin fire resistive coating for steel structure is a new type of fire resistive coating. It is applied on the surface of steel components in buildings and structures. When it is exposed to fire, the coating expands rapidly to form a carbonized fire-resistant and heat-insulating protective layer, thereby improving the fire resistance of steel structure.

Compared with traditional oil-based fire resistive coatings for steel structures, water based ultra-thin fire resistive coatings for steel structures are environmentally friendly, non-toxic and non-polluting. In addition to thin coating thickness, smooth coating surface and good decorative effect, the product also has a white coating color and no chemical reaction with any anti-corrosion primer[1-5]. It is the preferred product for fire-proof coating and fire-proof protection of steel structural components (especially tubular steel components) in various industrial and civil construction projects. It has developed rapidly in recent years.

A water based ultra-thin fire resistive coatings for steel structures using APP as the main flame retardant and titanium dioxide as filler was studied. The full-scale fire resistance test was carried out according to the national standard GB 14907-2002.

2. Formulation of water based ultra-thin fire resistive coating
Table 1. Materials and Formulation of the coating.

| No. | Material name       | Formulation |
|-----|---------------------|-------------|
| 1   | Titanium dioxide    | 150         |
| 2   | APP                 | 475         |
| 3   | Melamine            | 175         |
| 4   | Pentaerythritol     | 180         |
| 5   | Water               | 480         |
| 6   | Emulsion            | 480         |
| 7   | Other auxiliaries   | 80          |

3. Full scale fire resistance test

3.1. Substrate and coating

According to the Chinese national standard GB 14907[6], the fire resistive coating for steel structures should be coated on the surface of I-beam before testing. The I40b I-steel beam with a length of 5200 mm is used as the base material of beam.

After the rust removal of the substrate steel beam, the epoxy zinc rich primer was coated on the surface of the beam with a thickness of about 0.1mm. After coating, the sample is maintained indoors for 3 months at a temperature of 10-30 °C and a humidity of 10-70%. The average thickness of the coating was 2.84mm before the fire test.

![Figure 1. The beam with coating before the fire test.](image)

3.2. Loading before fire test

Installation of fire test carried out according to GB 14907-2002. In the fire test, the steel beam is simply supported with a span of 5000 mm(L0). The steel beam is subjected to vertical downward force. The load is simulated uniformly and the total load is about 227 kN. Schematic diagram of steel beam and loading is shown in Figure 2.

![Figure 2. Schematic diagram of steel beam loading](image)
There is no structural connection between concrete plate and steel beam during testing. The Cross-section of the I beam and concrete slab is shown in Figure 3.

3.3. Fire test
The fire test was carried out in the fire test Laboratory of Qingyuan Branch of Guangzhou Building Materials Institute Limited Company. The refractory test was carried out in a horizontal furnace with an internal dimension of 4500 mm long, 3000 mm wide and 1500 mm high.

The test photo is shown in Figure 4 to Figure 11.
The temperature of the fire test was carried out in accordance with GB/T 9978.1-2008[7]. The time-temperature curve and the time-deformation curve of the midpoint beam span is shown in Figure 12 and Figure 13.

3.4. Result of the fire test
According to GB 14907-2002, when the midpoint deformation of the beam span exceeds 1/20 of the span, it indicates that the beam has lost its fire resistance. The midpoint deformation of the steel beam is 222 mm at 72 min and 269 mm at 73 min. The fire resistance of the steel beam is 72 min.

The fire resistance of steel beams without coating is 15 min, and the fire resistance of steel beams coated with water based ultra-thin fire resistive coating reaches 72 min, indicating that the water based ultra-thin fire resistive coating have a significant effect on the fire protection of steel structures.
4. Conclusion
The results show that: 1) When the coating thickness is 2.84 mm, the fire resistance of the steel beam coated with the water-based ultra-thin fire resistive coating can reach 72 min; 2) water-based ultra-thin fire resistive coating can have effective fire resistance to steel structure.

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