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Corrosion of Metals and Alloys - Test Method for Determining Susceptibility to Stress Corrosion of Steel Reinforcement in Simulated Marine Environment

金属和合金的腐蚀 模拟海洋环境中钢筋应力腐蚀敏感性试验方法

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1 Scope

This document specifies the principle, test solutions, specimens, test procedures and test report of the test method for determining susceptibility to stress corrosion of steel reinforcement in simulated marine environment.

This document is applicable to the test of susceptibility to stress corrosion of steel reinforcement in simulated marine environment, such as: atmospheric areas, splash areas, tidal range areas (water-level change areas) and seawater immersion areas, etc., under concrete pore fluid conditions, using constant-load uniaxially loaded tension and slow strain rate methods.

2 Normative References

The contents of the following documents constitute indispensable clauses of this document through the normative references in the text. In terms of references with a specified date, only versions with a specified date are applicable to this document. In terms of references without a specified date, the latest version (including all the modifications) is applicable to this document.

GB/T 1499.1 Steel for the Reinforcement of Concrete - Part 1: Hot Rolled Plain Bars

GB/T 1499.2 Steel for the Reinforcement of Concrete - Part 2: Hot Rolled Ribbed Bars

GB/T 10123 Corrosion of Metals and Alloys - Vocabulary

GB/T 15970.1 Corrosion of Metals and Alloys - Stress Corrosion Testing - Part 1: General Guidance on Testing Procedures

GB/T 15970.4 Corrosion of Metals and Alloys - Stress Corrosion Testing - Part 4: Preparation and Use of Uniaxially Loaded Tension Specimens

GB/T 15970.7 Corrosion of Metals and Alloys - Stress Corrosion Testing - Part 7: Slow Strain Rate Testing

GB/T 16825.1-2022 Metallic Materials - Calibration and Verification of Static Uniaxial Testing Machines - Part 1: Tension / compression Testing Machines - Calibration and Verification of the Force-measuring System

6 Specimens

6.1 General Requirements

6.1.1 Steel reinforcements that comply with the stipulations of GB/T 1499.1 and GB/T 1499.2 shall be adopted. Generally, the cross-section of the steel reinforcements is circular, the surface of the steel reinforcements is smooth round or ribbed, and the specifications are 6 mm ~ 50 mm.

6.1.2 If the testing machine satisfies the requirements, it is recommended to use raw materials of steel reinforcements for testing. The recommended specimen specifications are 16 mm, and the length is 2,000 mm. The clamping ends of the steel reinforcements can be machined to satisfy the requirements of the testing machine. The surface of the parallel lengths between the clamping parts shall not be machined in any mode.

6.1.3 Through negotiation between two parties of the test, the surface of the steel reinforcements can also be cut. During process, the effect of external stress concentration shall be avoided, and the shape and size of the specimens shall comply with the requirements of GB/T 15970.4.

For example, after machining of the steel reinforcements with specifications of 16 mm, the gauge length of the specimen size can be 50 mm, and the cross-sectional size is 10.0 mm. Small cross-section specimens can also be used, with the gauge length greater than 10 mm and the cross-sectional size less than 3.0 mm.

6.1.4 Before the test, the appearance of the specimen shall be inspected to ensure that there are no visible cracks or other defects that may affect fracture.

6.1.5 The quantity of specimens is generally 3 ~ 5, or as specified in relevant product standards or as negotiated between both parties of the test.

6.2 Specimen Preparation

For the treatment of the steel reinforcements, use 10% sulfuric acid to wash them for 10 min ~ 15 min at room temperature of 10 °C ~ 35 °C, and use distilled water or deionized water to rinse them, until the surface reveals the true metal color; use hot air from a hair dryer to blow-dry them.

The raw material specimens of the steel reinforcements shall be protected by anti-corrosion methods, for example, painting, for at least 50 mm long when they enter the container.

The specimens should be marked with a permanent identification mark or number. In order to avoid affecting the test results, pay attention to the position of the mark on the specimens and keep it as far away from the test area as possible.

During specimen preparation, overheating or overpressure shall be avoided, otherwise, it will cause residual stress or metallurgical changes on the surface. Heat treatment, chemical polishing or electropolishing can be used to overcome this effect under certain circumstances. Care shall

also be taken to reduce contamination of the surface by polishing residues.

Other requirements shall comply with the stipulations of GB/T 15970.1 and GB/T 15970.4.

7 Stress Corrosion Test by Constant-load Uniaxially Loaded Tension

7.1 Selection of Corrosive Solution

In accordance with the purpose of the test, and the requirements of Chapter 5, select and prepare the corresponding test solution. The test solution must be prepared immediately before use and cannot be reused.

7.2 Test Procedures of Raw Material Specimens

7.2.1 Test devices

7.2.1.1 Test container

The material of the test container shall be resistant to corrosion by the test solution at 60 ° C. Structural materials in contact with the test shall not be affected by corrosive agents, so as to avoid contaminating the solution and changing the corrosiveness of the solution. When feasible, the use of inert materials is recommended. The container shall remain closed during the test and avoid the ingress of air.

The container shall be cylindrical, and the inner diameter shall be designed to ensure that the specimen in contact with the solution contains at least 5 mL of solution per 100 mm^2 of surface area.

The container shall be of sufficient length, so that the test length immersed in the solution is not less than 200 mm. The container shall be designed so that the specimen can pass through it, meanwhile, the end of the specimen shall be thoroughly exposed outside the container, so as to allow tensile force to be applied.

The schematic diagram of the test container is shown in Figure 1.

influence of the external stress.

7.2.6 Termination of test

When the specimen breaks, the test is completed. The specimen shall be removed in time, so as to protect the fracture. If necessary, observe the fracture.

After the test has been proceeded to the specified time, even if the specimen is not broken, the test can be terminated. At this moment, the specimen may contain cracks, but they have not yet expanded to the extent of complete fracture. All unbroken specimens shall be inspected for cracks. Use clean water to wash the surface residue on the specimens and use hot air from a hair dryer to blow-dry them. At a magnification of 8 ~ 16 times, conduct visual inspection, select the most severely corroded area, and record the number of cracks with a length of 1 cm or above on the surface of the specimens. Alternatively, take a cross-section of the most severely cracked area and measure the length of the longest crack. If necessary, use a metallographic microscope or scanning electron microscope for measurement.

If it is necessary to remove corrosion products on the surface of the specimen, the method described in GB/T 16545 can be used.

For specimens without cracks, carry out a tensile test on the solution immersion area of the cut specimen and the steel reinforcement after the comparison test without external stress under the same conditions, compare the tensile strength and elongation after break, and respectively record the differences as the residual strength and the residual elongation after break.

NOTE: at the end of the test, the comparison specimen of steel reinforcement without external stress shall not break, otherwise, this test condition is not applicable to the test of susceptibility to stress corrosion.

7.3 Machined Specimen Test

The loading requirements and test time of the machined specimens shall comply with the requirements of 7.2.2, the test temperature shall comply with the requirements of 7.2.4, and other requirements shall comply with the stipulations of GB/T 15970.4.

7.4 Result Assessment

The assessment of the test results are as follows:

a) When the specimen breaks, the susceptibility to stress corrosion can be expressed by the time it takes for the specimen to completely break;

b) If the specimen is not broken, the test results can be assessed by the number of cracks with a length of 1 cm and above on the specimen surface, and the length of the longest crack.

c) If the specimen is not broken, the corroded steel reinforcement can also be subject to a tensile test, and the test results can be assessed by the residual strength and residual

elongation after break.

8 Stress Corrosion Test by Slow Strain Rate

8.1 Test Device

Use a stress corrosion testing machine that can control the tensile rate to 10^{-3} S^{-1} ~ 10^{-7} S^{-1}, or improve the tensile testing machine. The specimen is connected to the two clamps of the testing machine through the corrosion tank. The various tensile parameters, such as: load, displacement and time, etc., are controlled and collected by a microcomputer system connected to the testing machine.

8.2 Test Procedures

The steel reinforcement specimens are machined and prepared in accordance with the requirements of Chapter 6. The test may be conducted under open circuit conditions, or cathodic polarization may be applied to the specimens through constant potential or galvanostatic methods. After the specimen breaks, the specimen shall be removed in time to protect the fracture, and if necessary, observe the fracture. The other steps shall be carried out in accordance with the requirements of GB/T 15970.7.

8.3 Non-solution Environmental Test

Carry out the test in a general atmospheric environment, without adding corrosive solution and without controlling the test temperature. Other test conditions are the same as the requirements for the test of steel reinforcement specimens.

8.4 Result Assessment

The susceptibility to stress corrosion can be assessed by comparing identical specimens exposed to the test environment with those exposed to a non-solution environment. The farther the ratio deviates, the higher the susceptibility to cracking. The ratio calculation method shall comply with Formula (1).

$$\text{Ratio} = \frac{\text{Results of the specimens obtained in test environment}}{\text{Results of the specimens obtained in non-solution environment}} \quad \cdots\cdots (1)$$

The results can be expressed by one or multiple parameters at the same initial strain rate:

---Break time;

---Plastic strain at fracture;

---Ductility, which is assessed by percentage reduction of area or elongation after break;

---The maximum load reached.

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