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Influence of corrosion morphology on the Fatigue strength of Bolted joints

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Abstract

This note summarizes some recent investigation results on the behavior of corroded steel bolted joints under uniaxial fatigue loading. Fatigue test specimens, were made up using S355 structural steel plates joined together with preloaded M12 bolts of class 10.9 with a geometry that corresponds to the $\Delta\sigma$ = 112 MPa EC3 detail category.
The accelerated corrosion process was accomplished using an electrolyte consisting of an aqueous 5% NaCl solution whereby the specimens were treated. In particular, during the corrosion process specimens were repeatedly immersed for 2 minutes in the electrolyte and then removed keeping them 60 minutes long in free air at 35 °C.
An atmospheric corrosion in marine-industrial environment is well-represented through corrosion test. Fatigue loading tests and surface morphology measurement of uncorroded and corroded specimens were performed and the results were compared.

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Keywords: Corrosion Fatigue, fatiuge tests, fatigue and material degradation, bolted joints

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1. Introduction

In civil engineering, the structures most affected by mechanical fatigue are steel railway bridges that are subjected to a large number of traffic load cycles during their service life. In this type of structures, the most critical elements from the point of view of fatigue strength are the connections between the members; the irregularity of the connections geometry is one of the factors that affect the fatigue life of these structural elements. Another important factor of great influence on the fatigue strength of bridge structure is the material degradation. In particular, corrosion phenomenon is perhaps one of the problems that most affects the integrity of metal structures in all countries.

In this context, understanding the corrosion effects on the fatigue life of steel structures is becoming a topic on which research is investing.

Aim of this paper is to investigate the influence of the corrosive phenomenon on the fatigue strength of a friction type joint made of high strength preloaded bolts (M12 class 10.9). To work out these analyses the fatigue behaviour of virgin bolted joints (without any degradation effect) and the behaviour of the same joints, (having the same geometric and material properties) after corrosion effects were compared.

To make so, an accelerated corrosion process was carried out on a lot of n. 10 specimens. At the end of the procedure, it was possible to perform fatigue tests (R=0) to plot the S-N fatigue curve of uncorroded and corroded specimens.

Nomenclature

k	Inverse slope of the S-N curve
$\Delta\sigma_C$	Stress range at 2 million cycles of the detail category
$\Delta\sigma_R$	Stress range (independent variable)
N_R	Number of cycles (dependent variable)

2. Accelerated corrosion process

2.1. Material and geometric properties of the specimens

The structural detail under investigation is a slip resistant bolted joint made with high strength preloaded bolts (with geometry carried out from Berto et al 2016). In particular, two plates of 10mm thickness, 40mm width and 229.5mm length are longitudinally joined by means of two cover plates and n.6 M12 class 10.9 bolts tightened with a torque of 91Nm (Figure 1). The plates are made of S355 structural steel with drilled holes. All the plates were treated with a SA3+ sandblasting process that guarantees a white metal cleaning and consequently a quite uniform friction coefficient equal to 0.5. In regard the friction, between the bolt shank, the nut and the bolt washers, the manufacturer's technical data sheet was considered, which provides a friction coefficient value equal to 0.128.