Fe(O,OH)$_6$ Network Nanostructure of Rusts Formed on 3 mass% Ni-added Weathering Steel (III)

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Introduction

Improvement of the corrosion resistance of steel without coating is very important from the viewpoint of life-cycle assessments of materials. Weathering steel (WS) has been developed for the application to bridges without coating. WS, containing a 0.3-0.7 mass% Cr and Cu, forms a protective rust layer after a few years of corrosion in atmosphere and shows a good corrosion resistance [1,2].

However, a conventional WS shows a good corrosion resistance only when it is exposed to atmosphere containing little air born salt. A new type of WS (the advanced WS) was developed; the addition of 3 mass % Ni increases the corrosion resistance by a factor more than 10 [3]. In this study, the mechanism has been investigated using X-ray absorption fine structure (XAFS) with a special attention to effects of nickel and copper addition on the formation of rust at early stage of corrosion.

Experiments

XAFS in situ measurements were performed for a block specimen of the advanced WS (3.0Ni-0.4Cu-Fe in mass %) [5,6]. The surface of the specimen was covered with a thickness of ca. 20 µm of diluted artificial seawater and then dried in air at 300 K. One wet-dry cycle was about 90 min. XAFS spectra of rusts were measured in the florescence geometry using a 19-element SSD [4]. XAFS measurements were carried out at BL-9A and 12C at PF, KEK, Tsukuba, Japan.

Results and Discussion

XAFS spectra were measured during the wet-dry cycles around Ni and Cu [5,6,7]. Before corrosion begins, Fe, Ni and Cu atoms are in a solid solution (an alloy). As corrosion progresses, RDF around Ni shows additional peaks, which indicating that nickel atoms substitute iron atoms in the “16d” sites in Fe3O4 to form Fe2NiO4 (Fig.1). Cu atoms form CuO during corrosion.

The detailed analysis showed that formation of Fe2NiO4 and CuO alter the evolution of “Fe(O,OH)$_6$ network [1,2] during corrosion (Fig. 2). This results in formation of rust composed of fine grains negatively-charged, which prevents chloride ions penetrating from the outer into the inner layer, and enrichment of chloride ions is suppressed [8,9]. The good corrosion resistance of the advanced WS can be attributed to these unique structures of the protective rusts.

References


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