

## Fe(O,OH)<sub>6</sub> 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 fluorescence 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 Fe<sub>3</sub>O<sub>4</sub> to form Fe<sub>2</sub>NiO<sub>4</sub> (Fig.1). Cu atoms form CuO during corrosion.

The detailed analysis showed that formation of Fe<sub>2</sub>NiO<sub>4</sub> and CuO alter the evolution of “Fe(O,OH)<sub>6</sub> 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.

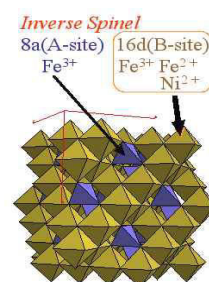


Fig.1 Atomic structure of Fe<sub>2</sub>NiO<sub>4</sub> composed of (Fe,Ni)O<sub>6</sub> octahedrons and FeO<sub>4</sub> tetrahedrons.

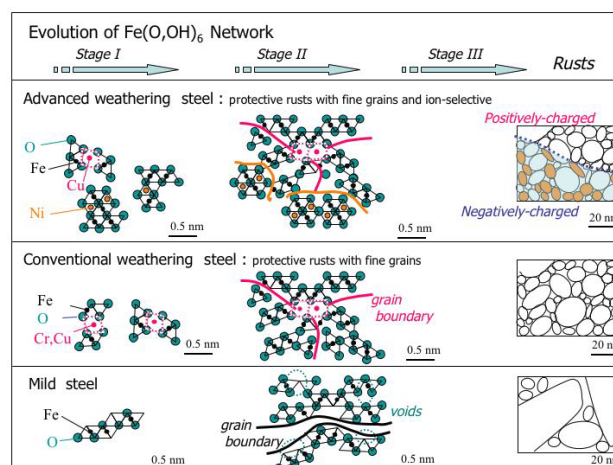


Fig. 2 Schematic diagram of the evolution of the Fe(O,OH)<sub>6</sub> nano-network of the rust formed on the advanced WS in an atmosphere containing relatively high air-born salinity (top), conventional WS in milder condition (middle), and mild steel in milder condition (bottom) [8,9].

### References

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