Ferritic Stainless Steels for Architectural Material*

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1 Introduction

SUS430 is a representative steel grade of ferritic stainless steel. But SUS430 is inferior in corrosion resistance, weldability and formability to austenitic stainless steels, such as SUS304 and SUS316, which are widely used in architecture. For this reason, ferritic stainless steels in general were not regarded as steels suitable for an architectural material. A series of highly corrosion-resistant ferritic stainless steels in which these disadvantages were eliminated were developed at Kawasaki Steel for use in an architectural material.

The features of these steels are described and examples of representative applications in construction work are presented.

2 Specifications and Features of Products

2.1 Chemical Composition

Chemical compositions of developed steels are shown in **Table 1**. These steels are designed to obtain the single phase of ferrite, even in welded portions, to prevent a decrease in the corrosion resistance in the heat-affected zone and to improve toughness and ductility. For these purposes, C and N contents of these steels are extremely low, with this being a characteristic of these steels.

2.2 Corrosion Resistance

An example of corrosion resistance of the developed steels is shown in **Fig. 1**. It shows the results of an exposure test in a coastal industrial area (exposure lasted for 1.5 years at a place 5 m away from a revetment in the Oihama district of Chiba City) and the results of pitting potential measured in a 3.5% NaCl solution at 70°C. RSX-1 and R445MT are designed to obtain the corrosion resistance equivalent to SUS304 and SUS316, respectively, in pitting potential, and moreover, the exposure test reveal that RSX-1 and R445MT have better corrosion resistance than SUS304 and SUS316, respectively. R24-2 and R30-2 show much more excellent resistance to corrosion compared with SUS316. Among four steel grades developed, R30-2 is suitable for the severest corrosive environment, and RSX-1 is suitable for a moderately corrosive environment in which SUS304 has been used until now. R24-2 and R445MT are used in an environment that falls somewhere between the two types of environment. Thus the four steel grades can be applied selectively according to the corrosiveness of the environment.

Table 1 Chemical compositions

(%)

Steel	C	Si	Mn	P	S	Cr	Ni	Mo	N
RSX-1	0.003	0.10	0.15	0.030	0.005	17.8	0.2	1.45	0.007
R445MT	0.004	0.10	0.15	0.030	0.005	22.0	0.2	1.50	0.005
R24-2	0.004	0.29	0.10	—	0.005	24.0	0.2	2.00	0.006
R30-2	0.003	0.13	0.11	0.020	0.004	29.6	0.1	2.09	0.006
SUS304	0.060	0.32	1.02	0.031	0.005	18.2	8.5	0.20	0.020

2.3 Surface Finishes

All of these steels have a "Silver Soft" dull finish in addition to the ordinary surface finishes applied (2B, BA, No.4, #400 and HL). Since "Silver Soft" has a fine

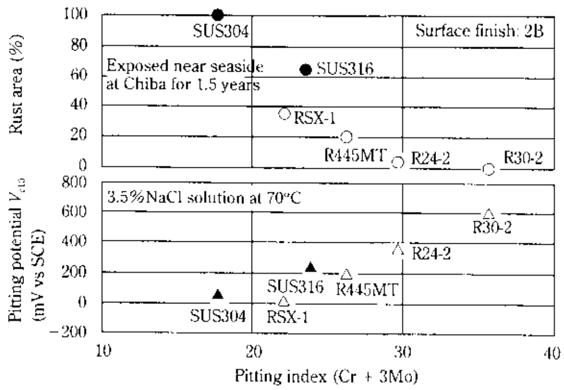

Fig. 1 Corrosion resistance of the developed ferritic stainless steels

* Originally published in *Kawasaki Steel Giho*, **30**(1998)2, 118–120

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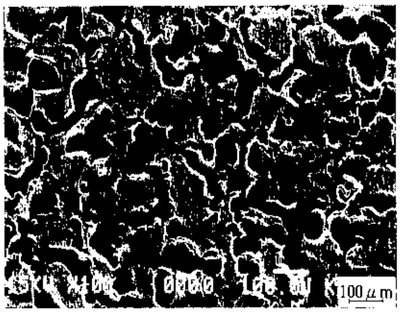

Photo 1 Surface of dull finish "Silver Soft" observed by SEM

Table 2 Mechanical and physical properties

Steel	YS (N/mm^2)	TS (N/mm^2)	El (%)	λ (W/mK)	α (K^{-1})	d (g/cm^3)
RSX-1	328	492	33	—	10.3×10^{-6}	7.75
R445MT	342	490	32	19.5	10.1×10^{-6}	7.68
R24-2	392	520	31	—	9.8×10^{-6}	7.66
R30-2	430	539	30	18.9	9.6×10^{-6}	7.64
SUS304	284	637	58	16.2	16.0×10^{-6}	7.93

λ: Thermal conductivity measured at 298 K
α: Coeffiicient of expansion at the temperature between 273K and 573 K
d: Density

and uneven surface, as shown in **Photo 1**, the steel can take on a matte tone with disminished luster.

2.4 Mechanical and Physical Properties

The mechanical and physical properties of the developed steels are shown in **Table 2**. These newly developed steels can be formed into panels, roofing members, etc. by ordinary bending, press forming or roll forming, although they have a higher yield strength and smaller elongation potential than SUS304. Furthermore, since the developed steels have smaller thermal expansion coefficients and greater thermal conductivity than austenitic stainless steels, the thermal strains due to changes of temperature in welding or atmospheric temperature change between day and night are small. Consequently, the characteristics make these ferritic stainless steels suitable for use in long panels and roofing.

3 Results of Use

The R30-2 stainless steel, excellent in corrosion resistance, was used in the metal panels that covered the roof of the passenger terminal building of Kansai International Airport (designed by Renzo Piano Building Workshop Japan, **Photo 2**), the first offshore airport in Japan. A total of about 1 000 t of Silver Soft finish steel sheets, 1.0 and 1.5 mm in thickness, was used.

In the standing seam roofing method, which is one of the methods used in making of large-scale roofs, the facing roof panels are required to provide good flexibility

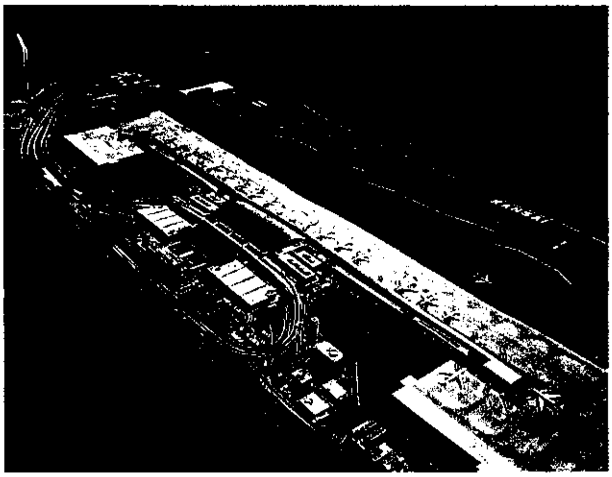

Photo 2 An aerial view of the passenger terminal building at Kansai International Airport: R30-2 panels of 1.0 and 1.5 mm thick cover the entire 90 000 m^2 roof of the building

of form because they repeatedly bend and unbend. Because of its ultra-low carbon and nitrogen contents, R30-2 is very ductile in seam welds and can be used in roofs constructed by the standing seam roofing method. The dome roof of the Aero Plaza (designed by MHS) in the Kansai International Airport was constructed by the standing seam roofing method. R30-2 sheets 0.4 mm thick with Silver Soft finish were used to make the roof material.

In addition to the above applications, R30-2 is used for the exterior walls of the Suntory Museum (designed by Tadao Ando Architect and Associated, **Photo 3**) at the Osaka Minami Port, the walls of the Public Hostel "Katsurahama-so" in the Kochi Pref., etc. These buildings are all situated near the coast, so this steel is required to provide high corrosion resistance.

R24-2 has better corrosion resistance than SUS316, and can be used in coastal regions subjected to relatively small amounts of chloride ion in the atmosphere. Representative applications of R24-2 are the roof of the passenger terminal building (desigend by Nikken Sekkei Ltd., **Photo 4**) at Niigata Airport and the dome of Herbis Osaka (designed by Takenaka Corp., **Photo 5**) near Osaka Station. The passenger building roof was formed by rolling. A total of about 150 t of 0.8 mm thick coils and steel sheets 1.0 ~ 1.5 mm thick were used. The latter dome was made by combining perforated panels and using about 40 t of 1.5 mm thick steel sheets.

R445MT is a modified R445 steel, which was used for the exterior of the Japan Convention Center (designed by Azusa Sekkei Co., Ltd.) and for the business center building and corridor of Kibi High Land City (**Photo 6**). About 130 t of R445MT steel was used to make the roof of a copper smelter works abroad.

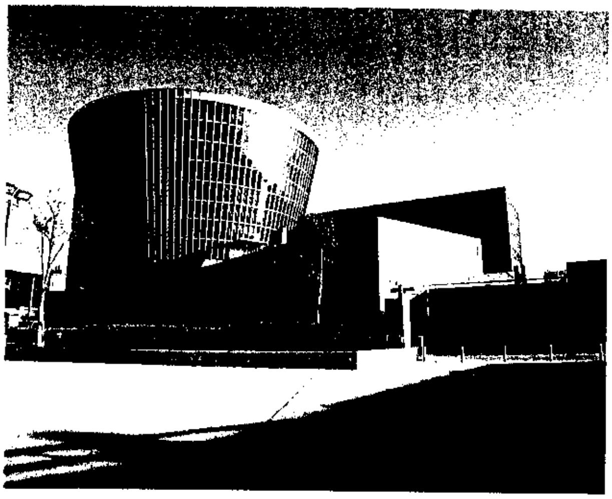

Photo 3 A perspective view of Suntory Museum: R30-2 panels of 1.5 mm thick have been used as outer wall

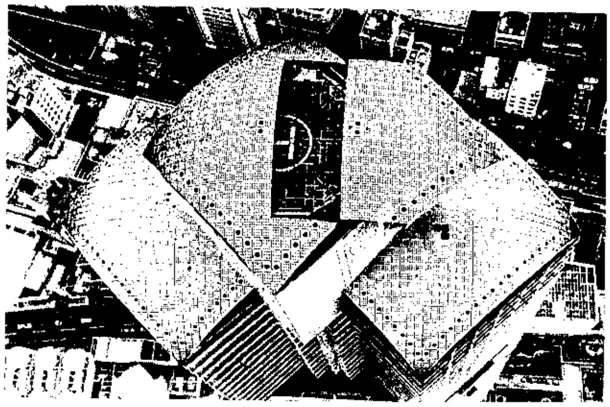

Photo 5 A bird's-eye view of Herbis Osaka: top of the building is covered with R24-2 puched panels (photo by courtesy of the Mainichi Shinbun)

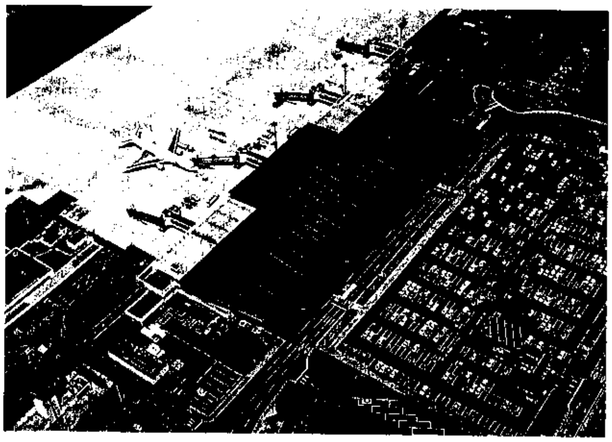

Photo 4 An aerial view of the passenger terminal building at Niigata Airport: the building is roofed with R24-2

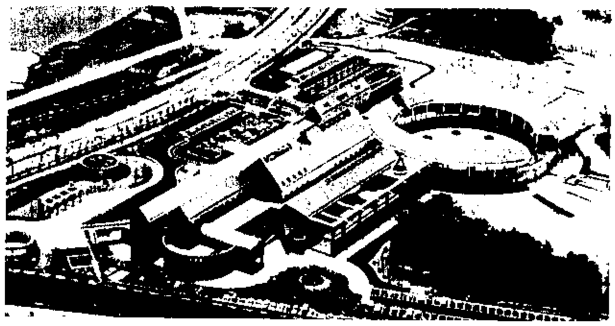

Photo 6 A perspective view of a business center building and corridor roofed with R445 panels in Kibi High Land City

RSX-1 is widely used to substitute for SUS304 used in the coated stainless steel roofs of the Japanese Railway station buildings, in the roof fixings for the Osaka City Dome (designed by Nikken Sekkei Ltd), etc.

4 Conclusions

R30-2 was used in making the passenger terminal building of Kansai International Airport. And word spread throughout the architectural field that there are highly corrosion-resistant stainless steels capable of being used even in coastal areas without resin-coating. At present, highly corrosion-resistant ferritic stainless steels are increasingly used in severe corrosive environments or in order to reduce thermal strains. The authors hope ferritic stainless steels, including the steel grades described in this paper, will be used more widely for architectural purposes.