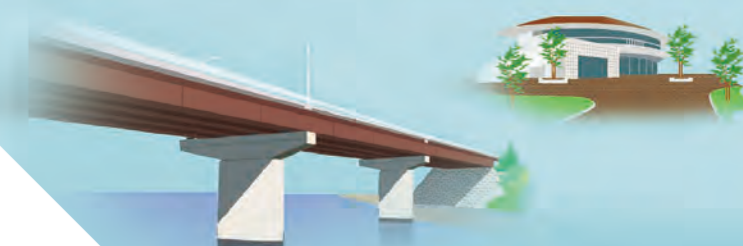


Corrosion-resistant Steel Plates



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Corrosion-resistant Steel Plates
A110en_04_202312f

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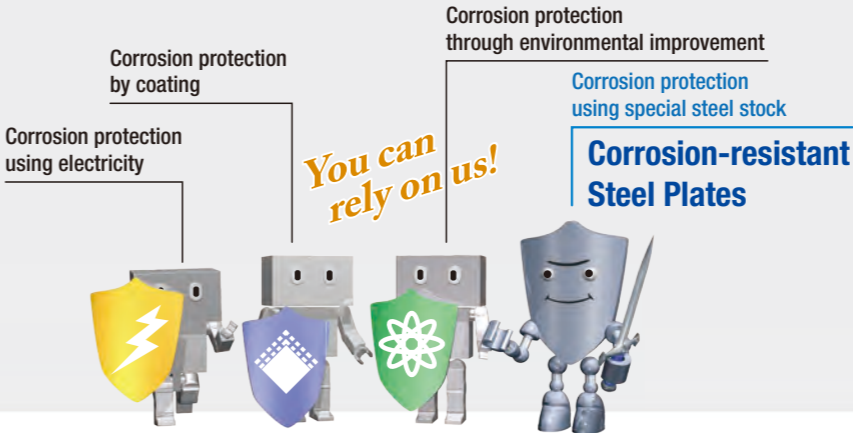
Corrosion (rusting)

We are surrounded every day by many steel objects in diverse shapes that are used for various purposes. A massive amount of steel is used in large structures (bridges, ships, vehicles, and buildings), oil well casings and pipelines, and automobiles and electric appliances. However, steel is intrinsically corrosive (rusty) if corrosion prevention measures are not employed.



Corrosion protection methods

There are roughly four corrosion protection methods: Coating, the use of special steel stock (with corrosion-resistant materials), the use of electricity, and environmental improvement. Each of them has its own characteristics such as the anti-corrosion effect, cost, workability, maintainability, etc., and is used on a case-by-case basis.



Corrosion-resistant Steel Plates

Corrosion-resistant Steel Plates are used as special steel stock for corrosion protection. They are steel materials with corrosion resistance improved by adding anti-corrosion elements (Cr, Cu, Ni, etc.) in an amount that most suits the environment in which the steel is used. Weather-proof steel, sulfate-resistant steel, etc., are available in accordance with the environment from which the object in need of an anti-corrosion measure is protected.

NIPPON STEEL
Corrosion-resistant
Steel Plate series

The Corrosion-resistant Steel Plates of NIPPON STEEL have been developed as a “shield” that protects the sustainability of steel structures from corrosion in both acid and neutral regions, atmospheric corrosion and dew-point corrosion, produced by various factors in diverse environments.

By selecting the Corrosion-resistant Steel Plate most suitable to the need that may vary according to the circumstances, the construction period and cost for maintenance can be reduced, effecting a significant life-cycle cost reduction.

- S-TEN™ P2
- NSGP™ P3
- NAW-TEN™ P4
- CORSPACE™ P5
- COR-TEN™ P6
- VINCOR™ P7

Acid region corrosion environments

Sulfuric acid/hydrochloric acid dew-point corrosion

- Exhaust gas treatment equipment at waste incineration facilities: >>> **S-TEN™ 1&2**
- Boiler air preheaters at thermal power generation facilities: >>> **S-TEN™ 1&2**

Acid corrosion

- Bottom plates and upper decks of crude oil tankers: >>> **NSGP™ 1&2**

Neutral region corrosion environments

Atmospheric/salt corrosion (coastal areas)

- Uncoated bridges and structures: >>> **NAW-TEN™ 12**
- Coated bridges and cranes: >>> **CORSPACE™**

Atmospheric/salt corrosion

- Building exteriors, bridges, towers in inland areas: >>> **COR-TEN™**
- Floors/walls designing: >>> **VINCOR™**

Acidic

Neutral

Alkaline

Sulfuric-acid/Hydrochloric-acid Dew-point Resistant Steel

S-TEN™

Applicable standard

NIPPON STEEL's
hot-rolled steel plates
comply with JIS G 3106.

S-TEN1 : SM400A
S-TEN2 : SM490A

Catalog QR code



Issues

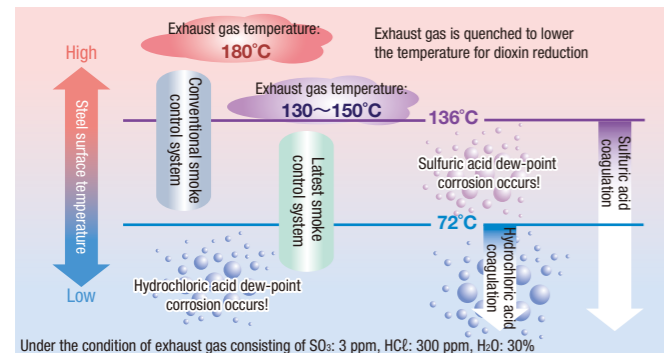
- Sulfuric acid dew-point corrosion due to fossil fuel-derived sulfur oxides.
- Hydrochloric acid dew-point corrosion derived from dioxins.

Effect of application

- Delivers superior performance against sulfuric acid/hydrochloric acid dew-point corrosion in smoke control systems of coal-fired boilers, waste incineration facilities, etc.

Hydrochloric acid dew-point corrosion of an inner cylinder of a chimney

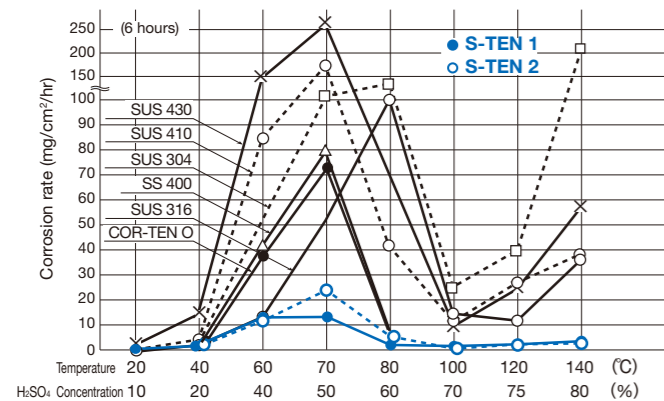
Mechanism of sulfuric acid/hydrochloric acid dew-point corrosion taking place in the smoke control system of a waste incineration facility



Has excellent corrosion resistance in a strong acid environment at low pH levels.

Sulfuric acid immersion test results in a vapor-liquid equilibrium state of sulfuric acid and the water system

- Under the conditions of 70°C and H₂SO₄ at 50%, S-TEN shows corrosion resistance of approx. five times that of conventional steel and approx. 10 times that of stainless steel.



Superior corrosion resistance is confirmed through a sulfuric acid immersion test.

Features

- S-TEN™ is NIPPON STEEL's original sulfuric/hydrochloric-acid dew-point resistant steel that has a long-term and excellent track record.
- More economical than stainless steel.
- It offers a wide variety of types including hot-rolled and cold-rolled steel plates, steel pipes, and weld materials.
- High accessibility is secured by steel product wholesalers that constantly have the product in stock.
- Comparable strength, workability, and weldability with those of conventional steel.
- Major prizes awarded
 - Ichimura Prize in Industry for Excellent Achievement (FY2006)
 - Award for excellence of Nikkei Excellent Products & Services Award (FY2003)

Has an excellent track record mainly in the area of smoke control systems.

Real machine test results

- The life extension effect of approx. five times that of conventional steel is confirmed in an air preheater of the steel pipe type for heavy oil-fired boilers.

Test subject		Air preheater of the steel pipe type for heavy oil-fired boilers at electric utility company K			
Test piece installation point		Used at the front of re-heater low-temperature tanks of the air preheater			
Test conditions	Exhaust gas temperature	124 ~ 130°C	Gas composition	SO _x	360ppm
	Sulfuric acid dew point	130°C		H ₂ O	Approx. 10%
	Metal temperature	70 ~ 80°C	Test time period	4,808 hours	
			Start and stop	35 cycles	
Test results	Steel type	Measurement value of reduced wall thickness due to corrosion (mm/4,808 hours)		Estimated annual corrosion amount (mm/year)	
		Maximum	Average		
	S-TEN 1	0.12	0.02	0.04 ~ 0.22	
	SS 400	0.62	0.25	0.46 ~ 1.13	

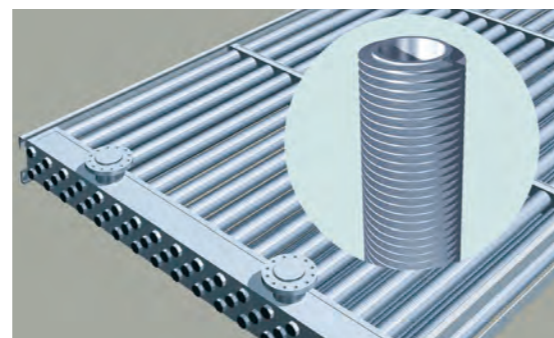
The effect is confirmed in a real machine exposure test as well.



Flue-gas desulfurization equipment in a coal-fired power station



City of Nagoya Environmental Affairs Bureau



Steel pipes for air fin coolers and fin tubes

High Corrosion-resistant Steel for Crude Oil Tankers

NSGP™-1&2

Applicable standard

Approved by classification societies as a corrosion-resistant steel product for cargo oil tanks.

Catalog QR code



Issues

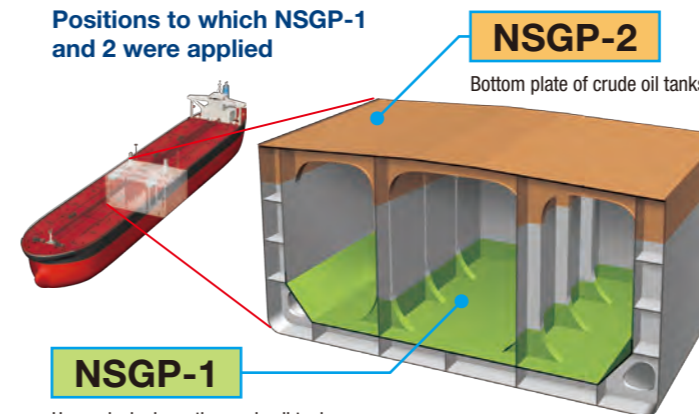
- Deep pits are formed in tank bottom plates.
- All surfaces of tanks under the upper deck corrode.
- Taking corrosion prevention measures for tanks was made obligatory in 2013.

Effect of application

- The frequency of pit forming in the bottom plate decreases to 1/15 of conventional steel.
- The corrosion amount under the upper deck decreases to approx. 60% of conventional steel.
- By eliminating the coating process, a reduction in construction cost and life-cycle cost can be achieved.

Pitting corrosion on the tank bottom plate of a crude oil tanker

Positions to which NSGP-1 and 2 were applied



NSGP-1

Upper deck above the crude oil tanks

NSGP-2

Bottom plate of crude oil tanks

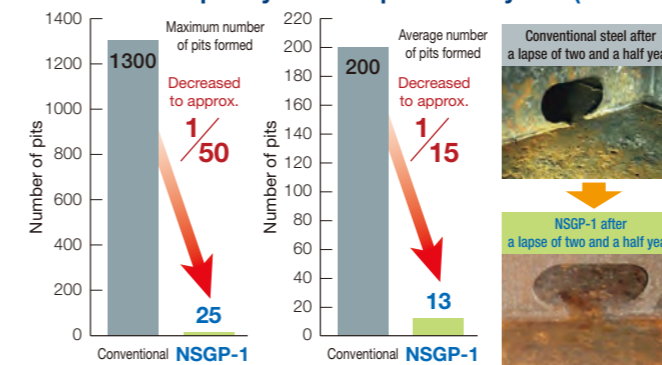
Produces corrosion reduction effect for COTs (cargo oil tank) of crude oil tankers.

Features

- NSGP-1 significantly delays the progress of pitting deep into bottom plates (pitting corrosion) attributable to salt water contained in crude oil.
- NSGP-2 significantly delays the corrosion expansion over all surfaces of tanks attributable to H₂S contained in crude oil, exhaust gas charged into tanks to prevent explosion, and dew condensation caused by the temperature gap between day and night.
- The corrosion resistance that is produced by the alloy components does not vary contrary to products with corrosion resistance provided by coating.
- Welding materials for exclusive use with enhanced corrosion resistance are also offered.
- Major prizes awarded
 - Ichimura Prize in Industry for Distinguished Achievement (FY2010)
 - Special Prize of Monozukuri Nippon Grand Award (FY2011)
 - Award for excellence of Nikkei Excellent Products & Services Award (FY2007)

Significantly suppresses the generation of pits and corrosion on all surfaces of crude oil tanks.

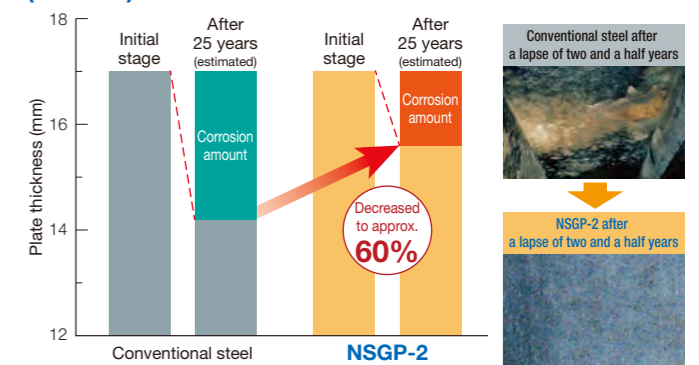
Comparison of pitting corrosion (4 mm deep or more) occurrence frequency after a lapse of five years (NSGP-1)



In ships that use conventional steel for tanks for five years, up to 1,300 pits of at least 4mm-deep per tank are formed from corrosion. In those that use NSGP-1 for tanks, the number of pits formed from corrosion has reduced to approx. 1/50 of those with conventional steel, or to approx. 1/15 on average.

The high performance of NSGP-1 and 2 has been confirmed in actual ships to which they have been applied.

Transition of the corrosion amount and comparison (NSGP-2)



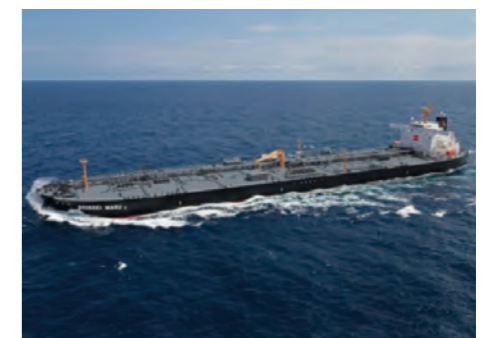
When the corrosion amount after 25 years is estimated from the results of the use of conventional steel and NSGP-2 in actual ships for eight years, it can be predicted that the corrosion amount of NSGP-2 can be reduced to approx. 60% of the corrosion amount of a ship with conventional steel in which the depth of a pit exceeded 2 mm.



VLCC/TAKAMINE (to which NSGP-1 was first applied)



VLCC/TSURUGA (to which NSGP-1 was applied)



Aframax tanker Shinsei Maru (to which NSGP-1 and 2 were applied at the same time)

Nickel-based High Weather-resistant Steel

NAW-TEN™

Applicable standard

NAW-TEN™ complies with JIS G 3114, with the chemical components excluded.



Issues

- Although the use of weather-resistant steel compliant with JIS (JISG3114) is desired, the Specifications for Highway Bridges, the Design Standard of Railway Structures, etc. (hereafter referred to as the "regulations") do not apply to the installation environment.

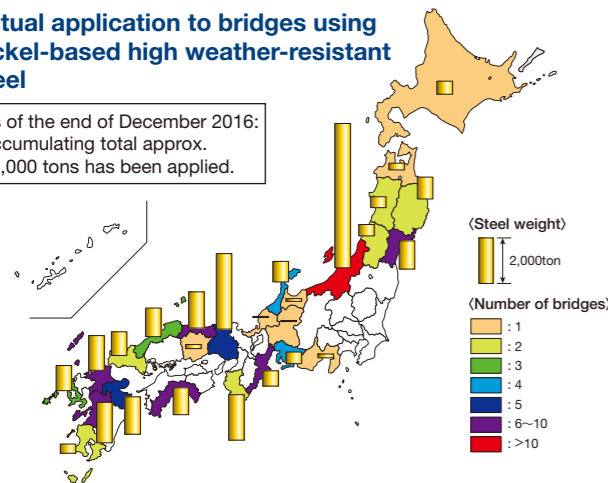
Corroding bridge (in an environment with severe salt injury)

Effect of application

- Displays superior weather resistance without coating even when installing the structure in an area not applicable to the regulations regarding weather-resistant steel compliant with JIS.
- The use with no coating is possible leading to LCC and VOC reductions.

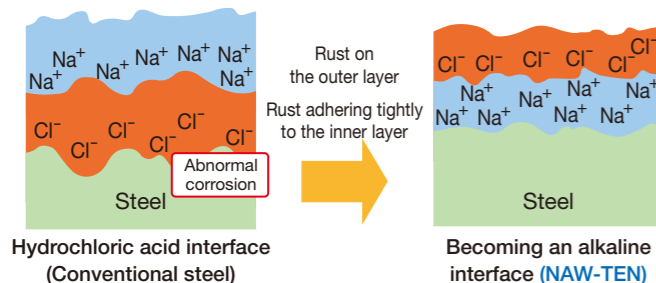
Actual application to bridges using nickel-based high weather-resistant steel

As of the end of December 2016: Accumulating total approx. 31,000 tons has been applied.



NAW-TEN™ has been applied to road bridges and railway bridges not applicable to the regulations of weather-resistant steel compliant with JIS.

Rusting mechanism control principle by alkalinizing the base steel interface



Rust has a two-layer structure; If the inner layer rust is stable and solid, the progress of corrosion is inhibited.

Conventional steel: Cl^- becomes hydrochloric acid, causing abnormal corrosion.
NAW-TEN: Na^+ becomes sodium hydrate, which is alkaline.

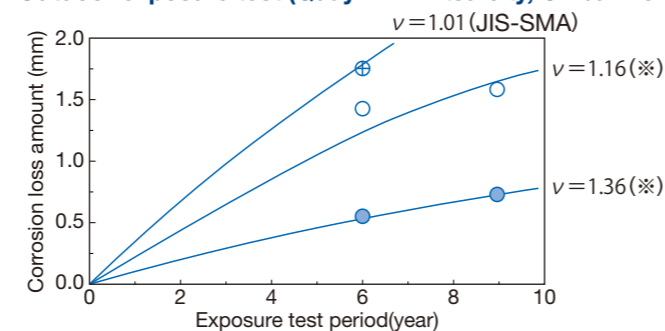
Cl^- detrimental to the formation of protective rust has concentrated in the outer layer rust.

Features

- Exhibits superior weather resistance without coating even in an environment not applicable to the regulation of weather-resistant steel compliant with JIS. (Applicable environment assessment is necessary.)
- Two types of steel that can be selected in accordance with the application environment and required performance are offered. (They comply with JIS with the components excluded.)
 - Lineup of products with tensile strength of 400–570 N/mm²
 - Welding materials and high-tension bolts for exclusive use are also included in the lineup
 - Comparable workability with that of conventional steel
- There are abundant application cases for about 20 years.
- Prediction of the corrosion loss amount is possible using the YOSOKU™ software.
- Major prizes awarded
 - Ichimura Prize in Industry for Distinguished Achievement (FY1999)
 - Excellence Prize of Monozukuri Nippon Grand Award (FY2009)
 - Tanaka Award in Excellence in Research Paper of the Japan Society of Civil Engineers Award (FY2005)

We offer products necessary for applicability evaluation technology and construction of steel structures.

Outdoor exposure test (Quay in Kimitsu city, Chiba Pref.)



※ A parameter to weather-resistant alloying elements (v value) is given by the following equation. Unit: mass%
 $v \text{ value} = 1 / \{ (1.0 - 0.16[\text{C}]) \times (1.05 - 0.05[\text{Si}]) \times (1.04 - 0.016[\text{Mn}]) \times (1.0 - 0.5[\text{P}]) \times (1.0 + 1.9[\text{S}]) \times (1.0 - 0.10[\text{Cu}]) \times (1.0 - 0.12[\text{Ni}]) \times (1.0 - 0.3[\text{Mo}]) \times (1.0 - 1.7[\text{Ti}]) \}$
 C. Miki, A. Ichikawa, M. Ukai, S. Takemura, T. Nakayama and H. Kihira: Proposal of Weather-resistant Alloying Parameters and Weather Resistance Assessment Methods, Journal of Japan Society of Civil Engineers, No. 738/1-64, pp 271-281, July 2003

NAW-TEN12 : v value ≥ 1.2

The corrosion loss amount is reduced compared to that of JIS weathering steel.



Hokuriku Shinkansen Hokurikudo Overbridge (Niigata Prefecture)



Uzu Viaduct Bridge (Nagasaki prefecture)



Azuma bridge (Nagoya city)

Corrosion Resistance Steel for Repainting Cycle Extension

CORSPACE™

Applicable standard

CORSPACE™ complies with JIS G 3101, JIS G 3106 and JIS G 3140.



Issues

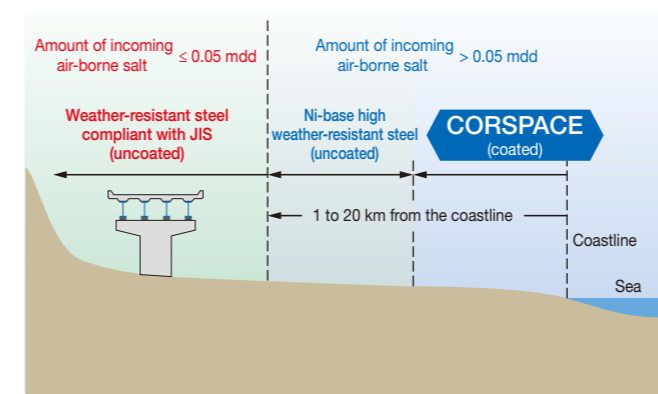
- Rusting from coating pinholes, deteriorated parts, etc.
- Rusting from the sharply angled part of a member

Peel-off of bridge coating (in an environment with severe salt injury)

Effect of application

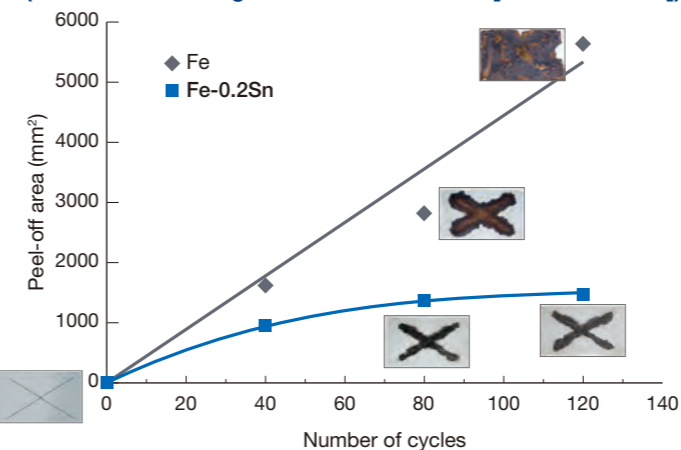
- In an environment in which salt damage is severe, extending the coating replacement period can lead to the reduction of maintenance cost and environmental load.

Concept of CORSPACE application to a bridge of Japan



Exhibits effect in coastal areas with severe salt injury.

Corrosion resistance properties (assessment through an acceleration test [SAE J2334 test])



The peel-off area of the flawed part is small; and corrosion is suppressed.



Kesenuma Bay Crossing Bridge



Hanshin Expressway Sambo Junction



Unloader

Advantages on order receipt, designing and manufacturing

- We can assist with the use of the NETIS registered technology (KK-150056-VR certified in January 2021) and in making technical proposals and construction performance rating.
- The standard extras are described as "Corrosion Resistance Steel for Repainting Cycle Extension" in the Kensetsu Bukka (Construction Research Institute) and Sekisan Shiryō (Economic Research Association).
- CORSPACE is listed as a "tin added steel" that can be used in Hanshin Expressway Company Limited "Part 2 Structural Design Standards (Bridge Edition)" (January 2021) and Metropolitan Expressway Company Limited "Bridge Structure Design/Construction Procedure" (June 2015).
- Complies with all JIS regarding steel products that are mainly used for bridges. The steel plate manufacturable range is also equivalent to that of conventional steel.
- Workability in cutting, bending, welding, etc., is comparable with those of conventional steel.
- Welding materials and bolts for exclusive use are offered.

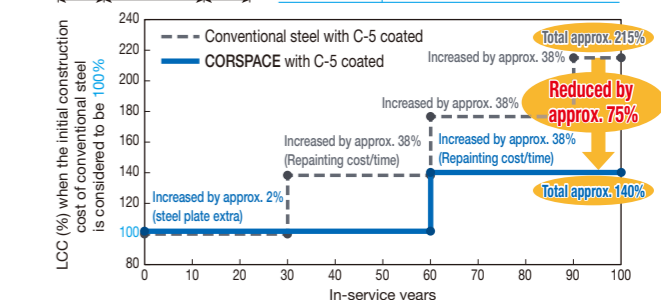


Provides point addition factors in assessment after completion when making proposals.

Concept of life-cycle cost reduction

3 span continuous twin plate-girder

Bridge type	3 span continuous twin plate-girder
Bridge length	121.0 m (37.0 + 46.0 + 37.0 m)
Total width	11.5 m
Total steel weight	187.3 t
Coated area	3,541 m ² (Repainting specification: Rc-I)



When the in-service years of the conventional steel with C5 coated in a salt damage environment is set to 30 years. When the repair/repainting is conducted for Rc-I coating on outer side of the girder.

Life-cycle cost can be reduced. Repainting frequency is reduced to once per 100 years.

High Weather-resistant Steel

COR-TEN™

Applicable standard

COR-TEN™ is equivalent to SMA400W to 570W for JIS G 3114, and SPA-H for JIS G 3125.

Catalog QR code

**Issues**

- Conventional steel requires coating to prevent corrosion, leading to the heavy burden of repainting and other maintenance and management costs.
- The use of steel in harmony with nature is desired.

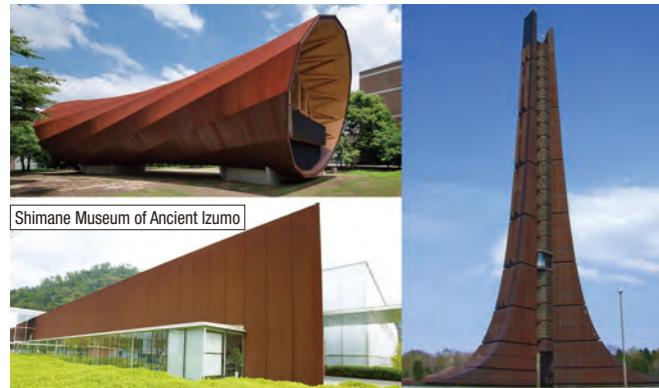
Effect of application

- The use without coating is allowed, which reduces repainting and other maintenance and management costs.
- The esthetic effect can be expected from the soft color of rust ("Beauty of Rust").



Daigo Fukuryu Maru Exhibition Hall

COR-TEN is a registered trademark owned by United States Steel Corp.

"Beauty of Rust" appearance change across the ages

Shimane Museum of Ancient Izumo

COR-TEN meets needs considering the scenery and for other aesthetic purposes.

Features

- COR-TEN is used without coating (including that of rust stabilization auxiliary treatment) to exhibit excellent weather resistance.
- The change of surface colors across the ages can be enjoyed.
- Coating is also possible in the same way as conventional steel. A repainting cost reduction can be expected by extending the cycle of repainting.
- The weldability and workability are comparable with those of conventional steel.
- Joining materials (welding materials and bolts) for exclusive use are also offered.
- Major prizes awarded
 - Otani Art Museum Prize (FY2011)

This weather-resistant steel has overcome rust as the biggest weakness of steel in a unique manner using rust to prevent rust.

Styling with uncoated COR-TEN

The soft color of the protective rust and the change across the ages provide the appearance with an excellent effect.



1969: At the time of completion

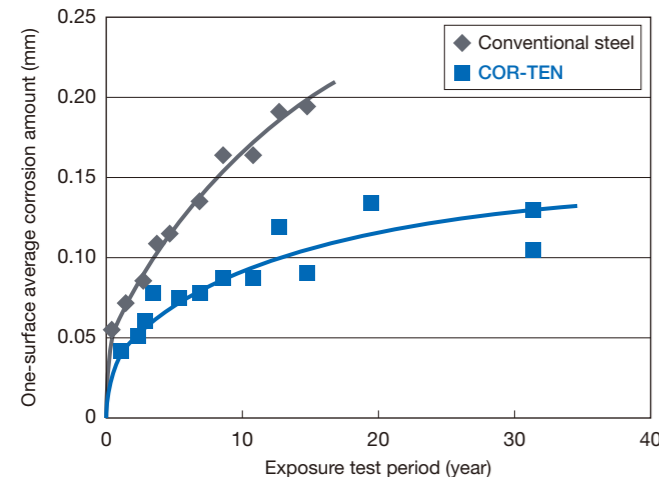


1973: After a lapse of four years



2010: After a lapse of 41 years

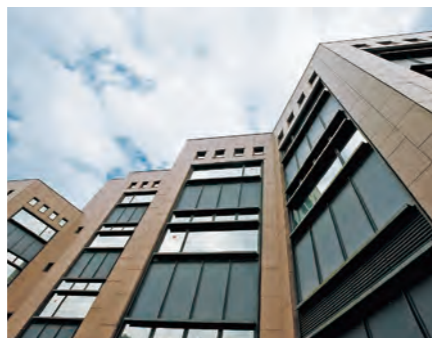
There are many socially important structures and buildings to which COR-TEN has been effectively applied.

Corrosion amount

The corrosion amount can be reduced more than that of conventional steel.



Used without coating/treatment



Used with rust stabilization auxiliary treatment



Used with coating

Vintage COR-TEN

VINCOR™

Catalog QR code

**Issues**

- The use of COR-TEN is desired indoors.
- There is a concern about initial rust in the shape of a flow or stream.

Effect of application

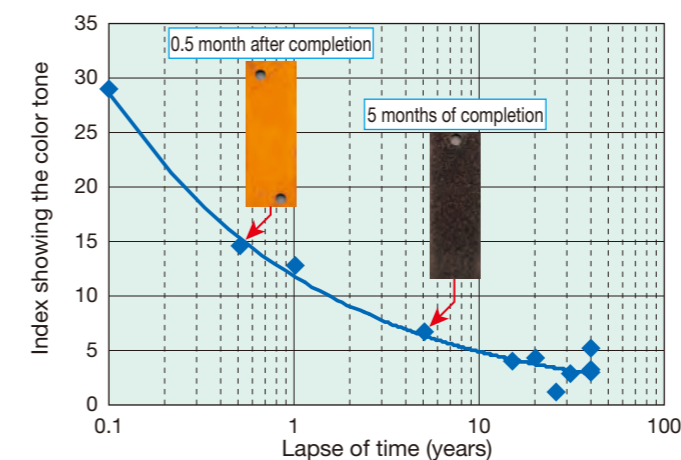
- COR-TEN in the aged state is provided.



Discoloration due to rust in the shape of a flow or stream

VINCOR (VINage COR-ten) is a product to consider the initial color tone with a state of being aged from shipment.

VINCOR is sold by Chikumakozai Co., Ltd (Tel: 81-47-354-5721).



Needs considering the scenery and for other aesthetic purposes can be satisfied.



9 years after completion



Partition wall in restaurant

Various application Examples of COR-TEN

"Stair in the Void" by Minoru Togashi (Yamagata)
Photo: Jun. 2005 (4 years after completion)



Kotohiragu cafe & restaurant "Kamitsubaki" (Kagawa)
Photo: 2009 (2 years after completion)



"Tamasora" by Noe Aoki
Photo: Tadasu Yamamoto



Yokohama Naka Ward Of ce (Kanagawa)
Photo: Oct. 2006 (23 years after completion)

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