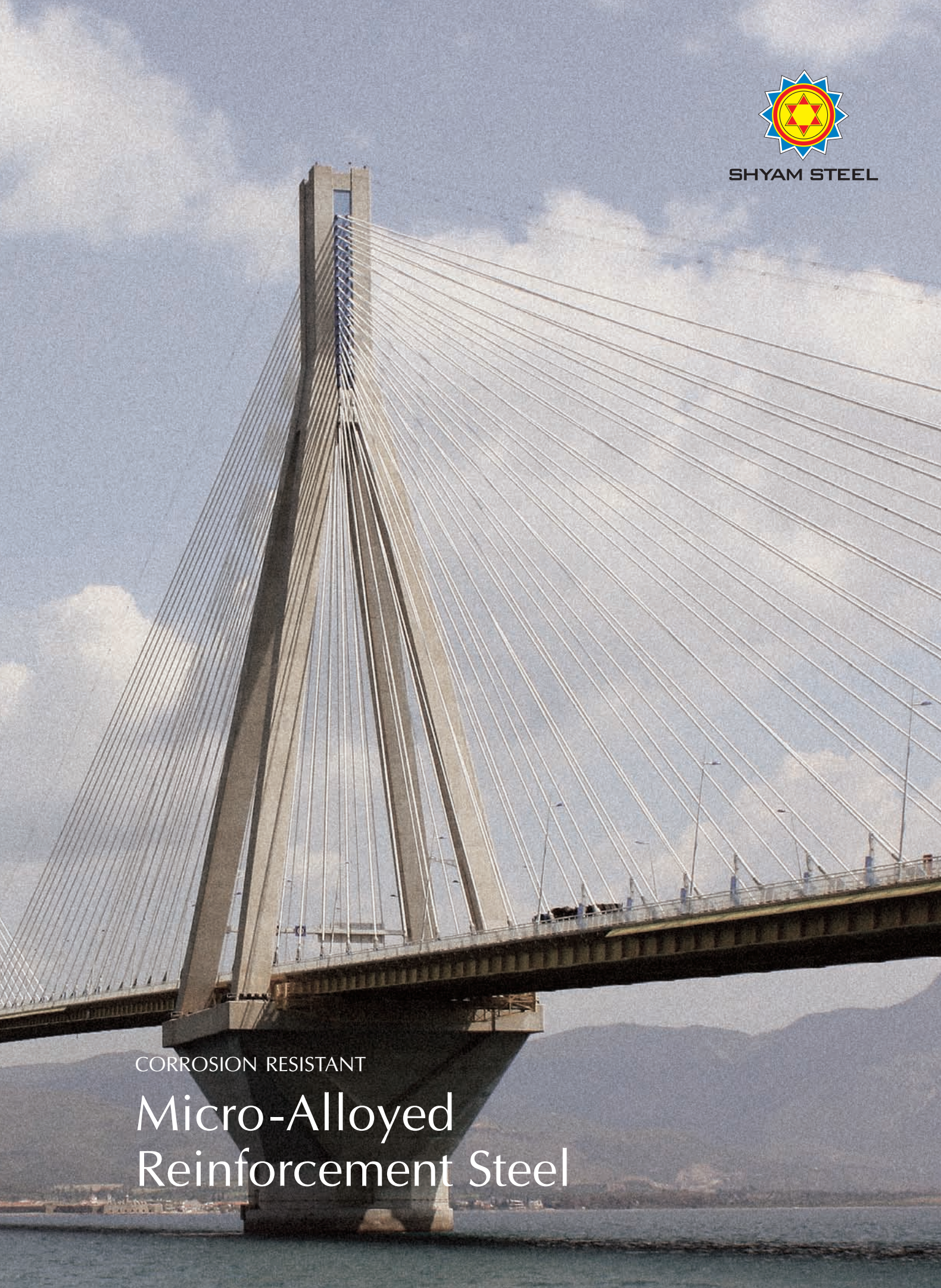
SHYAM STEEL



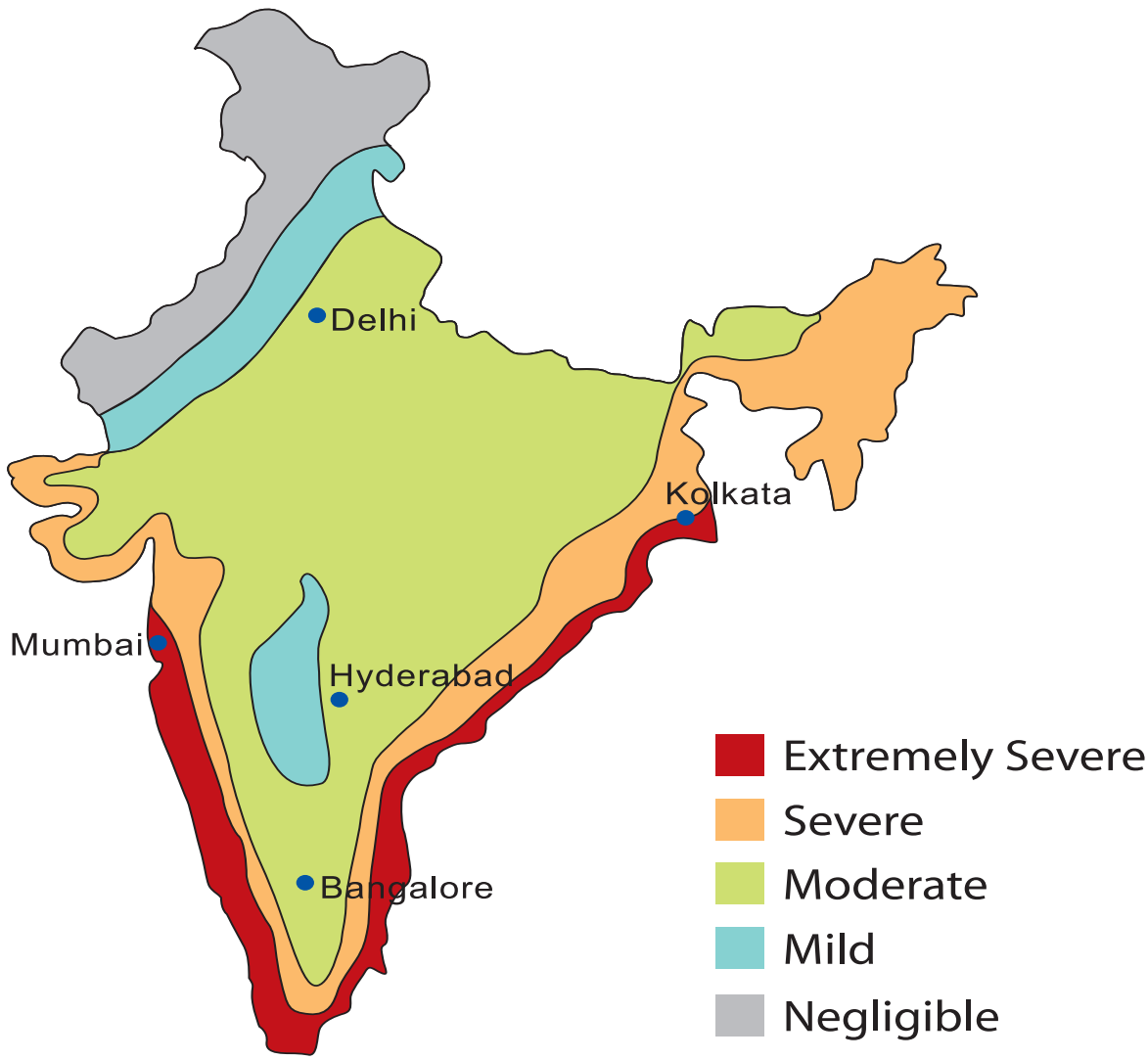
CORROSION RESISTANT

Micro-Alloyed Reinforcement Steel

Corrosion: An annual loss comparable to earthquakes and cyclones!

- The cost of corrosion in India has been estimated to be 2 to 4% of its GNP (Gross National Product).
- The approximate value of the loss is ₹1.5 lakh crore [Indian chapter of NACE International].
- Out of this ₹22,600 crore is incurred in the infrastructure sector.
- With more than 7,000 km of coastline, India's infrastructure suffers severely from salt water corrosion.
- Pollution and humidity also contribute to metallic corrosion.

Corrosion map of India*



*by CECRI

Corrosion in Reinforcing Steel – A threat to Infrastructure

How it affects

- Corrosion increases the volume of reinforcement bars, resulting in surface cracking and spoiling of the concrete.
- Scaling of bar surface severely affects bond strength.
- Loss of strength in steel leads to structural failure.

The aggravators

- Long wetness, due to excess atmospheric oxygen from elements like rainfall condensation etc.
- High atmospheric pollution forms soluble iron salts from sulphates, chloride and dust.
- Increased combustion of fossil fuels by vehicles and industrialization, thus increasing atmospheric sulphur dioxide.
- Coastal effect, from high concentration of chlorides present in coastal areas.
- Poor concreting, honeycombed surface and porosity.

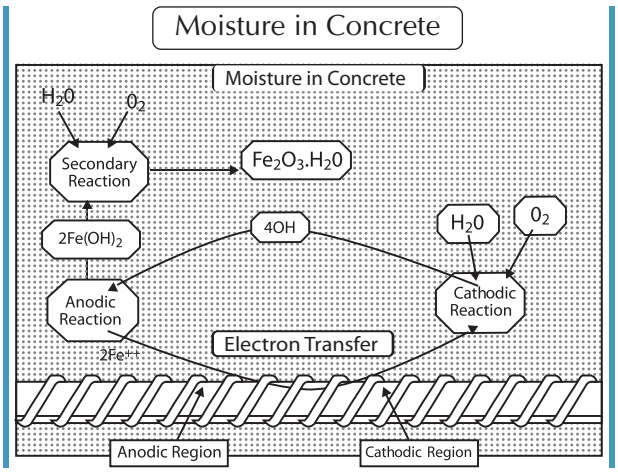
Types of Corrosion

Uniform Corrosion: When the structure is directly exposed to aggressive marine or industrial atmospheric conditions.

Pitting Corrosion: When chloride concentration is high enough to destroy passivity at weak points on metal surface.

Stress Corrosion: In pre-stress concrete where steel is initially held in tension, stress corrosion cracking occurs in a specific environment for a given alloy.

Corrosion mechanism of reinforcement steel in concrete



Electrochemical Reactions

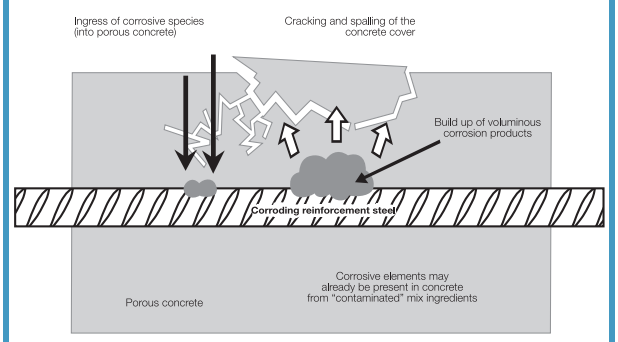
$2Fe \rightarrow 2Fe^{++} + 4e^-$

$2H_2O + O_2 + 4e- \rightarrow 4OH^-$

$2Fe^{2+} + 4OH- \rightarrow 2Fe(OH)_2$

$2Fe(OH)_2 + 2H_2O + O_2 \rightarrow 4Fe(OH)_3$

$Fe(OH)_3\ H_2O + Fe_2O_3$ (RUST)



Corrosion of metal is natural and rapid in areas with high humidity, seacoasts, high salinity, etc. This menace can destroy even the toughest buildings, bridges, dams, chimneys, plants, ports etc. The corrosion process can be broadly explained as follows:

Carbonation: Hydration of cement tends to make the poured solution of concrete alkaline (ph value typically within 12.5 -13.6). Here, reinforcing steel passivates and forms a corrosion-preventing oxide layer over the surface. Concrete's porosity enables corrosive chemical agents (moisture, water, chloride etc.) to enter and cause further reactions between atmospheric CO_2 (Carbon dioxide) and existing alkalis. Over the time, the ph values decreases below 10, causing loss of alkalinity and decaying the oxide layer of the steel. Once the layer is broken, the electromechanical reaction of corrosion starts.

Electrochemical process: It involves the transfer of ions. Electrochemical corrosion requires an anode, a cathode an electrolyte and an electronic circuit. The concrete media containing moisture and mainly $Co(OH)_2$ is an electrolyte conducting an electric current by ionic flow. The anodic and reduction reaction forms Ferric Hydroxide which dehydrates to form Ferric Oxide, commonly known as rust.

Effect of re-bar corrosion on concrete rust has five times more volume than steel. This causes tensile stresses which fractures the concrete around the reinforcement. As cracks grow, concrete permeability increases allowing greater access of oxygen, moisture and chlorides to the steel. The cracks cause significant loss of bond between the steel and concrete. In extreme cases, failure of reinforced concrete members also occurs.

Protecting the steel inside concrete against corrosion

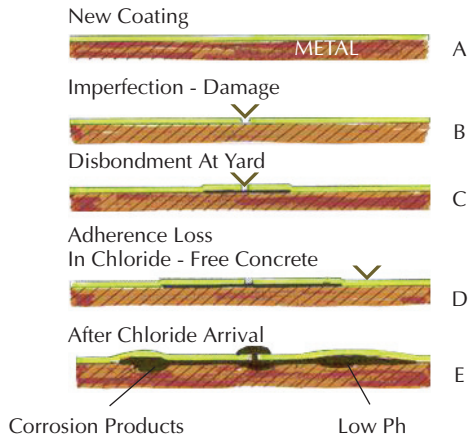
There have been several efforts to control corrosion viz: Fusion-Bonded Epoxy Coating, Hot Dip Galvanising, Zinc Coating through Cold Process - but these have failed in practical usage.

Epoxy coated Re-bars

The first logical corrosion protection that was tried, on the reinforcing steel in concrete, was the existing range of paints. These types of Re-bars offer limited corrosion resistance and have proven not to be effective in the long run, owing to several application-related issues.

The major problems

- Tiny pin holes like structure known as “Holidays” developes on the coated surface. Corrosion starts at these “Holiday” points.
- The coating is easily damaged during transportation, forming and placing the bars in forms.
- The coating reduces the bond strength.
- The coating is fragile, thus possesses limited life.
- High chloride concentrations makes the coating brittle, causing de-lamination from steel surface.
- Coating tends to break at the tension section exposing the base metal during bending, re-bending, cutting and concrete-pouring at site leading to faster corrosion.
- The coating looses stability beyond 2000°C, making structures less fire-resistant.
- The coating gets damaged at the point of welding and base metal gets exposed which in turn becomes the weak point of a structure.
- The cost of epoxy coating is very high.



Holidays corroding the coating underneath

Epoxy coated Re-bar

Knife adhesion test after 4 weeks of exposure

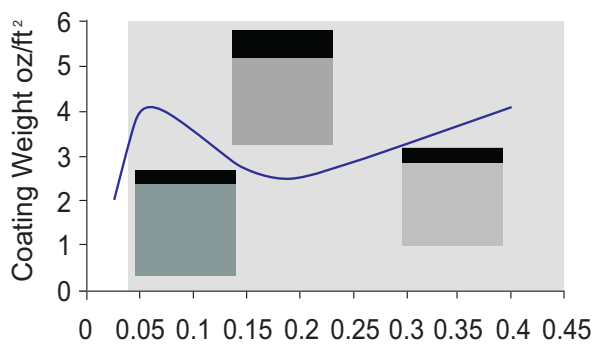
Zinc-coated Re-bars

Zinc-coated Re-bar give reasonably good corrosion resistance but has been proved not to be effective in the long run.

The major problems

- Silicon and phosphorous content in reinforcing steel severely affects galvanized coating. High silicon concentration causes very thick and brittle coating which peels off under mechanical stress.
- Cracks caused from Bending or Re-bending of galvanized Re-bar during fabrication at site, destroys galvanizing layer exposing base metal.
- Re-bar galvanized by hot-dip process do not provide enough concrete adhesion and Bond Strength.
- Re-bar needs to be galvanized in a factory which amounts to their size restriction.
- The cost of Zinc coating is very high in comparison to other measures.
- Zinc coated Re-bar cannot be used in combination of uncoated bars.
- Galvanizing bent Re-bar causes strain and ageing. Subsequently surface cracks develop on the coated layer at these places.
- Welding of Zinc coated Re-bar is not possible.

Zinc coated Re-bar



% Silicon Content

Microalloyed Re-bar – The Right Solution

The right anti-corrosion solution is a metallurgical route-controlled composition alloy with anti-corrosion elements and improved production process – Microalloyed (MA) Re-bars, **manufactured by Shyam Steel as Shyam CRS TMT Re-bars.**

In the Electric Arc Furnace, corrosion resistant elements like copper, chromium and phosphorous are added to the molten steel, while carbon and sulphur is reduced further through refining and deslagging. The microalloyed molten steel is then casted into billets and rolled in a controlled quenching and tempering process, imparting corrosion resistant properties far exceeding those of epoxy or zinc coated Re-bars.

The major advantages

- In such Re-bars, corrosion resistance is improved while retaining strength, toughness, ductility and formability.
- Higher strength of the Re-bars result in lower tonnage requirement, thus reducing construction cost.
- It is not a coated material. So it is unaffected by transport, handling or concrete pouring, thus eradicating touch-ups.

Properties

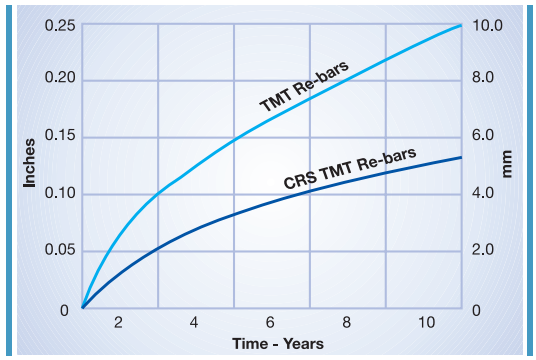
Description	Shyam Re-bars
0.2% Proof Stress (N/mm2, min)	540
Ultimate Tensile Strength (N/mm2, min)	620
% Elongation (min)	18
Bend	3D to 4D
Re-bend	4D to 6D
C (%max)	0.150
Mn (%max)	1.500
Si (% max)	0.035
P (% max)	0.100
CE (%max)	0.500
CRE (% min)	0.500

Performance Comparison of Re-bars

Parameters	Zinc Coated	Epoxy Coated	Microalloyed
Bond Strength to Concrete	Good	Poor	Excellent
UV Resistance	Excellent	Approximately 3 months, depends on the Epoxy paint	No adverse effect
Uniformity of Coating Thickness	May vary	May vary	No surface coating
Can be Dragged on Ground	Yes	No	Yes
Bond between Base Metal & Coating	Good	Poor compared to Galvanizing	No surface coating
Damage of coating after fabrication after coating application	Coating may get damaged locally but with no adverse effects	Coating may get damaged that may lead to crevice corrosion of Re-bar	No adverse effect since there is no coating
Construction Damage	Bending, rebending & cutting may cause cracks on coated surface	Bending, rebending & cutting may cause cracks on coated surface	No adverse effect since there is no coating
Touched up Paint after fabrication	Required	Required	Not Required
Problems In storage/ handling at factory or job site	Additional precaution to prevent 'white rusting'	Extensive	No

Source: Indian Institute of Technology, Kharagpur

Corrosion of re-bars in industrial atmosphere



CRS TMT Re-bars – Facts in favour

Worldwide demand for Microalloyed Re-bars generate majorly from industries like Power, Oil and Gas extraction, Road & Bridge construction and Port development. This is due to their improved strength, ductility, corrosion properties as well as increased toughness. These Re-bars offer the following major advantages:

- Increase in the lifespan of the structure.
- CRS TMT have intrinsically improved corrosion resistance as compared to other methods of combating corrosion.
- High yield strength coupled with good ductility and bendability.
- No extra precaution in handling and storage required.
- No extra precaution in Bending and Re-bending needed.
- Due to lower carbon equivalent, weldability is far superior than conventional Re-bars.
- Can perform better in case of earthquake and fire.

International projects where similar Re-bars have been used

- Australian Centre for Contemporary Art
- John Deere World Headquarters, Moline Illinois
- U.S Steel Tower, Pittsburgh
- Antioch River Bridge, California
- White Chick River Bridge, USA
- Foote Mineral Co. Bridge, Cleveland County

Indian projects where similar re-bars have been used

- Vizag Port
- Alwarpet Flyover, Chennai
- Krishnapatman Port
- Cochin Port
- Kakinada Basin
- Mangalore Sez
- UP Jal Nigam
- Delhi JAL Board

SHYAM STEEL

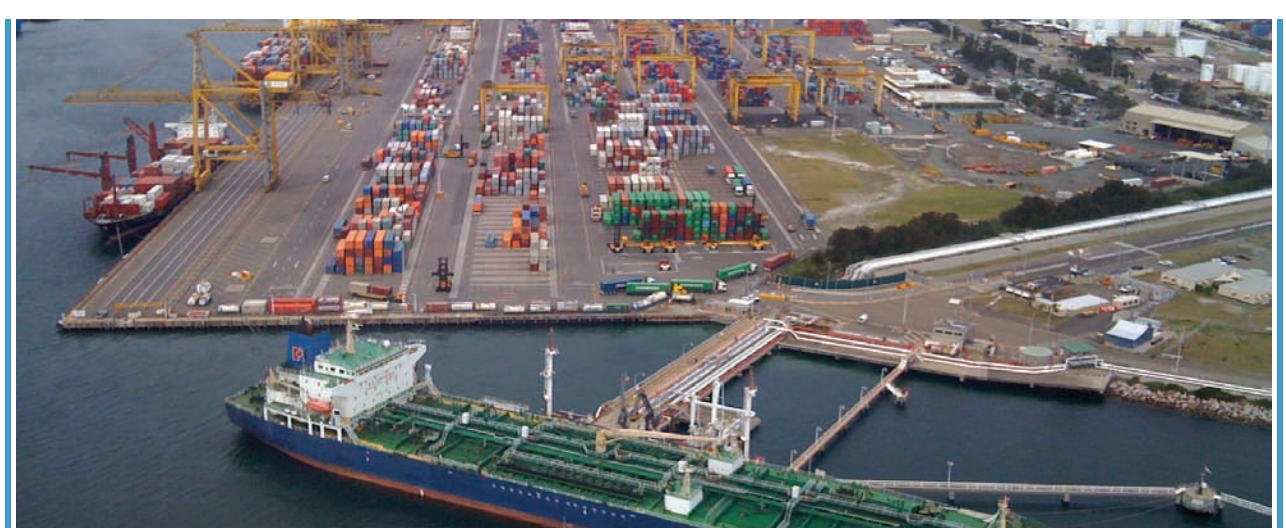
Shyam CRS TMT Re-bars – A proud presence throughout India

Shyam CRS TMT Re-bars have been used in projects like

- Kerala Water Board Project
- NTPL Tuticorin TPC, Tamilnadu
- Paradip Port National Highway, NHAI
- Haldia Port National Highway, NHAI
- Indian Oil Corporation Ltd, Haldia
- Kandla Port Trust
- JNPT IOCL Terminal
- Reliance KG Basin
- Mahagenco Bhusawal TPS Expansion
- Apgenco Krishnapatnam TPS

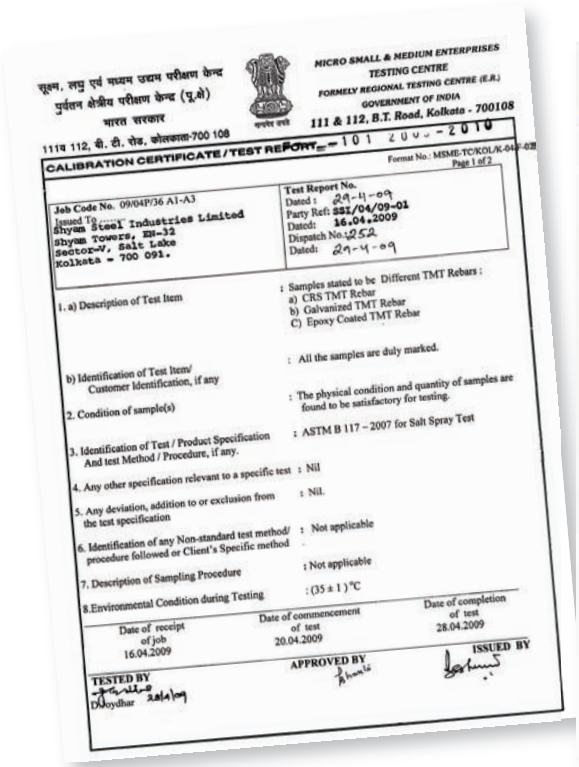
Shyam CRS TMT Re-bars are ideal for

- Oil & Gas Exploration Sites
- Dams & Bridges
- Highways & Flyovers Construction
- Ports & Jetties
- Thermal & Hydel Power Station
- Industrial Structures
- Hazardous Area Construction



Shyam CRS TMT Re-bars – thoroughly tested

Shyam CRS TMT Re-bars and similar microalloyed Re-bars have been tested in a number of premium research laboratories of India viz. • Indian Institute of Technology, Kharagpur • National Test House, Kolkata • Regional Testing Centre, Kolkata • National Metallurgical Laboratory, Jamshedpur • Structural / Engineering Research Centre, Chennai • Central Building Research Institute, Roorkee etc.



सूक्ष्म, लघु एवं मध्यम उद्यम परीक्षण केन्द्र
पूर्वांचल क्षेत्रीय परीक्षण केन्द्र (पू.क्षे)
भारत सरकार

MICRO SMALL & MEDIUM ENTERPRISES
TESTING CENTRE
FORMELY REGIONAL TESTING CENTRE (E.R.)
GOVERNMENT OF INDIA
111 & 112, B.T. Road, Kolkata - 700108

111व 112, बी. टी. रोड, कोलकाता-700 108

CALIBRATION CERTIFICATE / TEST REPORT – 101 2009 - 2010

Format No.: MSME/TC/KOL/K-04/F-028
Page 1 of 2

Job Code No. 09/04P/36 A1-A3
Issued To
Shyam Steel Industries Limited
Shyam Towers, EN-32
Sector-V, Salt Lake
Kolkata - 700 091.

Test Report No.
Dated : 29-4-09
Party Ref: SSI/04/09-01
Dated: 16.04.2009
Dispatch No. 1252
Dated: 29-4-09

1. a) Description of Test Item : Samples stated to be Different TMT Rebars :
a) CRS TMT Rebar
b) Galvanized TMT Rebar
C) Epoxy Coated TMT Rebar

b) Identification of Test Item/ Customer Identification, if any : All the samples are duly marked.

2. Condition of sample(s) : The physical condition and quantity of samples are found to be satisfactory for testing.

3. Identification of Test / Product Specification And test Method / Procedure, if any. : ASTM B 117 – 2007 for Salt Spray Test

4. Any other specification relevant to a specific test : Nil

5. Any deviation, addition to or exclusion from the test specification : Nil.

6. Identification of any Non-standard test method/ procedure followed or Client's Specific method : Not applicable

7. Description of Sampling Procedure : Not applicable

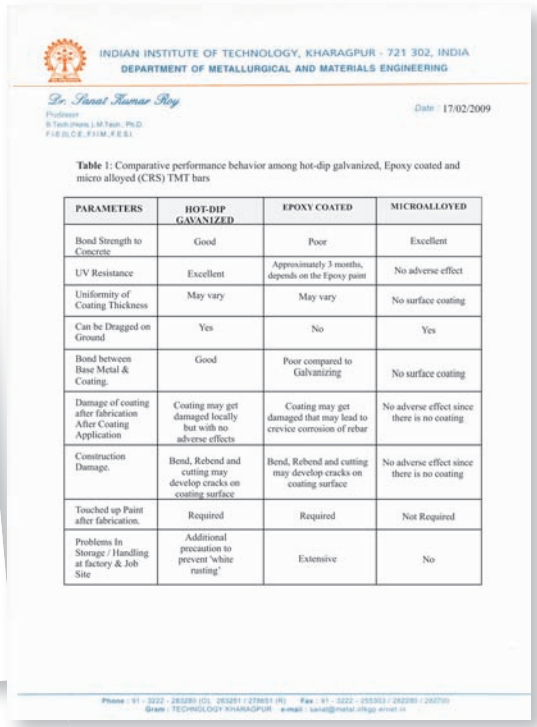
8.Environmental Condition during Testing : (35 ± 1)°C

Date of receipt of job	Date of commencement of test	Date of completion of test
16.04.2009	20.04.2009	28.04.2009

TESTED BY
D.Joydhar 29/4/09

APPROVED BY

ISSUED BY



INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR - 721 302, INDIA
DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

Dr. Sanat Kumar Roy
Professor
B.Tech.(Hons.), M.Tech., Ph.D.
F.I.E.(I),C.E., F.I.I.M., F.E.S.I.

Date : 17/02/2009

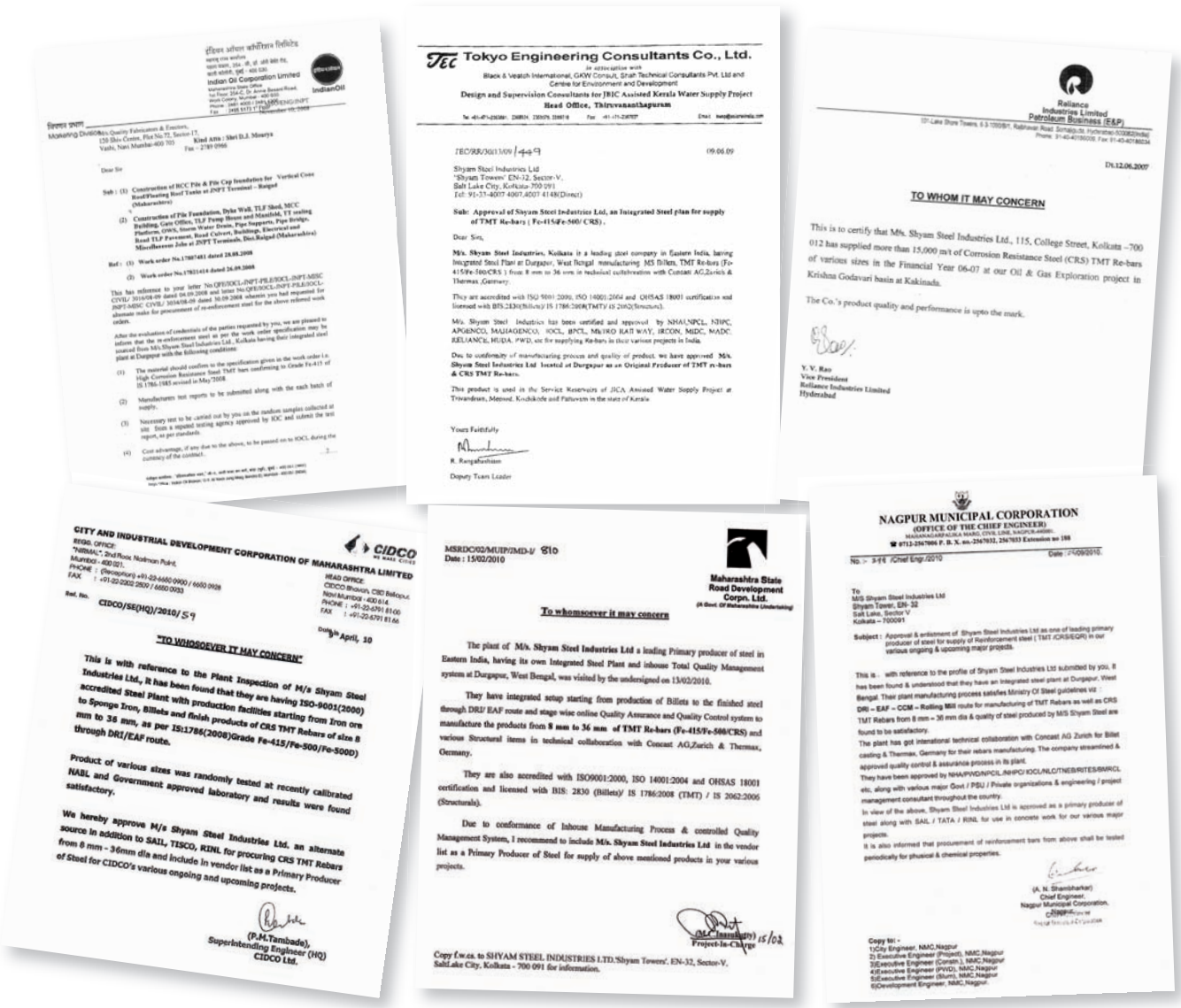
Table 1: Comparative performance behavior among hot-dip galvanized, Epoxy coated and micro alloyed (CRS) TMT bars

PARAMETERS	HOT-DIP GAVANIZED	EPOXY COATED	MICROALLOYED
Bond Strength to Concrete	Good	Poor	Excellent
UV Resistance	Excellent	Approximately 3 months, depends on the Epoxy paint	No adverse effect
Uniformity of Coating Thickness	May vary	May vary	No surface coating
Can be Dragged on Ground	Yes	No	Yes
Bond between Base Metal & Coating.	Good	Poor compared to Galvanizing	No surface coating
Damage of coating after fabrication After Coating Application	Coating may get damaged locally but with no adverse effects	Coating may get damaged that may lead to crevice corrosion of rebar	No adverse effect since there is no coating
Construction Damage.	Bend, Rebend and cutting may develop cracks on coating surface	Bend, Rebend and cutting may develop cracks on coating surface	No adverse effect since there is no coating
Touched up Paint after fabrication.	Required	Required	Not Required
Problems In Storage / Handling at factory & Job Site	Additional precaution to prevent 'white rusting'	Extensive	No

Phone : 91 - 3222 - 283280 (O), 283281 / 278651 (R) Fax : 91 - 3222 - 255303 / 282280 / 282700
Gram : TECHNOLOGY KHARAGPUR e-mail : sanat@metal.iitkgp.ernet.in

Type of Test	Non CRS TMT Re-bars	CRS TMT Re-bars
Potentio Dynamic Test	1.0	2.35
Salt Spray Test	1.0	1.59
Sulphur-Dioxide Test	1.0	1.68
Alternate Immersion Test	1.0	1.92

Customer Testimony



Tokyo Engineering Consultants Co., Ltd.

Reliance Industries Limited Petroleum Business (E&P)

TO WHOM IT MAY CONCERN

This is to certify that M/s. Shyam Steel Industries Ltd., 115, College Street, Kolkata – 700 012 has supplied more than 15,000 mt/ of Corrosion Resistance Steel (CRS) TMT Re-bars of various sizes in the Financial Year 06-07 at our Oil & Gas Exploration project in Krishna Godavari basin at Kakinada.

The Co.'s product quality and performance is upto the mark.

Y. V. Rao
Vice President
Reliance Industries Limited
Hyderabad

CITY AND INDUSTRIAL DEVELOPMENT CORPORATION OF MAHARASHTRA LIMITED

CIDCO

"TO WHOSOEVER IT MAY CONCERN"

This is with reference to the Plant Inspection of M/s Shyam Steel Industries Ltd., it has been found that they are having ISO-9001(2000) accredited Steel Plant with production facilities starting from Iron ore to Sponge Iron, Billets and finish products of CRS TMT Rebars of size 8 mm to 36 mm, as per IS:1786(2008)Grade Fe-415/Fe-500/Fe-500D) through DRI/EAF route.

Product of various sizes was randomly tested at recently calibrated NABL and Government approved laboratory and results were found satisfactory.

We hereby approve M/s Shyam Steel Industries Ltd. an alternate source in addition to SAIL, TISCO, RINL for procuring CRS TMT Rebars from 8 mm - 36mm dia and include in vendor list as a Primary Producer of Steel for CIDCO's various ongoing and upcoming projects.

(P.M.Tambade),
Superintending Engineer (HQ)
CIDCO Ltd.

Maharashtra State Road Development Corpn. Ltd.

To whomsoever it may concern

The plant of M/s. Shyam Steel Industries Ltd a leading Primary producer of steel in Eastern India, having its own Integrated Steel Plant and inhouse Total Quality Management system at Durgapur, West Bengal, was visited by the undersigned on 13/02/2010.

They have integrated setup starting from production of Billets to the finished steel through DRI/ EAF route and stage wise online Quality Assurance and Quality Control system to manufacture the products from 8 mm to 36 mm of TMT Re-bars (Fe-415/Fe-500/CRS) and various Structural items in technical collaboration with Concast AG,Zurich & Thermax, Germany.

They are also accredited with ISO9001:2000, ISO 14001:2004 and OHSAS 18001 certification and licensed with BIS: 2830 (Billets)/ IS 1786:2008 (TMT) / IS 2062:2006 (Structurals).

Due to conformance of Inhouse Manufacturing Process & controlled Quality Management System, I recommend to include M/s. Shyam Steel Industries Ltd in the vendor list as a Primary Producer of Steel for supply of above mentioned products in your various projects.

Project-In-Charge

Copy f.w.c.s. to SHYAM STEEL INDUSTRIES LTD.'Shyam Towers'. EN-32, Sector-V, Salt Lake City, Kolkata - 700 091 for information.

NAGPUR MUNICIPAL CORPORATION
(OFFICE OF THE CHIEF ENGINEER)

To
M/S Shyam Steel Industries Ltd
Shyam Tower, EN-32
Salt Lake, Sector V
Kolkata – 700091

Subject : Approval & enlistment of Shyam Steel Industries Ltd as one of leading primary producer of steel for supply of Reinforcement steel (TMT /CRS/EQR) in our various ongoing & upcoming major projects.

(A. N. Shanishankar)
Chief Engineer,
Nagpur Municipal Corporation,

Clock-wise from top left

- Indian Oil Corporation Ltd.
- Tokyo Engineering Consultants Co. Ltd.
- Reliance Industries Ltd.
- Nagpur Municipal Corporation
- MSRDC
- CIDCO

A Proud Presence

Sectors

- Roads and Highways
- Nuclear, Thermal and Hydel power
- Railways
- Metro Rail
- Defence
- Air and Sea ports
- Oil exploration and refinery

Projects of National Pride

- Vidyasagar Setu
- Reliance KG Basin
- Panipath Elevated Expressway
- P V Narshima Rao Expressway
- Hyderabad International Airport
- Bangalore International Airport
- Tau Devilal Power Plant
- Rosa Thermal Power Plant
- North-South and East-West Corridor Project
- NHAI
- Kothagudem Power Plant ...

Customers of National Repute

- L&T
- Simplex
- Gammon
- Punj Lloyd
- HCC
- GMR
- LANCO
- Reliance
- IVRCL
- ITD
- Soma
- GVK
- BGR Energy
- NCC
- IJM ...


Durgapur Plant

SHYAM STEEL

Shyam Steel at a glance

Established	1953
Plants	• Integrated Steel Plants (ISP) at Durgapur, West Bengal • DRI, Ferro and Cement Plant at Mejia, West Bengal • Speciality Rolling mills at Howrah, West Bengal
Head Office	Sector V, Salt Lake, West Bengal
Branches	13 Across India
Products	• TMT • CRS • EQR
Quality	Ten-point quality control system
Certificates	• ISO 9001 • OHSAS 18001 • ISO 14001

Electric Arc Furnace

SHYAM STEEL

Shyam Steel Industries Ltd
Shyam Towers, EN 32, Sector V, Salt Lake, Kolkata 700091
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www.shyamsteel.com