

कंक्रीट प्रबलन के लिए सतत हॉट-डिप  
जस्तीकृत इस्पात के सरिए — विशिष्टि

Continuous Hot-Dip Galvanized Steel  
Bars for Concrete Reinforcement —  
Specification

ICS 77.140.99; 91.080.40

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November 2024

Price Group 7

## FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Concrete Reinforcement Sectional Committee had been approved by the Civil Engineering Division Council.

Many reinforced concrete structures are experiencing the corrosion of embedded steel bars well before the design life (or target corrosion-free service life). This has been a serious concern for the concrete construction industry. Galvanized steel bars can enhance the corrosion resistance and help to achieve multi-decade corrosion-free service life in severe corrosive exposure conditions. These conditions include (a) inland/coastal/marine regions with high chloride conditions and (b) regions with 60 percent to 70 percent relative humidity and/or (c) carbon dioxide from vehicle exhaust, industrial units, etc. The galvanized coating (say, zinc) has higher chloride threshold and lower  $pH$  threshold than those of steel; and hence, can delay the onset of corrosion of embedded bars. Chloride threshold is the minimum amount of chlorides required to initiate corrosion and the  $pH$  threshold is the maximum  $pH$  of concrete at which the bar starts corroding. Nowadays, there is a concern about the use of supplementary cementitious materials (SCMs) because concretes with some of the SCMs can be prone to faster carbonation. The low  $pH$  threshold of zinc (say, 7 to 8) can increase the time to corrosion initiation – thereby promoting the use of SCMs.

The batchwise hot-dip galvanized steel bars with an approximately 100  $\mu m$  thick galvanized coating have been in use for several decades and are covered by the Indian Standard, IS 12594 : 1988 ‘Hot-dip zinc coating on structural steel bars for concrete reinforcement — Specification’. Continuous hot-dip galvanization process is a new technology by which approximately 50  $\mu m$  thick galvanized coating is possible. Worldwide, these bars are gaining acceptance as reinforcement in concrete and can be used to meet the demand of increased durability or corrosion-free service life of concrete structures. This standard covers the key physical, chemical and mechanical properties of the coating required for such bars to perform as desired. This standard also covers guidelines for the use of these bars at site as well as guidelines for using such bars with uncoated or bare steel forms in [Annex B](#) and [Annex C](#), respectively.

The composition of the Committee responsible for the formulation of this standard is given in [Annex E](#).

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Indian Standard***CONTINUOUS HOT-DIP GALVANIZED STEEL BARS FOR  
CONCRETE REINFORCEMENT — SPECIFICATION****1 SCOPE**

**1.1** This standard covers the requirements for continuous hot-dip galvanized steel bars for use in reinforced concrete structures. This specification covers steel bars, with protective zinc or zinc-alloy coatings applied by the continuous hot-dip process.

**1.2** Batch wise hot-dip galvanized steel bars for concrete reinforcement are covered in IS 12594.

**2 REFERENCES**

The standards listed in [Annex A](#) contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of these standards.

**3 TERMINOLOGY**

For the purpose of this standard, the following terms and their definitions shall apply.

**3.1 Continuous Hot-Dip Galvanizing** — The process of uninterrupted passage of long lengths of steel bars through a molten bath of zinc alloy.

**3.2 Lot** — All bars of same size and that have been galvanized in the same production shift.

**4 ORDERING INFORMATION**

**4.1** Orders for continuous hot-dip galvanized steel bars for concrete reinforcement as per this standard shall include the following information:

- a) Specification for steel bars to be coated, along with designation of Indian Standard and its year of issue;
- b) Quantity of bars; and
- c) Size and grade of bars.

**4.2** The purchaser shall have the option to specify additional requirements, including but not limited to, the following:

- a) Requirements of inspection;
- b) Manufacturer's certificate and report of test results; and

- c) Other special requirements, if any (such as, packing instructions, etc).

**5 MATERIALS****5.1 Steel Bars**

Steel bars to be galvanized shall comply with IS 432 (Part 1) or IS 1786.

**5.2 Coating Material**

Appropriate amounts of zinc, aluminum and other elements shall be decided to meet the chemical composition of the alloy for coating. The zinc ingot for producing the alloy shall contain at least 99.99 percent zinc.

The alloy used for the process shall contain aluminum in the range of 0.20 percent to 0.28 percent and the lead content shall be restricted to 0.007 percent, *Max*. The other impurities in the final alloy can be iron (0.007 5 percent, *Max*), cadmium (0.01 percent, *Max*), copper (0.01 percent, *Max*) and others (total of 0.01 percent, *Max*). The balance should be zinc.

**6 GALVANIZING PROCESS**

**6.1** It shall be the responsibility of the manufacturer to maintain identity of the steel bars throughout the galvanizing process and to the point of shipment.

**6.2 Continuous Hot-Dip Galvanizing**

After adequate pretreatment, the steel bars shall be coated by passing individual bars through a zinc-alloy flooded trough or tube located above a zinc-alloy bath, then immediately through an air or steam wiping device to remove excess material and provide a uniform coating. The aluminum can be added in the form of master alloy or as the specified ingredient in the zinc smelter.

**7 CHARACTERISTICS OF GALVANIZED STEEL BARS****7.1 Characteristics of Coating****7.1.1 Finish and Appearance**

The galvanized steel bars shall not have any uncoated areas. The coating shall be free from

blisters, flux spots or inclusions, dross, and acid spots. In addition, the presence of tears or sharp spikes, which make the bar hazardous to handle, shall be cause for rejection.

The cut ends of the bars shall be coated with an appropriate zinc-rich formulation.

### 7.1.2 Adherence

The adherence of the zinc alloy coating shall be evaluated by the bend test as specified in IS 432 (Part 1) or IS 1786. After the test, the coating on the outer surface of the bent bar shall not exhibit peeling or flaking, noticeable to a person with normal or corrected vision. In addition, the coating shall be adherent so that it cannot be removed by any reasonable process of handling.

### 7.1.3 Thickness

The average thickness of zinc alloy coating shall be at least 50  $\mu\text{m}$  (equivalent to 360  $\text{g}/\text{m}^2$ ). The measured thickness at any location shall be at least 40  $\mu\text{m}$ .

## 7.2 Testing of Continuous Hot-Dip Galvanized Steel Bars

### 7.2.1 Test Unit

A minimum of three samples from each lot shall be drawn and offered for inspection by the manufacturer, and tested for confirming the desired properties of galvanized coating.

7.2.2 The thickness of the coating shall be determined by magnetic thickness gauge measurements in accordance with IS 12554 (Part 2). For each sample, five or more measurements shall be made at various points throughout the sample so as to represent the entire surface of the samples. A total of at least fifteen measurements shall be averaged to obtain the coating thickness.

NOTE — Measuring the coating thickness on curved surfaces is difficult. It is essential that the probe in the measuring tool be positioned perpendicular to the surface in-between the ribs to determine the coating thickness; and accordingly, an appropriate probe shall be chosen for measurement.

7.2.3 The weight of the coating shall be determined by stripping the coating from the reinforcing bar in accordance with the test method as given in IS 6745. This test method shall not be used for deformed steel bars due to the variation in the surface area of deformed bars.

NOTE — This is a destructive test for small samples of plain bars with a minimum of 200  $\text{mm}^2$  of surface area.

### 7.2.4 Testing of Physical Properties

Continuous hot-dip galvanized steel bars shall meet the requirements of physical properties as specified in IS 432 (Part 1) or IS 1786 for that particular grade of parent bar which is coated.

### 7.2.5 Retests

If the requirements specified in 7.2.2 to 7.2.4 are not met, three additional random samples from the same lot shall be tested. The lot shall be accepted only if all three additional samples satisfy the requirement.

## 7.3 Chromating

The zinc coating shall be chromate treated, if required by the purchaser, as per Annex D.

## 8 PERMISSIBLE AMOUNT OF COATING DAMAGE AND REPAIR PROCEDURE

The total damaged surface area, noticeable to a person with normal or corrected vision, shall not exceed 1 percent of the surface area in a sample of 1 m length of a galvanized steel bar.

The coating damage shall be repaired using an appropriate zinc-rich formulation in accordance with A-6 IS 4759. The coating at repaired areas shall have a minimum thickness of 50  $\mu\text{m}$ .

### NOTES

1 This limit on coating damage does not include sheared or cut ends that are coated with the zinc-rich formulation.

2 The coating damage criteria is applicable to the galvanized steel bars when being accepted by the purchaser from the manufacturer and are not site acceptance criteria.

## 9 PACKING, HANDLING, STORAGE AND TRANSPORT

Continuous hot-dip galvanized steel bars shall be delivered in the form of bundle of straight bars subject to agreement between the manufacturer and the purchaser. Arrangements shall be made such that the coating is not significantly altered during handling, storage and transport.

## 10 MANUFACTURER'S CERTIFICATE

If specified in the purchase order or contract, the manufacturer shall furnish, at the time of shipment, a certificate that the material was manufactured and tested in accordance with this standard. A report of the test results, shall be included in the manufacturer's test certificate.

**11 MARKING**

**11.1** Labeling shall be sufficient to ensure product traceability. The following information shall be marked on each bundle of continuous hot-dip galvanized steel bars:

- a) Name or address of manufacturer's factory (both steel manufacturer and galvanizer);
- b) Product identification (grade, diameter, length, or configuration as appropriate);
- c) Mass of bundle of straight continuous hot-dip galvanized steel bars; and

- d) Batch number or equivalent information for cross reference to inspection documents.

**11.2 BIS Certification Marking**

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act, 2016* and the Rules and Regulations framed thereunder, and the products may be marked with the Standard Mark.

## ANNEX A

(Clause 2)

## LIST OF REFERRED STANDARDS

<i>IS No.</i>	<i>Title</i>	<i>IS No.</i>	<i>Title</i>
IS 432 (Part 1) : 1982	Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement: Part 1: Mild steel and medium tensile steel bars ( <i>third revision</i> )	IS 6745 : 1972	Method of determination of mass of zinc coating on zinc coated iron and steel articles
IS 1786 : 2008	High strength deformed steel bars and wires for concrete reinforcement — Specification ( <i>fourth revision</i> )	IS 12554 (Part 2) : 1999	Specification for non-destructive coating thickness testing instruments: Part 2 Magnetic instruments
IS 4759 : 1996	Hot-dip zinc coatings on structural steel and other allied products — Specification ( <i>third revision</i> )	IS 12594 : 1988	Hot-dip zinc coating on structural steel bars for concrete reinforcement — Specification
		IS 16172 : 2023	Reinforcement couplers for mechanical splices of steel bars in concrete — Specification ( <i>first revision</i> )

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## ANNEX B

*(Foreword)*

## GUIDELINES FOR SITE PRACTICE

**B-1** This standard is a product specification. Its requirements cease when the purchaser accepts the continuous hot-dip galvanized steel bars from the manufacturer. As a product standard, it does not delineate requirements for subsequent practices at the site.

The project specifications shall prescribe the requirements for the continuous hot-dip galvanized steel bars from the time the purchaser accepts the continuous hot-dip galvanized steel bars from the manufacturer, and subsequent practices at the site. In the absence of such requirements in the project specifications, the following guidelines for site practices are recommended:

- a) Exercise care when handling continuous hot-dip galvanized steel bars. Avoid bundle-to-bundle abrasion or bar-to-bar abrasion resulting from sagging bundles;
- b) Equipment for handling continuous hot-dip galvanized steel bars should have protected contact areas;
- c) Continuous hot-dip galvanized steel bars should be off-loaded as close as possible to their usage area in order to minimize re-handling;
- d) Continuous hot-dip galvanized steel bars should be stored off the ground on protective bearers and timbers placed between bundles when stacking is necessary. The supports should be spaced sufficiently close to prevent sags in the bundles;
- e) Continuous hot-dip galvanized steel bars and uncoated steel bars should be stored separately;
- f) Continuous hot-dip galvanized steel bars and uncoated steel bars should not be used in combination in reinforced concrete members;
- g) The maximum amount of repaired damaged areas of coating, including areas repaired at the manufacturer's facility, should not exceed 2 percent in any 1 m length of the coated bar:
  - 1) When the extent of damaged coating exceeds 2 percent of the surface area in any 1 m length of the coated steel bar, the coated bar should be discarded; and
  - 2) When the extent of damaged coating does not exceed 2 percent of the surface area in any 1 m length of the coated bar all damaged coating noticeable to a person with normal or corrected vision should be repaired with a zinc-rich formulation complying with this standard.
- h) In case continuous hot-dip galvanized steel bars are joined through welding or by using mechanical splices such as threaded couplers or coupling sleeves, the following is recommended:
  - 1) The threaded coupler or coupling sleeve conforming to IS 16172 used for mechanical splicing of continuous hot-dip galvanized steel bars should also be galvanized with zinc rich formulation complying with this standard; and
  - 2) After installing mechanical splices on continuous hot-dip galvanized steel bars, damaged coating and areas of removed coating around the mechanical splices should be repaired with zinc rich formulation complying with this standard.
- j) After completing welds on continuous hot-dip galvanized steel bars, damaged coating areas should be repaired with zinc rich formulation complying with this standard. Welded area should also be coated with the same zinc-rich formulation as used for the repair of damaged coating. Fixed continuous hot-dip galvanized steel bars should be inspected for damaged coating prior to pouring the concrete. Particular attention should be paid to sheared ends of coated bars. Where damage exists, it should be repaired with an appropriate zinc-rich formulation;
- k) When placing continuous hot-dip galvanized steel bars, all bar supports, and spacers, and binding wire should be coated with zinc or with dielectric material;

m) After placing, walking on continuous hot-dip galvanized reinforcing bars should be avoided. The positioning of construction equipment should be planned to avoid damage to the coated reinforcement; and

n) When immersion-type vibrators are used to consolidate concrete around coated steel bars, the vibrators should be equipped with non-metallic, resilient heads.

## ANNEX C

*(Foreword)*

### **GUIDELINES FOR USE OF CONTINUOUS HOT-DIP GALVANIZED STEEL BARS WITH NON-GALVANIZED STEEL FORMS**

**C-1** Continuous hot-dip galvanized steel bars contain a zinc or zinc-alloy coated surface that is of a different electrochemical potential than uncoated steel or stainless steel. When forms for casting concrete are made of uncoated steel or stainless steel, the use of continuous hot-dip galvanized steel bars necessitates an electrical isolation of the continuous hot-dip galvanized steel bars from the

forms. Should electrical contact between the two occur, the result will be a shadowing of a ghost appearance of the steel bar on the finished concrete surface. Zinc ions will tend to migrate to the surface of the concrete and appear in a darker color, or shadow, on the concrete surface, in the shape of the reinforcing bar configuration. In more severe cases, the concrete can adhere to the metal forms.

## ANNEX D

*(Clause 7.3)*

### **RECOMMENDED CHROMATE PRACTICE**

**D-1** If the chromate treatment is performed immediately after zinc or zinc-alloy coating, it shall be accomplished by quenching the steel bars in a solution containing at least 0.2 percent by weight of pure sodium dichromate in water or by quench chromating in a minimum of 0.2 percent chromic acid solution. The solution shall be at least 32 °C. The zinc or zinc-alloy coated reinforcing bars shall be immersed in the solution for at least 20 s.

**D-2** If the zinc or zinc-alloy coated reinforcing bars are at ambient temperature, the chromate treatment shall be the same as specified in **D-1** except that 0.5 percent to 1.0 percent concentration of sulphuric acid shall be added as an activator of the chromate solution. In this case, there is no temperature requirement for the activated chromate solution.



## ANNEX E

*(Foreword)*

## COMMITTEE COMPOSITION

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This Indian Standard has been developed from Doc No.: CED 54 (22059).

### Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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