
कंक्रीट में प्रयुक्त सरियों के यांत्रिक
संबंधन हेतु प्रबलन युग्मक — विशिष्टि

Reinforcement Couplers for
Mechanical Splices of Bars in
Concrete — Specification

ICS 77.140.15

© BIS 2014



भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली-110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.org.in www.standardsbis.in

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.

Various method of reinforcement splicing that are in use include lapping, welding and by mechanical means. Lapping of reinforcement bars using binding wires has been the conventional method and is still widely used in construction projects.

Mechanical means of splicing of reinforcement bars involve joining of two reinforcement bars end to end using a reinforcement coupler and is a relatively new method being adopted in some important projects. Mechanical splices may be reliable under conditions of cyclic loading into the inelastic range and may also be advantageous at locations where inelastic yielding may occur. Mechanical splicing of large diameter bars are often advantageous as this results in less congestion during concreting and faster construction. However, the condition and quality of the concrete and minimum clear cover requirements are to be ensured even in case of mechanical splicing of bars. Further, the material of the reinforcement coupler should be compatible with the material of the reinforcement bar to be spliced and as well as with the concrete.

With increased use of mechanical splicing systems and reinforcement couplers in construction, a need was felt to formulate an Indian Standard on the subject so as to specify the requirements for the couplers.

The reinforcement couplers covered in this standard are meant to be used with reinforcing bars conforming to IS 1786 : 2008 'High strength deformed steel bars and wires for concrete reinforcement (*fourth revision*)' and therefore the requirements have been arrived at on the basis of the properties of reinforcing bars conforming to IS 1786. The requirements for couplers have been based on the properties of reinforcing bars of grade Fe 550D of IS 1786 in order to rationalize varieties and avoid difficulty in storing/stacking, for ease of identification by users (including construction workers) and to avoid inadvertent wrong use of couplers at construction sites. Specific projects may however require use of reinforcement bars of grades lower than Fe 550D of IS 1786 only and the requirements for such couplers may be as agreed between the purchaser and the manufacturer or as specified by the Engineer in Charge of the project, subject to meeting the minimum requirements specified in this standard. Similarly, in view of limited production and use of reinforcement bars of Fe 600 grade of IS 1786 in the country, requirements of couplers to be used with such bars have not been presently covered in this standard and the same may also be mutually agreed.

This standard covers requirements that apply to reinforcement couplers only. This standard does not cover the performance requirements of mechanically spliced joints in the field. Information on commonly used reinforcement couplers are given in Annex A. Users may ascertain the limitations associated with use of different types of reinforcement couplers and are encouraged to follow minimum precautionary installation measures as applicable.

Users are also encouraged to carry out corrosion test in the coupler-bar connections exposed to marine or severe environmental conditions to rule out any risk of galvanic corrosion. Specialist literature may be referred to in such cases.

Splicing of bars shall be done in accordance with the relevant requirements specified in IS 456 : 2000 'Plain and reinforced concrete — Code of practice (*fourth revision*)'.

Assistance has been derived from the following International Standards in the formulation of this standard:

ISO 15835-1 : 2009	Steels for the reinforcement of concrete — Reinforcement couplers for mechanical splices of bars — Part 1: Requirements
ISO 15835 - 2 : 2009	Steels for the reinforcement of concrete — Reinforcement couplers for mechanical splices of bars — Part 2: Test methods

(Continued on third cover)

Indian Standard

REINFORCEMENT COUPLERS FOR MECHANICAL SPLICES OF BARS IN CONCRETE — SPECIFICATION

1 SCOPE

1.1 This standard covers the requirements and tests applicable to reinforcement couplers to be used in reinforced concrete constructions for mechanical splicing of bars conforming to IS 1786. The standard presently covers requirements of couplers to be used with bars conforming to grades less than and equal to Fe 550D of IS 1786.

NOTES

1 The performance requirements for couplers to be used with reinforcing bars conforming to grade Fe 600 of IS 1786 shall be mutually agreed to between the purchaser and the manufacturer as per specific project necessities.

2 In specific instances where in a project, reinforcement bars of grades lower than Fe 550D of IS 1786 are in use, the performance requirements of couplers to be used with such reinforcement bars may be mutually agreed between the purchaser and the manufacturer.

1.2 The provisions of this standard applies to tension and tension-compression couplers such as threaded couplers, swaged coupling sleeves, grout/steel filled coupling sleeve etc, subject to satisfying the performance criteria of this standard.

1.3 This standard does not cover compression-only couplers such as end bearing sleeves and coupling sleeve and wedge.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provision 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 editions of the standards indicated below:

<i>IS No.</i>	<i>Title</i>
1608 : 2005	Metallic materials — Tensile testing at ambient temperature (<i>third revision</i>)
1786 : 2008	High strength deformed steel bars and wires for concrete reinforcement — Specification (<i>fourth revision</i>)
1828 (Part 1) : 2005	Metallic materials — Verification of static uniaxial testing Machines: Part

IS No.

Title

	1 Tension/Compression testing machines — Verification and calibration of the force-measuring system
4905 : 1968	Methods for random sampling
12872 : 1990	Metallic materials — Verification of extensometers used in uniaxial testing

3 TERMINOLOGY

For the purpose of this standard, the terms and definitions given in IS 1786 and the following shall apply.

3.1 Mechanical Splice — Complete assembly of a coupler, or an end bearing sleeve including any additional intervening material or other components providing a splice of two reinforcing bars.

3.2 Reinforcement Coupler — Coupling sleeve or threaded coupler for mechanical splices of reinforcement bars for the purpose of providing transfer of axial tensile force and/or compressive force from one bar to the other, where,

- a) coupling sleeve is a device fitting over the ends of two reinforcing bars, and
- b) threaded coupler is a threaded device for joining reinforcing bars with matching threads.

3.3 Coupler Length — Actual length of the reinforcement coupler including all load transferring parts, if more than one, and including lock nuts, if any.

3.4 Length of Mechanical Splice — Length of reinforcement coupler plus two times the nominal bar diameter at both ends of the coupler (*see* Fig. 1).

NOTE — This is a conventionally accepted definition to take into account the affected zone in an approximate way.

3.5 Slip — The permanent extension of a mechanical splice after being loaded to a defined load level.

3.6 Slip Measurement Device — The assembly constituted by the extensometer and any system used to fix it to the mechanical splice.

3.7 Tests

3.7.1 Type Tests

Tests carried out to prove conformity with the standard. These are intended for product/type approval and are carried out whenever a change is made in the type of the reinforcement coupler or manufacturing process/conditions or crimping method or forging or threading machine

3.7.2 Acceptance Tests

Tests carried out on samples taken from a lot passing type tests for the purpose of acceptance of the lot.

4 TYPES OF REINFORCEMENT COUPLERS

There are various types of reinforcement couplers used in mechanical splicing of bars in reinforced concrete constructions. Some of the commonly used mechanical splicing systems based on the type of reinforcement coupler used in them have been described in Annex A.

5 CLASSIFICATION

5.1 Reinforcement couplers supplied in accordance with this standard shall be classified into the following classes:

- a) Class H, and
- b) Class L.

5.1.1 Couplers which meet both low cycle fatigue test and high cycle fatigue test requirements of 9.5.1 and 9.5.2 respectively shall be classified and designated as Class H coupler.

5.1.2 All other couplers which meet only low cycle fatigue test requirement of 9.5.1 shall be classified and designated as Class L coupler.

NOTE — Class H couplers are recommended for use in concrete structures which are subjected to high cycle of fatigue like road bridges, railway bridges, machine foundations, slender structures like stack, etc. For all other structures reinforcement couplers of Class L is recommended.

6 MANUFACTURE

Reinforcement couplers shall have adequate strength, length and internal threads as per manufacturer's design to be able to meet the performance requirements of this standard.

7 WORKMANSHIP AND FINISH

All reinforcement couplers shall be finished smooth and shall be free from burrs, cracks and other manufacturing defects. The threads shall be cleanly formed and shall be free from imperfections.

8 NOMINAL SIZES

The nominal sizes of reinforcement couplers based on

their internal diameter shall correspond to the nominal sizes of bars covered under IS 1786.

9 PERFORMANCE REQUIREMENTS

9.1 All reinforcement couplers shall meet the performance requirements of 9.2, 9.3, 9.4 and 9.5.1. Class H couplers in addition to above, shall also meet the requirements of 9.5.2.

9.1.1 The requirements apply to the reinforcement coupler even though the above tests on the coupler are carried out on a mechanical splice that has been installed in accordance with the manufacturer's written instructions.

9.2 Static Tensile Test

9.2.1 Tensile Strength

The tensile strength of the mechanical splice, when tested in accordance with the details given in Annex B shall not be less than 600 N/mm^2 which is the corresponding minimum tensile strength of reinforcement bar of Fe 550D grade specified in IS 1786.

NOTES

1 Where the performance requirements of couplers are mutually agreed to between the manufacturer and the purchaser the requirements for this test shall be as agreed. However, the tensile strength in such case shall not be less than the specified minimum tensile strength in IS 1786 for the grade of reinforcement bar to be spliced.

2 For important structures, the user may specify stringent requirement of bar break to avoid splice failure and to develop full tensile strength of the bar.

9.2.2 Percentage Elongation

The minimum percentage elongation at maximum force (also termed as uniform elongation) when measured in accordance with the method given in Annex B in the reinforcing bar outside the length of the mechanical splice shall be minimum 3 percent before the failure of the test piece.

9.3 Slip Test

The total slip value measured in accordance with the test procedure described in Annex C shall not exceed 0.10 mm.

9.4 Cyclic Tensile Test

The mechanical splice shall withstand 100 cycles of the stress variation from 5 percent to 90 percent of f_y (where $f_y = 550 \text{ N/mm}^2$) when tested in accordance with the details given in Annex D without loss of static tensile strength capacity when compared with like specimen. The static tensile strength capacity of the test piece shall be determined by testing it statically to failure in accordance with the procedure given in Annex B after subjecting it to stress cycles.

NOTE — Where the performance requirements of couplers are mutually agreed to between the manufacturer and the purchaser the test shall be carried out at least for a stress variation from 5 percent to 90 percent of f_y , where f_y is the specified minimum yield stress/0.2 percent proof stress in IS 1786 for the grade of reinforcement bar to be spliced.

9.5 Fatigue Test

There are two types of fatigue tests namely low cycle fatigue test and high cycle fatigue test. All reinforcement couplers shall satisfy the requirement for low cycle fatigue test as specified in 9.5.1. Couplers of Class H in addition to above shall also meet the high cycle fatigue test requirement as specified in 9.5.2.

9.5.1 Low Cycle Fatigue Test

The mechanical splice shall withstand 10 000 cycles of alternating tension and compression load when tested in accordance with the method given in Annex E.

9.5.2 High Cycle Fatigue Test for Class H Reinforcement Coupler Only

The mechanical splice, when tested in accordance with the method given in Annex E, shall withstand 2 000 000 cycles of varying axial tensile load with a stress range, $2\sigma_a$, of 60 N/mm² without failure. The upper stress, σ_{max} , in the test shall be $0.6f_y$, where $f_y = 550$ N/mm².

NOTE — Where the performance requirements of couplers are mutually agreed to between the manufacturer and the purchaser the test shall be carried out for an upper stress of at least $0.6f_y$, where f_y is the specified minimum yield stress/0.2 percent proof stress in IS 1786 for the grade of reinforcement bar to be spliced.

10 TESTS

10.1 Classification of Tests

10.1.1 The static tensile test shall constitute acceptance test.

10.1.2 The following shall constitute type tests:

- a) Static tensile test;
- b) Slip test;
- c) Cyclic tensile test;
- d) Low cycle fatigue test; and
- e) High cycle fatigue test for Class H couplers only.

10.2 Selection and Preparation of Test Sample for Performance Tests

10.2.1 All tests specified under 10.1.1 and 10.1.2 and described in Annex B to Annex E shall be carried out on mechanical splices assembled in the manner as they are prepared for normal use, with a reinforcement bar conforming to grade Fe 550D of IS 1786. The above tests shall be conducted on selected sample to ensure

conformity with the performance requirements laid down in 9.2 to 9.5.

NOTES

1 Assembled and prepared for normal use implies to carry out the assembling according to the manufacturer's installation instructions.

2 In specific instances where in a project, reinforcement bars of grades lower than Fe 550D of IS 1786 are in use and the performance requirements of couplers are mutually agreed to between the purchaser and the manufacturer, the grade of reinforcement bar conforming to IS 1786 to be used in the mechanical splice shall also be as agreed.

10.2.2 A reference bar from the same heat and conforming to grade Fe 550D of IS 1786 shall be tested to determine its actual mechanical properties. The performance of some types of mechanical splices is dependent on the rib geometry of the steel reinforcing bar. The specified rib geometry shall be provided by the supplier and recorded with the test results. This requirement shall not apply to threaded couplers.

10.2.3 The test pieces shall be prepared according to the installation instructions provided by the manufacturer. The coupler shall be positioned in the middle of the test piece.

11 SAMPLING AND CRITERIA FOR CONFORMITY

The sampling procedure and the criteria for conformity shall be as given in Annex F.

12 INSTALLATION INSTRUCTIONS

The manufacturer/supplier shall provide written installation instructions. The installation instructions shall be clear and understandable. The described installation procedure of the reinforcement coupler shall be repeatable and able to achieve its performance under different job site circumstances.

13 IDENTIFICATION AND MARKING

13.1 Each reinforcement coupler shall be indelibly and clearly marked indicating the class designation and nominal size and grade of reinforcing bar for which it is intended. The manufacturer or supplier shall mark the reinforcement coupler in such a way that all finished reinforcement couplers can be traced to the original cast from which they were made along with the date of manufacture. Every facility shall be given to the purchaser or his authorized representative for tracing the reinforcement couplers to the cast from which they were made.

13.2 Each coupler should be identifiable by marks/brands which indicate the name of the manufacturer or their brand name.

13.3 BIS Certification Marking

The reinforcement coupler may also be marked with the Standard Mark.

13.3.1 The use of the Standard Mark is governed by

the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The details of conditions under which a license for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(Foreword and Clause 4)

DIFFERENT MECHANICAL SPLICING SYSTEMS BASED ON TYPE OF REINFORCEMENT COUPLER USED

A-1 MECHANICAL SPLICING SYSTEMS BASED ON THREADED COUPLER

A-1.1 In these types of mechanical splicing systems, the threaded ends of the reinforcing bar are joined together using internally threaded coupler and with appropriate tightening (*see A-1.1.1, A-1.1.2 and A-1.1.3*).

A-1.1.1 Mechanical Splicing Systems with Parallel Threaded Couplers

A mechanical splice system with parallel threaded couplers is one in which the ends of the reinforcement bars are sawn square, parallel thread is formed on the ends, which are then connected by a coupler having matching internal parallel threads.

NOTE — The occurrence and impact of play between the reinforcement bars and the coupler should be kept in consideration when using such splicing systems. The effect of reduction in bar diameter at the ends due to threading, on strength capacity of the reinforcement bars should also be considered.

A-1.1.2 Mechanical Splicing Systems with Upset Parallel Threaded Couplers

A mechanical splice system with upset parallel threaded coupler is one in which the ends of the reinforcement bars are saw cut and then hydraulically enlarged by cold forging, such that the core diameter of the bar is increased to a pre-determined diameter. A parallel thread is cut or formed onto the upsized/enlarged end of the reinforcing bars, which are then connected by a coupler having matching internal parallel threads.

NOTE — The occurrence and impact of play between the reinforcement bars and the coupler should be kept in consideration when using such splicing systems.

A-1.1.3 Mechanical Splicing Systems with Tapered Threaded Couplers

A mechanical splice system with tapered threaded

coupler is one in which the ends of reinforcements bars are saw square and a tapered thread is formed onto the bar to suit the taper threads inside the coupler. The reinforcement bars are then connected by the coupler having matching internal threads.

NOTE — The effect of reduction in bar diameter at the ends due to threading, on strength capacity of the reinforcement bars should be kept in consideration when using such splicing systems.

A-2 MECHANICAL SPLICING SYSTEMS BASED ON COUPLING SLEEVE

A-2.1 Mechanical Splicing Systems with a Crimped Sleeve

Use of mechanical splicing systems with a crimped sleeve is applicable to all deformed reinforcing bars. It consists of the introduction of the bars to be spliced into a sleeve which is crimped by means of a hydraulic crimping tool onto the deformed bars in order to fill the voids between them and the inner surface of the sleeve. The deformations on the bar penetrate into the relatively softer steel of the sleeve and the deformations work in shear.

NOTE — The impact of lengthening of the sleeve during crimping should be kept in consideration while using such splicing systems.

A-2.2 Mechanical Splicing Systems with Injected Sleeves

In these mechanical splicing systems the space between the reinforcing bars and sleeve is filled/injected with special molten metal or grout or epoxy resin, which forms a rigid interlocking layer between the bar deformations surface and the preformed grooves inside the sleeve.

ANNEX B

(Clauses 9.2.1, 9.2.2 and 9.4)

METHOD OF STATIC TENSILE TEST

B-1 PREPARATION OF TEST PIECE

The test piece for the tensile test shall be prepared in accordance with 10.2. It shall be sufficiently long to ensure a free length between the grips of the testing machine to allow determination of percentage elongation at maximum force. The minimum sufficient free length of the test piece for the tensile test in millimeters is $400 + L$, where L is the length of mechanical splice (see 3.4).

B-2 TESTING EQUIPMENT

The testing equipment shall conform to IS 1608.

B-3 TEST PROCEDURE

B-3.1 Tensile Strength

The tensile strength shall be determined by means of test carried out in accordance with IS 1608. A tensile test on an un-spliced specimen from the same bar used for the preparation of spliced specimen shall be performed to establish actual tensile strength of the reinforcing bar.

For the calculation of stresses, the effective cross-sectional area of the reinforcing bar shall be used.

B-3.2 Percentage Elongation at Maximum Force

The gauge length for determining percentage elongation at maximum force for both spliced and un-spliced specimens shall be the same. In both spliced

and un-spliced specimen, it shall be located outside the length of the mechanical splice in both the bars (see Fig. 1).

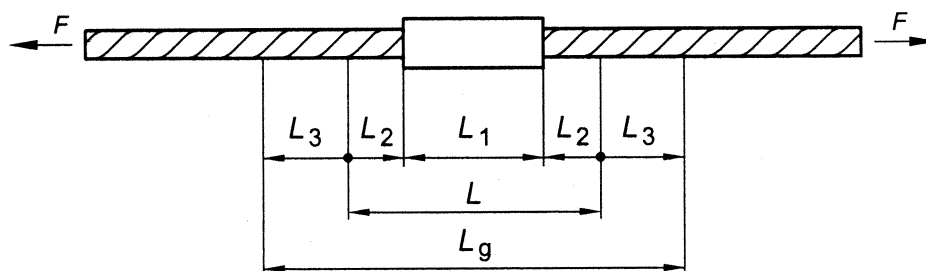
The percentage elongation at maximum force shall be tested and measured according to IS 1608 outside the length of the mechanical splice on both sides of the connection. Both values shall be recorded and the largest shall be used to assess conformity.

B-4 TEST REPORT

Each individual test report on both the spliced and un-spliced specimens shall include at least the following information:

- Tensile strength,
- Total percentage elongation at maximum force,
- Load-extension curve to the smaller of 2 percent strain or the strain at specified tensile strength of the reinforcing bar, and
- Location of failure, that is within the mechanical splice length or outside the mechanical splice length (see 3.4).

The location of failure shall be deemed to be in the bar, if it is outside the length of the mechanical splice as defined in 3.4. Where requirement of bar break is specified by the purchaser/user, a failure located inside the length of the mechanical splice shall be recorded as a splice failure.



Where

F = applied Force

L_1 = coupler Length

L_3 = in the Range, $2d$ to $3d$

L_g = overall Gauge Length in the Range from $L_1 + 8d$ to $L_1 + 10d$

L = length of the Mechanical Splice

L_2 = $2d$, Where d is the Nominal Diameter of the Reinforcing Bar

FIG. 1 DEFINITION OF LENGTHS FOR MEASURING ELONGATIONS OF THE MACHANICAL SPLICE

ANNEX C

(Clause 9.3)

METHOD OF SLIP TEST

C-1 PRINCIPLE

The slip (ΔL_s) shall be measured overall according to Fig. 2. The slip across the mechanical splice shall be found as the measured length of the mechanical splice after unloading from a load level of at least $0.6f_y$ (where f_y is the specified yield strength of the reinforcing bar = 550 N/mm²) minus the length prior to loading,

$$\Delta L_s = L_1 - L_2$$

where

L_1 = length of the mechanical splice measured after loading; and

L_2 = length of the mechanical splice measured before loading.

NOTE — Where the performance requirements of couplers are mutually agreed to between the manufacturer and the purchaser the test load shall be as agreed. However, for such cases the test load shall not be less than $0.6f_y$, where f_y is the specified minimum yield stress/0.2 percent proof stress in IS 1786 for the grade of reinforcement bar in the splice.

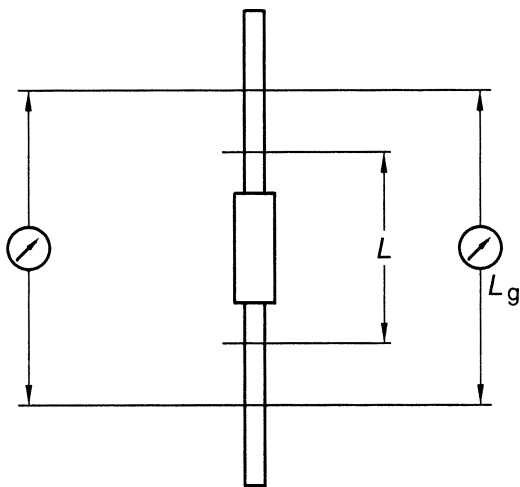


FIG. 2 PRINCIPLE OF MEASUREMENT

C-2 PREPARATION OF TEST PIECE

The test piece shall be prepared in accordance with 10.2. The test piece for the slip test may have a shorter free length than the test piece for the tensile test. However, the free length, in millimetres, should not be less than $250 + L$, where L is the length of the mechanical splice (see 3.4).

C-3 TESTING EQUIPMENT

C-3.1 The tensile testing machine to be used shall conform to IS 1608.

C-3.2 The extensometer used shall be of Class 2 or better and shall be in accordance with IS 12872. The extensometer used to determine the slip shall be at least a two-point (averaging) type, but preferably a three-point (averaging) type.

C-3.3 The slip measurement device shall be rigid enough, and fixed securely, so that the slip can be measured with an accuracy of not less than 0.01 mm.

C-3.3.1 The accuracy of slip measurement device should be checked periodically (for example annually and always, if there is a change in the testing conditions) by performing the test on a control bar with the same gauge length. The measurement accuracy is computed as the sum of the accuracy of the extensometer (as stated by its manufacturer) plus the error that could be generated by the fixing devices. If the slip measurement is done under load, the measurement accuracy is the difference between the measured and the calculated elastic elongation. If the measurement is done after load release, the measurement accuracy is the reading after the load is returned to zero.

C-4 TEST PROCEDURE

- a) The test piece shall be gripped in the tensile testing equipment in such a way that the load is transmitted axially and as much as possible free of any bending moment on the whole length of the test piece.
- b) The slip measurement should be carried out without any preloading of the test piece. If a small preloading is unavoidable to clamp the bar, the preloading stress in the bar shall be less than 4 N/mm² and the corresponding slip measurement, if any, shall be noted and included in the test report.

NOTE — Preloading of the test piece will normally take most of the slip out. A preloading does not normally occur for spliced bars in a structure.

- c) The slip measurement device shall then be attached such that the dial indicators are 180° apart. Zero them out.
- d) The gauges shall be set to zero after closure of the jaws of the tensile testing machine.
- e) An axial tensile load shall be applied such that the tensile stress in the reinforcing bar equals $0.6f_y$ ($f_y = 550$ N/mm²). The force to be applied shall be determined using the nominal cross-sectional area of the reinforcing bar. The

load shall be maintained until a steady reading is obtained on both dial indicators.

NOTES

1 Where the performance requirements of couplers are mutually agreed to between the manufacturer and the purchaser the test load shall be as agreed. However, for such cases the test load shall not be less than $0.6 f_y$, where f_y is the specified minimum yield stress/0.2 percent proof stress in IS 1786 for the grade of reinforcement bar in the splice.

2 The recommended maximum speed of loading is 500 MPa/min.

- f) The load shall then be reduced to 20 N/mm² and the readings of the two extensometers

shall be taken.

- g) Sum the value of the two readings and divide the resultant sum by two. The result shall be reported as total slip.
- h) The slip measurement device shall then be removed and an axial tensile load sufficient to cause failure of the test piece shall be applied to it.
- j) The load shall be recorded and the type and location of failure and any necking of the bar shall be noted. The maximum load attained shall be recorded as maximum test load.

ANNEX D

(Clause 9.4)

METHOD OF CYCLIC TENSILE TEST

D-1 PREPARATION OF TEST PIECE

The test piece shall be prepared in accordance with **B-1**.

D-2 TESTING EQUIPMENT

The testing equipment shall conform to IS 1608.

D-3 TEST PROCEDURE

D-3.1 The test specimen shall be subjected to 100 cycles of stress variation specified in **9.4**. One cycle is

defined as an increase from the lower load to higher load and return. The load shall vary cyclically according to a sinusoidal wave-form of constant frequency. The frequency shall be 0.5 Hz for bar sizes ≥ 36 mm and 0.7 Hz for bars of smaller size.

D-3.2 If the specimen does not fail at the end of 100 cycles, the axial tensile load shall be increased statically to cause failure in the specimen and its static tensile strength capacity shall be determined in accordance with Annex B.

ANNEX E

(Clauses 9.5.1 and 9.5.2)

METHOD OF FATIGUE TEST

E-1 The purpose of fatigue testing of mechanical splices for steel reinforcing bars is to determine the fatigue strength of the mechanical splice. The fatigue performance of a mechanically spliced bar will normally be lower than that of the un-spliced bar.

E-2 PREPARATION OF TEST PIECE

The test piece for the fatigue test shall be prepared in accordance with **10.2** and shall be sufficiently long to ensure a free length between the grips of the testing

machine, which is larger than the length of the mechanical splice.

E-3 LOW CYCLE FATIGUE TEST

E-3.1 Test Procedure

The fatigue test shall be conducted on the sample by loading it to +173 MPa to -173 MPa for 10 000 cycles. The load shall vary cyclically according to a sinusoidal wave-form of constant frequency. The frequency shall

be 0.083 Hz for bars of size ≥ 36 mm and 0.35 Hz for bars size < 36 mm. If the specimen does not fail at the end of 10 000 cycles, the axial tensile load shall be increased statically to cause failure in the specimen and its static tensile strength capacity shall be determined in accordance with Annex B.

E-4 HIGH CYCLE FATIGUE TEST

E-4.1 Principle

In the high cycle fatigue test, the test piece is subjected to an axial tensile load which varies cyclically according to a sinusoidal wave-form of constant frequency in the elastic range.

E-4.2 Testing Equipment

The fatigue test shall be carried out by means of a hydraulic ram under load control. The fatigue testing machine shall be calibrated as per IS 1828 (Part 1) and the accuracy shall be ± 1 percent or better and the machine shall be capable of maintaining the upper stress level, σ_{\max} , within ± 2 percent of the specified value and the lower stress level, σ_{\min} , within ± 2 percent of the specified value.

E-4.3 Test Procedure

- a) The test piece shall be gripped in the testing

equipment in such a way that the load is transmitted axially and as much as possible free of any bending moment on the whole test piece.

- b) The temperature in the testing laboratory should be $27 \pm 2^\circ\text{C}$.
- c) The test piece shall be subjected to sinusoidally varying axial tensile load with a stress range, $2\sigma_a$, of 60 N/mm^2 . The upper stress, σ_{\max} , in the test shall be (*see* Fig. 3) as specified in 9.5.2.
- d) The frequency of load cycles shall be constant during the test and shall be between 1 Hz and 200 Hz.

NOTE — A frequency of less than 60 Hz normally gives an acceptable temperature of the samples throughout the test.

- e) The test is terminated upon fracture of the test piece or upon reaching the specified number of cycles (2 000 000 cycles) without fracture.
- f) If the test piece fails in the gripping zone, and the mechanical splice is still intact, the test may be continued after re-gripping the test piece.

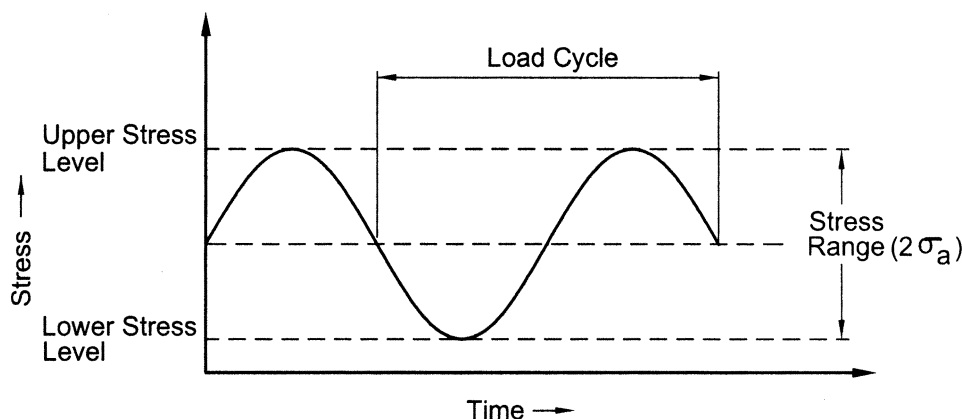


FIG. 3 LOAD CYCLE DIAGRAM FOR HIGH CYCLE FATIGUE TEST

ANNEX F (Clause 11)

SAMPLING AND CRITERIA FOR CONFORMITY

F-1 ACCEPTANCE TESTS

F-1.1 Acceptance tests are carried out on samples selected from a lot for the purpose of acceptance of the lot.

F-1.2 Lot

In any consignment, all the reinforcement couplers of the same size, type, class, material traceable to the same cast and manufactured under similar conditions of production shall be grouped together to constitute a lot.

F-1.3 For ascertaining the conformity of the lot to the requirements of the specification, samples shall be tested from each lot separately. The number of couplers to be selected from the lot shall depend on the size of the lot and shall be according to Table 1.

F-1.4 The couplers shall be selected at random from the lot and in order to ensure the randomness of selection, random number table shall be used. For guidance and use of random number tables IS 4905 may be referred to.

F-1.4.1 Workmanship and Finish and Nominal Size

The number of couplers given in col 3 of Table 1 shall be taken from the lot and examined for workmanship and finish and nominal size. A coupler failing to satisfy any of these requirements shall be considered as defective. If no defective is found in the sample, the lot shall be considered as conforming to these requirements.

F-1.4.2 Static Tensile Test

F-1.4.2.1 The lot having been found conforming to requirements of workmanship and finish and nominal size as per **F-1.4.1** shall be tested for static tensile test. For this purpose sub-samples as given in col 4 of Table 1 shall be taken and subjected to this test. The number of couplers required in the sub-sample may be taken from those already tested and found satisfactory according to **F-1.4.1**.

F-1.4.2.2 The lot shall be considered to have satisfied the requirement of static tensile test as per **F-1.4.2.1**, if the number of defective couplers found in the sub-sample is less than or equal to the corresponding acceptance number given in col 5 of Table 1.

F-2 TYPE TESTS

F-2.1 Type tests are intended to prove the suitability and performance of a new type of coupler or a new manufacturing process. Such tests therefore, need to be applied only when a change is made in the type of the coupler or in manufacturing process conditions or crimping method or forging or threading machine.

F-2.1.1 Slip Test

For this type test, the manufacturer or the supplier shall furnish to the testing authority a minimum of three samples of coupler of the largest size, three samples of the medium size and three samples of the smallest size (selected preferably from a regular production lot).

F-2.1.1.1 The samples so selected shall be tested for compliance with requirements of slip test as given in **9.3**.

F-2.1.1.2 If all the samples pass the requirements of slip test, the type of coupler or the change under consideration shall be considered to be eligible for type approval which shall be normally valid for a period of three years.

F-2.1.1.3 At the end of the validity period (normally three years) or earlier, if necessary, the testing authority may call for fresh samples for type test for the purpose of type approval.

F-2.1.2 100 Cycle Test

For this type test, the manufacturer or the supplier shall furnish to the testing authority a minimum of three samples of coupler of the largest size, three samples of the medium size and three samples of the smallest size (selected preferably from a regular production lot).

Table 1 Scale of Sampling and Criteria for Conformity
(Clause F-1.3)

Sl No. (1)	No. of Couplers in the Lot (2)	Sample Size (3)	Sub-Sample Size (4)	Acceptance Number (5)
i)	Up to 500	50	13	0
ii)	501 - 1 200	80	20	1
iii)	1 201 - 3 200	125	32	2
iv)	3 201 - 10 000	200	32	2
v)	10 001 and above	315	50	3

F-2.1.2.1 The samples so selected shall be tested for compliance with requirements of 100 cycle test as given in **9.4**.

F-2.1.2.2 If all the samples pass the requirements of 100 cycle test, the type of coupler or the change under consideration shall be considered to be eligible for type approval which shall be normally valid for a period of three years.

F-2.1.2.3 At the end of the validity period (normally three years) or earlier, if necessary, the testing authority may call for fresh samples for type test for the purpose of type approval.

F-2.1.3 *Low Cycle Fatigue Test*

For this type test, the manufacturer or the supplier shall furnish to the testing authority a minimum of three samples of coupler of the largest size, three samples of the medium size and three samples of the smallest size (selected preferably from a regular production lot).

F-2.1.3.1 The samples so selected shall be tested for compliance with requirements of low cycle fatigue test as given in **9.5.1**.

F-2.1.3.2 If all the samples pass the requirements of low cycle fatigue test, the type of coupler or the change under consideration shall be considered to be eligible for type approval which shall be normally valid for a period of three years.

F-2.1.3.3 At the end of the validity period (normally three years) or earlier, if necessary, the testing authority may call for fresh samples for type test for the purpose of type approval.

F-2.1.4 *High Cycle Fatigue Test (for Class H Coupler only)*

For this type test, the manufacturer or the supplier

shall furnish to the testing authority a minimum of three samples of coupler of the largest size, three samples of the medium size and three samples of the smallest size (selected preferably from a regular production lot).

F-2.1.4.1 The samples so selected shall be tested for compliance with requirements of high cycle fatigue test as given in **9.5.2**.

F-2.1.4.2 The following acceptance criteria shall be complied with:

- a) If all the samples pass the requirements of the high cycle fatigue test, the type of the coupler or the change under consideration shall be considered to be eligible for type approval which shall be normally valid for a period of three years;
- b) If one test sample fails the test, three additional samples of the same type and size that have failed shall be tested. If all three additional test samples pass, the test is passed and the type of the coupler or the change under consideration shall be considered to be eligible for type approval which shall be normally valid for a period of two year;
- c) If two or more test samples fail the fatigue test, the test is failed.

F-2.1.4.3 At the end of the validity period (normally three years) or earlier, if necessary, the testing authority may call for fresh samples for type test for the purpose of type approval.

F-2.1.5 The sampling and criteria for conformity for workmanship and finish, nominal size and static tensile test shall be in accordance with **F-1**.

ANNEX G*(Foreword)***COMMITTEE COMPOSITION****Concrete Reinforcement Sectional Committee, CED 54**

<i>Organization</i>	<i>Representative(s)</i>
In personal capacity (No. 17, Nalanda Apartments, D-Block, Vikaspuri, New Delhi 110018)	SHRI G. SHARAN (Chairman)
In personal capacity (A-39/B, DDA Flats, Munirka, New Delhi 110067)	SHRI P. B. VIJAY
Bhilai Steel Plant (SAIL), Bhilai	SHRI BHARAT LAL SHRI A. DASGUPTA (<i>Alternate</i>)
Central Building Research Institute, Roorkee	DR B. KAMESHWAR RAO SHRI S. K. AGARWAL (<i>Alternate</i>)
Central Electrochemical Research Institute, Karaikudi	SHRI K. SARAVANAN SHRI A. K. PARANDE (<i>Alternate</i>)
Central Public Works Department, New Delhi	SUPERINTENDING ENGINEER D-I (CDO) EXECUTIVE ENGINEER (CDO) (<i>Alternate</i>)
Central Road Research Institute, New Delhi	DIRECTOR
Central Water Commission, New Delhi	DIRECTOR (HCD-NW&S) DIRECTOR (HCD-N&W) (<i>Alternate</i>)
Construction Industry Development Council, New Delhi	SHRI P. R. SWARUP SHRI SUNIL MAHAJAN (<i>Alternate</i>)
Delhi College of Engineering, Delhi	DR A. K. GUPTA
Delhi Development Authority, New Delhi	REPRESENTATIVE
Delhi Tourism & Transportation Development Corporation Ltd, New Delhi	SHRI K. P. ABRAHAM
Department of Science and Technology (Fly Ash Unit), New Delhi	DR VIMAL KUMAR
Dextra India Pvt Ltd, Mumbai	SHRI SUNIL DESAI SHRI JITENDRA H. PATHAK (<i>Alternate</i>)
Durgapur Steel Plant (SAIL), Durgapur	DR ASIM KUMAR RAY SHRI MANOJ SINGH (<i>Alternate</i>)
Engineer-in-Chief's Branch, New Delhi	BRIG B. D. PANDEY LT COL MANOJ GUPTA (<i>Alternate</i>)
Engineers India Limited, New Delhi	DR V. R. KRISHNAN SHRI P. K. MITTAL (<i>Alternate</i>)
Gammon India Limited, Mumbai	SHRI V. N. HEGGADE SHRI SANDEEP PATTIWAR (<i>Alternate</i>)
Indian Association of Structural Engineers, New Delhi	SHRI HARI OM GUPTA SHRI MANOJ K MITTAL
Indian Institute of Technology Delhi, New Delhi	PROF A. K. NAGPAL PROF B. BHATTACHARJEE (<i>Alternate</i>)
Indian Stainless Steel Development Association, New Delhi	SHRI RAMESH R. GOPAL
Institute of Steel Development and Growth (INSDAG), Kolkata	SHRI ARIJIT GUHA
Larsen and Toubro Ltd (ECC Division), Chennai	SHRI S. KANAPPAN SHRI STHALADIPTI SAHA (<i>Alternate</i>)
Outokumpu India Pvt Ltd, New Delhi	SHRI YATINDER PAL SINGH SURI SHRI PURUSHOTHAMA REDDY (<i>Alternate</i>)
MECON Limited, Ranchi	SHRI U. CHAKRABORTY SHRI J. K. JHA (<i>Alternate</i>)
Ministry of Shipping, Road Transport & Highways, New Delhi	SHRI A. K. SHARMA SHRI S. K. MARWAH (<i>Alternate</i>)
Ministry of Steel, New Delhi	SHRI A. C. R. DAS SHRI B. D. GHOSH (<i>Alternate</i>)

IS 16172 : 2014

<i>Organization</i>	<i>Representative(s)</i>
National Council for Cement and Building Materials, Ballabgarh	SHRI V. V. ARORA SHRI S. SHARMA (<i>Alternate</i>)
National Highways Authority of India, New Delhi	SHRI M. P. SHARMA SHRI K. VENKATARAMANA (<i>Alternate</i>)
National Metallurgical Laboratory, Jamshedpur	SHRI D. D. N. SINGH
National Thermal Power Corporation, New Delhi	SHRI A. K. BANSAL
Nuclear Power Corporation India Limited, Mumbai	SHRI Y. T. PRAVEENCHANDRA SHRI R. N. SARANGI (<i>Alternate</i>)
P.S.L. Limited, Mumbai	SHRI R. K. BAHRI SHRI R. RADHAKRISHNAN (<i>Alternate</i>)
Rashtriya Ispat Nigam Ltd, Visakhapatnam	SHRI RAVI SUNDAR SHRI CH SRINIVASA RAO (<i>Alternate</i>)
Research, Designs and Standards Organization, Lucknow	SHRI ANIL KUMAR SHRI A. K. PANDEY (<i>Alternate</i>)
SAIL — Research & Development Centre for Iron and Steel, Ranchi	DR VINOD KUMAR SHRI D. KARMAKAR (<i>Alternate</i>)
Sardar Sarovar Narmada Nigam, Gandhinagar	SHRI VIVEK P. KAPADIA DR MUKESHBHAI B. JOSHI (<i>Alternate</i>)
Steel Re-Rolling Mills Association of India, Kolkata	SHRI B. M. BERIWALA COL SURENDRA SINGH (<i>Alternate</i>)
Structural Engineering Research Centre, Chennai	SHRI T. S. KRISHNAMOORTHY DR B. H. BHARATKUMAR (<i>Alternate</i>)
STUP Consultants Limited, Mumbai	SHRI C. R. ALIMCHANDANI SHRI AMIT KUMAR CHAKRABORTY (<i>Alternate</i>)
Tata Steel Limited, Jamshedpur	SHRI INDRANIL CHAKRABARTI SHRI TANMAY BHATTACHARYYA (<i>Alternate</i>)
Tata Steel Ltd (Wire Division), Mumbai	SHRI SHISHIR V. DESAI
Torsteel Research Foundation in India, Bangalore	DR SYED SHAHID SHRI M. S. SUDARSHAN (<i>Alternate</i>)
BIS Directorate General	SHRI A. K. SAINI, Scientist 'F' and Head (CED) [Representing Director General (<i>Ex-officio</i>)]

Member Secretaries

SHRI J. ROY CHOWDHURY
Scientist 'E' (Civil Engg), BIS
and
SHRIMATI MADHURIMA MADHAV
Scientist 'B' (Civil Engg), BIS

Working Group for formulation of Draft of the Standard, CED 54/WG 1

<i>Organization</i>	<i>Representative(s)</i>
Nuclear Power Corporation India Limited, Mumbai	SHRI Y. T. PRAVEENCHANDRA (Convener) SHRI R. N. SARANGI (<i>Alternate</i>)
Central Building Research Institute, Roorkee	DR B. KAMESHWAR RAO SHRI S. K. AGARWAL (<i>Alternate</i>)
Dextra India Pvt Ltd, Mumbai	SHRI SUNIL DESAI SHRI JITENDRA H. PATHAK (<i>Alternate</i>)
Larsen and Toubro Ltd (ECC Division), Chennai	SHRI S. KANAPPAN SHRI STHALADIPTI SAHA (<i>Alternate</i>)
Ministry of Shipping, Road Transport & Highways, New Delhi	SHRI A. K. SHARMA SHRI S. K. MARWAH (<i>Alternate</i>)
National Highways Authority of India, New Delhi	SHRI M. P. SHARMA SHRI K. VENKATARAMANA (<i>Alternate</i>)
P.S.L. Limited, Mumbai	SHRI R. K. BAHRI SHRI R. RADHAKRISHNAN (<i>Alternate</i>)

(Continued from second cover)

Keeping in consideration the design principles applicable for reinforced concrete, construction practices followed, installation techniques and equipments used in field and the skill level of construction workers, deviations have been made in this standard from the International Standards. The major deviations are:

- a) Changes have been made in the requirement of low fatigue test, considering the earthquake vulnerability of India and relevant testing facilities available in the country;
- b) As most parts of the country is earthquake prone, low cycle fatigue test requirement has been specified for all classes of couplers;
- c) A cyclic test of 100 cycles in tension has been specified which simulate to loading experienced in tall and stack like structures;
- d) Standard temperature conditions prevailing in the country have been adopted in the test methods;
- e) Requirements have been aligned for use of couplers with reinforcement bars conforming to IS 1786; and
- f) Sampling plan has been based on consignment sizes normally encountered and in accordance with IS 2500 (Part 1) : 2000/ISO 2589-1 : 1999 'Sampling procedure for inspection by attributes: Part 1 Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection (*third revision*)'.

Considerable contribution has been provided by Nuclear Power Corporation of India Limited, Mumbai in the formulation of this standard. The composition of the Committee and the working group responsible for formulation of this standard is given in Annex G.

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 : 1960 'Rules for rounding off numerical values (*revised*). The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act, 1986* to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Copyright

BIS has the copyright of all its publications. No part of these publications may be reproduced in any form without the prior permission in writing of BIS. This does not preclude the free use, in the course of implementing the standard, of necessary details, such as symbols and sizes, type or grade designations. Enquiries relating to copyright be addressed to the Director (Publications), BIS.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: CED 54 (7589).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002

Telephones : 2323 0131, 2323 3375, 2323 9402

Website: www.bis.org.in

Regional Offices:

Telephones

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110002

{ 2323 7617
2323 3841

Eastern : 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi
KOLKATA 700054

{ 2337 8499, 2337 8561
2337 8626, 2337 9120

Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022

{ 260 3843
260 9285

Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113

{ 2254 1216, 2254 1442
2254 2519, 2254 2315

Western : Manakalaya, E9 MIDC, Marol, Andheri (East)
MUMBAI 400093

{ 2832 9295, 2832 7858
2832 7891, 2832 7892

Branches: AHMEDABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. KOCHI. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAJKOT. VISAKHAPATNAM.