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भारत सरकार - रेल मंत्रालय

अनुसंधान अभिकल्प और मानक संगठन

लखनऊ - 226011

Government of India-Ministry of Railways  
Research Design & Standards Organisation  
Lucknow- 226011

No. CBS/GSP

Dated 02-01-2014

Principal Chief Engineer:

1. Central Railway, Mumbai CST-400 001.
2. Eastern Railway, Fairlie Place, Kolkata-700 001.
3. East Central Railway, Hazipur-844 101.
4. East-Coast Railway, Bhubaneshwar-751 016.
5. Northern Railway, Baroda House, New Delhi- 110 001.
6. North-Central Railway, Allahabad-211 001.
7. North Eastern Railway, Gorakhpur-273 001.
8. North-Western Railway, Jaipur-302 001.
9. Northeast Frontier Railway, Maligaon, Guwahati-781 011.
10. Southern Railway, Park Town, Chennai-600 003.
11. South Central Railway, Rail Nilayam, Secunderabad-500 371.
12. South East Central Railway, Bilaspur-495 004
13. South Eastern Railway, Garden Reach, Kolkata-700 043
14. South-West Railway, Hubli-580 023.
15. Western Railway, Mumbai-400 020.
16. West-Central Railway, Jabalpur-482 001.

**Sub:** Addendum and Corrigendum Slip No.6 to IRS B1-2001.

**Ref:** Railway Board's letter No.2011/CE-I/BR/BSC/81/Seminar/Pt. III dated 02-01-2014.

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In reference to above, Addendum and Corrigendum Slip No. 6 dated 02.01.2014 to IRS B1-2001 regarding HSFG Bolts is being sent for your information and necessary action please.

**Encl.:** Copy of A&C Slip No. 6  
to IRS B1-2001.

*(Handwritten signature and date)*  
02/01/14

**(A K Dadarya)**

Executive Director (B&S)  
R.D.S.O., Lucknow

GOVERNMENT OF INDIA  
MINISTRY OF RAILWAYS  
(RAILWAY BOARD)

**INDIAN RAILWAY STANDARD  
SPECIFICATION FOR FABRICATION AND ERECTION OF STEEL  
GIRDER BRIDGES AND LOCOMOTIVE TURN TABLES**

**Fabrication Specification (B1-2001)**

**Adopted – 1934  
REVISED – 2001**

**Addendum and Corrigendum Slip No. 6 dated 02.01.2014**

**New para 28.9 and 28.10 may be added as follows**

**28.9 Supply of High Strength Friction Grip (HSFG) Bolts**

**28.9.1 Reference Codes:**

- (i) IS 1367 (Part 6) – 1994 (reaffirmed 2004) – Mechanical Properties and test methods for nuts with specified proof loads
- (ii) IS 1367 (Part 8): 2002 – Prevailing Torque type Steel Hexagon Nuts - Mechanical and Performance Properties.
- (iii) IS 1367 (Part XII):1983(reaffirmed 2001) – Phosphate Coatings for Threaded Fasteners.
- (iv) IS 3757 – 1985 (reaffirmed 2003) – Specifications for High Strength Structural Bolts.
- (v) IS 4000: 1992 – High Strength Bolts in Steel Structures – Code of Practice.
- (vi) IS 6623:2004 - High Strength Structural Nuts - Specifications
- (vii) IS 6649:1985 - Specification for Hardened and Tempered Washers for High Strength Structural Bolts and Nuts.

**28.9.2 Hierarchy of Codes:** The hierarchy of codes shall be as follows:

- (i) Provisions of IRS codes.
- (ii) Where IRS codes are silent, relevant IS codes.
- (iii) Where both IRS and IS codes are silent, relevant EN codes.

**28.9.3 Definition:** HSFG bolts are high strength structural bolts which have been

tightened such as to induce predefined tension in the bolt shank. Provisions in this code apply to non – galvanized Bolts of dia. M12 to M36 only.

**28.9.4 Types of Bolts:** For the purpose of HSFG connections, only high strength structural bolts of two property classes: 8.8 and 10.9 can be used. Bolts shall conform to IS 3757. The bolts shall have the following characteristics:

- (i) **Identification:** The property class of bolts (8.8 or 10.9) shall be embossed or indented as 8S or 10S respectively on the top of head along with the manufacturer's identification symbol. Alternately, marking '8.8 S' or '10.9 S' are also acceptable. The suffix 'S' here denotes that the bolt is high strength structural bolt with a large series hexagon.
- (ii) **Length:** The length of bolt shall be chosen such as to hold the steel members in position, with provision for the nut, washer(s) and some projection beyond the bolt. Along with the overall length of the bolt, the thread length has to be specified. At least 4 full threads shall remain clear between the bearing surface of the nut and unthreaded part of the shank Further, minimum one full thread pitch must protrude from the nut after tightening.
- (iii) The minimum length of bolt shall be worked out on the basis of maximum grip length (covering ply thicknesses and all washers) plus an additional allowance as per table 1 of IS:4000.
- (iv) Maximum grip length of all plies, including packings and packing washers, shall not exceed 10 times the nominal diameter of the bolt.
- (v) **Surface Finish:** All bolts shall be supplied with coating consisting of zinc phosphate that is used in conjunction with suitable oil of rust preventive type as per IS 1367 (Part XII).

**28.9.5 Nut:** Each bolt shall be tightened using a high strength nut, conforming to IS 6623. The nut has to be strong enough to be able to impart the necessary torque to the bolt and also withstand the force during the life of the structure. Further, the threads in nut shall be matching with the threads in the HSFG bolt and the nut shall be free running on the threads of the HSFG bolts. Nuts shall have following characteristics:

- (i) **Property Class:** For HSFG bolts, the property classes to be used are 8 and 10 as specified in IS 1367 (Part 6), suitable for bolts of property class 8.8 and 10.9 respectively. Normal height of nut shall be more than 0.8 times the nominal bolt diameter.
- (ii) **Identification of Nut:** The nuts have the following markings:
  - (a) Manufacturer's identification symbol.
  - (b) Property class, marked as '8S' or '10S'. (The suffix 'S' denotes a high strength structural nut with a large series hexagon.) Alternately, '8.8 S' or '10.9 S' are also acceptable. The marking shall be either on the top or the bottom face of double chamfered nuts and shall be either indented or embossed on nonbearing surface

of washer faced nuts.

- (iii) **Surface of Nut:** All nuts shall be supplied with coating consisting of zinc phosphate that is used in conjunction with suitable oil of rust preventive type as per IS:1367 (Part XII).
- (iv) **Position of nut in bolt:** Nuts shall be provided in bolts preferably as follows:
  - (a) **In girder web:** Towards outside of the girder.
  - (b) **In flanges:** Towards bottom (Except when in composite construction).
  - (c) **In composite construction:** Towards inside of concrete.
  - (d) **In bracing:** Towards the rolled section side so that the space for rotation of the nut is not readily available.
  - (e) Where **Tapered washer** is used, the nut shall preferably be on the other side.

28.9.6 **Washer:** Annular rings which are provided between the bolt head/ nut and the members being joined are called washers. Washers for HSFG bolts shall conform to IS 6649. The washers have the following characteristics:

(i) **Types:** Three types of washers have been specified in IS 6649, clause 2:

- a) Type A: Plain hole circular washers.
- b) Type B: Square taper washers for use with channels ( $6^\circ$  taper)
- c) Type C: Square taper washers for use with I-beams ( $8^\circ$  taper)

**Identification:** Type A washers shall be identified by provision of two nibs (small projections) and manufacturer's identification symbol in indented character. The type B and C washers shall be identified by the type identification symbol, B or C and the manufacturer's identification symbol.

(ii) **Categories of washers:**

- a) **Plain washer:** Plain washers are used as per provisions of clause 28.10.2 where other types of washers are not suitable. HSFG bolts shall be provided with minimum one washer.
- b) **Packing washers:** If the bolt is longer than required, plain washers may be used as packing washers also. **However, the maximum number of packing washers shall be limited to 3, with maximum total combined thickness of 12 mm.**
- c) **Tapered Washer:** Where the angle between the axis of bolt and the joint surface is more than 3 degree off normal, a tapered washer shall be used against the tapered surface. Non rotating surface shall preferably be placed against tapered washer.
- d) **Direct Tension Indicators (DTI):** The Direct Tension Indicators are special type of washers with projections which get pressed when tension is applied. The pressing of projections to required level indicates that the required tension

has been applied in the bolts. DTIs have multiple projections, between which the feeler gauge is to be inserted to check if the bolt has been sufficiently tightened or not. The projections shall be kept in the direction of nut/head of bolt and not towards member.

**(iii) Calibration of Direct Tension Indicator:** Before the DTI are brought to site, the same shall be tested in the presence of engineer. Three nos. bolts of similar diameter and property class as to be used in the work shall be taken and installed with DTI. The installation procedure to be followed shall be similar to the one given for plain washers. On full tightening, the projections on DTI washers shall meet the requirements of checks specified after second stage tightening using DTIs. Alternately, calibrated load cells may be used to check the calibration of DTI washer. **Only the DTIs which satisfy the calibration shall be brought to site for work.**

**(iv) Surface Finish:** All washers (except Direct Tension Indicators i.e. DTIs which may have any surface finish, as specified by manufacturer, with condition that the surface finish shall be compatible with the metallurgy of the steel structure and the HSFG bolt/ nut) shall be supplied with coating consisting of zinc phosphate that is used in conjunction with suitable oil of rust preventive type as per IS 1367 (Part XII).

## 28.10 Fabrication and Assembly of High Strength Friction Grip (HSFG) Bolts

**28.10.1 Holes for HSFG Bolts:** Normal holes in the steel members being connected by the rivets shall be used for HSFG bolts also, subject to the following:

- (a) **Making of holes:** The holes shall be made by drilling only.
- (b) **Nominal Diameter of Hole:** The nominal diameter of hole shall be 1.5 mm more than the bolt diameter for less than 25mm bolt and 2mm more than the nominal diameter of the HSFG bolt for larger diameters.
- (c) **Oversize Holes:** In case the bolts are to be provided in existing structure, the maximum size of hole shall not exceed  $1.25 d$  or  $d + 4$  mm whichever is less.

### 28.10.2 Number of washers and their fixing:

(i) DTIs are very good method of ensuring that the bolts are tightened properly, and this method of tightening shall be preferred over the method with plain washers. Hence DTI washers shall be preferably used. If there is some problem with availability of DTIs, plain washers may be used for installation of HSFG bolts after approval of SAG officer in-charge of the work.

(ii) The DTIs used shall be the ones which are compatible metallurgically and also suitable for the bolts of property class 8.8 and 10.9. Suitable markings identifying the bolt manufacturer, property class of DTI and its diameter shall be engraved suitably

on the DTI.

(iii) **Number of washers to be provided:**

(a) Two washers shall be provided, one against head and one against the nut.

**(b) One DTI shall be used in one bolt.** In case DTI is being provided, the same will count as one washer i.e., one DTI and one plain washer shall be provided.

(c) DTIs shall normally be provided below the head of the bolt (with projections towards bolt head) in case nut is rotated. In case the bolt is to be rotated, DTI shall normally be provided under nut (with projections towards nut). In case other side is not accessible for measuring projection gap in DTI, the DTI may be provided under nut which is being rotated. In this case, an additional washer shall be provided on the DTI side to protect the projections from damage due to the abrasion during bolt tightening.

**28.10.3 Surface preparation for steel interface before providing HSFG bolts:**

The steel interface between the plies which form a joint having HSFG bolts shall have special surface preparation so that sufficient slip factor is available. The surface preparation shall be as assumed by designer in design, based on slip factor specified in Table XIII of Steel Bridge Code. The following surface preparation are recommended:

(i). **New construction:** The interface between the plies which are connected together by the HSFG bolts shall be "Aluminium metallised without any over coating". The aluminium metallising shall be as per para 39.2.1

(ii). **Existing structures:** The interface of plies which are to be included in the HSFG bolts shall be cleaned by wire brushing/ flame cleaning equivalent to the surface specified in IRBM para 217, 1 (b), (i) to (iv). The surfaces shall be cleaned to remove all loose rust and paint layers (Only isolated patches of coatings/ rust can remain). If, however, in existing structures, rivets are to be replaced by bolts but no surface preparation is possible, the slip factor shall be suitably reduced as per Table XIII of Steel Bridge Code.

**28.10.4 Personnel For Tightening:** The tightening of HSFG bolts is a technical procedure. Only trained personnel who understand the procedure shall carry out the installation of HSFG bolts. Before any person is deployed for installation, his knowledge of the procedure for tightening shall be checked and if found satisfactory, a competency certificate shall be issued by an engineer not below the rank of ADEN or equivalent. The competency certificate once issued shall be valid for six months. Any person deployed for installation of HSFG bolts must possess a valid competency certificate.

**28.10.5 Procedure for tightening:** Bolts shall be tightened so as to impart bolt tension as specified in para 7.12.6 of IRS Code Of Practice For The Design Of Steel

Or Wrought Iron Bridges carrying Rail, Road Or Pedestrian Traffic. The following steps shall be followed for tightening of bolts:

- (i) The holes shall be brought in alignment by using drifts etc. such that the bolt threads are not damaged during insertion of bolts. Drifting shall not distort the metal or enlarge the holes.
- (ii) The members being joined shall be held in position by insertion of few HSFG bolts (tightened to first stage (as defined in para 28.10.5) only). These bolts shall not be tightened to second stage as defined in para 28.10.5 till all the bolts in a joint are inserted and tightened to first stage.
- (iii) After the alignment/ geometry of members is verified to be correct as per drawings, balance bolts shall be inserted and tightened upto first stage of tightening. The drifts inserted as above shall also be replaced by HSFG bolts one by one.
- (iv) **Clearance between plies:** The final tightening shall not proceed until the gap between the plates has been closed. Residual gap, if any, shall be less than 2 mm at edges. There shall, however, be no gap in the central portion. In case the central portion is not in close contact or gap at edges is more than 2 mm, straightening of members may be done after opening out the bolts inserted and the entire procedure i) to iii) above shall be repeated.
- (v) **Sequence of tightening:** During tightening of bolts also, the steel members can continue to deform and hence the tightening of subsequent bolts can lead to loosening of already tightened bolts. In order to minimize the loosening of already tight bolts, tightening in the two stages shall be done starting from the stiffest part to the free edges. Stiffest parts of joint are generally towards the center of the joint.

#### **28.10.6 Procedure for Installation of HSFG Bolts Using Direct Tension Indicator:**

The tightening is done in two stages so that the bolts already tightened do not get loose when the subsequent bolts are tightened. The procedure shall be as follows:

- (a) **First Stage of Tightening:** As a first stage, all bolts in the joint shall be tightened to 'snug tight' condition in proper sequence for tightening. Snug tight condition means the nut is tightened using an ordinary wrench by an average worker, applying maximum force on the wrench. This stage is required to bring the plies in close contact.
- (b) **Checks after First stage tightening:** After first stage of tightening, the joint shall be checked to see if the plies are in close contact and the clearances are not exceeded.
- (c) **Second Stage of Tightening:** During the second stage of tightening, torque

wrench is used to tighten the bolts until the indentations on the DTI indicate full tightening. The bolts shall be tightened in proper sequence of tightening.

- (d) **Checks after Second stage tightening:** 0.40 mm thick feeler gauge shall be used to check 100% of the bolts for proper tightening. If 0.40 mm thick feeler gauge cannot be inserted in the space between indicator positions on a DTI, it is called a 'refusal'. If a 0.10 mm thick feeler gauge cannot be inserted in the space between indicator positions on a DTI, it is called 'full compression of the indicator'. The joint/bolts shall be said to be properly tightened if the following condition is met with:

Number of indicator positions in DTI washer	Minimum number of feeler gauge refusals*
4	3
5	3
6	4
7	4
8	5
9	5
*No more than 10% of the indicators in a connection bolt group shall exhibit full compression of the indicator.	

**28.10.7 Procedure for Installation of HSFG Bolts without DTI washers:** The tightening shall be done in two stages so that the bolts already tightened do not get loose when the subsequent bolts are tightened.

- i. **First Stage Tightening:** In the first stage, a calibrated wrench with an accuracy of  $\pm 10\%$  shall be set to 75% of the torque computed for the complete tightening of the bolt. The torque computed shall be as per manufacturer recommendation, duly certified to impart the bolt tension specified in para 7.12.6 of IRS Steel Bridge Code. All the bolts in the joint shall be tightened to this torque in proper sequence for tightening. After checking all bolts after the first stage, permanent marks shall be made with suitable marker on the bolt as well as nut steel member to indicate the relative position of the two. The mark shall be such that the same shall be visible for inspection upto 1 year after the date of installation.
- ii. **Checks after first stage:** After the first stage of tightening, following shall be checked:
  - a) The steel members that make up the plies of the joint with HSFG bolts shall be checked for proper contact as specified in para 28.10.4 (iv).
  - b) 10% bolts, subject to minimum 2 per joint shall be tried to be rotated with a separate calibrated torque wrench set at 75% of the proof load for the bolt. Any bolt turning by more than  $15^{\circ}$  during the check shall be rejected. If the improperly



tightened bolts thus found are more than 5 but less than 1% of the total, another 10% of the bolts shall be checked. If the total improperly tightened bolts thus found exceed 1% of the total, the tightening procedure and personnel involved shall be reviewed, the torque wrench used for tightening shall be calibrated afresh and the entire lot shall be checked for tightness.

- iii. **Second Stage Tightening:** The bolts tightened to first stage shall be turned by a further amount in proper sequence of tightening as specified below:

Total nominal thickness "t" of parts to be connected (including all packing and washers), d = dia of bolt	Further rotation to be applied, during the second stage of tightening	
	Degrees	Part turns
$t < 2d$	60	1/6
$2d \leq t < 6d$	90	1/4
$6d \leq t \leq 10d$	120	1/3

- iv. **Checks after second stage tightening:** After the second stage of tightening, following shall be checked:

- a) 100% bolts shall be checked and certified to have been turned through the requisite amount by verifying the permanent marks on the bolt and the nut/steel member.
- b) 1% of the bolts, subject to minimum of 10 per size of bolts shall be checked for gross under-tightening as per procedure given in Annexure D of IS 4000.

**28.10.8(i) Painting during initial installation:** In case of HSFG bolts with "Direct Tension Indicating" device, the final coat in field applied on complete structure may be applied on HSFG bolts also. In case part turn method of tensioning is used without "Direct Tension Indicating" device, the HSFG bolts shall not be painted and the permanent location marks made on the bolts shall be visible after 1 year of installation.

**28.10.8(ii) Painting in service:** HSFG bolts shall be painted as per normal painting schedules and painting methodologies as specified in the Indian Railways Bridge Manual for the girder as a whole.

**28.10.9 Retensioning of bolts:**

- i. The HSFG bolts are tightened beyond yield stress level and undergo plastic deformation once tightened fully. If the bolt is opened out after complete tightening, its length gets increased permanently as compared with the initial length. The initial few threads which transfer the load from the nut to the bolt suffer the maximum damage. **Therefore, a bolt completely tightened shall not be reused under any circumstances.**
- ii. A bolt which has been snug tightened or partially tightened (tightened to first stage of tightening) and then opened out will not be considered to have been fully

tensioned and reuse of such bolt will be permissible in the same or different hole, as required.

28.10.10 **Specifications of torque wrench:** Except for works of minor nature where number of HSFG bolts to be installed is very less, only mechanical torque wrenches (pneumatic, hydraulic, electronic etc.) shall be used for tightening of bolts. For small quantum of work, manual torque wrenches may be used with permission of site- in-charge.

28.10.11 **Calibration of torque wrench:** Calibrated torque wrenches, accompanied with a certificate to the effect, shall be brought to site. Torque wrenches shall be calibrated periodically at least once in a year to an accuracy of  $\pm 10\%$ . These shall be re-calibrated in case of any incidence involving the wrench during use resulting in heavy impact (such as fall, mishandling etc.) or if the joint is found to have been improperly tightened using the same. The procedure for calibration of torque wrench shall be as specified by the manufacturer.

X-----X

BY ORDER

*(Handwritten signature)*  
N.3. GSJUT  
02/11/14

(A K Dadarya)

Executive Director (B&S)  
RDSO, Lucknow