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भारत सरकार - Government of India

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पुलों के निरीक्षण के लिए आवश्यक औजार / उपकरण

Tools / Equipments Required For Inspection of Bridges

केमटेक/2023/सि/टीईआईबी/1.0
CAMTECH/2023/C/TEIB/1.0

मार्च - 2023
March – 2023

EXCELLENCE IN MAINTENANCE
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Foreword

In civil engineering structures, bridges are key elements in the transportation infrastructure and required to be inspected regularly as per schedule specified in IRBM. The safety and maintenance of bridges must be accorded high priority as such to ensure safe running of trains all the time on Indian Railway.

The document prepared by CAMTECH on Tools/ Equipment Required for Inspection of Bridges is informative and serves as a ready reference to bridge inspectors for recording measurements or any built-in imperfections during service life of bridges.

I hope that this document will be quite helpful to field engineers of open line, who are engaged in inspection and maintenance of bridges in Indian Railways.

CAMTECH/Gwalior ***(Jitendra Singh)***
28th March, 2023 ***Principal Executive Director***

Preface

Bridges on Indian Railways are the expensive and key elements of the Railway transportation infrastructure in respect of both the passenger and the freight traffic in the country. One of the major activities, which are entrusted to Railway engineering officials, is the maintenance of these bridges and to ensure their safety in accordance with the schedule of inspection as specified in IRBM.

Inspection is needed to identify or follow up the effect of any built-in imperfections, which may be caused by applied loads and other factors such as dead load, live load, wind load and physical and chemical influence of climate apart of the natural or accidental calamities. Inspection can also help to increase life of older bridges.

In current document, the various tools/ equipment as suggested in Annexure 11/15 of Para 1109 of IRBM are covered in detail for better understanding of these equipment generally used by field officials to record measurements or any built-in imperfections during service life of bridges.

It is expected that the document will be highly useful to field engineers and will serve as a ready reference during inspection of bridges.

The document is not statutory & contents are only for the purpose of knowledge dissemination. Most of the data & information in some form or the other are based on literature available and internet search. For more in-depth information/knowledge, the relevant detailed literature, BIS Codes, IRBM, IRICEN/RDSO literature, etc. available on the subject may be referred to.

I am grateful for the assistance given by Shri K.C. Shakya, SSE/Civil for his continuous study, hard work, sincere efforts & dedication to make this publication useful for the field engineers.

We welcome valuable suggestions from our readers for further improvements of this document.

CAMTECH/Gwalior ***(Deepak Mehra)***
28th March, 2023 ***Director/Civil***

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संशोधन पर्चियों का प्रकाशन
ISSUE OF CORRECTION SLIPS

इस हस्तपुस्तिका के लिए भविष्य में प्रकाशित होने वाली संशोधन पर्चियों को निम्नानुसार संख्यांकित किया जाएगा :

The correction slips to be issued in future for this handbook will be numbered as follows:

केमटेक/2023/सि/टीईआईबी/1.0/सीएस# XX दिनांक_____

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जहाँ XX संबन्धित संशोधन पर्ची की क्रम संख्या है (01 से प्रारम्भ होकर आगे की ओर)

Where "XX" is the serial number of the concerned correction slip (starting from 01 onwards).

प्रकाशित संशोधन पर्चियाँ
CORRECTION SLIPS ISSUED

क्र.सं./ Sr. No.	प्रकाशन दिनांक/ Date of issue	संशोधित पृष्ठ संख्या तथा मद संख्या/ Page No. and Item No. modified	टिप्पणी/ Remarks

1.0 INTRODUCTION

In Indian Railways, bridges are key elements and required to be inspected regularly as per schedule of inspection as specified in IRBM. Timely and economic planning and programming of remedial and preventive maintenance and repair work, or even bridge replacement with the minimum interruption to traffic are dependent upon detailed bridge inspection. Inspection is needed to identify or follow up the effect of any built-in imperfections. Inspection can also help to increase life of older bridges. For example, there are certain types of deterioration which appear early in the life of a bridge and which, if not recorded and repaired promptly, can lead to considerable reduction in the length of service life of the bridge.

Necessity of equipment for inspection of bridges depends on several factors such as type of inspection, type of bridge and its location. If the bridge is located over water, certain pieces of equipment such as life jackets and boats are necessary to have. It is therefore important to review every facet about the bridge before beginning an inspection.

The purpose of this document is meant to serve as a ready reference to field personnel of Indian Railways for better understanding of tools/ equipment generally used by field officials to record measurements or any built-in imperfections during service life of bridges.

This document is not statutory & contents are only for the purpose of knowledge dissemination. Most of the data & information in some form or the other are based on literature available and internet search. For more in-depth information / knowledge, the relevant detailed literature, BIS Codes, IRBM, IRICEN/RDSO literature, etc. available on the subject may be referred prior to actual implementation in the field.

1.1 SCOPE OF DOCUMENT

The scope of this reference document is limited to cover the tools/ equipment as specified in IRBM for general knowledge purpose only.

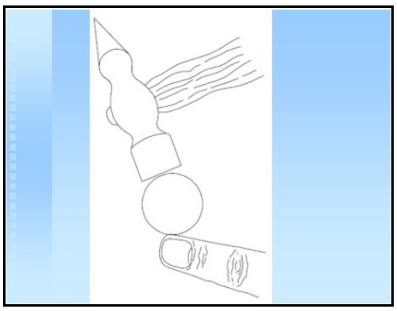
2.0 RIVET TESTING HAMMER (110 G)



Rivets, which are driven at site known as field rivets during assembly and launching of girder with pneumatic hand riveting machine, are prone to become loose in service. Also rivets, which are subjected to heavy dynamic loads and vibrations, tend to get loose. Therefore, during technical inspection it is essential to check critical location and record the status of the rivets properly.

Driven rivets should be checked with rivet testing hammer. When struck sharply on head with rivet testing hammer, rivet should be free from movement and vibration.

The rivet, which requires to be tested, is tapped smartly on Dolly Side. If the vibrations are felt by finger on other side, it means the rivets are loose and their firmness should be ensured.



To test whether a rivet is loose, left hand index finger is placed on one side of the rivet head in such a manner so that finger touches both the plate and the rivet head. The loose rivets are marked with white paint and entered in loose rivet diagram.

Critical Locations for testing loose rivets are as follows –

a) In plate girder/ composite girder:
   i) Rivets connecting web plate to flange angle of Top and bottom flange particularly at the ends of girder and below the sleeper for top flange plate.
   ii) Bearing stiffener rivets.
   iii) Splice rivets (if any)
   iv) Bracing and cross frame connection.

b) For open web girder:
   i) Rivets connecting rail bearer (stringer) to cross girder (in case of through span)
   ii) Rivets connecting cross girder to panel point gusset (in case of through span)
   iii) Rivets connection at all panel points (with main gussets to truss components) of top chord and bottom chord (field connections)
   iv) Rivets connection bottom lateral bracing to end cross girder as well as top lateral bracings and portal bracings.

Rivet testing hammer is 310 mm long having weight of 110 gm. It is used by inspection personnel BRI, PWI, AEN, and officials from Divisional and Zonal Railways Head Quarters for testing of looseness of rivets.

3.0 INSPECTION CUM CHIPPING HAMMER



Chipping hammers are lightweight, hand-held tools offering a controlled chipping action precisely to allow operators to chip away only specific areas.

Such type of chipping tools is required for prodding the surface of the concrete to determine the depth of deterioration in the materials of construction in the bridges, which are exposed to severe environmental conditions, over long periods of time.

Areas of the bridge structure which undergo alternate drying and wetting are prone to exhibit weathering damage. This defect can be easily identified by tapping the masonry with a chipping hammer. Surface deterioration will be indicated by layers of material spalling off. Hollow sound indicates deterioration of masonry stones/bricks/concrete as the case may be.

The tool is used during inspection by BRI, PWI, and AEN for checking hollow pocket/ honeycomb in masonry and concrete structure including PSC by tapping and for examining the extent of corrosion, adherence of paint on girders, and for removing loose scales.

4.0 COATING THICKNESS GAUGE



Non-destructive methods are generally applied for determining the thickness of dry paint films on metallic substrates.

Coating thickness gauge, which is used during inspection, is a digital device which is specifically designed to provide highly accurate, reliable and repeatable coating thickness measurements of paint, metalized coating, etc. on ferro-magnetic substrates.



The gauge works on principle of electromagnetic induction, when used for non-destructive coating thickness measurement on iron and steel, i.e. ferro-magnetic substrates. The coating must be non-magnetic, for instance, varnish, paint, enamel, plastic, glass, aluminium, lead, chrome, copper, brass, zinc, tin, etc.

Before use,

- It should be ascertained that the instrument is in good working condition and correctly adjusted.
- Verification should then be carried out on uncoated test plates at zero and with verified foils/shims above and below the specified dry-film thickness.
- Pre-coated test plates may be used instead of verified foils/shims.

- If the result of the verification is outside the range given by the manufacturer, the instrument should not be used.

Measurements on the dry film should only be taken after instrument accuracy has been checked. The maker's instructions should be strictly observed when making measurements with the instrument.

The gauge is specifically used during inspection by BRI, PWI, for measurement of thickness of paint, metalized coating, etc.

5.0 POCKET STEEL TAPE (3M)



Pocket Steel tape is a 3 m long measuring tool, which is used to measure deficiencies such as gap between girders or between girder and abutment, dimension of steel members, size of cracks, etc.

The characteristics of steel tape as according to IS 1269 (Part 2) should be as follows –

- It should be provided with a rust proof coating and should be free from burrs so as to ensure a longer life of the tape.
- Length of the tape is 3 metre.
- It should possess characteristics such as easy read, bold printing, comfortable for people with a weak eyesight.
- Steel tape measures of nominal length 0.5 m to 5 m should belong to accuracy class I or Class II.
- The nominal length of a steel tape measure is the distance at the reference temperature between the initial and terminal graduation lines, when the tape measure is stretched without friction, on a horizontal plane surface under a tension of 50 Newton.
- It should be provided with belt clip for easier portability.
- Its compact size gives a comfortable grip in tough working Conditions.

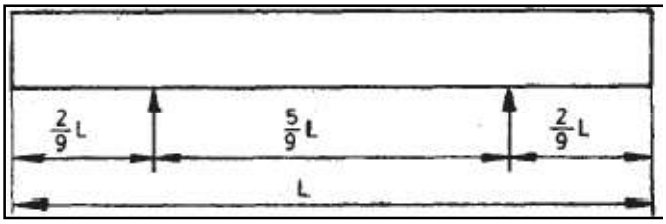
It is an essential tool required during inspection by BRI, PWI & AEN for measuring gap between girders or between girder and abutment, dimension of steel members, size of cracks, etc.

6.0 STRAIGHT EDGE (1M)

Straight edge is a physical representation, to a given accuracy, of a straight reference line, with reference to which departure from straightness or flatness of a surface may be determined. It is made of suitable steel conforming to IS 7016 (Part 1) with a rectangular section having a nominal length 1000 mm and thickness 8 mm. The Grade 00 and Grade 0 shall be used for inspection purpose.

The accuracy of straightedge, when supported at the points of best support, depends upon the tolerances (error in straightness in μm) as specified for Grade 00 as 8 and for Grade 0 as 12.

Two points on the straightedge, which when used for supporting the straightedge, result in the minimum natural deflection. These points are at 2/9 L from each end, where L is the total length of the straightedge.



Source: Para 3.5 of IS 2220:1990

Benefits of Straight Edge

- Mark straight lines with matchless accuracy.
- Quickly check the straightness of work piece.
- Stays firmly in place for improved precision when marking or scoring.
- Designed with a bevelled edge for unobstructed vision.
- Thickness ensures safety when using a metal scriber.

It is used during inspection by BRI, PWI, AEN for checking deformation/distortion/buckling of steel components, bulge of masonry structure, etc.

7.0 METALLIC TAPE (30M)

A common measuring tool, which consists of a metal strip with linear measurement markings allows for a measure of great length and to be easily carried in pocket. It is widely used for taking measurements such as clear span, overall length of girders, etc. over 100 m.



Para 8.5 of IS 1269 (Part 2): 1997 specifies that tape measures of nominal length above 5 m to 200 m shall belong to accuracy Class I, Class II or Class III.

It is an essential tool required during inspection by BRI, PWI, AEN, and officials from Divisional and Zonal Railways Head Quarters for taking measurements such as clear span, overall length of girders, etc. over 100 m.

8.0 LOG LINE WITH 20 KG BALL

The logline with 20 kg ball, which is to be kept at bridge site, is used by PWI when required for measuring scour depth, lifting/lowering of tools and tackles for examination purpose, etc.

The most commonly used and least expensive method of inspection of scour is taking of soundings with a log line. The sophisticated method of measuring this scour as well as bed levels in other parts of the bridge is by using an echo sounder.

9.0 PROBING ROD

A probing rod is an inspection tool such as a range pole, piece of reinforcing steel, a survey rod, a folding rule, or even a tree limb.

When wading in water, it is important to be aware of any scour holes and be careful not slip or fall on objects in the water. If an inspector slips or steps into a scour hole, their waders can fill with water and drag them under, making swimming impossible. It is also important to wear a life vest while wading to help prevent the inspector from being pulled down if the waders were to fill up with water. It is beneficial for the inspector to carry and use probing rod to locate scour holes and soft stream bed material.

Extensive streambed scour may result in channel depressions. During periods of low flow the depth of water in these holes may be significantly greater than the remainder of the stream bed. This could give the inspector the impression that wading is safe. It is advisable that the inspector use a probing rod to check water depth wherever he/she plans to walk.



Inspection for scour includes probing around the abutment and wing-wall footings for signs of undermining.

One should have to consider utilizing straight steel or aluminum probing rods to probe loose sediments deposited along abutments and around footings. If sediment is finer than average bed material sizes or if the sediment is easily penetrated by the rod, it is indicative that the present sediment has accumulated in the scour hole and local scour is more severe than indicated by present accumulations of sediments.

Wading inspection is the basic method of underwater inspection used on structures over wade-able streams. A wading inspection can often be performed by regular bridge inspection teams. A probing rod, sounding rod or line, waders, and possibly a boat can be used for evaluation of a substructure unit.



During wading inspection, one should preferably wear hip boots and chest waders. Boots and waders provide protection from cold and pollutants as well as from underwater objects. In deeper water, wearing of a personal floating device may be desirable during wading activities.

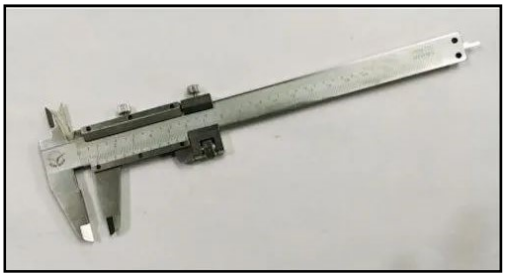
It is an inspection tool used on need basis and provides safety to inspectors during inspection for checking firmness of ground and scour measurements of the underwater portion of a bridge substructure and the surrounding channel.

10.0 CALIPER

Calipers (inside & outside) when used during inspection are required to measure correct gaps/ thickness of various parts of bridge.

Calipers are generally used for measuring the thickness of a member beyond an exposed edge. It is seen that steel members exhibit corrosion and result in loss of cross section. The section loss may be measured by using calipers as a more exact method to measure the remaining section of steel.

For steel members, remove corrosion and rust down to bare metal and use calipers to measure and record remaining section thickness.



a- When applied internally, it measures the thickness of steel sections, dia. of solid.
b- When applied externally, it measures the thickness of Hollow pipes, dia. of rivets/bolts/holes, etc.

It is a tool used during inspection by BRI, PWI, AEN for measuring correct gaps/ thickness of various parts of bridge.

The following Indian Standards may be referred while selecting vernier calipers for accuracy in measurements of gaps/ thickness of various parts of bridge.

1. IS 3651 (Part 1) – 1982 (Reaffirmed 2005) (Second Revision) for Vernier calipers with least count 0.1 mm and 0.05 mm with a maximum measuring range of 1000 mm.
2. IS 3651 (Part 2) – 1985 (Reaffirmed 2005) for Vernier calipers with least count 0.02 mm with a maximum measuring range from 0 to 150 mm only.
3. IS 3651 (Part 3) – 1982 (Reaffirmed 1998) for Vernier calipers available with least count 0.1 mm with a maximum measuring range above 1000 mm up to and including 4000 mm.

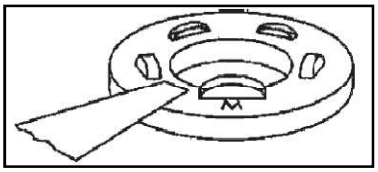
11.0 SET OF FEELER GAUGES (0.1 TO 5 MM)

Feeler gauges are mostly used in engineering to measure the width of fine cracks and cavity between parts or adjacent components.



They consist of a number of small lengths of steel of different thicknesses with measurements marked on each piece. They are flexible enough that, even if they are all on the same hinge, several can be stacked together to gauge intermediate values. The lengths of steel are sometimes called leaves or blades, although they have no sharp edge.

As shown in Figure, the feeler gauge is to be inserted between the projections to check if the bolt has been sufficiently tightened or not.



The feeler gauges are equipment required for visual examination and used by BRI, PWI, AEN during inspection of bridges as a primary inspection for surface deficiencies.

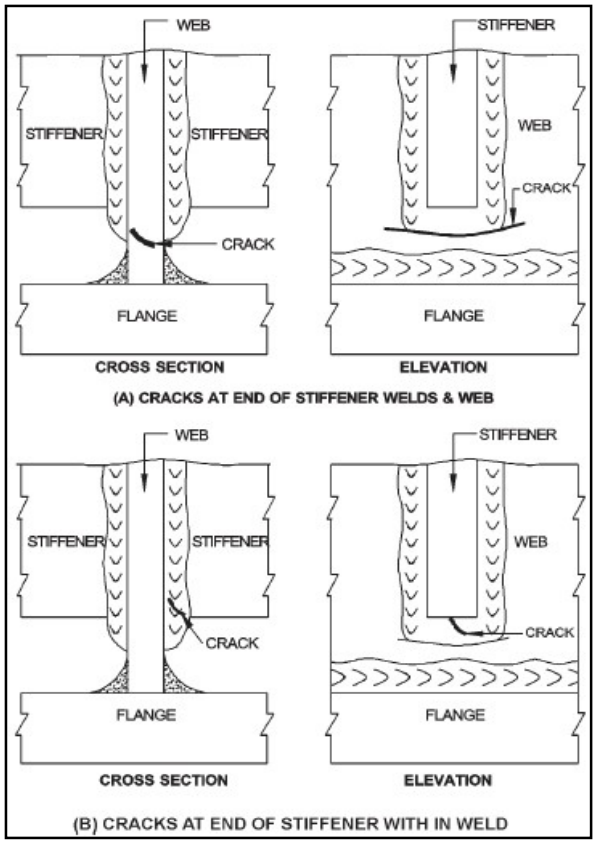
12.0 MIRROR (10 X 15 CM)

Mirror is used during inspection of bridges for inspecting parts in any awkward location by reflection method and to lit objects in dark location by directing sun rays to facilitate inspection.



As shown in Figure, the mirror enables inspection team to view hidden parts of damaged surfaces of bridge where normal human eyes cannot easily see them. A torch light also fitted on the extended arm of the mirror.

It is a useful tool required to inspect inaccessible or hard-to-reach areas that may have been missed during painting. A flashlight and inspection mirror may be needed to visually inspect these areas.



In case of welded members of steel bridges, all welds should be inspected visually to detect any crack in the weld or heat affected zone of parent metal. Any crack will show sign of corrosion around it (as the paint film is broken along the crack). Visual inspection includes using powerful magnifying glass. Mirror may be used to reflect the light on the particular location.

The following locations are to be observed especially to detect cracks during inspection:

(1) All butt joints in flange plates, particularly tension flanges.
(2) All discontinuities of weld edges such as ends of girders, adjoining cope holes in web, intermediate stiffener bottom ends of fillet welds near tension flange.

(3) Welds near the rivetted splice joints
(4) Intersecting welds (crossing one weld over the other weld)
(5) Any locations where weld repairs are already done during fabrication.
(6) In composite girders, any crack in top flange near shear connectors or cracks in adjoining concrete slab.
(7) In composite girders any vertical separation of top flange of girder and slab.

Mirror is an essential tool required during visual examination of bridges generally used by BRI, PWI, AEN for inspecting the hidden damaged surfaces, which are inaccessible (e.g., underside of deck joints) through naked eyes.

13.0 TORCH LIGHT (5 CELL)

Torch light is required during inspection by BRI, PWI, AEN and used along with mirror for identification of fine cracks in dark location; for safe passage through tunnels and other dark areas, etc.



14.0 MAGNIFYING GLASS (100 MM DIA.)

Magnifying glass (10 X or higher magnification) is a tool used during visual examination for identifying very fine cracks in members/welds which may not be visible with naked eyes.

A magnifying glass is a convex lens that is used to produce a magnified image of an object. The lens is usually mounted in a frame with a handle. The magnification of a magnifying glass depends upon where it is placed between the user's eye and the object being viewed, and the total distance between them.

It is used for close examination of cracks and areas prone to cracking.



- To arrest the crack propagation, a hole should be drilled at the end of the crack in plate and cover material is provided with rivets. The usual inspection for the detection of fatigue cracking is done with magnifying glass.
- If a crack is suspected at any location, paint film should be removed and detailed examination carried out using magnifying glass.
- As in case of Girder, when it is lifted about 10 mm and rollers are free, link plate and tooth bar are removed after opening the stud connections. All rollers should be taken out and cleaned with scraper and these are sand-papered with a fine sandpaper of zero grade. Rollers should be examined for any possible signs of flattening or minute cracks with a magnifying glass.

- The surface of concrete should be checked by a magnifying glass for any cracks.

Mangifing glass is an essential tool required during visual examination of bridges generally used by BRI, PWI, AEN for identifying very fine cracks in members/welds and areas prone to cracking.

15.0 PIANO WIRE WITH CLAMPS AND 2 NOS. 10 KG WEIGHT

Piano Wire with clamps and 2 Nos. 10 Kg weight is normally used by BRI during inspection for measuring camber in PSC girders, etc.

16.0 PLUMB BOB



A plumb bob is a weight, usually with a pointed tip on the bottom, suspended from a string and used as a vertical reference line, or plumb-line. It is a precursor to the sprit level and used to establish a vertical datum. It is generally used for visual examination to measure vertical alignment of a superstructure or substructure member of bridges.

- While checking the vertical alignment of the abutment using a plumb bob, it should be kept in mind that some abutments are constructed with a battered or sloped front face.

- Inspections of end treatments primarily involve visual inspection involving use of hand tools such as a plumb bob to check misalignment.

Plumb bob is a tool essentially required during inspection by BRI, PWI, AEN for checking verticality of girder member/pier/abutment/ trestles, etc.

17.0 CHISEL



Chisel is a cutting tool with a sharpened edge at the end of a metal blade, used often by driving with a mallet or hammer in dressing, shaping, or working a solid material such as wood, stone, or metal. It is made of steel in various sizes and degrees of hardness, depending on use.

As specified in IS 1930:2003, the cutting edge should be formed at an angle of $25^0 \pm 5^0$. The cutting edge should be ground sharp and ready for final honing. The edge should be at 90^0 to the centre line of the blade.

The tool is useful for removing unwanted hard deposits like concrete, etc. during inspection/ maintenance purposes by BRI.

18.0 STEEL SCRAPPER

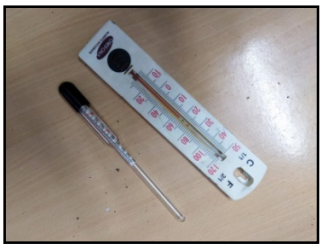


The steel scrapper is a tool used by BRI during inspection for scrapping rust/dirt/paint for inspection, for pre-treatment to dye penetration tests of welds, etc.

The scrapper is manufactured from suitable steel. This may be required where a surface needs to be trued, corrected for fit to a mating part, needs to retain oil (usually on a freshly ground surface), or to give a decorative finish.

A flat blade scraper consists of a straight flat blade with a sharpened tip end for scraping. This type of scraper can only be used on flat surfaces but is the most efficient scraper for this job. The sharpened scraping tip is often slightly convex to help prevent the corners of the scraping surface from causing burrs.

19.0 THERMOMETER



A thermometer is a device that measures temperature or a temperature gradient (the degree of hotness or coldness of an object).

The superstructure temperature can be taken by a regular thermometer or by placing a surface temperature thermometer against the superstructure member itself.



Now-a-days, laser thermometers also known as infrared thermometers are available and can be used to measure temperature from a distance without contact with the object to be measured. The design essentially consists of a lens to focus the infrared thermal radiation on to a detector, which converts the radiant power to an electrical signal that can be displayed in units of temperature after being compensated for ambient temperature. The shape is more or less like a gun and there is a region from where the laser is emitted.

- They work on the principle of laser, which is based on the simple physics concept that the molecules of matter are constantly in the motion to generate the temperature which is recorded using the laser thermometers.
- The infrared thermometers are characterized by specifications including accuracy and angular coverage. Simpler instruments may have a measurement error of about ±2 °C.
- The distance-to-spot ratio is the ratio of the distance to the measurement surface and the diameter of the temperature measurement area. For instance, if the ratio is 12:1, the diameter of the measurement area is one-twelfth of the distance to the object.

Thermometer is an important device which is required by BRI during inspection of bridge members for recording temperature at the time of measuring camber, for the purpose of setting of bearings at the desired position.

20.0 SPIRIT LEVEL

A spirit level is an instrument designed to indicate whether a surface is horizontal (level) or vertical (plumb). The spirit level is used to define a reference horizontal plane to compare the horizontality of the base of the spirit level with the plane containing the touching surfaces of the rail seating of the gauge-cum-level.

The spirit level should have the following technical features:

(i)	Base length	: 200 mm + 1 mm
(ii)	Base width	: 20 mm + 0 - 1
(iii)	Height	: 25 + 1 mm
(iv)	Bubble opening	: 50 mm x 8 mm (length x width)
(v)	Sensitivity	: 2 Min. 30 Sec per 2 mm arc division of the vial
(vi)	Least count of graduation	: 2 mm
(vii)	Weight (Without packing box)	: 150 gms. (approx).
(viii)	Effective length of bubble	: 20 + 1 mm

The spirit level should be durable and its functioning should not be affected by aging up to its life span.



Calibration should be made as per following requirements:

(i) Adjustable Calibration test bench should have the facility for tilting the spirit level, being calibrated, from one end with an accuracy to match the bubble's sensitivity.
(ii) The test bench should have a suitable dial to indicate the tilting angle of the horizontal plane on which the spirit level is placed during calibration. The dial should have circular graduated scales along its periphery divided in four quadrants each of which have least count of one second.
(iii) The sensitivity of the test bench should be tested and calibrated from time to time for which the manufacture should have the facility.

The sensitivity is to be tested on the calibration bench. For an angular movement (in the vertical plane) of the spirit level for an angle of 2 min 30 sec of the spirit level, the bubble should run one smallest divisions (2 mm) in the linear scale. The sensitivity is to be tested twice by reversing the spirit level to 180^0 on the calibration bench.

As specified in IS 5706:1993, the recommended accuracies of all types of levels for precision engineering should be from 0.05 mm/meter to 0.1 mm/meter at 27 °C.
Spirit level is an essential device required to be used by BRI during inspection for checking gauge and cross level of track on bridges or at bridge approaches, for proper setting of girders on bearings, etc.

21.0 BINOCULARS



Binoculars are two refracting telescopes mounted side-by-side and aligned to point in the same direction, allowing the viewer to use both eyes when viewing distant objects. Most binoculars are sized to be held using both hands.

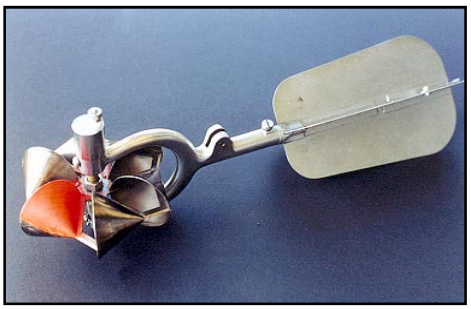
Binoculars give users a three-dimensional range: each eyepiece presents a slightly different image to each of the viewer's eyes and the parallax allows the visual cortex to generate an impression of depth. Binoculars have a focusing arrangement which changes the distance between eyepiece and objective lenses or internally mounted lens elements.

There is a limitation where visual inspection with binoculars from a boat or from the bed of the river can hardly reveal the actual condition and state of distress in the vulnerable areas. The choice, therefore, automatically falls on mobile bridge inspection units, which can cater to the needs of both horizontal and vertical accessibility all along the span. The mobile bridge inspection units may include provision of ladders, swings, cat walks, scaffoldings and platform etc. required as per the site conditions.

Binocular is an essential device used by officials from divisional head quarters during inspection of bridge components which are at inaccessible location, tall piers, arches in viaducts, etc. prior to closer examination. As it is recommended that cuttings with height 5 to 10m should be inspected using binoculars and integrity of cuttings judiciously examined.

22.0 CURRENT METER

A current meter is an instrument that measures the velocity of flowing water. While there are several types of current meters, they all have a blade or cup that spins when the meter is placed in flowing water.



The current meter is based on the principle that the velocity of water is proportional to the angular velocity of the meter's rotor. The velocity of water at a given point can be determined by counting the number of revolutions of the rotor during a specified or measured interval of time.

Current meters are classified according to their rotors.

- Vertical-axis rotors, which have cups or vanes, operate in lower velocities than horizontal axis meters. Their bearings are also protected from silty water. The rotor is also repairable in

the field without impacting the rating, and the single rotor serves for the entire range of velocities.

- In contrast, the horizontal rotor meters disturb less flow because of the axial symmetry with the flow direction. The rotor is less likely to be entangled with debris, and the bearing friction is less than for vertical axis rotors since the bending moments on the rotor are eliminated.

A limitation of all vertical axis current meters is that they do not register velocities accurately adjacent to a vertical wall.

Current meter that measures velocity of water is a useful device required by officials from divisional head quarters and zonal railways when inspection of bridge members is carried out by them through flowing water in natural streams and artificial channels normally experience turbulent flow. Local eddying always accompanies turbulent flow, and results in pulsations in the velocity at a point.

23.0 ECHO SOUNDER

Echo sounder is a device based on use of sonar for ranging, normally to determine or measure the depth of water for assessment of scour.



It involves transmitting acoustic waves into water and recording the time interval between emission and return of a pulse; the resulting time of flight, along with knowledge of the speed of sound in water, allows determining the distance between sonar and target.

Depending on the bridge site and the need envisaged during inspection, the most commonly used and least expensive method of inspection of scour is taking of soundings with a log line. The sophisticated method of measuring this scour as well as bed levels in other parts of the bridge is by using an echo sounder.

The echo sounder is a useful device normally required to be used by zonal railway officials during inspection for measuring depth of water, for assessment of scour.

24.0 SCHMIDT'S CONCRETE TESTING HAMMER

A Schmidt's concrete testing hammer (also known as rebound test hammer) is a device that is used to measure the compressive strength of concrete. It is generally helpful as a non-destructive testing method for evaluating the compressive power of concrete.

The Rebound test hammer is a practical tool for testing the hardness of concrete. The hammer measures the rebound of a spring-loaded mass impacting against the surface of a sample. The test



hammer hits the concrete at a defined energy. Its rebound is dependent on the hardness of the concrete and is measured by the test equipment.

The higher is the rebound height, the higher the compressive strength of the concrete.

When conducting the test, the hammer should be held at right angles to the surface, which in turn should be flat and smooth. The rebound reading will be affected by the orientation of the hammer: when used oriented upward (for example, on the underside of a suspended slab), gravity will increase the rebound distance of the mass, and vice versa for a test conducted on a floor slab.

Schmidt hammer measurements are on an arbitrary scale ranging from 10 to 100 and available from manufacturers in several different energy ranges, including (i) Type L-0.735 Nm impact energy, (ii) Type N-2.207 Nm impact energy, and (iii) Type M-29.43 Nm impact energy.

In accordance with BS 103 Guidelines on NDT of Bridges (RDSO), the impact energy required for rebound hammer for different applications is given below –

S. No.	**Application**	**Approximate impact energy required for the rebound hammers (N-m)**
1.	For testing normal weight concrete	2.25
2.	For light weight concrete or small and impact sensitive part of concrete	0.75
3.	For testing mass concrete i.e. in roads, airfield pavements and hydraulic structures	30.00

Prior to testing, the Schmidt hammer should be calibrated using a calibration test anvil supplied by the manufacturer. Twelve readings should be taken, dropping the highest and lowest, and then taking the average of the ten remaining. This method of testing is classed as indirect as it does not give a direct measurement of the strength of the material. It simply gives an indication based on surface properties, and as such is suitable only for making comparisons between samples.

A waterproof rebound hammer can be used underwater to estimate the compressive strength of in-place concrete based on its surface hardness. To use the hammer, the diver places and then presses it to the concrete surface until a mass in the hammer is released causing impact. The inspector estimates the concrete's strength with the use of the data.

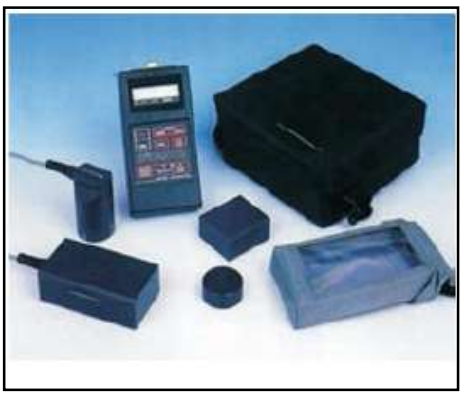
The rebound hammer testing is to be carried out as per IS 516 (Part 5/Sec 4):2020.

The device is important while being used during inspection by officials from divisional head quarters and zonal railways for assessment the strength of concrete structure by NDT method.

25.0 CONCRETE COVER METER

A cover meter is an instrument to locate rebars and measure the exact concrete cover. Rebar detectors are less sophisticated devices that can only locate metallic objects below the surface.

This is a portable and handy instrument weighing about 0.5 kg. This is normally provided with two types of search heads one for parallel bars having range approx. 360 mm and other for mesh and close spaced bars having range of approx. 120 mm. It can function over the temperature range of 0 ^{0}C to 45 ^{0}C. One of the micro cover meters commercially available in the market is shown in Figure.



The equipment is of 180mm X 100mm X 45mm size approximately. The equipment is available with volatile memory that helps in storing data while taking measurements.

Due to the cost-effective design, the pulse-induction method is one of the most commonly used solutions. The pulse-induction method is based on electromagnetic pulse induction technology to detect rebars. Coils in the probe are periodically charged by current pulses and thus generate a magnetic field. On the surface of any electrically conductive material which is in the magnetic field eddy currents are produced. They induce a magnetic field in opposite directions. The resulting change in voltage can be utilized for the measurement. Rebars that are closer to the probe or of larger size produce a stronger magnetic field.

The instrument is suitable for early diagnosis and analysis of seemingly healthy concrete cover and reinforcement status, which allows pre-emptive corrosion control measures to reduce unwanted risks to structural safety.

The test is aimed mainly to detect the location and cover of reinforcement. The test may be used for analyzing the integrity of the structures as the cover thickness is an important aspect of construction. In the coastal areas, the test can be used for deciding the effectiveness of cover as well as rehabilitation measures required.

For measurement of the cover,

- The probe is placed directly over the concrete member and moved slowly until reading is obtained on the dial. The probe should be kept parallel to the length of rebar. Depending upon the diameter of the bar, the dial reading gives directly the cover to the reinforcement.

- While moving, the cover displayed on the screen reduces and sound of the buzzer/beep increases when probe comes near reinforcement bars. The minimum reading displayed will be cover and the sound of the buzzer is strongest when the reinforcement bar is just below the search head (probe).

The method is very fast and large area can be covered within short time. The instrument works on batteries and does not require any electric supply. Since the equipment is very small and portable, the test can be conducted by single person without any assistance.

The cover meter is essential equipment specifically used during inspection by officials from zonal railways for assessing the cover available to reinforcement in existing RCC structures by NDT method.

26.0 DIAL GAUGE



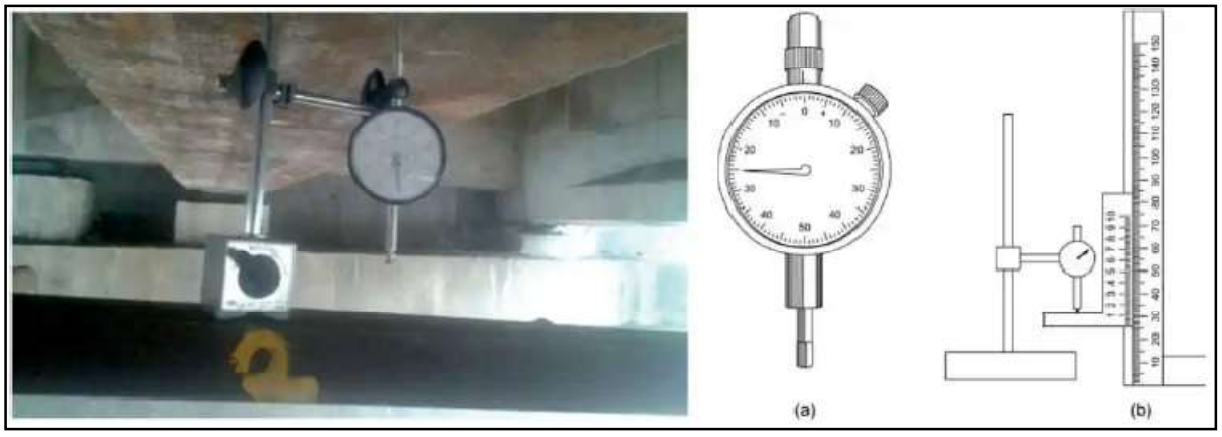
Dial gauges with least count of 0.01 mm are generally used to record the deflection measurements in load testing of arch/steel/PSC bridges, etc.

Dial gauges are fixed to magnetic stands, which rest on firm scaffolding platforms with steel plates so that the magnetic stands are firmly located. Wherever dial gauges are used, the reading should be recorded at height from the closest range possible to avoid parallax.

Glass plate of size 50 x 50 x 5 mm should be fixed to the structure at the location of Dial gauges. The spindle of Dial gauge should be in touch with the glass plate always while testing.

Due to temperature variation, the superstructure will tend to hog or sag, therefore, it should be ensured that, contact with the spindle of the dial gauges is not lost. Spindle extension should be fixed to take care of this aspect.

Dial gauges are the instruments required during inspection by officials from zonal railways for measurement of deflections in case like load testing of arch/steel/PSC bridges, etc.



27.0 DYE PENETRATION KIT



Dye penetration kit consists of coloured penetrants and developer, which are used during inspection to inspect for flaws that breaks the surface of the sample. One of the major limitations of this inspection is that flaws must be open to the surface.

Some of these flaws are listed below:

- Cracks
- Overload and impact features
- Porosity
- Laps seams
- Pin holes in welds
- Lack of fusion or braising along the edge of the bond line

1) Coloured Penetrant material is applied on thoroughly cleaned and dried surface by spraying, brushing.

   To perform well, a penetrant must possess a number of important characteristics, and

   - Spread easily over the surface of the material being inspected to provide complete and even coverage.
   - Be drawn into surface breaking defects by capillary action.
   - Remain in the defect but remove easily from the surface of the part.
   - Remain fluid so it can be drawn back to the surface of the part through the drying and developing steps.
   - Be highly visible or fluoresce brightly to produce easy to see indications.
   - Must not be harmful to the material being tested or the inspector.

   Penetrant materials come into two basic types:

   - Type 1 – Fluorescent Penetrants contain a dye or several dyes that fluoresce when exposed to ultraviolet radiation.
   - Type 2 – Visible Penetrants contain a red dye that provides high contrast against white developer background.

   Penetrants are classified by method used to remove the excess penetrant from the part:

   - Water washable penetrants can be removed from the part by rinsing with water alone.
   - Post Emulsifiable (Lipothilic) penetrants are oil soluble and interact with the oil-based emulsifier to make removal possible.
   - Solvent Removal pentrants require the use of a solvent to remove the penetrant from the part.

- Post Emulsifiable (Hydrophilic) penetrants use an emulsifier that is water soluble detergent which lifts the excesss penetrant from the surface of the part with a water wash.

Penetrants are then classified based on the strength or detectibility of the indication that is produced for a number of very small and tight fatigue cracks. The five sensibility levels are as under:

Level ½ – Ultra low Sensitivity
Level 1 – Low Sensitivity
Level 2 – Medium Sensitivity
Level 3 – High Sensitivity
Level 4 – Ultra-High Sensitivity

2) Developer to draw penetrant trapped in flaws back to surface

The role of developer is to pull the trapped penetrant material out of defects and to spread the developer out on the surface of the part so it can be seen by an inspector. The fine developer particles both reflect and refract the incident ultraviolet light, allowing more of it to interact with the penetrant, causing more efficient fluorescence. The developer also allows more light to be emitted through the same mechanism. This is why indications are brighter than the penetrant itself under UV light. Another function that some developers perform is to create a white background so there is a greater degree of contrast between the indication and the surrounding background.

- Non aqueous developers are generally recognized as the most sensitive when properly applied.
- Aqueous wet developers form a finer matrix of particles that is more in contact with the part surface. However, if the thickness of the coating becomes too great, defects can be masked. Also aqueous wet developers can cause leaching and blurring of indications when used with water washable penetrants.

The relative sensitivities of developers and application techniques are shown in the table below. There is general industry agreement with this table, but some industry experts feel that water suspendible developers are more sensitive than water-soluble developers.

Ranking	Developer Form	Method of Application
1	Non aqueous Wet Solvent	Spray
2	Plastic Film	Spray
3	Water-soluble	Spray
4	Water Suspendible	Spray
5	Water-soluble	Immersion
6	Water Suspendible	Immersion
7	Dry	Dust Cloud (Electrostatic)

8	Dry	Fluidized Bed
9	Dry	Dust Cloud (Air Agitation)
10	Dry	Immersion (Dip)

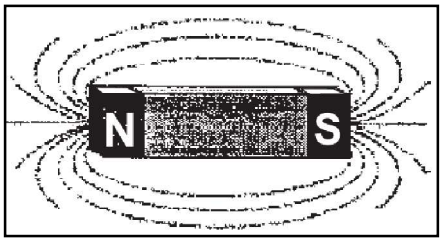
Dry penetration kit is required to be used during inspection of welded bridges by officials from zonal railways.

28.0 MAGNETIC CRACK DETECTOR

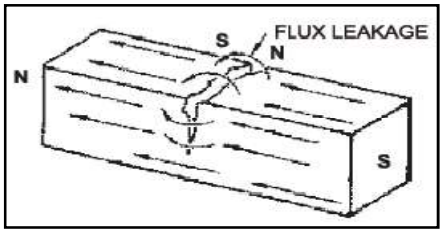
Magnetic particle inspection (MPI) is a NDT method used for defect detection in steel structures. This is a fast and relatively easy method to apply in field. MPI uses magnetic fields and small magnetic particles such as iron fillings to detect flaws in components. The component being inspected must be made of a ferromagnetic particle such as iron, nickel, cobalt or some of their alloys. Ferromagnetic materials are materials that can be magnetized to a level that will allow the inspection to be effective.

The method may be used effectively for inspection of steel girders and other bridge parts made of steel.

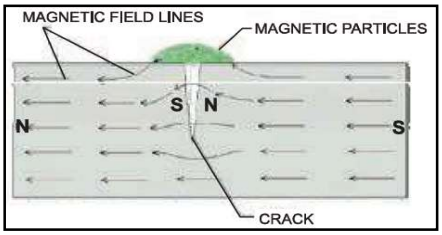
When ferromagnetic material or component (weld) is magnetized, magnetic discontinuities that lie in direction approx. perpendicular to the field direction will result in formation of a strong field. This leakage field is present at and above the surface of magnetized component and its presence can be visibly detected by the cluster of finely divided magnetic particle i.e. when crack is met to magnetic field direction it will form local magnet and will attract fine particles along the crack when sprayed. Magnetization may be induced in the component by using permanent magnet or electromagnet.



If the magnet is just cracked but not broken completely in two, a north and south pole will form at each edge of crack. The magnetic field exits the North Pole and re-enters at the South Pole. The magnetic field spreads out when it encounters the small air gap created by the crack, because the air cannot support as much magnetic field per unit volume as a magnet can. When the field spreads out, it appears to leak out of the material and, thus it is called a flux leakage field.



If the iron particles are sprinkled on a cracked magnet, the particles will be attracted to and cluster will be formed not only at the ends of the magnet (poles) but also at poles formed at the edges of cracks. This formation cluster of particles along edges of cracks can be easily detected.



The direction of magnetic field in an electromagnetic circuit is controlled by the direction of current flow. The effectiveness of the defect indication will depend on the orientation of the flaw to the induced magnetic field and greatest when defect is perpendicular. Hence to detect a defect in a member/weld, it has to be tested in both axis i.e. X-X axis as well as Y-Y axis.

For establishing magnetic field in component various types of equipments, which are portable and can be used in the field without any handling problems are as under –

- **Permanent magnets:** These are bar magnets and horseshoes (yoke) magnets which are very strong and difficult to handle in field. Normally these are used for underwater inspection and for explosive environment, where electromagnets cannot be used.

- **Electromagnets:** These are magnets widely used in the MPI equipments. An electromagnetic yoke is a very common piece of equipment which is made by wrapping an electrical coil around a piece of soft ferromagnetic steel. This type of magnet generates a strong magnetic field in a local area where the poles of magnet touch the part to be inspected.

- **Prods:** These are hand held electrodes that are pressed against the surface of the component being inspected to make contact for passing electrical current through steel. The current passing between the prods creates a circular magnetic field around the prods that can be used for magnetic particle inspection. Prods are made from copper and have an insulated handle. Sometimes two prods are connected by any insulator to facilitate one hand operation. This is known as dual prod also and generally used for weld inspection.

- **Portable coils and conductive cables:** These are used to establish a longitudinal magnetic field within a component. When a preformed coil is used, the component is placed against the inside surface on the coil.

While performing the test in the field, it should be ensured that

1. The surface should be cleaned and must be free of grease, oil or other moisture before inspection.
2. Apply the magnetizing force using permanent magnets, electromagnetic yoke, prods, a coil or other means to establish the necessary magnetic flux.
3. Dust on the lighter layer of magnetic particles with the magnetizing force still applied, remove the excess powder from the surface with few gentle puff of dry air.
4. If wet suspension is used, then the suspension is gently sprayed or flowed over the surface to be tested. Immediately after the application of wet suspension the magnetizing force should be applied.
5. After this the area should be inspected carefully for finding out the cluster of particles. Surface discontinuities will produce a sharp indication.

Magnetic particles: The magnetic particles that are used for inspection are a key gradient as they form the indications that alert the inspector to defects. Particles start out as tiny milled (a

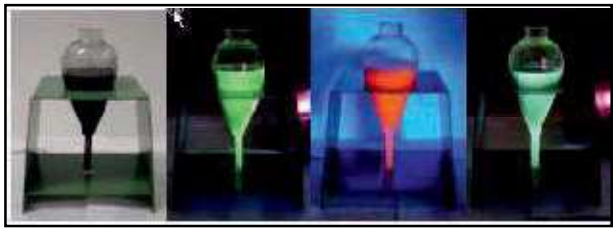
machining process) pieces of iron or iron oxide. A pigment (somewhat like paint) is bonded to their surfaces to give the particles colour. Particles are available in a dry mix or a wet solution.

- Dry magnetic particles can typically be purchased in red, black, grey, yellow and several other colours so that a high level of contrast between the particles and the part being inspected can be achieved. The fine particles are around 50 µm in size are about three times smaller in diameter and more than 20 times lighter than the coarse particles of 150 µm in size, which makes them more sensitive to the leakage fields from very small discontinuities. However, dry testing particles cannot be made exclusively of the fine particles. Coarse particles are needed to bridge large discontinuities and to reduce the powder's dusty nature. Additionally, small particles easily adhere to surface contamination, such as remanent dirt or moisture, and get trapped in surface roughness features producing a high level background. The particle size is also important. Elongated particles come from the dispenser in clumps and lack ability to flow freely and form the desired "cloud" of particles floating on the component. Therefore, globular particles are added that are shorter. The mix of globular and elongated particles results in a dry powder that flows well and maintains good sensitivity.



  - Dry particle inspection is well suited for the inspection conducted on rough surfaces. When an electromagnetic yoke is used, the AC or half wave DC current creates a pulsating magnetic field that provides mobility to the powder. The primary applications for dry powders are ungrounded welds and rough as-cast surfaces.
  - Dry particle inspection is also used to detect shallow subsurface cracks. Dry particles with half wave DC is the best approach when inspecting for lack-of-root penetration in welds of thin materials. Half wave DC with prods and dry particles is commonly used when inspecting large castings for hot tears and cracks.

- Wet magnetic particles are supplied in a wet suspension such as water or oil. The wet magnetic particle testing method is generally more sensitive than dry because the suspension provides the particles with more mobility and makes it possible for smaller particles to be used since dust and adherence to surface contamination is reduced or eliminated. The wet method also makes it easy to apply the particles uniformly to a relatively large area. Most non fluorescent particles are ferromagnetic iron oxides, which are either black or brown in colour. Fluorescent particles are coated with pigments that fluoresce when exposed to UV light. Particles that fluoresce green-yellow are most common to take advantage of the peak colour sensitivity of the eye but other colours are also available. The particles used with wet method are smaller in size than those used in dry method. Particles are typically 10 µm and smaller and the synthetic iron oxides have particle diameters around 0.1 µm. however, due to their slight



residual magnetism, the oxide particles are present mostly in clusters that settle out of suspension much faster than the individual particles. Wet particles are also a mix of long slender and globular particles.

The carrier solutions can be water-based or oil-based. Water-based carriers form quicker indications, are generally less expansive, present little or no fire hazard, give off no petrochemical fumes, and are easier to clean from the part. Water-based solutions are usually formulated with a corrosion inhibitor to offer some corrosion protection. However, oil-based carrier solutions offer superior corrosion and hydrogen embrittlement protection to those materials that are prone to attack by these mechanisms.

- Wet particle inspection involves applying the particles while they are suspended in a liquid carrier and is most commonly performed using a stationary, wet, horizontal inspection unit but suspensions are also available in spray cans for use with an electromagnetic yoke. A wet inspection has several advantages over a dry inspection. First, all the surfaces of the component can be quickly and easily covered with a relatively uniform layer of particles. Second, the liquid carrier provides mobility to the particles for an extended period of time, which allows enough particles to float to small leakage fields to form a visible indication. Therefore, wet inspection is considered best for detecting very small discontinuities on smooth surfaces. On tough surfaces, however, the particles (which are much smaller in wet suspensions) can settle in the surface valleys and loose mobility rendering them less effective than dry powders under these conditions.

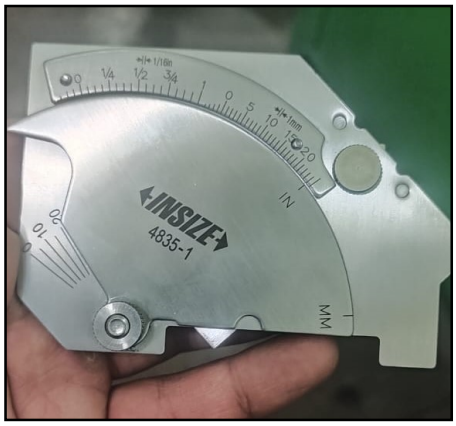
- Suspension liquids used in wet magnetic particle inspection method can be either a well refined light petroleum distillate or water containing additives. Petroleum based liquids are most desirable carriers because they provided good wetting of the surface of metallic parts. However, water-based carriers are used more because of low cost, low fire hazard, and the ability to form indications quicker than solvent-based carriers. Petroleum based carriers are primarily used in systems where maintaining the proper particle concentration is a concern. The petroleum based carriers require less maintenance because they evaporate at a slower rate than the water-based carriers. Therefore, petroleum based carriers might be a better choice for a system that only gets occasional use and adjusting the carrier volume with each use is undesirable.

Magnetic crack detector is part of NDT methods that are required to be applied during inspection of welded bridges by officials from zonal railways.

29.0 WELDING GAUGES

There are many different types of welding gauges used for inspection especially on welded surface and joints. One of the widely used welding gauges is Bridge Cam Gauge, which is a simple, versatile, accurate, easy to use, and handy to perform many tasks. The gauge has a rotating dial and a sliding pointer to measure weld features. The measurement is displayed in inches and millimetre up to 2 inch or 60 mm.

Calibration of Bridge Cam Gauge



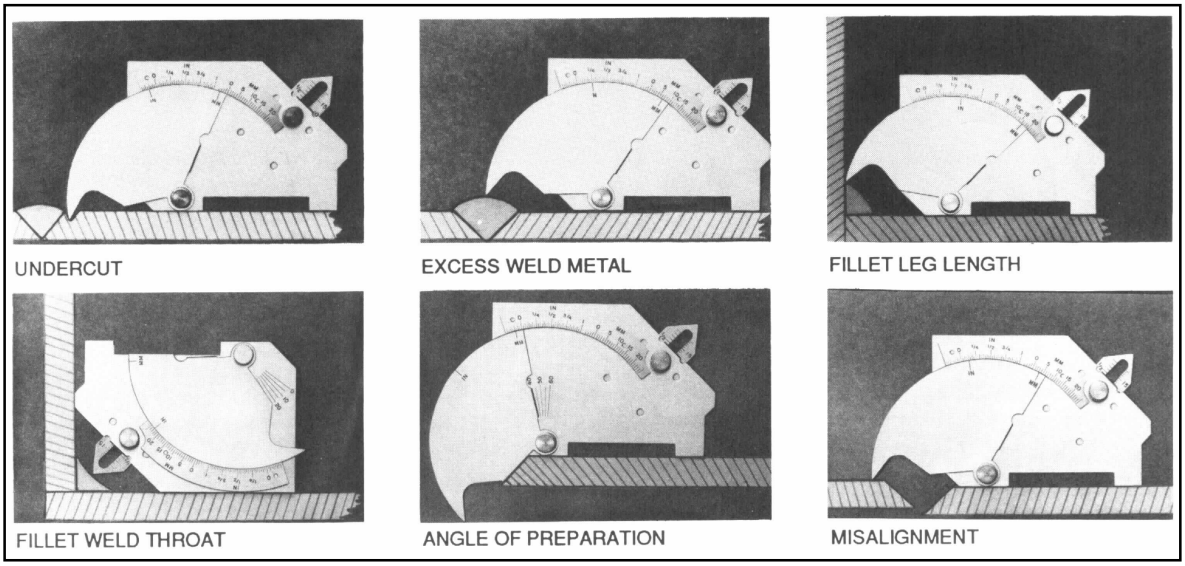
Welding gauge calibration is an important part of welding Quality Control & Assurance. It ensures that the welds meet the minimum weld size requirements & meet the required specifications.

Welders & Welding Inspectors use welding gauges to measure the weld size and to make sure that they are within the acceptance limit. If the weld is not within specification, it will not meet the strength requirements, which could lead to a failure in the weld.

Calibration of bridge cam gauge should be made using the calibration block. It's always advisable to calibrate the welding gauges with the manufacturers. Welding gauge calibration should be done on a regular basis, preferably every 6 months frequency tor when there are visible damages to the gauge. This will ensure the welding gauges are in the proper state & conditions.

Bridge Cam Gauge is a unique, simple, versatile, accurate, easy to use and handy instrument to perform many tasks during inspection of welded surfaces and joints. It measures the followings:

1. The angle of preparation from 0 to 60 deg
2. Excess weld metal (welding cap or capping size)
3. The depth of welding undercut or pitting
4. Fillet weld throat size
5. Fillet leg length
6. Misalignment (high-low)



Another type of welding gauge i.e. Fillet Weld Gauge is very handy and commonly used to check fillet welds either concave or convex. It is made of stainless steel and measures weld preparations and completed butt & fillet welds, angle of preparation, excess weld metal, fillet leg length & throat size. It has an accuracy of ±0.5 mm and 07 blades of sizes 3-12mm, 14mm, 16mm, 19mm, 22mm, 25mm.



As specified, the welding gauge is an important tool required to be used by BRI during inspection of welded surfaces and joints of steel structures.

30.0 HELMET

During inspection, top priority must be given to safety. Safety helmet including other safety gears serves the purpose of protecting inspection team member from head injury.

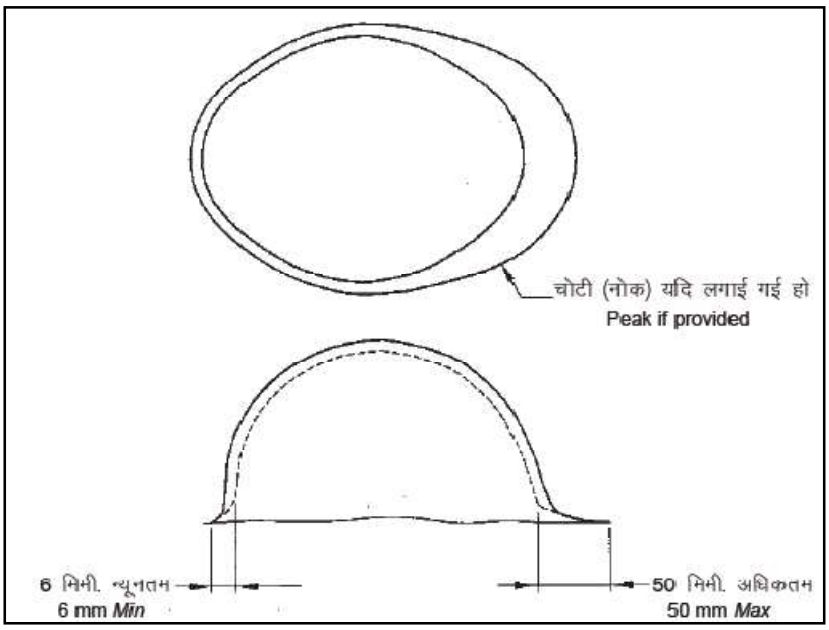


The requirement of helmet is intended to provide protection against falling objects and other hazards which may be encountered in mining, tunneling, quarrying, ship building, construction projects and similar other industrial occupations.

The hard smoothly finished material that provides the general outer form of the helmet, called as shell, should be dome shaped and provided with a brim with or without a peak. The brim and peak (where provided) should be integral part of the shell and these should have no sharp edges. The brim should be continuous around the dome. The dimensions of brim and the peak (were provided) should be in accordance with Figure as shown below:

The position of ventilation holes should be such that the central axis of the holes is almost horizontal when the helmet is in normal wearing position. The diameter of any hole should not exceed 6 mm nor the edges of adjacent holes closer than 15 mm. The minimum number of holes on each of the two sides should be not less than 3 and total aggregate area of holes should not be less than 180 mm^2 and not exceed 300 mm^2.

Helmet should be complete fitted with headband, cradle, chin strap or nap strap, cable clip, etc. It is an essential safety requirement by BRI during inspection of welded bridges.



Source: IS 2925: 1984 (Reaffirmed 1995) (Second Edition)

31.0 SAFETY BELT



Safety belts are required to protect persons from injury by arresting the fall in the event of the user losing his/her balance or support and failing from the place of working either at an elevation or in closed locations or containers.

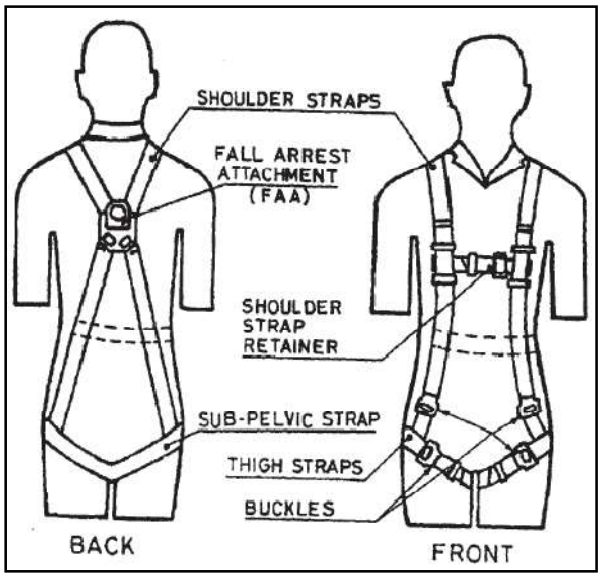
All belts and harnesses should be made from nylon or other synthetic materials, such as polyester. The material should have a uniform thickness and uniform width. The waist belt, shoulder straps, hoisting straps, pole straps and all types of safety belts and harnesses should be made from nylon/ polyester webbing. The test specimen should be of entire cross section whose minimum width and thickness should be 40 mm and 3 mm respectively. All the materials used in the production of webbing and rope should pass the flammability tests.

All metal components should be solid or forged in such a manner that the joints are not visible and the joined part of the metal does not impair the strength or quality. The surface should be of smooth finished and free from any manufacturing defects, burrs or uneven surface. Hooks, clamps or other fastening and holding devices should be of similar quality and properly treated or plated.

The minimum width of all straps should be 40 mm except shoulder retaining strap, which should be of minimum width of 20 mm.

In selecting belt or harness for a particular duty, care should be taken to ensure that equipment gives the wearer protection, as far as possible, and also ensures safety, maximum degree of comfort, freedom of movement and in the event of falling, the greatest possible security against injury either from the impact from ground or from surrounding structures or from the belt itself.

The equipment should be tested before its actual use by human wearer.



Source: IS 3521: 1999 (Reaffirmed 2002) (Third Revision)

- **Procedure for Performance Test:** Attach the safety belt or harness to the dummy as it would be worn by the worker. Secure the work positioning attachment element with a properly affixed rigid anchorage. Raise the dummy in an upright position until the axis of the work positioning attachment round the dummy and anchorage point are horizontal. Hold the dummy in position by a quick release device. After the release when the dummy has come to rest examine for any slippage, damage or other deterioration.

- **Procedure for Dynamic Load Test:** Fit the articulated human dummy with the harness equipped with lanyard and without an energy absorber. Suspend the dummy by its upper attachment point and raise to an extent that the total free fall shall be of 4 m and the maximum horizontal distance from the central line shall be 300 mm. Hold it with the quick release device. Release the dummy without initial velocity, the feet first free fall being 4 m. Observe whether the harness releases the dummy. Also observe the orientation of the dummy and measure angle between the longitudinal axis of the dorsal plane of the dummy and the vertical. Using same rope, repeat the test procedure within 15±1 min suspended from its lower attachment point and achieve a head first free-fall of 4 m.

The workers engaged in construction, erection, installation and such other jobs should be trained and instructed in the safe use of the equipment and be observant of such training and instruction.

While using safety belt by inspecting officials (BRI), the manufacturer's instructions should be followed to ensure adequate safety during visual inspection of welded bridges.

32.0 FIBERGLASS BOAT

If the bridge is located over water, certain pieces of equipment such as life jackets and boats are necessary to have. The boats are used for soundings and inspection; safety for over water work.

A boat is a watercraft of a large range of types and sizes, but generally smaller than a ship. Small boats, generally Lifeboats equipped with safety functions are typically found on inland waterways such as rivers and lakes, or in protected coastal areas. Boats can be propelled by manpower (e.g. paddle boats), wind (e.g. sailors), and inboard/outboard motors (including gasoline, diesel, and electric).



Boats made of fiberglass are popular and strong against structural degradation from sunlight and extremes in temperature over their lifespan.

Onboard Safety Aspects

- Always wear a life jacket when working over water or in a boat.
- There must be one rescue person present and specifically assigned to respond to water emergencies at all times when the inspection over water is active. Whenever possible, a manned boat should be in the water. In situations where the use of a boat is not practical, a rescue person should be stationed on the river bank with a life ring.
- Be sure the boat is equipped with a life ring and radio communication with the inspection crew.
- The safety of the inspection personnel, boat operators is a primary concern.

A boat can be used for inspection, as well as providing access to areas for taking photographs. Also, a safety boat is required when performing an inspection over water.

The facility to gain access to bridge structures located in water, etc. is required only for officials who have bridges with large waterways requiring the use of boats to be decided by CBE.

33.0 TOTAL STATION/ THEODOLITE/ AUTO LEVEL

Measurement of Camber in Steel Open Web girders & PSC girders for assessing camber loss, if any is a part of detailed bridge inspection of SSE/Bridges and AEN/Bridges. IRBM mentions the use of a reliable method for camber measurement which includes Piano wire, Leveling instrument or Theodolite.

An **Auto Level** is commonly used as a levelling instrument to locate the points in same horizontal plane. It is used to determine the elevations of different points and distance between the points of same elevation. The telescope is fixed to its supports and it cannot be rotated in vertical axis. Good level instrument shall have property of automatic horizontal adjustment of the line of sight, an erect figure and a horizontal circle of 0 - 360° and large ribbed control buttons to simplify the adjustment of the instrument. The compensator shall be magnet damped, so that after the instrument has been set almost



horizontal, the line of sight can be carefully leveled using the automatic compensation mechanism.



A **Theodolite** is an instrument for measuring both horizontal and vertical angles, as used in triangulation networks. It is a key tool in surveying and engineering work, particularly on inaccessible ground. A modern theodolite consists of a movable telescope mounted within two perpendicular axes—the horizontal or turn-on axis and the vertical axis. When the telescope is pointed at a desired object, the angle of each of these axes can be measured with great precision, typically on the scale of arc seconds.



A **Total Station** is an electronic/ optical instrument, which combines the functions of a theodolite and a level and more. It uses a laser or infrared beam to measure both vertical and horizontal angles and the slope distance from the instrument to a particular point, and an on-board computer to collect data and perform triangulation calculations. Robotic total stations allow the operator to control the instrument from a distance via remote control. This eliminates the need for an assistant staff member as the operator holds the reflector and controls the total station from the observed point.

The importance of Total Station in modern days may be appreciated from the following instructions issued from the office of Chief Bridge Engineer/SCR vide Letter No. W71/BrL/P/9/Vol-VIII, dated 22.02.2021 for measuring the camber of both Steel & PSC girders:

- Camber shall be measured at the time of initial erection and subsequently during the detailed inspection of Superstructure as per schedule given in IRBM.
- Readings should be taken over the same marked locations for comparison of camber values measured periodically. Camber is measured by taking the relative position of the nominated locations of the girders with reference to the end points i.e., average of the readings taken at end points of the girder will be the reference for camber measurement at other points of the girder.
- All readings of a girder span should be taken between passage of two consecutive trains. If any train passes over the bridge while taking the readings, all readings of this girder span shall be repeated again.
- Temperature at the time of taking camber measurements shall also be recorded.

Camber Measurement in Steel Triangulated Girders

- Good quality Levelling instrument shall be used for measuring the camber and readings shall be taken on the cross girder at the panel point locations. Instrument shall be placed on the bridge approaches for taking measurements of the end spans and on trolley refuges for intermediate span measurements

- For reliable measurements, the readings of each girder shall be taken from a single setting of the instrument. To minimize errors, the instrument shall be set in such a way that there is a minimum or no traversing of telescope in horizontal plane.
- A sliding vernier scale over the levelling staff with a least count of at least 0.5 mm shall be used to improve accuracy of measurements.
- Two readings shall be taken at each panel point over the cross girder, one on each side of the track which is well marked with paint. Average of the two readings shall be considered.

Camber Measurement in PSC Girders

- Camber measurements shall be taken underside of the girders. Total Station instrument shall be used for taking the measurements.
- For girders with span up to 20 m, camber readings at mid-span are sufficient. For girders of span greater than 20 m, camber readings at quarter spans are also required to be taken.
- In case of PSC 1-girders, readings are to be taken for each of the I-girders in a span. For PSC BOX girders, readings along the centre line of girder bottom shall be taken at end, mid and quarter points.
- End/Mid/quarter point locations shall be marked clearly with paint on the bottom surface of each of the girders. For easy visibility, the respective points shall be painted with a white circle of 10 cm dia. along the centre line of the girder bottom. White paint will facilitate proper reflection of laser beam back to the instrument where reflector less method of Total Station is adopted for measurement. If the concrete surface at the marking location is uneven or having any projections, mild grinding of the surface shall be done before painting the circle.
- End point locations of each girder shall be marked near the face of pier cap so that they are visible to the telescope of the Total station and facilitate placement of prism reflector staff over the points.
- It is preferable to take the Total station readings by using a Prism reflector staff wherever feasible. For spans having shorter pier heights and which are easily accessible during dry season of the year without any water flow in the span, it is possible to place the reflector staff on the girder underside for measurements.
- For spans having flowing water throughout the year or where piers are very tall and girder underside is not easily accessible for placing the staff, readings may be taken using Reflector less method of Total station.
- To minimize errors, the Total station shall be positioned approximately mid-way of each of the spans at a minimum lateral distance from the bridge. All readings of a span shall be taken with a single setting of the instrument. Taking readings of two or more spans with a single setting should not be resorted to.
- If it is not possible to position the instrument mid-way of a particular span of the bridge due to water flow or any other reason, cradle type arrangement shall be made around the piers of this span for positioning the Total Instrument. Two sets of readings shall be taken for such spans with instrument positioned over the cradles at each pier and average of these readings shall be considered.

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NOTES

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If at any point contradiction is observed, then Indian Standards, regulations issued by Government bodies, Railway Board/ RDSO guidelines shall be referred.

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To upgrade Maintenance Technologies and Methodologies and achieve improvement in productivity and performance of all Railway assets and manpower which inter-alia would cover Reliability, Availability, and Utilisation.

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