भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS

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हमारा संदर्भ : सीईडी 43/टी-7 **25 अक्टूबर 2022**

तकनीकी समिति : मृदा एवं नींव इंजीनियरी विषय समिति, सीईडी 43

प्राप्तकर्ता :

1 सिविल इंजीनियरी विभाग परिषद, सीईडीसी के सभी सदस्य
2 मृदा एवं नींव इंजीनियरी विषय समिति, सीईडी 43 के सभी सदस्य
3 IS 2131 और IS 9640 के पुनरीक्षण के लिए पैनल, सीईडी 43:P4
4 रूचि रखने वाले अन्य निकाय।

महोदया/महोदय,

निम्नलिखित मसौदा संलग्न है:

प्रलेख संख्या	शीर्षक
सीईडी 43 (21115)WC	**मृदा की मानक भेदन परीक्षण – परीक्षण की विधि का भारतीय मानक मसौदा (IS 2131 *का दूसरा पुनरीक्षण*)** **(ICS No. 93.020)**

कृपया इस मसौदे का अवलोकन करें और अपनी सम्मतियाँ यह बताते हुए भेजे कि यह मसौदा प्रकाशित हो तो इस पर अमल करने में, आपको व्यवसाय अथवा कारोबार में क्या कठिनाइयॉ आ सकती हैं।

सम्मतियॉ भेजने की अंतिम तिथि: 25 नवंबर 2022

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को ई मेल द्वारा **madhurima@bis.gov.in** पर या उपरलिखित पते पर, संलग्न फोर्मेट में भेजें।

यदि कोई सम्मति प्राप्त नहीं होती है अथवा सम्मति में केवल भाषा संबंधी त्रुटि हुई तो उपरोक्त प्रलेख को यथावत अंतिम रूप दे दिया जाएगा। यदि सम्मति तकनीकी प्रकृति की हुई तो विषय समिति के अध्यक्ष के परामर्श से अथवा उनकी इच्छा पर आगे की कार्यवाही के लिए विषय समिति को भेजे जाने के बाद प्रलेख को अंतिम रूप दे दिया जाएगा।

यह प्रलेख भारतीय मानक ब्यूरो की वैबसाइट **www.bis.gov.in** पर भी उपलब्ध हैं।

धन्यवाद।

भवदीय

ह/-

(अरुण कुमार एस.)
वै. 'ई'/निर्देशक और प्रमुख (सिविल इंजीनियरी)

सलंग्न: उपरिलिखित

भारतीय मानक ब्यूरो
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DRAFT IN WIDE CIRCULATION

DOCUMENT DESPATCH ADVICE

Reference	Date
CED 43/T-7	25 October 2022

TECHNICAL COMMITTEE:

SOIL AND FOUNDATION ENGINEERING SECTIONAL COMMITTEE, CED 43

ADDRESSED TO:

1. All Members of Civil Engineering Division Council, CEDC
2. All Members of Soil and Foundation Engineering Sectional Committee, CED 43
3. All Members of the Panel for Revision of IS 2131 and IS 9640, CED 43:P4
4. All other interests

Dear Madam/Sir,

Please find enclosed the following draft:

Doc. No.	Title
CED 43 (21115)WC	**Draft Indian Standard Standard Penetration Test of Soil — Method of Test (*Second Revision of* IS 2131) (ICS No. 93.020)**

Kindly examine the draft and forward your views stating any difficulties which you are likely to experience in your business or profession, if this is finally adopted as National Standard.

Last Date for comments: 25 November 2022

Comments if any, may please be made in the enclosed format and emailed at **madhurima@bis.gov.in** or sent at the above address.

In case no comments are received or comments received are of editorial nature, you will kindly permit us to presume your approval for the above document as finalized. However, in case comments, technical in nature are received, then it may be finalized either in consultation with the Chairman, Sectional Committee or referred to the Sectional Committee for further necessary action if so desired by the Chairman, Sectional Committee.

The document is also hosted on BIS website **www.bis.gov.in**.

Thanking you,

Yours faithfully,

Sd/-

(Arun Kumar S.)
Sc. 'E'/Director and Head (Civil Engg.)

Encl: As above

FORMAT FOR SENDING COMMENTS ON BIS DOCUMENTS

(Please use A4 size sheet of paper only and type within fields indicated. Comments on each clause/subclause/table/fig etc. be started on a fresh box. Information in column 5 should include reasons for the comments, and those in column 4 should include suggestions for modified wording of the clauses when the existing text is found not acceptable. Adherence to this format facilitates Secretariat's work) {Please e-mail your comments to madhurima@bis.gov.in }

DOC. NO.	**Doc: CED 43 (21115)WC**
TITLE	**Draft Indian Standard Standard Penetration Test of Soil — Method of Test (*Second Revision of* IS 2131) (ICS No. 93.020)**
LAST DATE OF COMMENTS	**25 November 2022**
NAME OF THE COMMENTATOR/ ORGANIZATION	_____

Sl No. (1)	Clause/Sub-clause/Para No. (2)	Comments/Suggestions (3)	Modified Wording of the Clause (4)	Reasons/ Justifications for the Proposed Changes (5)

Doc: CED 43 (21115)WC
October 2022

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENT ONLY

Draft Indian Standard

STANDARD PENETRATION TEST OF SOIL — METHOD OF TEST

(*Second Revision of* IS 2131)

Soil and Foundation Engineering Sectional Committee, CED 43	Last date for Comments: **25 November 2022**

FOREWORD

(*Formal clauses to be added later*)

A subsurface investigation for a construction site is of paramount importance for preliminary design to finalize the foundation feasibility and subsequent detailed design. The investigation has to be done in accordance with the provisions of IS 1892 : 2021 'Subsurface investigation for foundations — Code of practice (*second revision*)'. The investigation provides necessary information relating to the prevailing ground condition of the site under consideration. Standard penetration test conducted by means of the split spoon sampler, specified in this standard, furnishes data about resistance of the soils to penetration which can be used to evaluate relevant strength data, in the form of N-values (number of blows per 300 mm of penetration of the standard split spoon sampler) of the soil. A standard procedure is necessary for obtaining dependable and reproducible N-values, and this standard has been therefore formulated to provide necessary guidance for conducting the test.

The standard was first published in 1963 and subsequently revised in 1981. In the first revision of the standard, standardized split spoon sampler for conducting the test, were added. The details of the correction factors necessary in calculation of bearing capacity were also added. In this revision of the standard, the latest advancements in the field of conducting standard penetration test, particularly those for minimizing human error have been added. The following major modifications have been incorporated in this revision of the standard:

a) A clause on terminology has been added for defining the various terms used in the standard.
b) Provisions on SPT tools and equipment have been updated as per the current best practices.

c) Do-nut hammer or safety hammer with auto-trip mechanism and automatic SPT hammer have been specified to ensure consistent transfer of energy and minimize human errors.
d) Requirements for sounding rods and hammer drop systems have been included.
e) Tolerances on height of free fall and hammer weight have been provided.
f) Schematic arrangement of SPT equipment assembly has been illustrated.
g) Provisions to measure the energy efficiency of the driving weight assembly have been incorporated for implementation in specific cases as per the project requirements.

The following International Standards available on the subject have been referred by the technical committee in the course of preparation of this standard:

a) ASTM D1586/D1586M-18 Standard test method for standard penetration test (SPT) and split-barrel sampling of soils
b) BS EN ISO 22476-3 : 2005 Geotechnical investigation and testing – Field testing –Part 3 – Standard penetration test

In reporting the result of a test or analysis made in accordance with this standard, is to be rounded off, it shall be done in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’.

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENT ONLY

Draft Indian Standard

STANDARD PENETRATION TEST OF SOIL — METHOD OF TEST

(*Second Revision of* IS 2131)

Soil and Foundation Engineering Sectional Committee, CED 43	Last date for Comments: **25 November 2022**

1 SCOPE

1.1 This standard specifies a standard procedure for execution and reporting of the standard penetration test of soil.

1.1.1 The standard penetration test (SPT) aims to determine the resistance of soils at the base of a borehole to the dynamic penetration of a split spoon sampler and the recovering of disturbed samples for identification purposes.

1.1.2 The basis of the test consists of driving a split spoon sampler by dropping a hammer of 63.5 kg mass on to an anvil or drive head from a height of 750 mm. The number of blows (*N*) necessary to achieve 300 mm penetration of the sampler (after a seating penetration of 150 mm including self penetration under gravity) is the penetration resistance.

1.2 SPT is used mainly to assess the strength and deformation parameters of cohesionless soils, but some valuable data may also be obtained in other soil types.

2 REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subjected to revision and the user is encouraged to refer to the most recent editions of the standards indicated below:

IS No.	*Title*
1892 : 2021	Subsurface investigation for foundations — Code of practice (*second revision*)
9640 : 1980	Specification for split spoon sampler
10208 : 1982	Specification for diamond core drilling equipment

3 TERMINOLOGY

For the purpose of this standard, the terms and definitions as given below shall apply.

3.1 Anvil (or SPT Driving Head) — That portion of the drive-weight assembly on which the SPT hammer strikes and through which the SPT hammer energy passes into the sounding rods.

3.2 Automatic Hammer — A type of SPT hammer with automatic system (hydraulic, mechanical or equivalent) of lifting and dropping of the hammer to produce the blow.

3.3 Auto-trip Hammer — A do-nut or safety hammer with a mechanical drop system for lifting and releasing the hammer, allowing the hammer to fall freely.

3.4 Borehole — A vertical shaft of 100 mm to 150 mm diameter sunk into the ground to the prescribed test depth using a suitable boring procedure.

3.5 Casing — Mild steel or special steel pipes driven to stabilize the borehole sides for the full or partial depth.

3.6 Centralizer — A steel circular plate fitted on to the sounding rod to maintain the rods at the center of the borehole diameter. The outer diameter of the centralizer is 15 mm to 20 mm smaller than the borehole diameter.

3.7 Do-nut Hammer — A type of SPT hammer which is cylindrical with a central hole and the straight bottom face striking on the anvil.

3.8 Drilling Fluid — Usually, the bentonite slurry of specific gravity ranging between 1.04 and 1.08 to stabilize the borehole sides and bottom and to maintain a positive hydraulic head inside the borehole.

3.9 Drill Rods — Suitable rod (tubular) with straight and tight coupling for drilling the boreholes to the test depth.

NOTE — Drilling rods can be the sounding rods itself.

3.10 Drive-Weight Assembly — An assembly that consists of the SPT hammer, anvil, SPT hammer fall guide system, drill rod attachment system, and a hammer drop system.

3.11 Ground Water Table — The steady water level in the exploratory borehole stabilized after 24 h of lowering the water in the borehole well below the expected water table.

3.12 Hammer Drop System —The system used to lift and drop the SPT hammer ensuring minimum loss in striking energy.

3.13 Length of Recovery — The length of soil not mixed with drilling fluid or water collected in the split spoon sampler.

3.14 Sample Container — A well-labelled watertight jar or double-layered polyethylene bag to store the sample recovered from the split spoon sampler.

3.15 Safety Hammer — A type of SPT hammer having a thick tubular section and the striking face located at the top inside of the tube.

3.16 Self-Weight Penetration — The case in which the split spoon sampler sinks into the soil under its own weight and that of the sounding rods because of the soft consistency of the soil.

3.17 Seating Drive — The initial 150 mm penetration of the sampler from the bottom of the borehole taken as the test starting depth.

3.18 Sounding Rods — Standard rods (tubular) with straight and tight coupling for transferring the striking energy from the SPT driving head to the split spoon sampler.

3.19 Split Spoon Sampler — A steel tubular sampler with a split body of standard dimensions and held together by SPT sampler head and SPT sampler shoe.

3.20 SPT Hammer — That portion of the drive-weight assembly consisting of the 63.5 ± 0.5 kg impact weight which is successively lifted and dropped to provide the energy that accomplishes the sampler penetration.

3.21 SPT Sampler Head — A tubular section of standard dimensions with a ball check valve to hold the split spoon of the sampler on its top through a threaded connection.

3.22 SPT Sampler Shoe — A beveled tubular section of standard dimensions to hold the split spoon of the sampler at its bottom through a threaded connection.

3.23 Test Depth — The depth at which the shoe of the split spoon sampler is placed inside the borehole and then driven into the soil, either reported as the starting depth alone or both the starting and finishing depths.

4 EQUIPMENT

4.1 Drilling Equipment

4.1.1 The equipment used shall provide a clean borehole, 100 mm to 150 mm in diameter in soil, for insertion of the sampler to ensure that the penetration test is performed on undisturbed soil. The equipment shall permit driving of the split spoon sampler to obtain penetration record and the sample in accordance with the procedure specified in **5**. The schematic arrangement of SPT equipment assembly is illustrated in Fig. 1.

4.1.2 The drill rods shall be kept vertical and in center of the borehole by using suitable guide (a threaded cap with central hole fixed on the casing pipe) at working level so that the borehole is vertical.

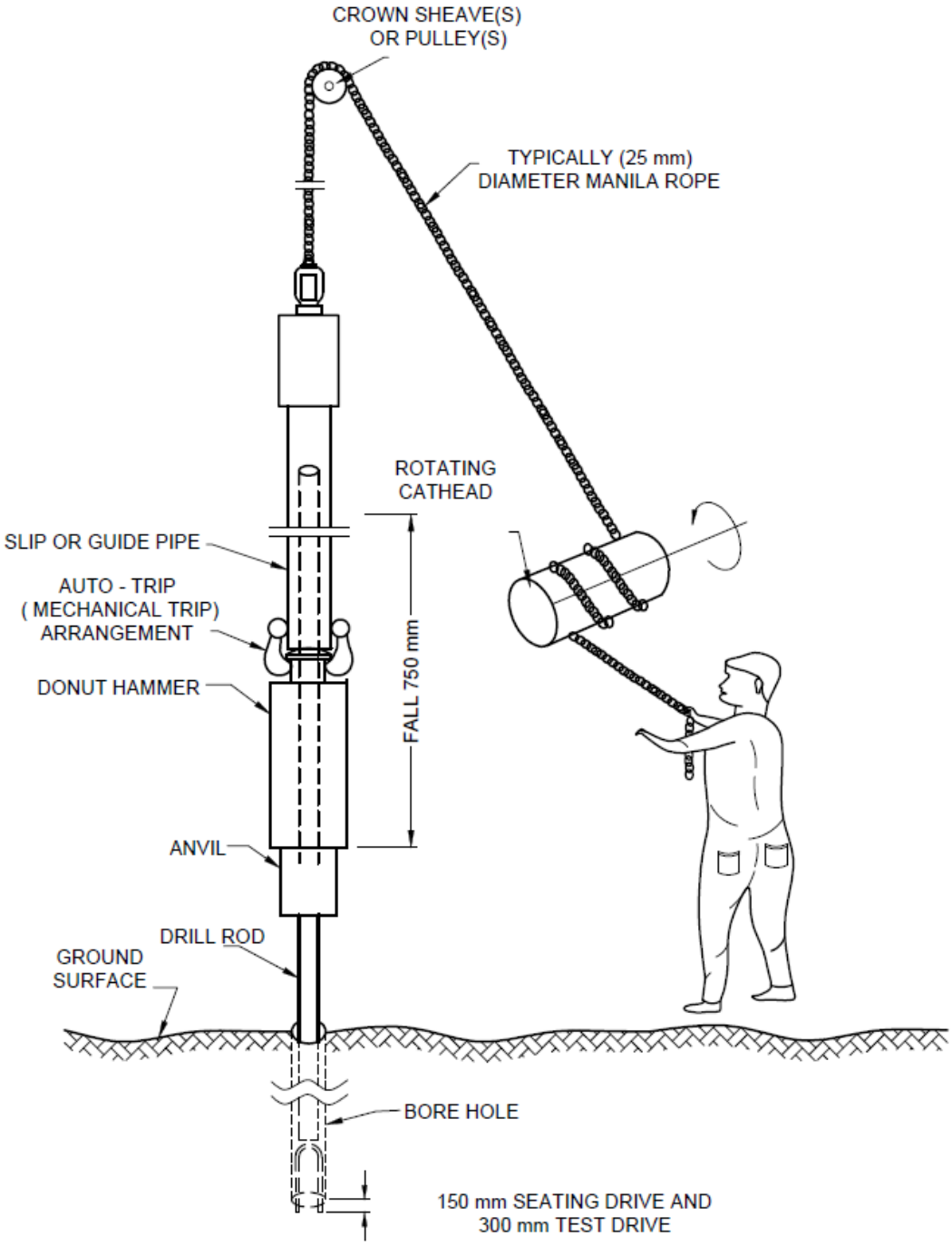


FIG. 1 ILLUSTRATION OF THE SPT SAMPLER IN-PLACE IN THE BORING WITH HAMMER, ROPE AND CATHEAD IN PLACE (SHOWN INDICATIVELY)

4.2 Split-spoon Sampler

4.2.1 The split spoon sampler shall conform to IS 9640. The sampler shall be periodically checked for its shape, shoe conditions and the ball check valve functioning.

4.2.2 The use of liner inside the split spoon sampler may be considered as a special case and the SPT sampler shoe dimensions shall be suitably adjusted to match with the inner diameter of the liner. The inner diameter of the liner shall be 35 mm $\pm$ 0.5 mm.

4.3 Drive Weight Assembly

4.3.1 The drive weight assembly shall consist of a drive head and a 63.5 ± 0.5 kg weight with 750 ± 10 mm free fall. It shall be ensured that the energy lost by friction between the drive weight and the guides or between rope and winch drum is minimal.

4.3.2 Any one of the drive weight assembly listed below can be used to conduct SPT:

a) Do-nut hammer guided through a guide rod and falling over the drive head striking over exposed anvil (*see* Fig. 2A);
b) Safety hammer with inner guide rod assembly and concealed anvil over which the hammer strikes (*see* Fig. 2B);
c) Automatic hammer system with housing (*see* Fig. 2C); and
d) Do-nut hammer or safety hammer equipped with auto-trip mechanism (*see* Fig. 3).

4.3.2.1 The systems listed at **4.3.2 (b), (c)** and **(d)** are preferred for consistent energy under each strike.

4.3.3 The drive weight assembly shall be calibrated periodically using standard measuring system.

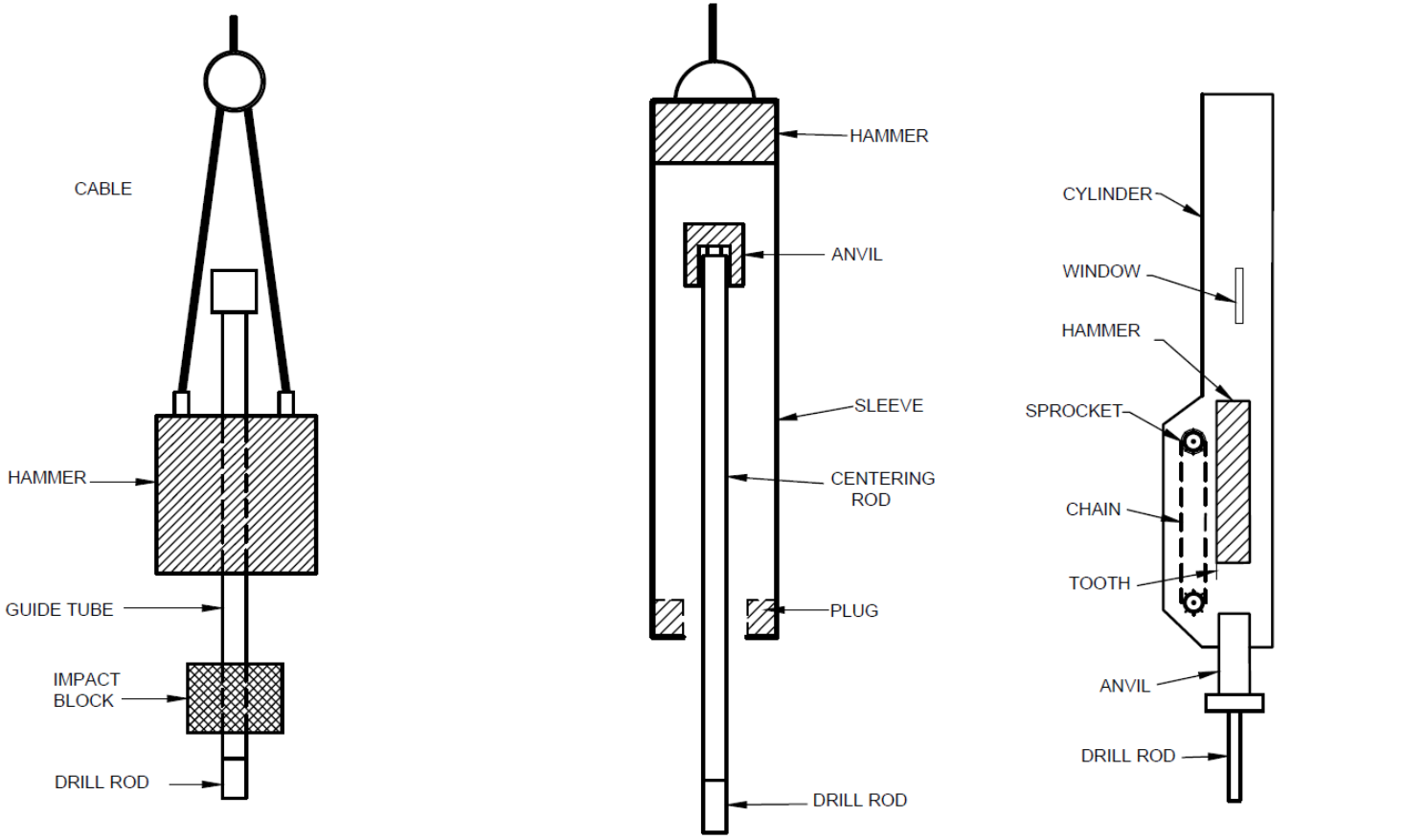
4.3.4 The weight of the anvil and the guide rod shall preferably be less than one-fifth of the SPT hammer weight. The anvil shall firmly connect to the sounding rod through threaded coupling.

4.3.4 The guide rod shall have permanent marking of the 750 mm fall height to guide the operator.

4.3.5 Any stopper collar fitted to the guide rod for controlling the hammer fall height shall not allow lifting of the sampler-sounding rod assembly during SPT.

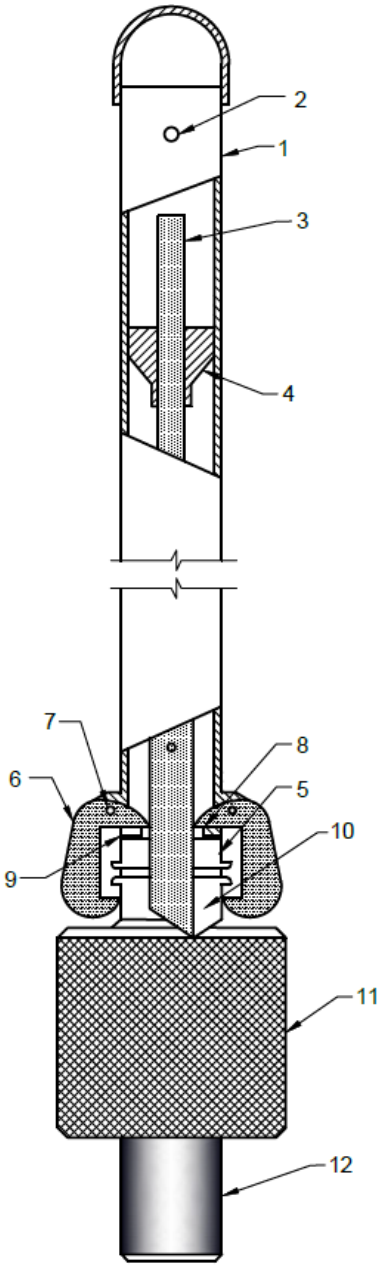
4.4 Sounding Rods

4.4.1 The rods to which the sampler is attached for driving should be straight, tightly coupled and straight in alignment.



2A DO-NUT HAMMER 2B SAFETY HAMMER 2C SAFETY HAMMER

FIG. 2 TYPES OF SPT HAMMER



Key

1	HAMMER PIPE BODY
2	HAMMER PIPE BOLT
3	HAMMER SPINDLE
4	HAMMER SPINDLE BUSH
5	HAMMER LATCH BODY
6	HAMMER LATCH-2 Nos.
7	SOLID PEN-2 Nos.
8	LATCH SPRING WASHER
9	HAMMER COMPRESSION SPRING
10	HAMMER LOAD BUSH
11	HAMMER 63.5 KG WEIGHT
12	HAMMER AW ROD COLLAR

FIG. 3 SCHEMATIC ARRANGEMENT OF AUTO-TRIP MECHANISM FOR DO-NUT HAMMERS AND SAFETY HAMMERS

4.4.2 The sounding rods if allowed to whip during driving influences the N value. The sounding rods shall have stiffness of AW rod up to 20 m depth and that of a BW/NW rod for greater depth. Alternatively, AW rods with centralizers or spacers at 10 m depth interval may be used for depths greater than 20 m. AW rods with 43.7 mm OD and 30.7 mm ID, BW rods with 54 mm OD and 38 mm ID and NW rods with 66.8 mm OD and 51 mm ID as per IS 10208 shall be used.

4.4.3 Sounding rods with a mass of more than 8 kg/m shall not be used.

4.5 Hammer Drop Systems

4.5.1 The following hammer drop systems shall be used for lifting and dropping the SPT hammer.

a) Rope and cat-head mechanism using a winch to lift and drop either do-nut or safety hammer;
b) Mechanical auto trip system to lift and drop the SPT hammer; and
c) Fully automated system with an SPT hammer housing.

4.5.2 *Rope and Cat-head System*

4.5.2.1 The winch drum used as the cat-head shall be 150 mm to 200 mm diameter so that 750 mm lift of the hammer is possible with one and one-half to two turns of the drum. The drum shall be rotating at a speed of 100 to 150 rpm. The cat-head shall be free from rust, excessive oil and grease.

4.5.2.2 The winding and release of rope on and off the cat-head can be done manually or mechanically, but mechanical operation is preferred for consistent rate of hammer falls. Twisted manila rope of 20 mm to 25 mm diameter or twisted flexible steel rope of 8 mm to 12 mm diameter can be used in the system. The cat-head rope should be relatively dry, clean, and should be replaced when it becomes excessively frayed, oily, or burned. Ropes with kinks and blisters shall be replaced immediately. The lifting chain or rope connected to the hammer shall be longer than the guide rod.

4.5.2.3 There shall be only one well lubricated crown pulley for guiding the rope. More crown pulleys will increase the friction resulting loss in energy.

4.5.2.4 The cat-head operator shall have full visibility of the SPT drive assembly during the test.

4.5.3 *Mechanical Auto Trip System*

4.5.3.1 The SPT hammer guide system and the SPT hammer are suitably modified to operate the mechanical auto trip system. The auto release system shall have minimum impact on the SPT hammer guide so that the sampler penetrated into the soil is not lifted during the release.

4.5.3.2 The fingers or pawls used to hold the SPT hammer shall be arranged symmetrically so that the hammer is lifted without a tilt. The fingers or pawls shall open and close smoothly exerting minimal or nil impact on the SPT hammer.

4.5.4 *Fully Automated System*

4.5.4.1 The fully automated SPT system comes as a single unit comprising the SPT hammer, guide, anvil and the hammer lifting housing. A chain cam hammer lifting system operated by hydraulic power is usually employed.

4.5.4.2 The fully automated SPT system are generally heavier and designed to float over the impact anvil. The self-weight of the system shall be kept minimal (preferably within 120 to 130 kg) for making use of the system in loose deposits. These hammers are safer and produce very reproducible drop heights or energy.

5 PROCEDURE

5.1 Borehole Preparation and Cleaning

5.1.1 The borehole shall be advanced incrementally to permit intermittent or continuous testing and sampling.

5.1.2 Any drilling procedure that provides a stable borehole before insertion of the sampler and ensures sampler penetration into the intact soil for the test length of 300 mm after 150 mm seating drive is appropriate.

5.1.3 Borehole preparation for SPT shall preferably be done using rotary boring with bentonite fluid supplement as per **5.4.4** of IS 1892. Other methods of boring described in **5.4** of IS 1892 can also be followed addressing the issues related to disturbance at the borehole bottom and stability of borehole sides.

5.1.4 The borehole shall always have a positive hydraulic head during drilling and testing.

5.1.5 The ball check valve in the SPT head shall be clean and free to move. The SPT shoe shall be without any distortion and smudge. The tapered tip of the SPT shoe shall be 1.5 mm thickness.

5.2 Conducting SPT and Sampling

5.2.1 *SPT Test Depth*

SPT test shall be conducted at specified borehole depth within a tolerance of $\pm$ 50 mm. The SPT value obtained corresponds to the borehole depth at which the test is conducted.

5.2.2 The vertical spacing between each SPT shall be as per IS 1892 or project requirements, whichever is stringent.

5.2.3 *Test Execution*

5.2.3.1 The test depth is marked on the topmost sounding rod for ensuring the sampler position at the test depth. Subsequent 150 mm or 75 mm incremental penetration

marking are made for a total penetration of 450 mm. Then the sampler attached to the sounding rods is lowered to the bottom of the borehole. The following information shall be noted and recorded.

a) Depth of bottom of borehole below ground level;
b) Penetration of the sampler into the soil under the combined weight of sampler and rods (marking preferably can be done on the topmost sounding rod);
c) Water level in the borehole or casing; and
d) Depth of bottom of casing below ground level, wherever casing is used.

5.2.3.2 The sampler and the drive rods shall be lowered to the bottom of the borehole and then the hammer assembly added. Any penetration of the sampler at this step shall be recorded. The sampler may penetrate into the soil under the self-weight depending on the weight of the drive weight assembly and soil consistency. In the case of do-nut hammer and safety hammer without auto-trip system, the SPT hammer should be gently placed over the anvil to note and record the self-penetration. The initial markings made for penetration test shall not be altered at this stage.

5.2.3.3 If the self-penetration is smaller than 150 mm, the sampler shall be driven to the seating drive of 150 mm using the SPT hammer falling free from 750 mm height. The number of blows required to complete the seating drive shall be recorded as n0.

5.2.3.4 The sampler penetration for the test depth starts from this stage. The SPT sampler shall be driven using the SPT hammer falling free from 750 mm height counting and recording the number of blows required for two subsequent penetrations of 150 mm each over a depth of 300 mm. These blow counts shall be recorded as n1 and n2. Alternatively, blow counts for four increments of 75 mm each may be recorded and reported in which case the blow counts shall be designated as n1, n2, n3 and n4.

5.2.3.5 If the self-penetration is exceeding the seating drive, the additional blow counts required to reach the next incremental marking shall be recorded as n1, noting that n0 is zero. Similarly, the n1 and n2 may be zero if self-penetration exceeds 300 mm or 450 mm.

5.2.3.6 The particular SPT shall be complete once the sampler penetration is 450 mm. SPT ‘N’ is then computed as the number of blows required to penetrate the sampler for the test depth of 300 mm, that is, n1 + n2 (or n1 + n2 + n3 + n4 in the case of 75 mm incremental markings).

5.2.3.7 If on lowering the sampler by means of sounding rods, it is found that the sampler rests at a level above the test depth, the penetration test and sampling shall not be carried out at that depth. Such instance may be an indication of borehole collapse or inadequate cleaning and the next SPT shall be conducted after advancing the borehole for a minimum distance of 750 mm.

5.3 Termination of Standard Penetration Test

5.3.1 The sampler shall be driven with blows from the SPT hammer and the number of blows applied in each 150 mm increment shall be counted until one of the following occurs:

a) A total of 50 blows have been applied during any one of the 150 mm test drive including seating drive as described in **5.2.3.2**.
b) A total of 100 blows have been applied, the number of blows versus penetration (that is, N/mm) shall be recorded.
c) There is advancement of the sampler less than or equal to 50 mm during the application of 25 successive blows of the hammer.

The seating drive shall be 150 mm or 50 blows, whichever is reached first. If the seating drive is terminated at 50 blows as in case of **5.3 (a)**, the depth of penetration corresponding to the applied number of blows shall be recorded. It shall also be reported that SPT cannot be conducted in the given stratum depth. The SPT shall be terminated at this stage and proceed to conduct the test or sampling at the next designated depth, if recommended.

If the SPT 'N' value greater than 100 with characteristics of rock is met with, further guidance as given in IS 1892 shall be followed for further drilling procedures.

5.4 Extraction of Sampler and Sample Preservation

5.4.1 The sampler shall be brought to the surface and placed on a clean and firm surface. The water or drilling fluid on the sampler shall be wiped out before opening the split sampler.

5.4.2 The total length of the soil sample not contaminated with drilling fluid shall be measured and recorded. The whole intact sample shall be transferred to the sample container, labelled and sealed. If there are more than one distinctly different soil types in the sampler, these samples shall be transferred into separate containers before placing them in one common container.

5.4.3 If the liner is used for special purposes, the contaminated soil is discarded before sealing both sides of the liner.

5.4.2 Labels shall be fixed to the sample container with the following information:

a) Origin of sample;
b) Job designation;
c) Boring number;
d) Sample number;
e) Depth of sampling;
f) Penetration record;
g) Length of recovery; and
h) Date of sampling.

If more than one type of soil is present, length of each layer shall be noted.

5.4.3 The jars containing samples shall be stored in suitable containers for shipment. Samples shall not be placed in the sun.

5.4.4 Samples recovered shall be recorded and handled in accordance with IS 1892.

5.5 Ground Water Table

5.5.1 When testing below the groundwater table, particular care shall be taken to avoid any entry of water through the bottom of the borehole, as this will tend to loosen the soil or even lead to piping. For this purpose, the level of the water or drilling fluid in the borehole shall be maintained at a sufficient level above the groundwater level in the layer with the highest pressure (potential) at all times, even during withdrawal of the boring tools. Withdrawal shall be performed slowly and with drilling tools providing enough clearance to prevent suction effects at the bottom. When a casing is used, it shall not be driven below the level at which the test will start.

5.5.2 The process of jetting through an open tube sampler and then sampling or conducting SPT when the desired depth is reached shall not be permitted.

5.5.3 Any loss of drilling mud or water at any depth during the progress of the borehole shall be reported. The loss of drilling fluid is usually experienced at the interface of an impervious soil layer and weathered rock.

5.6 Energy Calibration

5.6.1 *Energy Calibration*

SPT energy measurement may be conducted, wherever so desired as per the project requirements. It is recommended to use auto trip mechanism or automatic hammer for conducting SPT in such cases. The SPT observations shall record the energy applicable to the auto trip mechanism/auto trip hammer used. The corrections for respective energy efficiency in such cases shall be carried out as per **5.7.2**.

5.7 Correction Factors

5.7.1 Except for the correction due to hammer energy (wherever required), other corrections as given in **5.7.3** and **5.7.4** shall be applied only as required by the use of SPT N. The field SPT N value shall be corrected in sequential order as given in **5.7.2** to **5.7.4**.

5.7.2 *Due to Hammer Energy*

The SPT N obtained in the field shall be corrected to the standard energy levels by multiplying the same with the inverse energy ratio called energy correction factor, as given below:

$$N_E = \frac{E_{actual}}{E_r} \times N$$

where,

N_E = SPT *N* value corrected for energy;

E_{actual} = energy efficiency of the drive weight assembly used in the SPT; and

E_r = designated energy level (that is, 55 percent or 60 percent or as the case may be).

5.7.3 *Due to Overburden*

The *N* or N_E value (as the case may be) for soil shall be corrected for effective overburden pressure. The correction factor for overburden pressure (or stress normalization parameter), *CN* shall be obtained from Fig. 4. The blow count normalized for overburden shall be designated as N_1 or $(N_1)_E$ (as the case may be), and shall be determined as below:

$$N_1 = CN \times N \text{ , or } (N_1)_E = CN \times N_E$$

The number of blows corrected to an energy ratio *E*r of 60 percent and normalized for an effective vertical stress is generally termed as $(N_1)_{60}$.

5.7.4 *Due to Dilatancy*

The value obtained in **5.7.3** shall be corrected for dilatancy if the stratum consists of fine sand and silt (to be assessed from the study of grain size analyses including hydrometer analyses) below water table for values of N_1 greater than 15, as under (N_1''):

$$N_1'' = 15 + \frac{1}{2}(N_1 - 15)$$

However, this correction may not be necessary when the number of blows per minute is more than 30.

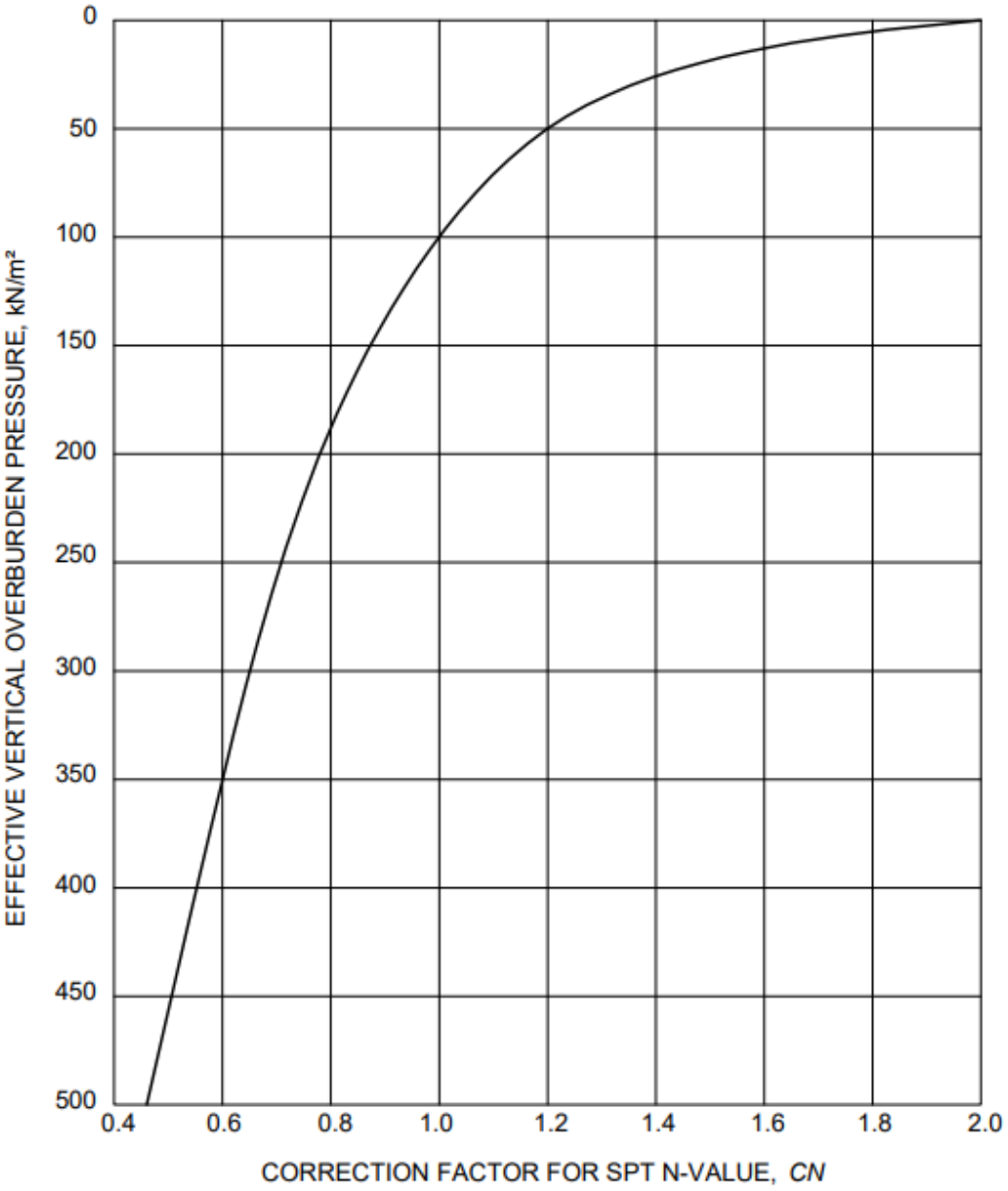


FIG. 4 CORRECTION FACTOR FOR SPT N-VALUE FOR EFFECTIVE VERTICAL OVERBURDEN PRESSURE IN COHESIONLESS SOIL

6 REPORT

6.1 All the observations during the borehole preparation and the SPT shall be recorded in the standard bore log. The following minimum information pertaining to SPT shall be made available in the bore log format as given in IS 1892.

a) Job identification;
b) Date of start and finish of the borehole and SPT Test;
c) Borehole number;
d) Borehole location;
e) Elevation of the ground at the borehole location;
f) Ground water table information;
g) The boring procedure used in the preparation of the borehole;
h) Diameter of the borehole;
j) The sounding rods used in the conduct of the SPT;
k) The type of drive weight assembly used in the SPT;
m) Energy efficiency of used equipment, wherever applicable;
n) The average length of sounding rod projecting above the ground during the start of the SPTs at different depths (only one average value shall be reported);
p) The number of blows per minute during SPT;
q) The depth of each SPT, sampling, other tests and complete penetration records and SPT 'N' as recorded;
r) Soil identification, including condition of samples;
s) The depth at which any loss of drilling mud occurred or artesian condition occurred;
t) Depths/elevations of other test like disturbed sampling (DS), undisturbed sampling (UDS) and field vane shear test; and
u) Weather condition.

6.2 The data obtained shall be prepared in a final borehole format as a soil profile to show the nature and extent of the soil strata pertaining to the given borehole.