भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG, NEW DELHI 110002

व्यापक परिचालन मसौदा

हमारा संदर्भः सीईडी 48/टी-37 **21 नवंबर 2024**

तकनीकी समिति: रॉक मैकेनिक्स विषय समिति, सीईडी 48

प्राप्तकर्ता:

क) सिविल इंजीनियरी विभाग परिषद्, सीईडीसी के सभी सदस्य
ख) सीईडी 48 के सभी सदस्य
ग) रूचि रखने वाले अन्य निकाय

प्रिय महोदय/महोदया,

निम्नलिखित भारतीय मानक का मसौदा संलग्न है:

प्रलेख संख्या	शीर्षक
सीईडी 48 (26954)WC	**बहु बिन्दु वेध छिद्र एक्सटेन्सो मीटर का उपयोग करते हुए शैल संचालन को मानीटर करना — मार्गदर्शी सिद्धांत का भारतीय मानक मसौदा** [IS 13414 का *पहला पुनरीक्षण*] ICS 93.020

कृपया इस मानक के मसौदे का अवलोकन करें और अपनी सम्मतियॉ यह बताते हुए भेजे कि यदि यह मानक के रूप में प्रकाशित हो तो इस पर अमल करने में आपके व्यवसाय अथवा कारोबार में क्या कठिनाइयाँ आ सकती हैं ।

सम्मतियाँ भेजने की अंतिम तिथि : **21 दिसंबर 2024**

सम्मति यदि कोई हो तो कृपया अधोहस्ताक्षरी को उपरिलिखित पते पर संलग्न फोर्मेट में भेजें या manoj@bis.gov.in पर ईमेल कर दें ।

यदि कोई सम्मति प्राप्त नही होती है अथवा सम्मति में केवल भाषा सम्बन्धी त्रुटि हुई तो उपरोक्त प्रलेख को यथावत अंतिम रूप दिया जाएगा। यदि सम्मित तकनीकी प्रकृति की हुई 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,

(द्वैपायन भद्र)
प्रमुख (सिविल इंजीनियरी)

संलग्नक : उपरिलिखित

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG, NEW DELHI 110002

DRAFT IN WIDE CIRCULATION

Ref: CED 48/T-37 **21 November 2024**

TECHNICAL COMMITTEE: Rock Mechanics Sectional Committee, CED 48

ADDRESSED TO:

a) All Members of Civil Engineering Division Council, CEDC
b) All Members of CED 48
c) All others interests.

Dear Sir/Madam,

Please find enclosed the following document:

Doc No.	Title
CED 48 (26954)WC	**Draft Indian Standard** **Monitoring of Rock Movements using Multi-Point Borehole Extensometers — Guidelines** (*First Revision* of IS 13414) ICS 93.020

Kindly examine the draft standard 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**: 21 December 2024**

Comments if any, may please be made in the attached format and mailed to the undersigned at the above address or preferably through e-mail to manoj@bis.gov.in.

In case no comments are received or comments received are of editorial nature, you may kindly permit us to presume your approval for the above document as finalized. However, in case of comments of 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,

(Dwaipayan Bhadra)
Head (Civil Engineering)

Encl: As above

FORMAT FOR SENDING COMMENTS ON BIS DOCUMENTS

(Please use A-4 size sheet of paper only and type within fields indicated. Comments on each clause/sub-clause/table/fig etc. be started on a fresh box. Information in column 3 should include reasons for the comments and suggestions for modified working 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 manoj@bis.gov.in)

Doc. No.: CED 48 (26954) WC

Title: Draft Indian Standard Monitoring of Rock Movements using Multi-Point Borehole Extensometers — Guidelines
(*First Revision* of IS 13414) ICS 93.020

LAST DATE OF COMMENT: **21/12/2024**

NAME OF THE COMMENTATOR/ORGANIZATION: _____

Sl. No.	Clause/Para/Table/ Figure No. Commented	Comments/Modified Wordings	Justification of the Proposed Change

BUREAU OF INDIAN STANDARDS

DRAFT FOR COMMENTS ONLY

Draft Indian Standard

MONITORING OF ROCK MOVEMENTS USING MULTI-POINT BOREHOLE EXTENSOMETERS — GUIDELINES

(*First Revision* of IS 13414)

ICS 93.020

Rock Mechanics Sectional Committee, CED 48

Last date of Comments: **21 December 2024**

FOREWORD

(*Formal clauses will be added later*)

Rock movement is monitored to ensure safe and economic construction of some civil and mining works. It helps in receiving a forewarning of impending failure and taking corrective measures. One of the methods to measure rock movement is by using borehole extensometer. Borehole extensometers are used to measure rock movements that may take place as the result of surface and underground excavation, foundation loading, movement of natural slopes or *in-situ* testing.

This Standard was first published in 1992. This revision incorporates modifications found necessary as a result of the experience gained with the use of the standard and to bring the standard in line with present good practices being followed in the country and abroad. The principal modifications in this revision are as follows:

a) Stainless steel rod and fibre glass rod are introduced for transferring element of the anchor;
b) Guidelines have been provided for the use of different movement transferring element of the anchor;
c) Hydraulic type anchor has been introduced;
d) Figures have been added to illustrate the different anchor types used in borehole extensometers;
e) Guidelines for installation and data analysis of bi-reflex target for measuring tunnel roof/wall deformation has been included;
f) The format for recording bi-reflex target observations has been added;
g) Parameter Q/RMR has been added in the format for standard data sheet for rock movement monitoring using borehole extensometer; and
h) Reference of Indian standards has been updated.

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

Draft Indian Standard

MONITORING OF ROCK MOVEMENTS USING MULTI-POINT BOREHOLE EXTENSOMETERS — GUIDELINES

(*First Revision*)

1 SCOPE

This standard describes the method of rock movement measurement using multi-point borehole extensometer (MPBX). This covers the measurement of static rock movements that may take place as a result of surface and underground excavations, foundation loading, movement of natural slopes or *in-situ* testing.

2 REFERENCES

The Indian Standards given below contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on these standards are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
IS 11358 : 1987	Glossary of terms and symbols relating to rock mechanics

3 TERMINOLOGY

For the purpose of this Standard, the definition given in IS 11358 shall apply in addition to the following.

3.1 Rock Movement

It is the relative displacement of the rock mass between the anchorage point and the collar of the extensometer, which may be caused due to one or more than one of such processes as loosening, squeezing, swelling, creeping, distressing, etc. It may or may not cause strata separation.

4 INSTRUMENT/EQUIPMENT

4.1 General

The borehole extensometer is an instrument used for monitoring movement of rock mass at several points around underground openings, rock slopes and other excavations. This instrument consists of anchors embedded in a borehole at different depths, movement-transferring elements, which are fixed to the anchors and extend up to a reference head connected to borehole collar. Each movement-transferring element is covered by a rigid PVC pipe, so that these elements are free to transfer the displacements of the rock mass from anchor positions to borehole collar position. The relative displacement between the collar and the

movement transferring elements is measured by means of a mechanical or an electrical read out unit. The relative displacement may also be monitored through a computerized data acquisition system.

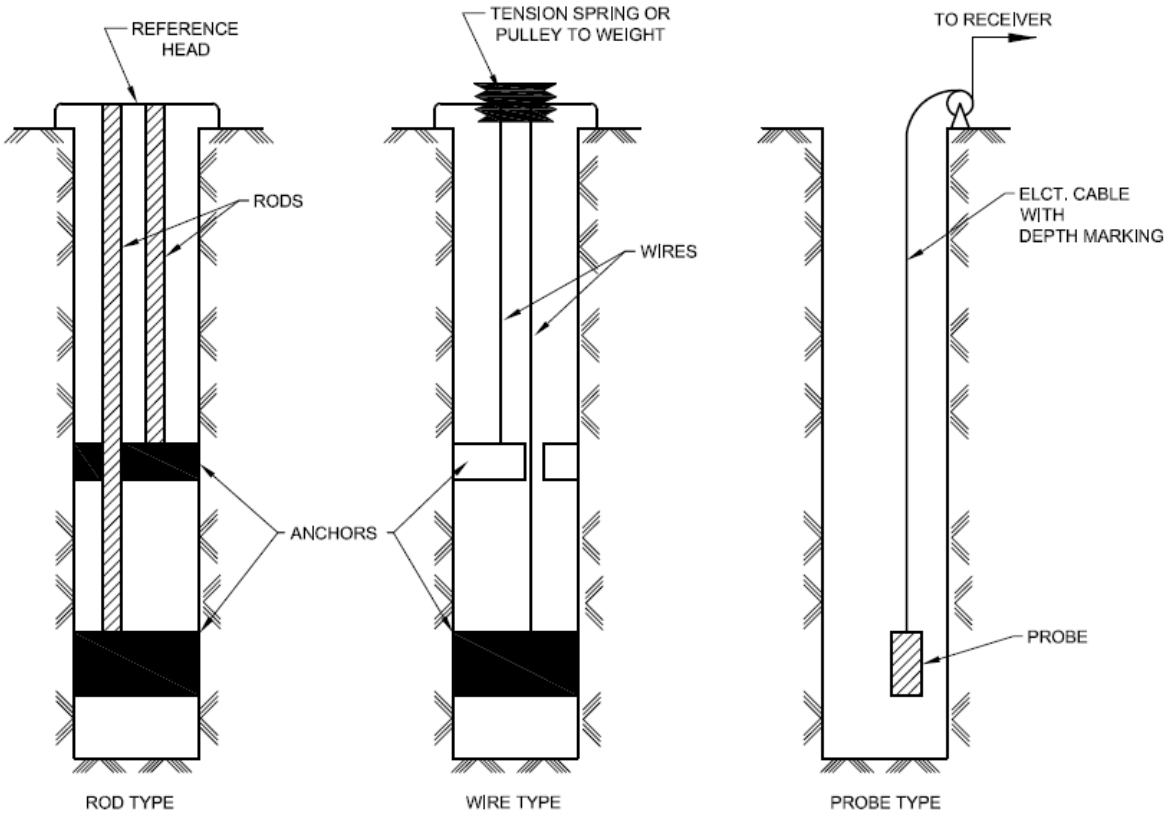
4.2 Classification

4.2.1 Depending upon the movement-transferring element between anchors and the borehole collar (*see* Fig. 1A):

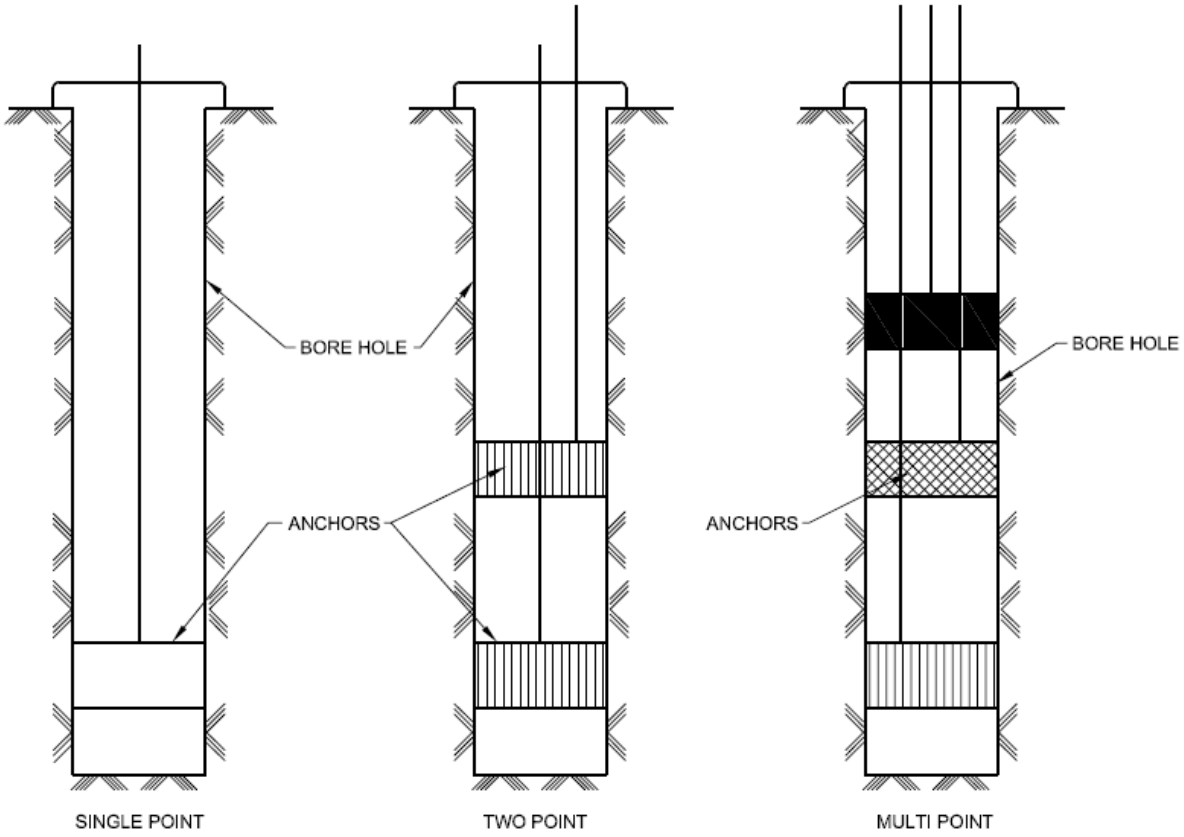
a) Wire type borehole extensometer – connecting element is wire;
b) Rod type borehole extensometer – connecting element is rod; and
c) Probe type borehole extensometer – no direct connection between the anchors and the borehole collar.

4.2.2 Depending upon the number of anchors (*see* Fig. 1B):

a) *Single Point Borehole Extensometer (SPBX)* – anchorage at one point;
b) *Double Point Borehole Extensometer (DPBX)* – anchorage at two points; and
c) *Multipoint Borehole Extensometer (MPBX)* – anchorage at more than two points.



1A Classification based on movement transferring element



1B Classification based on number of anchors

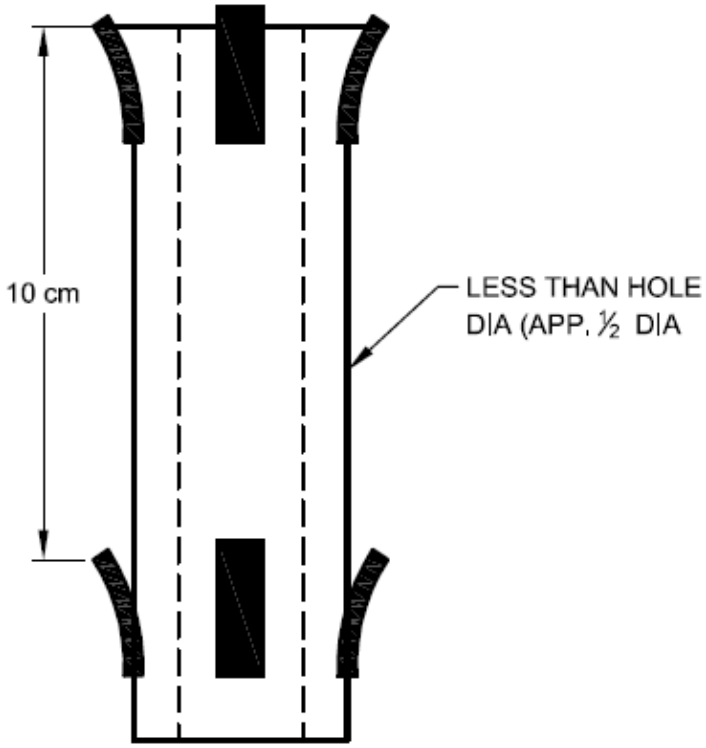
FIG. 1 ROCK MOVEMENT MONITORING APPARATUS (BASIC TYPES)

4.2.3 Depending upon the reading facility:

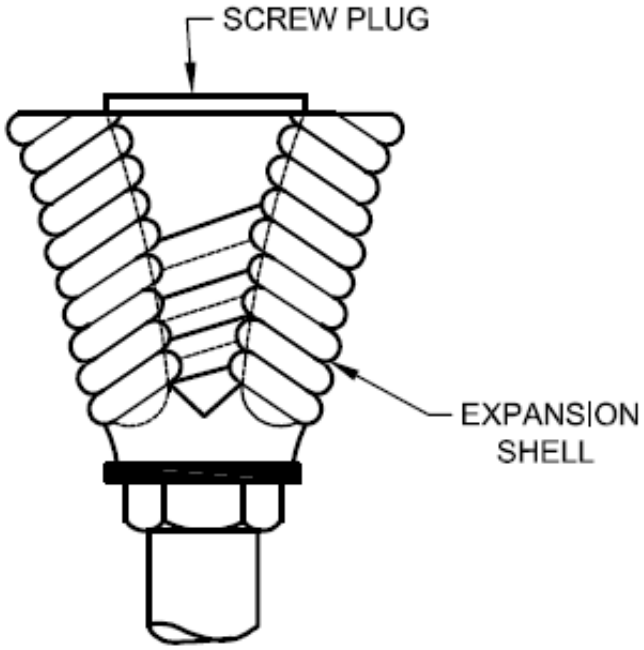
a) *Mechanical* – with direct reading facility;
b) *Electro-mechanical* – with remote and direct reading facility; and
c) *Electrical* – with remote reading facility only.

4.2.4 Depending on anchor types:

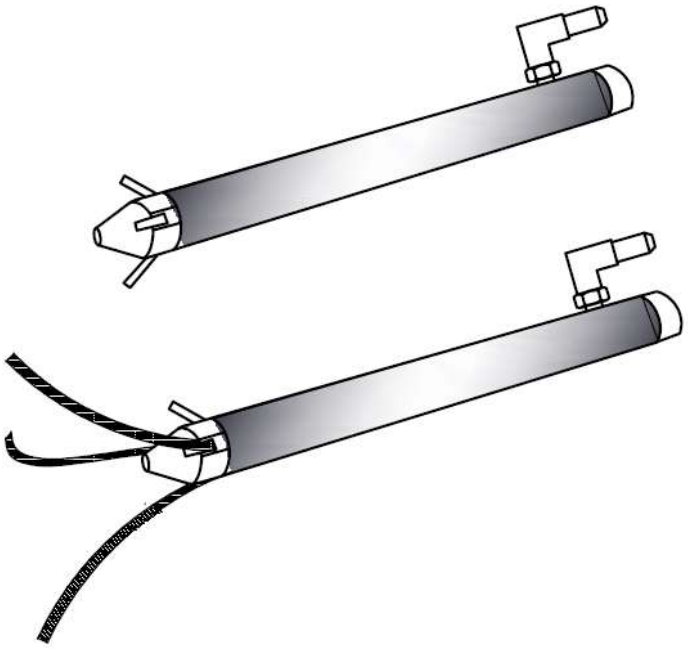
a) Mechanical type with prong type, expansion shell type and hydraulic anchors [*see* Figs. 2(a), 2(b) and 2(c)]; and
b) Grouted type [Fig. 2(d)], in, which the anchors are grouted into the borehole, while keeping the movement transferring elements free within rigid PVC pipes.



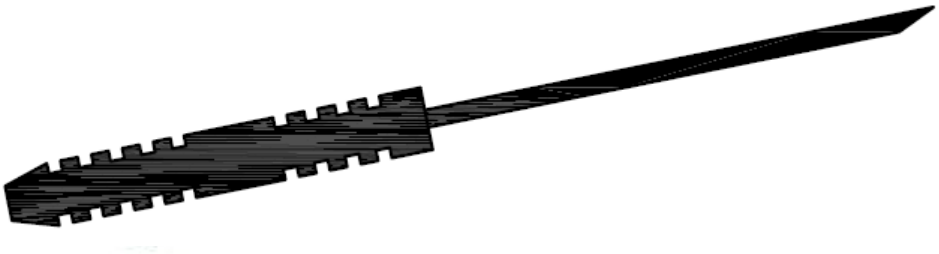
2(a) Prongs Type Anchor



2(b) Expansion Shell with Screw Plug Type Anchor



2(c) Hydraulic Anchor



2(d) Grouting Anchor

FIG. 2 DEFFERENT TYPE OF ANCHORAGE

4.3 Multi-point Borehole Extensometer (*see* Fig. 3)

A multi-point borehole extensometer comprises the following four main components:

a) Anchors;
b) Rods or wires;
c) Collar head or mouthpiece; and
d) Displacement sensors.

4.3.1 *Anchors*

4.3.1.1 Anchors are reference points in a borehole and consist of expansion shells (as used in rock bolting), spring loaded wedges, prongs or simply lengths of twisted steel bar fixed to the borehole wall using cement, chemical or resin and grout (Fig. 2).

4.3.1.2 These anchors represent the displacement of the rock mass along the longitudinal axis of the borehole. Grouted types of anchors are preferred in areas susceptible to vibrations due to blasting where the rock mass is highly jointed.

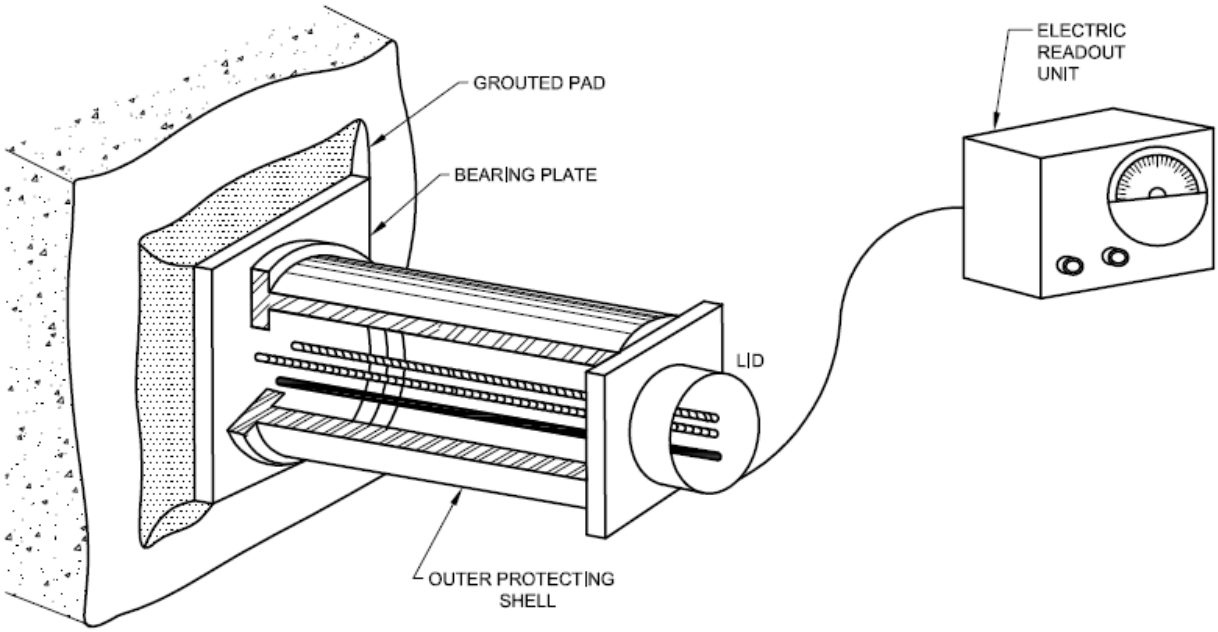
4.3.2 *Roads or Wires*

4.3.2.1 Rods or wires are the movement-transferring element of the anchors embedded in the borehole. Rods or wires are laid in rigid PVC pipes for their free displacement. *Spacers* should be used to align and control the position of these PVC pipes in the borehole. Stainless steel rods should be threaded on both the sides with a provision of joining two such rods using a coupler. The stainless steel rods are available in lengths of 2 m, 1 m, 0.5 m, 0.25 m and 0.1 m or as per the requirements. Fibreglass connecting rods are available in continuous length as per the requirement.

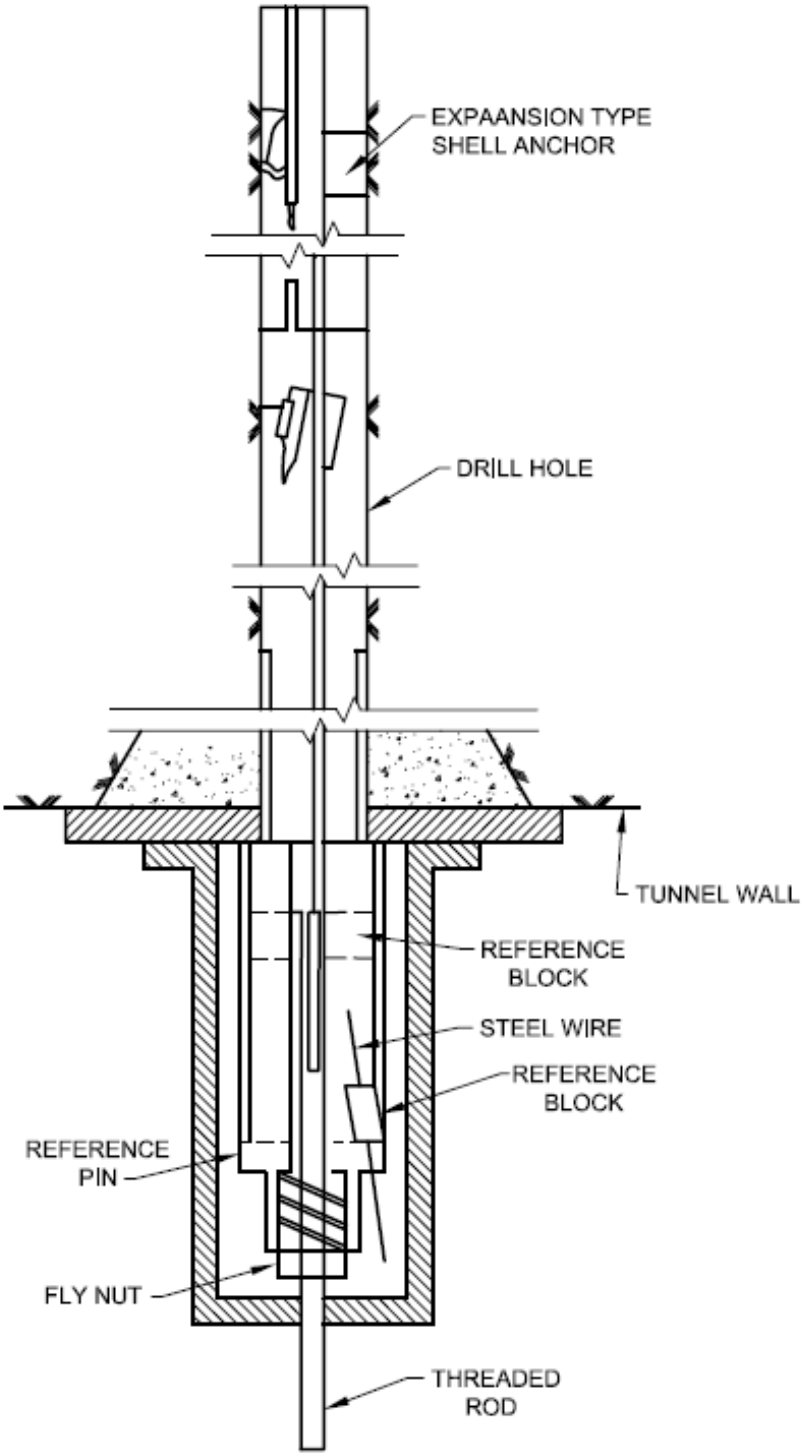
4.3.2.2 The use of either wire or rod in a borehole extensometer depends on the following factors:

a) The length of time of the observations;
b) Degree or precision;
c) Maximum depth of the anchor; and
d) The direction of the borehole.

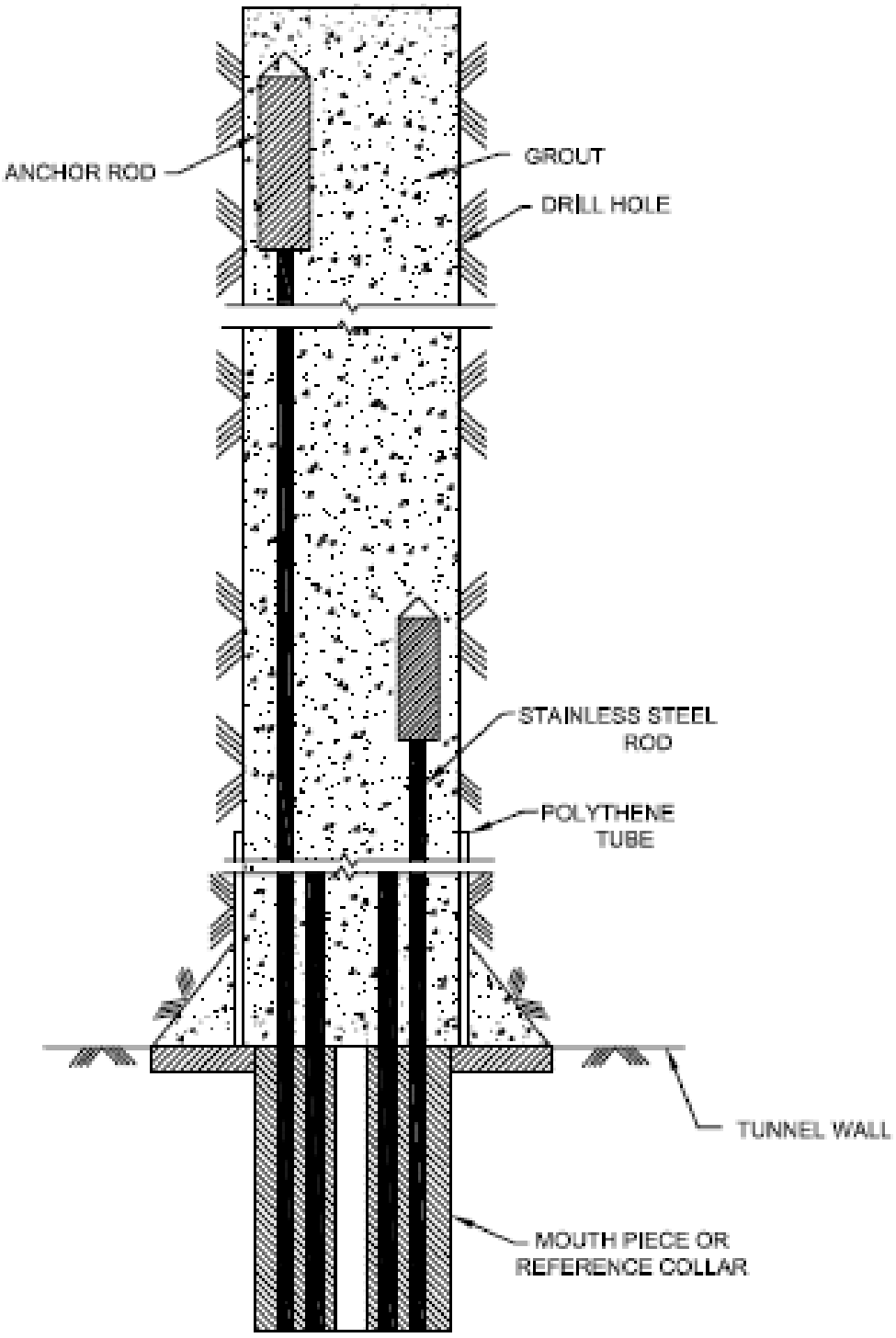
4.3.2.3 Wires may be used for short-term observations up to 3 months. Wires should not be used for depths in excess of 10 m. Similarly, wires may be used only in vertical boreholes. Wires require the application of a fixed tension at each observation. Mild steel rods may be used for observations up to one year. Stainless steel rods are essential if observation are required for periods exceeding one year. Stainless steel rods are essential for precise measurements. Fibreglass rods are not suggested for upward installations of boreholes greater than 30 m because they lack rigidity. Fibreglass rods are more stable thermally and recommended in areas where temperature vary.



3(a) Borehole extensometer at an installation



3(b) Multi-point wire type borehole extensometer



3(c) Multi-point rod type borehole extensometer with grouted anchors

FIG. 3 MULTI-POINT BOREHOLE EXTENSOMETERS

4.3.2.4 Recommended dimensions of rods and tension in wire for borehole extensometers are as follows:

a) Rods:
   1) *Stainless Steel* – 6 mm dia for depths less than 30 m, and 12 mm dia for depths greater than 30 m; and
   2) *Fibre Glass* – The 6 mm dia fiberglass rods are encased in polyethylene tubing for borehole length less than 30 m and nylon tubing for boreholes of greater depths.
b) Wires – 0.5 mm to 1.5 mm dia;
c) Wire tension shall be as follows:
   1) *For in-situ measurements* – suitable tension may be applied through coil or leaf spring; and
   2) *For other measurements* – suitable constant tension (that is the member should be capable to withstand the tension) may be applied through dead weight or spring balance.

4.3.3 *Collar Head or the Mouthpiece*

The collar head should be made of non-rusting stable material such as stainless steel. It is fixed to the mouth of the borehole. It should have holes to receive movement-transferring elements.

In case of the wire type MPBX, the wires should be taken out of the collar head, reference points fixed on both the collar head and the wires and readings between the reference points be taken.

In the case of the rod type MPBX, the rod lengths should be so adjusted that the heads of the rods remain within the holes of the collar head. The external face of the collar head should be used as the reference surface and the distance between this reference surface and the face of the rods should be read by a depth gauge in the case of the mechanical MPBX. Electrical sensors between the collar head and the rods should be connected in the case of the electrical MPBX.

4.3.4 *Displacement Sensors*

Displacement sensors are either of the electrical type or the mechanical type. The mechanical sensor may be a depth micrometer, a dial gauge, or vernier calipers. Electrical sensors, rotary or linear potentiometers or cantilever displacement sensing devices using vibrating wire or resistance strain gauges.

Electrical sensors should be used for stable long-term measurements. These sensors are preferred over the mechanical type where a large number of instruments are involved and computerized data acquisition system is required. In all cases, where the reliability of the electrical sensors has not been established, arrangements for both electrical and mechanical sensors should be preferred so that periodic cross check by a mechanical sensor is possible

5 INSTALLATION PROCEDURE

5.1 The procedure of installation and monitoring should be carried out strictly under the guidance of an experienced instrumentation and rock mechanics expert.

5.2 The recommended procedure of the installation of a multi-point borehole extensometer is as follows:

a) Decide the actual place of installation, orientation and depth of borehole and number of anchors in each hole by closely examining the site of installation, keeping in view the purpose of instrumentation. To avoid the effect of temperature, the collar head should be kept inside the underground opening. If the borehole extensometers are to be installed ahead of an excavation face, which require the collar head on the ground surface, super invar rods should be used as movement transferring elements. In the case of slopes, it is suggested to use super invar rods instead of ordinary steel rods;
b) Drill the borehole up to a depth slightly more than the required depth in the desired direction using diamond coring drill. The minimum borehole diameter generally required is 75 mm;
c) Study the cores and fix the depth of anchors depending upon the stability considerations and positions of geological discontinuities, if any;
d) If possible, the deepest anchor should be installed in stable ground so that it can serve as a stationary reference point for collar head and the rest of anchors. For extensometer installed within tunnels, the deepest anchor should be installed at least two tunnel diameters away from the tunnel wall/roof or as per the instructions from the design team;
e) The borehole should be cleaned before installing the instrument;
f) Use spacers for the proper alignment of each anchor and the PVC pipe in the borehole;
g) Anchors should be fixed at their designated positions in the borehole by grouting or any other suitable method of anchorage. For grouted anchorage, at least 24 h should be allowed for setting and hardening of the grout before installation of the electrical sensor unit. A protective covering is required for the safety of the collar head;
h) ln case of vertically upward and upward inclined holes a breather tube of rigid PVC pipe should be inserted up to the full depth of the borehole to take out air while grout is injected;
j) Sensors and readout unit should be thoroughly checked before connecting to the movement transferring rods;
k) A bi-reflex target shall also be fixed either on the MPBX collar head or adjacent to it for recording the tunnel roof/wall deformation. The observation of bi-reflex target shall also be started on the date of the observation of MPBX; and
m) The readings of the instruments, MPBX and bi-reflex target, should be recorded in a field notebook as per the given data sheet (*see* Annex A and Annex B). Every entry in the data sheet should be recorded in explicitly clear manner. 'Remarks' column should point out any specific information to be furnished to the data analysis agency.

NOTE – The extensometer head and bi-reflex target should be protected from blasting or other construction-related damage. In exposed locations, a protective enclosure or a box shall be provided to protect from falling objects, moving equipments, vandalism, etc.

6 DATA ANALYSIS

6.1 The calculation of relative displacement of anchors is the first step in data analysis. The calculation depends upon the type of displacement sensor used for taking the observation. If a mechanical sensor is used for observations, then the change in reading directly gives the change in distance between the reference head and the anchor. In case of an electrical displacement sensor, the reading shall be corrected with the calibration chart to obtain the change in distance. The permissible error should not exceed $\pm$ 0.02 mm.

6.2 The calculated relative displacement should be plotted against time (*see* Fig. 4). Deepest point of anchor of the borehole extensometer shall show maximum relative displacement with respect to the borehole collar or the mouthpiece. The relative displacement of other anchored points will reduce and the minimum displacement shall be shown by the shallowest point of anchor. In case the deepest anchor is in stable ground, its relative displacement will be the absolute displacement of the collar head of MPBX.

6.3 The deformation/displacement shown by the bi-reflex target shall either be equal to the deepest anchor or shall be more than the deepest anchor. Accordingly, this helps in the MPBX data analysis.

6.4 Rate of relative displacement should also be calculated and the rate of change of relative displacement with time be plotted as shown in Fig. 5.

6.5 The deformation obtained from the bi-reflex readings will help in calculating the absolute movement of each anchor point.

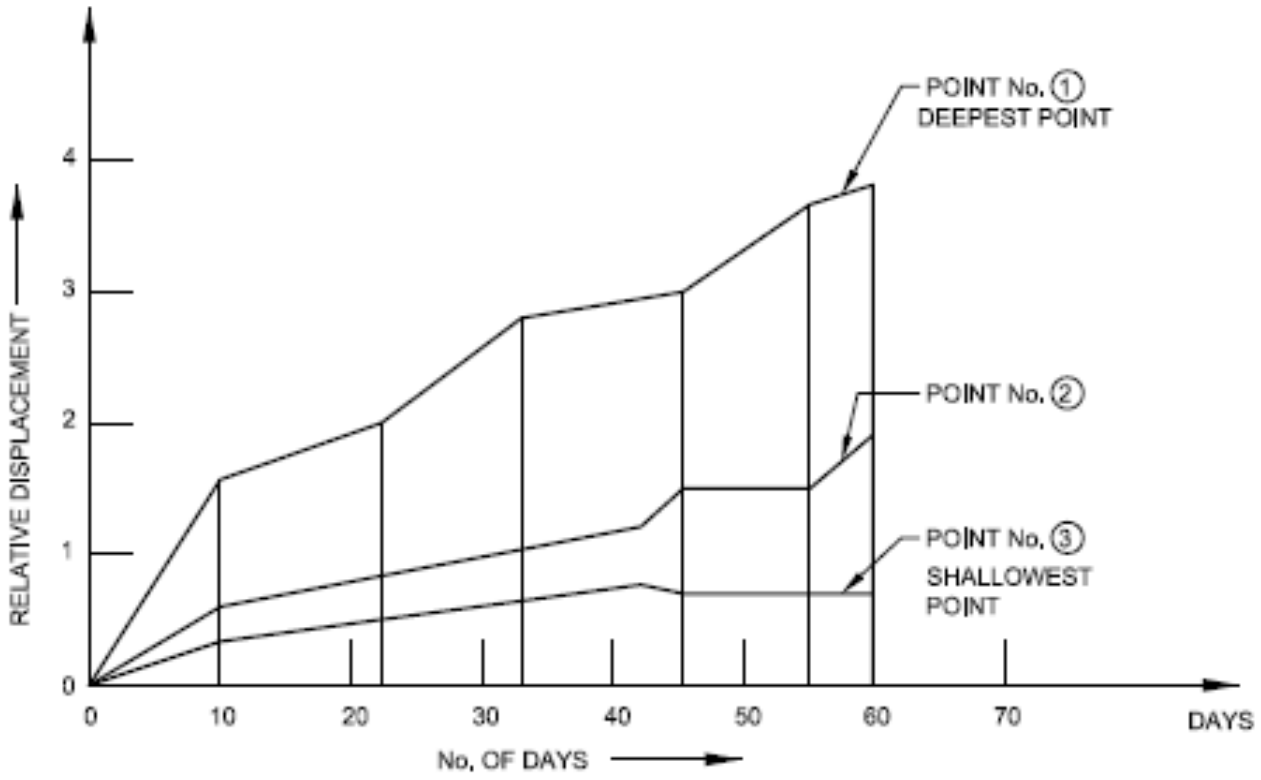


FIG. 4 PLOT OF TIME VERSUS RELATIVE ROCK MOVEMENT OF THREE POINT BOREHOLE EXTENSOMETER

6.6 Following inferences can be drawn from these plots:

a) Curves 2 and 3 in Fig. 5 indicate instability of the structure, whereas curve 1 indicates the stability;
b) A high rate of displacement or a sudden increase in rock movement is indicative of unstable conditions; and
c) Large displacements also indicate an unstable condition.

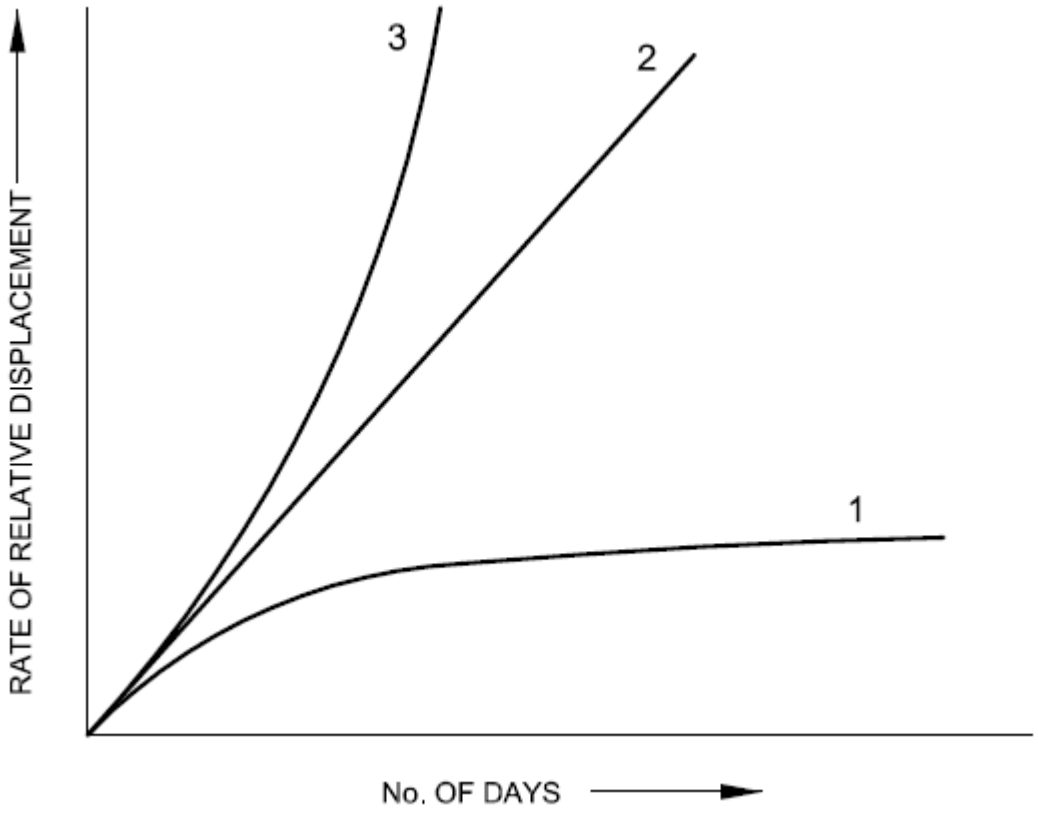


FIG. 5 PLOT OF RATE OF RELATIVE DISPLACEMENT VERSUS TIME

ANNEX A
(*Clause* 5.2)

STANDARD DATA SHEET FOR ROCK MOVEMENT MONITORING USING BOREHOLE EXTENSOMETER

Name of Project:
Location of the instrument (Chainage and roof/wall, etc):
Date of Excavation:
Date of Installation:
Date of First Reading:
Face Chainage on the Date of First observation:
Size of Opening (in Tunnels):
Rock Mass Type:
Q/RMR Value:
Overburden or Tunnel Depth:
Angle of Borehole:
Depth of Anchors (from Collar Head):
Anchor No. 1:
Anchor No. 2:
Anchor No. 3:
Anchor No. 4:

Observation Record:

Sl No.	**Date of Observation**	**Face Chainage,** m	**Observations,** mm				**Remarks**
			Anchor 1	Anchor 2	Anchor 3	Anchor 4	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

NOTES

1 Provide information on joint or shear zone or the weak zone in the 'Remarks' column.
2 Write down date and time of repositioning of reference point on a wire or readjustment of rod length if the range of measurement has exceeded the designated range.
3 Collect information on date and time of blast or excavation cycle, support installation, etc. for use in the analysis.
4 Protect the Instruments from blast damage and manhandling of cables.

ANNEX B
(*Clause* 5.2)

FORMAT FOR RECORDING THE BI-REFLEX TARGET OBSERVATIONS

Name of Project:
Location of the Instrument (Chainage and Tunnel roof/wall, etc):
Date of Excavation:
Date of Installation:
Date of First Reading:
Face Chainage on the Date of First Observation:
Size of Opening:
Rock Mass Type:
Q/RMR Value:
Overburden or Tunnel Depth:

Observation Record:

Sl No.	**Date of Observation**	**Face Chainage,** m	**Observations**	**Deformation,** mm	**Remarks**
(1)	(2)	(3)	(4)	(6)	(7)

NOTES – Frequency of taking the observations should be as follows:

1 Initially take observations before and after each blast. This should be continued till the tunnel face forwarded 3D away,
2 Afterwards take observations twice a week till the observations becomes constant, and
3 Protect the bi-reflex target from blast damage and manhandling of cables.

All figures shall be reviewed for modifications, if any, and shall be drawn neatly again.