IS 9401 (Part 16) : 1999

भारतीय मानक

नदी घाटी परियोजनाओं में कार्यमापन की पद्धति (बाँध और सम्बद्ध संरचनाएँ)

भाग 16 सुरंग निर्माण

Indian Standard

METHOD OF MEASUREMENT OF WORKS IN RIVER VALLEY PROJECTS (DAMS AND APPURTENANT STRUCTURES)

PART 16 TUNNELING

ICS 93.160

BUREAU OF INDIAN STANDARDS
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Price Group 2

FOREWORD

This Indian Standard (Part 16) was adopted by the Bureau of Indian Standards, after the draft finalized by the Measurement of Works of River Valley Projects Sectional Committee had been approved by the River Valley Division Council.

In measurement of quantities, in construction of river valley projects, a large diversity of methods exist at present according to local practices. Lack of uniformity may at times create complications regarding measurements and payments. This standard is intended to provide a uniform basis for measurement of various items of tunneling in river valley projects.

In reporting the results of a test or measurements made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'.

Indian Standard

METHOD OF MEASUREMENT OF WORKS IN RIVER VALLEY PROJECTS (DAMS AND APPURTENANT STRUCTURES)

PART 16 TUNNELING

1 SCOPE

This standard (Part 16) covers the method for measurement of tunneling for River Valley Projects, in the three main work areas involved, namely excavation, support system and concrete lining.

2 REFERENCES

The following standard contains provisions which through reference in this text, constitutes 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 this standard are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below:

IS No.	*Title*
9401 (Part 10) : 1990	Method of measurement of works in river valley projects (dams and appurtenant structures) : Part 10 Formwork

3 GENERAL

3.1 Clubbing of Items

Items may be clubbed together provided that the break-up of the clubbed items is agreed to be on the basis of the detailed description of the items stated in this standard.

3.2 Booking of Dimensions

In booking dimensions, the order shall be consistent and generally in the sequence of length, breadth or width and height or depth or thickness.

3.3 Measurements

All works shall be measured net in the decimal system:

a) Linear dimensions shall be measured to the nearest 0.01 m.

b) Areas shall be worked out to the nearest 0.01 m^2.

3.4 Description of Items

The description of each item shall, unless stated otherwise, be held to include all labour, construction plant and equipment, materials and all activities required for performance of the work. The following items shall not be measured separately and allowance for the same shall be deemed to have been made in the description of the main item:

a) Setting out work, profiles, bench marks, etc;

b) Cleaning up, washing and surface preparation;

c) Working in wet conditions;

d) Scaling, wherever required, of excavated surfaces;

e) Ventilation during construction;

f) Lighting during construction;

g) Safety items, protection barriers and signals;

h) Telecommunication requirements; and

j) Documentation for various activities.

3.5 Definitions

For the purpose of this standard the definitions given in **3.5.1** to **3.5.5** shall apply.

3.5.1 *A-Line*

The A-Line (Minimum Excavation Line) of the tunnel is the line within which no rock and no support, other than permanent support systems, shall be permitted to remain.

3.5.2 *B-Line*

The B-Line (Pay Line) of the tunnel is a line which is beyond and parallel to the A-Line. The distance between A-Line and B-Line may vary from 0.0 m to 0.2 m. depending upon the excavation conditions and this distance shall be clearly specified in the work description and/or tunnel drawings.

3.5.3 *C-Line*

The C-Line is a line which is beyond and parallel to the B-Line. The distance between B-Line and C-Line may vary from 0.2 m to 0.5 m, depending upon the tunnel dimensions and strata of the medium through which the tunnel is being excavated.

3.5.4 *Overbreak*

'Overbreak' consists of the volume of rock removed during excavation operations outside the B-Line irrespective of its extent.

3.5.5 *Approved Overbreak*

'Approved Overbreak' consists of that portion of overbreak outside the C-Line, the occurrence of which is an unavoidable result of adverse geological conditions due to concealed joints, faults and other structural defects in rock and not due to negligence or lack of reasonable care and skill in excavation operations.

4 BILL OF QUANTITIES

In the bill of quantities, the nomenclature of various items of work involved shall be specific and should accurately represent the activity to be executed. For each item of bill of quantities, there shall be reference to the corresponding technical specifications.

5 TECHNICAL SPECIFICATIONS

5.1 The technical specifications of items of work shall fully and accurately describe the scope of work, materials including specifications, workmanship and desired output. Reference to the relevant standards to be followed for execution of items of work shall be invariably made in the technical specifications.

5.2 General nature of the site should be stated. All available information like strata through which the tunnel is to be driven along with the ridges and valleys which the tunnel crosses, shall be stated along with the inclination at which the tunnel is to be driven.

6 METHOD OF MEASUREMENT OF EXCAVATION

6.1 Depending upon the rock conditions, suitable excavation methods shall be adopted like full face excavation; or top heading and benching; or multidrifting with suitable drilling methodology like perimeter blasting/line drilling/presplitting etc; or using Tunnel Boring Machine. When excavation is carried out without use of Tunnel Boring Machine it shall be classified as given in **6.2**.

6.2 The items of tunnel excavation shall be classified as follows:

a) *Excavation in tunnel not requiring steel rib supports* — This can be with or without rockbolts and shotcrete with or without wiremesh as a temporary measure.

b) *Excavation in tunnel in all classes of soil, soft and hard rock, requiring temporary or permanent supports during excavation* — The supports shall be measured separately (*see* 7).

6.3 The description of the item shall unless otherwise stated, be held to include drilling, charging of with explosives, blasting and removal and disposal of excavated material in the dump area specified and stockpiling of useful rock as instructed by the Engineer-in-Charge.

6.4 The quantity of excavation, including that obtained by controlled perimeter blasting shall be measured of the volume in solid contained up to the B-Line (Pay line) irrespective of whether the actual excavation falls within/beyond the said line. Each class of excavation shall be measured separately.

6.5 Overbreaks

The volume of rock in 'Overbreak' except that contained in 'Approved Overbreak' shall not be measured. The 'Approved Overbreak' shall be measured separately. The 'Approved Overbreak' shall be approved by the Engineer-in-Charge.

If,

A = actual cross-sectional area of the tunnel after excavation,

A_c = cross-sectional area of tunnel at C-Line,

L = linear distance between the mid point of the present section to last section and mid point of present section to next section, and

V_o = volume of 'Approved Overbreak'.

Then,

$$V_o = (A - A_c) \times L$$

The section should be measured at intervals varying from 0.5 to 5.0 m depending upon tunnel excavation conditions and shall be decided by the Engineer-in-Charge.

6.6 Tunnel Enlargement

In case, if determined by the Engineer-in-Charge, the minimum excavation line is increased, necessitating enlargement of the excavated tunnel, separate measurement of the quantity of the excavation shall be made between the original B-Line and revised B-Line that is established.

6.7 Dental Rock Excavation

The layers of soft or disintegrated rock bedded with hard rocks or seams or faults, required to be excavated beyond the pay line and removed by hand or pneumatic or other implements without requiring continuous and systematic blasting, shall be measured separately as a net quantity.

7 MEASUREMENT OF SUPPORT SYSTEM

7.1 Temporary Supports

The item of temporary support, when used, shall include furnishing, installing, maintenance and removal including materials, labour and equipment.

7.1.1 When timber is used, in or as, temporary support, it shall be measured separately.

7.1.2 When ordered by the Engineer-in-Charge, the work of protecting weak rocks temporarily to facilitate construction, either by guniting or shotcreting, shall be measured separately.

7.1.3 Reinforcing bars used as forepoling rods shall be measured separately.

7.2 Permanent Supports

The item of permanent supports, shall consist of furnishing and installing the supports, complete with all bolts, nuts, butt plates, feather plates, dowels, wedges, tie rods, temporary timber spreaders and concrete pedestals if any, lagging, blocking and back packing with excavated material. The work of strengthening supports already erected, by adding additional members, shall be measured separately.

7.3 Measurement

7.3.1 The measurement of steel rib supports as permanent supports, shall be done by weight, in kilograms. The weight shall be determined by multiplying measured length of section with nominal mass per unit length of section as specified in relevant Indian Standards for the section used. Steel support accessories like nuts, bolts, butt plates, feather plates, tie rods and wastages, etc, shall not be measured separately.

7.3.2 In case precast concrete blocks are provided as lagging, so as to form part of the concrete lining, the same shall be measured separately in cubic meters. The volume of such blocks shall be deducted from the volume of the concrete lining (*see* **9.4**).

7.3.3 The space between the rock and the support system with lagging filled by cement concrete for the purpose of backfilling shall be measured separately as backfill concrete in cubic meters (*see* **9.5**).

7.3.4 At times it is considered necessary to provide rock reinforcement in the form of tensioned/untensioned rock bolts set in resin/cement or rock dowels straight/ hooked or chain-link/welded wiremesh with anchors to facilitate tunnel construction.

7.3.4.1 Measurement of rock bolts fully set in resin / cement cartridges shall be done in metres, measuring the length. The diameter of the rock bolts should be clearly specified.

7.3.4.2 There shall be no separate measurement for cement/resin cartridges, bearing plates, nuts, quick setting cement for bearing plates, pads, rust protection materials and drilling.

7.3.4.3 Measurement of straight/hooked rock dowels fully set in grout shall be done in metres, measuring the length. There shall be no separate measurement for cement and additives for grout mixes, rust protection materials, drilling etc.

7.3.4.4 Measurement for chainlink/welded wiremesh complete with mesh anchors or other securing devices, shall be made by area of the rock covered by wiremesh as projected on the B-Line, in square metres. Mesh anchors or other securing devices and overlaps of wiremesh shall not be measured separately. The size of wire and mesh size for wiremesh shall be clearly specified.

7.3.5 Measurement for timber support shall be made of the volume in cubic meters of collar braces installed and timber lagging. Other accessories for timber support shall not be measured separately.

7.3.6 Reinforcing bars/sections used for forepoling shall be measured by weight, in kilograms, by multiplying length of section with nominal mass per unit length of section as specified in relevant Indian Standards.

7.3.7 Tension testing of selected rock bolts shall be done as decided by the Engineer-in-Charge and measurement of the same shall be done based on the number of tests performed which shall include all labour, material and equipment.

8 MEASUREMENT OF SHOTCRETE

8.1 The item of shotcrete shall consist of supplying and placing shotcrete in specified thickness including all labour, material, equipment, performance of control tests for proper mix design, strength tests as required by Engineer-in-Charge and casting of required test-panels. Shotcrete shall be measured in cubic metres computed by multiplying the payment area by the specified thickness. The payment area shall be defined as under:

a) When the excavated profile does not extend to portion beyond C-Line, the payment area shall be the projection of the irregular area covered, onto the pay Line (B-line).

b) When the excavated profile extends to the portion of 'Approved Overbreak' but the actual cross-sectional area of the excavation is not more than the area at C-Line, the payment area shall be the projection of the irregular area covered, onto the payline (B-Line).

c) When the excavated profile extends to the

portion of 'Approved overbreak' and when the actual cross sectional area of the excavation is more than the area at C-Line, an imaginary line parallel to C-Line shall be drawn in such a way that it depicts average line of actual excavation. The payment area shall be the projection of the irregular area covered, onto this imaginary line.

8.2 No separate measurement shall be made for preparation of surface, drainage arrangement required for control of seepage water during the placement of shotcrete, making arrangements for protection of exposed threads of rock bolts prior to placement of shotcrete, development of limits and controls, provision of test specimen, trial mixes, etc, and these shall be deemed to be included in the item of the shotcrete.

8.3 No separate measurement shall be done for rebound and/or wasted shotcrete, additives or admixtures and these shall be deemed to be included in the item of shotcrete.

8.4 When cement is issued departmentally by the Engineer-in-Charge, the cement consumed in rebound shall be limited to 20 percent of the total quantity of cement required for measured shotcrete as per design mixes.

9 MEASUREMENT OF CONCRETE LINING

9.1 The item of concrete lining shall comprise the supply of all labour, plant and materials and the performance of all work necessary for supplying, mixing, transporting from the batching plant, placing, compacting, curing and finishing concrete including cleaning and preparing construction joints.

9.2 Where no precast concrete slabs or laggings have been installed, measurement of concrete lining shall be made of the theoretical quantity of concrete placed in cubic meters between the finished surface and the B-Line (Pay line) of the tunnel. No deduction shall be made for the volume of reinforcement. However, the volume of steel ribs and volume of shotcrete, if the shotcrete has been measured by projecting the excavated profile of the tunnel onto the B-Line, shall be deducted from the total theoretical volume of concrete lining.

9.3 The concrete required to backfill overbreaks, if any, beyond B-Line shall be measured separately in two parts as below:

a) That part of volume of concrete which is contained between B-Line and C-Line, limited to actual excavated profile of tunnel.

b) That part of volume of concrete which is contained between C-Line and actual excavated profile of tunnel less the volume of shotcrete, where shotcrete has been measured by projecting the actual excavated profile of tunnel on an imaginary line parallel to and beyond C-Line as in **8.1**(c) above. In case this volume of concrete is a negative figure, it shall be deducted from the volume as obtained in (a) above and the same shall be treated as volume of concrete backfill.

9.4 Where precast concrete slabs/lagging have been installed, measurement of concrete lining shall be made of theoretical volume of concrete placed in cubic meters between the finished surface and the B-Line (Pay line) of the tunnel. No deduction shall be made for the volume of reinforcement. However the volume of steel ribs and precast concrete slabs or laggings installed shall be deducted from the total theoretical volume of concrete lining. The volume so obtained shall be further reduced by volume of shotcrete, if the shotcrete has been measured by projecting the excavated profile of the tunnel onto the B-Line.

9.5 The concrete required to backfill the space between the rock and precast concrete slabs or laggings shall be measured separately in two parts as in **9.3.**

9.6 The item of formwork for tunnel lining, except bulkheads and formworks used exclusively for backfill concrete in Overbreak and/or Approved Overbreak portions, shall be measured separately.

9.6.1 Formwork shall be measured in accordance with IS 9401 (Part 10).

9.6.2 Formwork for concrete lining shall be measured in square metres of the finished surface of tunnel. No deductions shall be made for openings less than 0.4 m^2.

9.7 Concrete lining shall be held to include items like air entraining agents, admixtures, curing compounds, development of limits and controls, arrangement of test specimens, trial mixes, etc, and these shall not be measured separately.

9.8 No separate measurement for void filling by grouting in the concrete portion shall be made and allowance for the same shall be deemed to have been included in the main item.

9.9 In case the work is being executed on contract basis, the aspect of payment of excavation and concrete in 'Overbreak' and 'Approved Overbreak' shall be suitably taken care of, while framing tender documents.

Bureau of Indian Standards

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

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Review of Indian Standards

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

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