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

कार्यसूची

हमारा संदर्भ: सीईडी 48/ए-2.31 **24 सितम्बर 2024**

विषय : रॉक मैकेनिक्स विषय समिति, सीईडी 48 की इकत्तीसवीं बैठक की कार्यसूची

सीईडी 48 के सभी सदस्य

प्रिय महोदय/महोदया,

हमारे सम संख्यक पत्र दिनांक **11 सितम्बर 2024** के संदर्भ में रॉक मैकेनिक्स विषय समिति, सीईडी 48 की इकत्तीसवीं बैठक की कार्यसूची की एक प्रति आपको भेज रहें हैं । बैठक निम्नानुसार आयोजित होगी:

तकनीकी समिति	दिन	तिथि	समय	स्थान
रॉक मैकेनिक्स विषय समिति, सीईडी 48	सोमवार	30 सितम्बर 2024	16:00 बजे	**अनुशीलन (कॉपर कक्ष), (ऑनलाइन+ऑफलाइन)** भारतीय मानक ब्यूरो, मानक भवन, 9, बहादुर शाह जफर मार्ग नई दिल्ली 110 002

Webex लिंक का विवरण नीचे दिया गया है:

मीटिंग लिंक : https://bismanak.webex.com/bismanak/j.php?MTID=m38c90a112d44f329395ecbd515d59d0e
बैठक संख्या : 2510 643 1047
पासवर्ड : manojced48

कृपया ध्यान दें कि बीआईएस द्वारा उठाए गए नए सुधार उपाय के अनुसार, अनुभागीय समिति की बैठक में भाग लेना सभी सदस्यों के लिए अनिवार्य है, दो बैठकों में अनुपस्थित रहने पर अनुभागीय समिति में नामांकन वापस लिया जा सकता है।

हम आशा करते हैं कि आप इस महत्वपूर्ण बैठक में भाग लेंगे । इस बैठक में भाग लेने की पुष्टि कृपया ईमेल से भेज दें ।-

सधन्यवाद ।

भवदीय,

(**डॉ मनोज कुमार रजक**)
सदस्य सचिव , सीईडी 48
ई-मेलः manoj@bis.gov.in
फोन न. 011-23238253

संगलन : उपरिलिखित

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

AGENDA

Our Ref: CED 48/A-2.31 **24 September 2024**

Subject: Agenda for the Thirty-first Meeting of Rock Mechanics Sectional Committee, CED 48

ALL MEMBERS OF CED 48

Dear Sir/Madam,

In continuation to our Meeting Notice of even number dated **11 September 2024**, please find enclosed herewith a copy of the Agenda of the Thirty-first Meeting of Rock Mechanics Sectional Committee, CED 48. The schedule of the meeting is as given below:

Technical Committee	Day	Date	Time	Venue
Rock Mechanics Sectional Committee, CED 48	Monday	30 September 2024	16:00 h	**Anushilan (Copper Room), (Online + Offline)** Bureau of Indian Standards, Manak Bhavan, 9, Bahadur Shah Zafar Marg New Delhi 110 002

The detail of **Webex** link is as given below:

URL : https://bismanak.webex.com/bismanak/j.php?MTID=m38c90a112d44f329395ecbd515d59d0e
Meeting ID : 2510 643 1047
Password : manojced48

NOTE: - Please note that as per new reform measure taken by the BIS, participation in the sectional committee meeting is mandatory for all the members, absent in two meeting may liable to withdrawal the nomination of the committee in the sectional committee.

You are kindly requested to make it convenient to participate in the meeting and a line in confirmation through E-mail would be highly appreciated.

Thanking you,

Yours faithfully,

(**Dr Manoj Kumar Rajak**)
Member Secretary CED 48
E-mail Id: manoj@bis.gov.in
Phone No. 011-23238253

Encl: As above

BUREAU OF INDIAN STANDARDS

AGENDA

Rock Mechanics Sectional Committee, CED 48 : Thirty-first Meeting

Monday, 30 September 2024 : 16:00 h

Venue: Anushilan (Copper Room), (Online + Offline), Bureau of Indian Standards, Manak Bhavan, 9, Bahadur Shah Zafar Marg, New Delhi 110 002

CHAIRPERSON : Dr N. K. Samadhiya, (IIT Roorkee)
MEMBER SECRETARY : Dr Manoj Kumar Rajak

ITEM 0 OPENING REMARKS BY THE CHAIRMAN

ITEM 1 CONFIRMATION OF THE MINUTES OF THE LAST MEETING

The Minutes of the Thirtieth Meeting of CED 48 held on 21 March 2024 were circulated to the members vide letter No. CED 48/A-2.30 Dated 05 April 2024.

The Committee may confirm the minutes.

ITEM 2 COMPOSITION

The present composition of the sectional committee is given at **Annex 1**.

The Committee may consider and review the composition.

ITEM 3 PROGRAMME OF WORK

The present position of Programme of Work is given at **Annex 2**.

ITEM 4 DRAFT STANDARDS/AMENDMENTS FOR APPROVAL FOR FINALIZATION

4.1 IS 13365 (Part 1) : 1998 Quantitative Classification System of Rock Mass – Guidelines: Part 1 RMR for Predicting of Engineering Properties

The WC draft Doc. No. CED 48(25742)WC was circulated vide BIS Letter No. CED48/T-31 Dated 29 May 2024 in wide circulation. The comment received on this draft is given in **Annex 3**.

The Committee may consider.

4.2 IS 13365 (Part 3) : 1997 Quantitative Classification Systems of Rock Mass – Guidelines: Part 3 Determination of Slope Mass Rating

The WC draft Doc. No. CED 48(25744)WC was circulated vide BIS Letter No. CED48/T-33 Dated 29 May 2024 in wide circulation. The comment received on this draft is given in **Annex 4**.

The Committee may consider.

ITEM 5 ISSUES CARRIED OVER FROM PREVIOUS MEETING

5.1 Application of Numerical Modeling in Rock Mechanics

In the last meeting, Committee requested CWPRS to submit the revised draft on this subject.

Revised draft received and enclosed as **Annex 5**.

The Committee may consider.

5.2 Revision of Indian Standard IS 12634 : 1989 and IS 12608 : 1989

In the last meeting, Committee requested IIT, Khargpur to prepare the draft revision for the following Indian Standard.

a) IS 12634 : 1989 Rock joints-direct shear strength – Laboratory of method of determination. Draft revision received, wide circulation pending.
b) IS 12608 : 1989 Method for determination of hardness of rock. Input awaited

The committee may consider and advise.

5.2 Revision of Indian Standard IS 13365 (Part 4) : 2014 'Quantitative Classification System of Rock Mass – Guidelines: Part 4 Geological Strength Index (GSI)'

In the last meeting, Committee requested CIMFR to prepare the draft revision for this Indian Standard.

The input is awaited.

The committee may consider and advise.

5.3 Revision of Indian Standard related to Testing of Rock

In the last meeting, Committee requested CWPRS to prepare the draft revision for the following Indian Standard.

a) IS 13372 (Part 1) : 1992 Seismic testing of rock mass - Code of practice: Part 1 Within a borehole
b) IS 13372 (Part 2) : 1992 Seismic testing of rock mass - Code of practice: Part 2 Between the borehole
c) IS 14396 (Parts 1 to 4) : 1996 Argillaceous swelling rocks – Methods for laboratory testing
d) IS 14436 : 1997 Guidelines on determination of resistivity of rock specimen

The input is awaited.

The committee may consider and advise.

5.4 Revision of Indian Standard IS 13063 : 1991 'Structural Safety of Buildings on Shallow Foundations on Rocks – Code of Practice'

In the last meeting, Committee requested IIT, Roorkee to prepare the draft revision for this Indian Standard.

The input is awaited.

The committee may consider and advise.

5.5 Revision of Indian Standard IS 13414 : 1992 'Monitoring of Rock Movement Using Multi-point Borehole Extensometers – Guidelines'

In the last meeting, Committee requested Dr R. K. Goel to prepare the draft revision for this Indian Standard.

The input is awaited.

The committee may consider and advise.

5.6 Revision of Indian Standard related to Testing of Rock

In the last meeting, Committee requested CSMRS to prepare the draft revision for the following Indian Standard.

a)	IS 8764 : 1998	Method for determination of point load strength index of rocks (*first revision*)
b)	IS 9143 : 1979	Method for the determination of unconfined compressive strength of rock materials
c)	IS 9179 : 1979	Method for preparation of rock specimen for laboratory testing
d)	IS 9221 : 1979	Method for the determination of modulus of elasticity and Poisson's ratio of rock materials in uniaxial compression
e)	IS 10050 : 1981	Method for determination of slake durability index of rocks
f)	IS 10082 : 1981	Method of test for determination of tensile strength by indirect tests on rock specimens
g)	IS 10782 : 1983	Method for the laboratory determination of dynamic modulus of rock core specimens
h)	IS 13030 : 1991	Method of test for laboratory determination of water content, porosity, density and related properties of rock material
j)	IS 13047 : 1991	Method for determination of strength of rock materials in triaxial compression
k)	13946 (Part 2) : 1994	Determination of rock stress – Code of practice: Part 2 Using USBM type drill hole deformation gauge
m)	13946 (Part 3) : 1994	Determination of rock stress – Code of practice: Part 3 Using a CSIR or CSIRO type cell with 9 or 12 strain gauges
n)	13946 (Part 4) : 1994	Determination of rock stress – Code of practice: Part 4 Using flat jack technique

The input is awaited.

The committee may consider and advise.

5.7 Revision of Indian Standard IS 11358 and 14448

In the last meeting, Committee requested MVerman to prepare the draft revision for the following Indian Standard.

a) IS 11358 : 1987 Glossary of terms and symbols relating to rock mechanics
b) IS 14448 : 1997 Code of practice for reinforcement of rock slopes with plane wedge failure

The input is awaited.

The committee may consider and advise.

5.8 Revision of Indian Standard IS 14395 : 1996 'Monitoring of Rock Movements using Probe Inclinometer – Guidelines'

In the last meeting, Committee requested Working Group to prepare the draft revision for this Indian Standard. The composition of the working group is as given below:

a) CSIR-Central Building Research Institute, Roorkee
b) Central Soil and Materials Research Station, New Delhi

The input is awaited.

The committee may consider and advise.

5.9 Revision of Indian Standard IS 12955 (Part 1 and 2) : 1990 'In-situ Determination of Rock Mass Deformability using a Flexible Dilatometer – Code of Practice: Part 1 With Volume Change and Part 2 With Radial Displacement'

In the last meeting, Committee finalized the TOR for revision of this Indian Standard.

TOR is awaited for uploading.

The committee may consider.

ITEM 6 ANY OTHER BUSINESS

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Annex 1

TITLE: **ROCK MECHANICS SECTIONAL COMMITTEE, CED 48**

SCOPE: Formulation of Indian standard in the field of rock mechanics, tunnelling technology and rock slopes covering field and laboratory tests, rock sampling, classification of rock and rock masses for engineering purposes, engineering design & stability analysis approaches, instrumentation & monitoring and improvement of rock mass.

Nos. of Meetings	Date	Place
Twenty-eighth	13 Jun 2023	New Delhi
Twenty-ninth	30 Nov 2023	New Delhi
Thirtieth	21 Mar 2024	Roorkee

SI No.	**NAME OF THE ORGANISATION**	**REPRESENTED BY**	**MEETINGS**			**ATTEN-DANCE**
			28th	**29th**	**30th**	
1	Indian Institute of Technology Roorkee, Roorkee	Dr N. K Samadhiya **(*Chairperson*)**	P	P	P	3/3
2	Amberg Engineering AG India Private Limited, Gurugram	Shri Kripal Choudhary Shri Rakesh Pandita (*Alternate*)	A	P	A	1/3
3	Aquagreen Engineering Management Private Limited, Gurugram	Shri Imran Sayeed	C	P	P	2/2
4	CSIR–Central Building Research Institute, Roorkee	Dr Manojit Samanta Dr Anindya Pain (*Alternate* I) Smt Ashwathy M.S. (*Alternate* II)	P	P	P	3/3
5	CSIR–Central Institute of Mining & Fuel Research, Dhanbad	Dr J. K. Mohnot Dr R. D. Dwivedi (*Alternate* I) Dr Ashok Kumar Singh (*Alternate* II)	P	P	P	3/3
6	CSIR–Central Road Research Institute, New Delhi	Dr Pankaj Gupta Shri R. K. Panigrahi (*Alternate*)	P	P	A	2/3
7	Central Soil & Materials Research Station, New Delhi	Shri Hari Dev Shri Mahabir Dixit (*Alternate*)	P	P	P	3/3
8	Central Water Commission, New Delhi	Shri Darpan Talwar Ms M.S. Harshitha (*Alternate*)	A	P	P	2/3
9	Central Water and Power Research Station, Pune	Shri Rizwan Ali Dr S. A. Burele (*Alternate*)	P	P	P	3/3
10	Engineers India Ltd,	Dr Altaf Usmani	P	P	P	3/3

SI No.	NAME OF THE ORGANISATION	REPRESENTED BY	MEETINGS			ATTEN-DANCE
			28th	29th	30th	
	New Delhi	Shri Saikat Pal (*Alternate*)				
11	Geological Survey of India, Kolkata	Shri Santosh Kumar Tripathi Shri D. P. Dangwal (*Alternate*)	P	P	P	3/3
12	In Personal Capacity, Noida	Shri R. K. Goel	P	P	P	3/3
13	Indian Institute of Technology Kharagpur, Kharagpur	Shri Abhiram Kumar Verma Shri Rakesh Kumar (*Alternate*)	–	C	P	1/1
14	Indian Institute of Technology Roorkee, Roorkee	Dr Mahendra Singh Dr Priti Maheshwari (*Alternate*) Prof Sumit Sen (*YP*)	P	P	P	3/3
15	Irrigation Research Institute, Roorkee	Shri Dinesh Chandra Shri Shankar Kumar Saha (*Alternate*)	P	P	A	2/3
16	MVerman, gurugram	Dr Manoj Verman	C	P	P	2/2
17	National Hydroelectric Power Corporation Ltd, Faridabad	Shri Rajesh Kumar Shri Ajay Kumar Verma (*Alternate* I) Shri Pradeep Kumar Garnayak (*Alternate* II)	P	P	P	3/3
18	National Disaster Management Authority, New Delhi	JS (Mitigation) Shri Safi Ahsan Rizvi (*Alternate*)	A	P	P	2/3
19	National Institute of Rock Mechanics, Bengaluru	Shri B. H. Vijay Sekar	–	–	C	0/0
20	RITES Limited, Gurugram	Smt Jyotsna Dixit Shri Sandeep Singh Nirmal (*Alternate*) Shri Ahmed Shaz (*YP*)	A	P	A	1/3
21	Rail Vikas Nigam Limited, New Delhi	Shri Sumit Jain Shri Vijay Dangwal (*Alternate*)	P	P	P	3/3

Annex 2

CED 48 ROCK MECHANICS SACTIONAL COMMITTEE

SCOPE Formulation of Indian standard in the field of rock mechanics, tunnelling technology and rock slopes covering field and laboratory tests, rock sampling, classification of rock and rock masses for engineering purposes, *engineering* design & stability analysis approaches, instrumentation & monitoring and improvement of rock mass

LIAISON ISO/TC 182 (O) GEOTECHNICS

SI No.	IS No.	Title	Reaffirm M-Y	No. of Amds
I	IS 7317 : 2020	Uniaxial jacking test for deformation modulus of rock mass – Code of practice (*second revision*)	-	-
2	IS 7746 : 2022	In-situ shear test on rock mass – Code of practice (*second revision*)		-
3	IS 8764 : 1998	Method for determination of point load strength index of rocks (*first revision*)	Mar, 2019	2
4	IS 9143 : 1979	Method for the determination of unconfined compressive strength of rock materials	Apr, 2021	-
5	IS 9179 : 1979	Method for preparation of rock specimen for laboratory testing	Apr, 2021	-
6	IS 9221 : 1979	Method for the determination of modulus of elasticity and Poisson's ratio of rock materials in uniaxial compression	Apr, 2021	-
7	IS 10050 : 1981	Method for determination of slake durability index of rocks	Apr, 2021	-
8	IS 10082 : 1981	Method of test for determination of tensile strength by indirect tests on rock specimens	Apr, 2021	-
9	IS 10782 : 1983	Method for the laboratory determination of dynamic modulus of rock core specimens	Apr, 2021	-
10	IS 11309 : 2023	Method for conducting pull-out test on anchor bars and rock bolts (*first revision*)		-
11	IS 11315 (Part 1) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 1 Orientation (*first revision*)		-
12	IS 11315 (Part 2) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 2 Spacing (*first revision*)		-
13	IS 11315 (Part 3) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 3 Persistence (*first revision*)		-
14	IS 11315 (Part 4) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 4 Roughness (*first revision*)		-

15	IS 11315 (Part 5) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 5 Wall strength (*first revision*)		-
16	IS 11315 (Part 6) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 6 Aperture (*first revision*)		-
17	IS 11315 (Part 7) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 7 Filling (*first revision*)		-
18	IS 11315 (Part 8) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 8 Seepage (*first revision*)		-
19	IS 11315 (Part 9) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 9 Number of sets (*first revision*)		-
20	IS 11315 (Part 10) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 10 Block size (*first revision*)		-
21	IS 11315 (Part 11) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 11 Core recovery and rock quality designation (*first revision*)		-
22	IS 11315 (Part 12) : 2023	Methods for quantitative description of discontinuities in rock masses: Part 12 Drill core study (*first revision*)		-
23	IS 11358 : 1987	Glossary of terms and symbols relating to rock mechanics	Apr, 2020	-
24	IS 12608 : 1989	Method for determination of hardness of rock	Apr, 2020	-
25	IS 12634 : 1989	Rock joints-direct shear strength – Laboratory of method of determination	Apr, 2020	1
26	IS 12955 (Part 1) : 1990	Code of practice for in-situ determination of rock mass deformability using a flexible dilatometer: Part 1 With volume change	Apr, 2021	-
27	IS 12955 (Part 2) : 1990	In-situ determination of rock mass deformability using a flexible dilatometer – Code of practice: Part 2 With radial displacement	Apr, 2021	-
28	IS 13030 : 1991	Method of test for laboratory determination of water content, porosity, density and related properties of rock material	Apr, 2021	-
29	IS 13047 : 1991	Method for determination of strength of rock materials in triaxial compression	Apr, 2021	1
30	IS 13063 : 1991	Structural safety of buildings on shallow foundations on rocks – Code of practice	Apr, 2021	-
31	IS 13365 (Part 1) : 1998	Quantitative classification system of rock mass – Guidelines : Part 1 Rock mass rating (RMR) for predicting of engineering properties	Apr, 2021	1

32	IS 13365 (Part 2) : 2019	Quantitative classification systems of rock mass – Guidelines: Part 2 Rock mass quality for prediction of support pressure, support system and engineering properties in underground openings (*first revision*)	-	-
33	IS 13365 (Part 3) : 1997	Quantitative classification system of rock mass – Guidelines: Part 3 Determination of slope mass rating	Apr, 2022	-
34	IS 13365 (Part 4) : 2014	Quantitative classification system of rock mass – Guidelines Part 4 Geological strength index (GSI)	Jul, 2024	-
35	IS 13372 (Part 1) : 1992	Seismic testing of rock mass – Code of practice: Part 1 Within a borehole	Apr, 2021	-
36	IS 13372 (Part 2) : 1992	Seismic testing of rock mass – Code of practice: Part 2 Between the borehole	Apr, 2021	-
37	IS 13414 : 1992	Monitoring of rock movement using multi-point borehole extensometers –- Guidelines	Apr, 2021	-
38	IS 13946 (Part 1) : 2022	Determination of Rock Stress – Code of Practice: Part 1 Using the hydraulic fracturing test and hydraulic tests on pre-existing fractures techniques (*first revision*)		-
39	IS 13946 (Part 2) : 1994	Determination of rock stress – Code of practice: Part 2 Using USBM type drill hole deformation gauge	Apr, 2020	-
40	IS 13946 (Part 3) : 1994	Determination of rock stress – Code of practice: Part 3 Using a CSIR or CSIRO type cell with 9 or 12 strain gauges	Apr, 2020	-
41	IS 13946 (Part 4) : 1994	Determination of rock stress-Code of practice Part 4 Using flat jack technique	Apr, 2021	-
42	IS 14243 (Part 1) : 1995	Selection and development of site for building in hill areas – Guidelines: Part 1 Microzonation of urban centres	Apr, 2020	-
43	IS 14243 (Part 2) : 1995	Selection and development of site for building in hill areas – Guidelines: Part 2 Selection and development	Apr, 2020	-
44	IS 14395 : 1996	Monitoring of rock movements using probe inclinometer – Guidelines	Apr, 2022	1
45	IS 14396 (Part 14) : 1996	Argillaceous Swelling Rocks – Methods for Laboratory Testing	Apr, 2021	-
46	IS 14436 : 1997	Guidelines on determination of resistivity of rock specimen	Apr, 2022	1
47	IS 14448 : 1997	Code of practice for reinforcement of rock slopes with plane wedge failure	Apr, 2022	1
48	IS 14881 : 2001	Method for blast vibration monitoring – Guidelines	Apr, 2021	-
49	IS 15026 (Part 1) : 2022	Tunnelling in Rock Masses – Guidelines: Part 1 Conventional Tunnelling Methods (*first revision*)		-

50	IS 15026 (Part 2) : 2023	Tunnelling in Rock Masses – Guidelines: Part 2 Mechanized Tunnelling Methods by Tunnel Boring Machines		-
51	IS 15180 : 2002	Guidelines for use in prediction of subsidence and associated parameters in coal mines having nearly horizontal single seam workings	Apr, 2022	-
52	IS 17446 : 2020	Observational Method for Tunnelling in Rock Masses – Guidelines		-
53	IS 17511 : 2020	Borehole Jack Test for Determination of Modulus of Deformation of Rock Mass – Code of Practice		-
54	IS 18300 : 2023	Determination of Rock Mass Shear Strength of Landslide Affected Slopes – Guidelines		-

DRAFT STANDARDS COMPLETED WC STAGE		
1	COD.CED 48 (25742) Revision of IS 13365:1998	Quantitative classification systems of rock mass – Guidelines: Part 1 Rock mass rating RMR for predicting engineering properties
2	DOC.CED 48 (25744) Revision of IS 13365:1997	Quantitative classification systems of rock mass – Guidelines: Part 3 Determination of slope mass rating

Annex 3

Doc. No. CED 48 (25742)
Title: Quantitative Classification Systems of Rock Mass – Guidelines:
Part 1 Rock Mass Rating RMR for Predicting Engineering Properties of IS 13365 (Part 1)

Sl No.	Clause/Para/Table / Figure No. Commented	Comments/Modified Wordings	Justification of the Proposed Change	Name of The Commentator
1	Clause 3(a)	Uniaxial compressive strength of intact rock material (IS 9143 or IS 8764),	Suggested as given in the clause 3.3.1 of IS 13365 (Part 1)	NPCIL
2	Clause 5.1.7	(7.5 $B^{0.1}$ $H^{0.5}$ – RMR)/20 RMR, in MPa	Based on the IS 13365 (Part 1): 1998 and unit converted from kg/cm^2 to MPa	NPCIL
3	Clause 3.1.2	Another formula presented in cl. 6.3.2 of IS 11315 (Part 11) may also be included for uniformity across codes.	Maintain uniformity across codes. Similarly, the provision of minimum RQD of 10 may be introduced in IS 11315 (Part 11).	TCE
4	Clause 5.1.3.2	For deformation modulus (Ed) of hard rock mass two formulas are given, the minimum from the two to be adopted.	Clarification on calculated value of Ed to be adopted in design	TCE
5	Clause 5.1.6	Shear strength of jointed rock mass – parameters in the formula and range of values of constants A and B are not found.	Mention that parameters are provided in Table 2.	TCE

NOTS –
TCE – **MANOS DE**
NPCIL – Y**.T. PRAVEENCHANDRA**

Annex 4

Doc. No. CED 48 (25744)
Title: Quantitative Classification Systems of Rock Mass – Guidelines:
Part 3 Determination of Slope Mass Rating of IS 13365 (Part 3)

Sl No.	Clause/Para/Table / Figure No. Commented	Comments/Modified Wordings	Justification of the Proposed Change	Name of The Commentator
	Fig.1	Titles are illegible	Provide clear and sharp pictures with titles for ease of understanding.	TCE
	Table 1	This is repeat of data in Annex B of IS 13365 Part 1	Repetition may be avoided by providing reference	TCE
	Clause 3.4	Description and values of SMR may be removed from here as it is already presented in Table 4.	Repetition may be avoided by providing reference	TCE

NOTS –
TCE – **MANOS DE**

Indian Standard

APPLICATION OF NUMERICAL MODELLING IN ROCK MECHANICS

1 SCOPE

1.1 A representation of a problem is the formulation of mathematical equations and finding a solution that gives useful results in numerical modeling.

1.1.1 This code specifies the input, output requires to determine the stability of the structures through 1-D, 2-D and 3-D numerical models.

1.1.2 In sub-sequence code details of structure will be available for following structure :-

i) Abutment foundation pile
ii) Retaining wall
iii) Tunnel connection
iv) Shield TBM
v) Dam stability of concrete, earthen, rock fill, composite etc.
vi) Embankment consolidation
vii) Slope stability of natural soil and rock slopes.
viii) Tunnel construction stage
ix) Tunnel lining
x) Moving train load time history
xi) Location and alignment of instruments used in dam
xii) Construction excavations
xiii) Open-pit highwalls
xiv) Tailings dam stability
xv) Dam stability during rapid drawdown
xvi) Slopes with surcharge or seismic loading
xvii) Partially and totally submerged slopes
xviii) Unsaturated slopes subjected to infiltration

2 NUMERICAL METHODS IN ROCK MECHANICS

The basic inputs and outputs for a numerical modelling procedure and its applications to rock mechanics are given as below:

2.1 Numerical Models

Numerical model must accommodate the following:

a) Three dimensions
b) Any excavation shape
c) A variety of material types

A preparation of input data and interpretation of the results thus plays a major role in the use of numerical methods.

2.2 Input Data

The basic input data required for numerical modelling are listed below:

a) The elastic properties of the rock mass
b) The initial in-situ stress state
c) Rock mass strength properties
d) Excavation shape
e) The requisite boundary conditions
f) The location of points in the rock mass where it is necessary to evaluate the stresses and displacements

2.2.1 *Elastic Properties of the Rock Mass*

The numerical model needs the values of the Young's modulus of elasticity, Poisson's ratio, Cohesion, friction angle, dilatory angle, permeability values, model type etc.

a) For non-linear elastic modelling problems, incremental values of the modulus of elasticity are required.
b) For boundary element method, the rock medium is in any case assumed to be linear and elastic.
c) If rock behaviour is time-dependent in nature, this should be included in the equations of numerical model.

In addition, Lithostratigraphic (herein after referred as litho) units are bodies of rocks, bedded or unbedded, that are defined and characterized on the basis of their lithologic properties and their stratigraphic relations. However, if the difference in the properties is small or width of the litho unit negligible in comparison to a major litho unit, a weighted average value can be assumed to reduce the number of material types.

2.2.2 *In-situ State of Stress*

a) In many cases, requisite data is not generally determined in the field. Therefore, simplified assumptions are used regarding the magnitude and direction of the in-situ stresses.
b) The vertical stress and the horizontal stresses are assumed to be directly proportional to the depth below the surface.

2.2.3 *Rock Mass Strength and Failure Criteria*

a) Data of Young's modulus of elasticity, Poisson's ratio, Cohesion, friction angle are easily determined in the laboratory on Intact rock.But, these values used in modeling may lead to erratic results.
b) The rock mass strengths may be considerably lower due to the presence of structural features such as, joints, shears and faults, etc.
c) Rock mass strength is determinedthrough large-scale field-testing, field evaluation or the application of the correction factors based onrock characterization to the intact rock strength.
d) Discrete element method requires information aboutthe nature and orientation of joints, shears and faults forthe development of moving wedges.The failure criteria define the relationship between the normal stress and the shear stress atfailure.
e) In many of the numerical methods, the rock can be defined as a no tension material isassumed to have failed if the element is under tension. In case of shear failure, the modulus of therock may change. The failure criterion is ofimportance in those methods where the evaluation isincremental and the model behaviour is affected in the next

iteration due to the failure of someelements. In other cases, the model will show the nature of failure expected at critical location.

2.2.4 *Excavation Shapes*

- Excavations are irregular in shape. For the purpose of modelling, the general shape of the excavation rather than the minor detail is of significance. Simplifying the assumptions about the shape can result in an easier and faster computation.

2.2.5 *Boundary Conditions*

- Numerical modelling is essentially the solution of a boundary value problem; the selection of the requisite boundary conditions is an important part of the modelling process. Boundary conditions can be either stresses or displacements or both.

2.2.6 *Location of the Field Points*

- The formulation should yield results, which are relevant to the problem being modelled and at points, which can be verified through field observations and/ or measurements. The simplest measurement in the field is the measurement closure to the study area and this can be easily related to the output from numerical modeling.

3.0 OUTPUT DATA

The output information is in the form of stresses and displacements at various points in the problem regime, as desired by the user. This information is used initially to determine the validity of the model by cross checking the results with field observations and instrumentation readings. The parameters of the model can be adjusted in such a way that the field observations are reflected in the model.

4.0 SENSITIVITY OF THE MODEL

The numerical modelling methods are useful mostly for qualitative analysis of field problems and attempts to relate the results to numerical values of strengths and instrument readings can be misleading.The purpose of such techniques is not to replace engineering judgment but to assist it in the evaluation of several options in the face of various influencing parameters. It is especially true as the input data used for the analysis are but idealisations of the actual field conditions.

5.0 TESTS

A) Laboratory tests

a) Determination of unit weight of rock sample as per IS: 13030
b) Determination of specific gravity of rock sample as per IS: 13030
c) Conducting Unconfined Compressive Strength test as per IS: 9143-1979
   i) with saturation
   ii) without saturation
d) Determination of modulus of elasticity and poison's ratio of rock material in uniaxial compression test including stress strain curves etc. complete as per IS: 9221.
e) Determination of triaxial compressive strength of rock core with internal pressure up to 80 kg per sq cm on a set of 3 samples with 3 different confining pressures as per IS: 13047, as per Technical specifications and as directed by the Engineer.
   i) With saturation
   ii) Without saturation
f) Determination of water absorption and porosity as per IS: 13030

g) Determination of Point load strength of rock core as per IS: 8764
h) Determination of Brazillian tensile strength of rock core as per IS: 10082-1981
I) Determination of laboratory shear strength IS: 12634-1989
J) E-dynamic (PUNDIT test) to check the quality of rocks.

B) Field test (for finding In-situ parameters)

a) Evaluation of properties for rock mass (tunneling) / concrete dam /stone masonry dam / brick masonry by using Flat Jack Method (Non-Destructive test) IS: 13948-1994
b) In-situ shear test of rock as per IS: 7746- 1991

6.0 STEPS FOR DESIGNING STRUCTURES

a) **Modelling Geometry**
This process makes line/face solid by extruding from geometries of lower dimension: point /edge/face. With lines which constitute a closed domain, it is possible to directly make a solid. Generate solid for 3D soil, base slab and embankment; create faces to classify each stratum.

b) **Define property**
Set the material for the ground property. Set type of structure and cross-section shape for the structure property.
Example:- soil – weathering soil, rock – weathered rock, soft rock, embankment, abutment and Pile – tip bearing capacity, tip spring stiffness.

c) **Define material of ground and structure**
Fix type of model, material properties like elastic modulus, Poisson's ratio, unit weight, cohesion and frictional angle.

d) **Generate Mesh**
Mesh shape an mesh quality are very important in finite element analysis. Generally speaking, small mesh size makes good mesh shape. However small mesh sizes will also extend analysis time. So it is recommended to determine the mesh size considering both accuracy and efficiency of the analysis.

e) **Setting load condition**
1) Self-weight:- Gravity applied on the model is calculated automatically by the multiplication of the ground and structure unit weight with the acceleration of the gravity.
2) Load/pressure:- Apply a surface load at the top of the embankment and water pressure according to direction of surface acting.

f) **Setting boundary condition**
Constraint:- In this step, we will see how to set boundary condition to constraint displacements and rotations of the model in the global coordinate system.

g) **Setting boundary condition**
Set the type of analysis, using the data to be considered during analysis along with output options.

1) Nodal results:- displacement, applied load, reaction force and grid point force
2) Elements results:- force, stress, strain and stress.
And then perform analysis

h) **Results**

The main result items which need to be checked are as follows:-

1) The horizontal displacement in the structure.
2) The difference of the displacement in the structure
3) The member force of base slab and pile foundation.
4) The surrounding friction and relative displacement in the structure