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-33 **29 मई 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(25744)WC	**शैल संहति का मात्रात्मक वर्गीकरण तंत्र — दिशानिर्देश सिद्धांत भाग 3 ढलान संहति रेटिंग का निर्धारण का भारतीय मानक मसौदा** [IS 13365 (भाग 3) 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 : **30 जून 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 ।

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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-33 **29 May 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(25744)WC	**Draft Indian Standard** **Quantitative Classification Systems of Rock Mass – Guidelines** **Part 3 Determination of Slope Mass Rating** [*First Revision* of IS 13365 (Part 3)] 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**: 30 June 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(25744)WC

Title: Draft Indian Standard Quantitative Classification Systems of Rock Mass – Guidelines
Part 3 Determination of Slope Mass Rating
[*First Revision* of IS 13365 (Part 3)] ICS 93.020

LAST DATE OF COMMENT: **30 June 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

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Draft Indian Standard

QUANTITATIVE CLASSIFICATION SYSTEMS OF ROCK MASS – GUIDELINES PART 3 DETERMINATION OF SLOPE MASS RATING

[*First Revision* of IS 13365 (Part 3)]
ICS 93.020

Rock Mechanics	Last date of Comments
Sectional Committee, CED 48	**30 June 2024**

FOREWORD

(*Formal clauses will be added later*)

Quantitative classification of rock masses has many advantages. It provides a basis for understanding characteristics of different groups. It also provides a common basis for communication besides yielding quantitative data for designs for feasibility studies of project. This is the reason why quantitative classifications have become very popular all over the world.

This standard (Part 3) covers the procedures for obtaining the value of slope mass rating (SMR) for preliminary assessment of the stability of rock slopes. The approach is based on modification of RMR system using adjustment factors related to discontinuity orientation with reference to slope as well as failure mode and slope excavation methods. Slope mass rating (SMR) is a measure of degree of stability of rock slopes. The determination of slope mass rating is very easy and yet reliable. This method is recommended for landslide hazard zonation for feasibility studies in the hilly areas where rock is exposed.

Slope mass rating takes into account orientation of joints, seepage forces, fracture spacing, degree of weathering and method of excavation. It also considers mode of failures; for example, planar slide, wedge slide and toppling failure. Detailed study of rock slopes is needed, if SMR is found to be less than 60 or slope appears to be in distress.

This standard has been published in four parts. The other parts in the series are:

Part 1 Rock Mass Rating (RMR), for predicting Engineering properties
Part 2 Rock Mass Quality for Prediction of Support Pressure, Support System and Engineering Properties in Underground Openings
Part 4 Geological Strength Index (GSI)

This standard (Part 3) was first published in 1997. This revision of the standard has been brought out based on the experience gained in use of the standard since its last revision. In this revision, the following major modifications have been mode:

a) Slope height of cut slope angle has been clarified,

b) Ambiguity in the formula for estimation of slope mass rating has been remove,
c) Improved table has been introduced for the adjustments rating for joints,
d) Notation, symbol and their explanation has been improved as per the current practices, and
e) Reference of various Indian standard 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 of 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

QUANTITATIVE CLASSIFICATION SYSTEMS OF ROCK MASS – GUIDELINES PART 3 DETERMINATION OF SLOPE MASS RATING

(First Revision)

1 SCOPE

1.1 This standard (Part 3) covers the procedures for obtaining the value of slope mass rating (SMR) for preliminary assessment of the stability of rock slopes. The approach is based on modification of RMR system using adjustment factors related to discontinuity orientation with reference to slope as well as failure mode and slope excavation methods.

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 editions indicated were 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 8764 : 1998	Method of determination of point-load strength index of rocks (*first revision*)
IS 11315	Method for quantitative description of discontinuities in rock mass:
(Part 1) : 2023	Orientation (*first revision*)
(Part 2) : 2023	Spacing (*first revision*)
(Part 4) : 2023	Roughness (*first revision*)
(Part 8) : 2023	Seepage (*first revision*)
(Part 11) : 2023	Core recovery and rock quality designation (*first revision*)
IS 13365 (Part 1) : 1998	Quantitative classification systems of rock mass – Guidelines: Part 1 Rock mass rating (RMR) for predicting engineering properties

3 PROCEDURE

3.1 Estimation of Rock Mass Rating (RMR_{basic})

The geomechanical properties of rock mass shall be evaluated by RMR system. The RMR_{basic} shall be determined by adding the rating values for the following five parameters as given in Table 1. The procedure has been elaborated in detail in IS 13365 (Part 1).

a) Uniaxial compressive strength of intact material (*see* IS 8764),
b) Spacing of discontinuities (*see* IS 11315 (Part 2)],
c) Condition of discontinuities (*see* IS 11315 (Part 4)],
d) Ground water conditions (*see* IS 11315 (Part 8)], and
e) Rock quality designation (RQD) (*see* IS 11315 (Part 11)].

3.2 Determination of Failure Modes in Rock Slopes

The slope failures in rock mass are governed by geological discontinuities and movement occurs along surfaces formed by one or several sets of geological discontinuities. Basic modes of failures are given in IS 11315 (Part 1) and summarised below.

3.2.1 *Plane Failure (Plain Wedge Slide)*

Plane failure takes place along continuous joints dipping towards the slope or valley with strike nearly parallel to the slope face [Fig. 1(a)]. The instability conditions occur if critical joint dips less than slope, and the mobilised shear strength along the joint is not enough for stability.

3.2.2 *Wedge Failure (3D Wedge Slide)*

Wedge failure takes place along two geological discontinuities of different sets, whose line of inter-section is towards the slope or valley, but the plunge is less than the inclination of the slope [Fig. 1(b)]. It is generally more frequent than the planar slides.

It may be noted that plane failure is a special case of wedge failure.

Table 1 RMR_{basic} Rating
(*Clause* 3.1)

Sl No.	Parameter	Ranges of Values							
i)	Strength of intact rock	Point load Strength Index	> 10 MPa	4 to 10 MPa	2 to 4 MPa	1 to 2 MPa	< 1 MPa for this low range, uniaxial compressive test is preferred		
		Uniaxial Compressive Strength	> 250 MPa	100 to 250 MPa	50 to 100 MPa	25 to 50 MPa	5-25 MPa	1-5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
ii)	Drill core quality	RQD	90 to 100 percent	75 to 90 percent	50 to 75 percent	25 to 50 percent	< 25 percent		
	Rating		20	17	13	8	3		
iii)	Spacing of discontinuities		> 2 m	0.6 to 2 m	200 to 600 mm	60 to 200 mm	< 60 mm		
	Rating		20	15	10	8	5		
iv)	Condition of discontinuities		Very rough surfaces; Not continuous No separation Unweathered wall rock	Slightly rough Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge 5 mm thick or Separation 1-5 mm Continuous	Soft gouge > 5 mm or Separation > 5 mm continuous		
	Rating		30	25	20	10	0		
v)	Ground water condition		Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		

3.2.3 *Toppling Failure*

Toppling failure takes place along a continuous set of joints which dips against the slope, and with strike nearly parallel to slope face [Fig. 1(c)]. Joints are generally weathered in these cases. In practice, two kinds of instability can happen, that is, minor toppling near the surface of slope, and deep toppling, which can produce large deformations. In both the cases the failures develop slowly, and are not prone to sudden rock falls.

3.2.4 *Collection of Field Data*

The determination of failure modes in rock slopes shall be done on the basis of graphical analysis of the geological discontinuities observed on the slope. Depending upon the structural complexity of the area, 100 to 500 readings of the geological discontinuities shall be taken, the poles shall be plotted in an equal area stereonet and contoured to get the maximas of pole concentrations. The failure modes can be identified from the pattern of maximas of pole concentrations [Fig.1 (a), (b) and (c)].

3.3 Determination of Adjustment Rating for Rock Slopes

The adjustment rating for joints in rock slopes is a product of the following three factors:

a) F_1 depends on parallelism between the slope dip and the discontinuity dip direction;
b) F_2 depends on the dip of discontinuity; and
c) F_3 depends on the relationship of dips of discontinuity and slope.

NOTES

1 Discontinuity refers to the planar discontinuity or the line of intersection of two planar discontinuities whichever is important from the point of view of instability of rock slopes.
2 The effect of ground water on the SMR has been considered indirectly by $\mathrm{RMR_{basic}}$
3 The SMR shall not be applicable where length of joints along dip direction is less than 5 percent of affected slope height.

Table 2 gives rating for F_1, F_2 and F_3. The notations are as follows:

a_s = dip direction or inclination direction of the slope face;
β_s = dip or inclination of slope face;
a_j = dip direction of discontinuity in the case of planar slide;
= plunge or dip-direction of line of intersection of the unstable wedge;
β_j = dip of discontinuity in the case of planar slide;
P = planar failure or wedge failure; and
T = toppling failure.

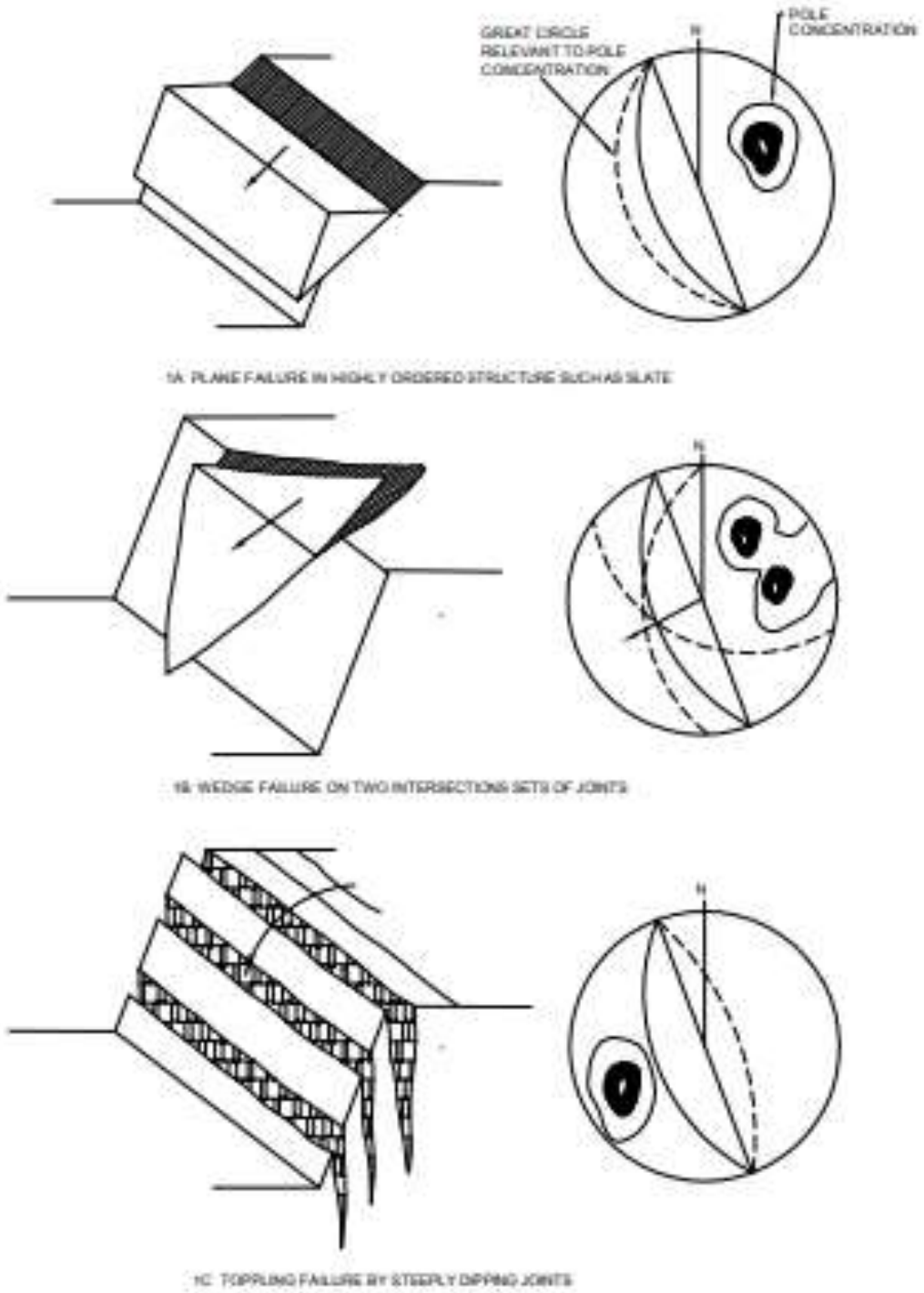

FIG. 1 REPRESENTATION OF STRUCTURAL DATA CONCERNING THREE POSSIBLE SLOPE FAILURE MODES IN ROCKS BASED ON STEREONET PLOITING.

Table 2 Adjustments Rating for Joints
(*Clauses* 3.3, 3.6, *and Note* 3)

Case	Adjustment Factors	Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
P	$[a_j - a_s]$	> 30°	30° to 20°	20° to 10°	10° to 5°	< 5°
T	$[a_j - a_s - 180°]$					
P or T	F_1	0.15	0.40	0.70	0.85	1.00
P or T	$[\beta_j]$	< 20°	20° to 30°	30° to 35°	35° to 45°	> 45°
P	F_2	0.15	0.40	0.70	0.85	1.00
T	F_2	1	1	1	1	1
P	$\beta_j - \beta_s$	> 10°	10° to 0°	0°	0°- (-10°)	< - 10°
T	$\beta_j + \beta_s$	< 110°	110° to 120°	> 120°	–	–
P or T	F_3	0	- 6	- 25	- 50	- 60

P = plane failure; T = topping failure; a_s = slope dip direction; a_j = joint dip direction; β_j = dip of joint; β_s= dip of slope.

The adjustment rating F_4 for slope in a natural condition or excavated by pre-splitting blasting, smooth blasting, mechanical or poor excavation methods is given in Table 3.

Table 3 Adjustments Rating for Methods of Excavation of Slopes
(*Clause* 3.3)

Method	**Natural Slope**	**Presplitting**	**Smooth Blasting**	**Blasting or Mechanical**	**Deficient Blasting**
F_4	+ 15	+ 10	+ 8	0	- 8
$\text{SMR} = \text{RMR}_{\text{basic}} + (F_1 \times F_2 \times F_3) + F_4$					

3.4 Estimation of Slope Mass Rating

The product of F_1, F_2 and F_3 shall be added to $\text{RMR}_{\text{basic}}$ rating and add F_4 to obtain slope mass rating (SMR).

Slope mass rating $\text{SMR} = \text{RMR}_{\text{basic}} + (F_1 \times F_2 \times F_3) + F_4$

On the basis of the values of slope mass rating, the stability of rock slopes should be classified as fully stable (81 to 100), stable (61 to 80), partially stable (41 to 60), unstable (21 to 40) and very unstable (< 20) as given in Table 4.

3.5 Remedial Measures

Accordingly the very unstable cut slope may require re-excavation, unstable slope may need extensive corrective measures, partially stable slopes may have to be supported with systematic supports such as rock bolts, and rock anchors and stable to fully stable slopes may need occasional to no supports.

3.6 Cut Slope Angle (Slope Height < 20 m)

Safe cut slope angle can be determined from Table 2 by varying slope angle β_s till SMR of cut slope is more than 60. In weaker rocks cut slope angle may be taken equal to or less than

apparent dip/dip of discontinuity in planar slide or dip of line of intersection of unstable wedges wherever excavation is feasible.

Table 4 Tentative Description of SMR Classes
(*Clause* 3.4)

Class No	**V**	**IV**	**III**	**II**	**I**
SMR	0 to 20	21 to 40	41 to 60	61 to 80	81 to 100
Description	Very bad	Bad	Normal	Good	Very Good
Stability	Completely unstable	Unstable	Partially stable	Stable	Completely stable
Probable Type of Failure	Big planar or rotational	Planar or big wedge	Planar or many wedges	Blocks	None
Support	Re-excavation	Important corrective measures	Systematic supports	Occasional supports	None