Rock mass classification and rock mass slope failures along Bang Pa-In to Nakhon Ratchasima intercity motorway (M6) Project, Thailand

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Abstract. This research intends to use the Rock Mass Rating (RMR) and the Slope Mass Rating (SMR) systems to evaluate the rock mass classes of the road cut slope in the construction of the Bang Pa-In-Nakhon Ratchasima intercity motorway (M6) project, sections 19, 20, and 21. The study area consists of a mountain and plain landform with limestone, sandstone interbedded with shale, and structural control. Drill and blast techniques were utilized to excavate and develop the slope face as well. Kinematic analysis was also used to classify potential slope failure and estimate the adjustment factors. The result found that three sections of the study area have the potential failures of the wedge, toppling, and planar. In section 19, the SMR class is normal to good and stable to a partial stable of slope that is a failure with toppling and wedge on the right and wedge on the left side. Section 20 is normal and partially slope stable, with three types of failure on the left side, but a wedge and toppling on the right side. Section 21 is a good class, and the slope is stable, but slightly wedged and toppling failure on some blocks on the right side and only wedged on the left site as indicated.

1. Introduction
The construction of the Bang Pa-In to Nakhon Ratchasima intercity motorway (M6) Project is one of the important projects that is urgently needed. It reaches around 196 kilometers in total. Contribute to the development of road transportation and logistics systems, as well as the reduction of traffic congestion on Phaholyothin and Mittrapaph Road. In addition to linking northeastern transportation to Laem Chabang Port, the northeastern region's tourism will be encouraged. There are two phases to the building. The first phase consists of six traffic lanes covering 103 kilometers, starting in Bang Pa-in district in Phra Nakhon Si Ayutthaya province and ending in Pak Chong district in Nakhon Ratchasima province. The second phase is a 93-kilometer expressway with four traffic lanes that reaches from Pak Chong district to Nakhon Ratchasima. Most of the construction styles are on the ground level, but it has an overpass style in the valley area [1]. The research area is in the first phase in Muak Lek district, Saraburi province, and is on a ground construction road, as shown in figure 1. The research location is a mountainous terrain and plain with limestone, chert, sandstone, and shale, as well as folding structural rock control. Therefore, drill and blast techniques were used to excavate and develop the road cut slope. As a result, three sections, 19, 20, and 21, with both sides of the road slope were chosen for evaluation. The stability of rock slopes is considered important for public safety on roadways that pass-through rock cuts, as well as for the safety of personnel and equipment in open-pit
mines. Many factors impact slope instability and failures, including unstable slope geometries, geological discontinuities, weak or weathered slope materials, and natural disasters. Slope stability problems have attracted the attention of researchers. Consequently, different methods and techniques for assessing slope stability have been suggested. Rock mass classification systems or empirical methods are important tools that are commonly used as means of the engineering behaviors of rock masses. This study aims to assess the rock rating and suggest a reasonable method for slope support or stabilization. As a result, the Rock Mass Rating (RMR) system and the slope mass rating (SMR) system of road cut slopes were proposed to determine the rock masses, which could be useful for assessing slope stability of road cut slopes in the study area. Kinematic analysis was also used to classify the potential slope failure.

![Figure 1. Study area.](image)

2. Classification systems for rock slopes

Many rock mass classification methods are often used for a variety of purposes, including evaluating the strength and deformability of rock masses, assessing the stability of rock slopes, tunneling and underground mining activities, and so forth. In this paper, two rock mass classification methods are chosen. The rock mass rating (RMR) system and the slope mass rating (SMR) system is commonly used for rock mass slope classification. Furthermore, the RMR value is also used to calculate the SMR. The results of the rock mass are as follows:

2.1. Rock mass rating (RMR)

Bieniawski [2], who established the system to evaluate the quality of rock masses for underground constructions, proposed a rock mass rating (RMR) system in 1973. The RMR system is made up of six main characteristics that include different rock conditions, discontinuities, and orientation of discontinuities. These parameters are: (1) Uniaxial compressive strength (UCS) of intact rock, (2) Rock Quality Designation (RQD), (3) spacing between discontinuities, (4) condition of discontinuities,
(5) groundwater, and (6) orientation of discontinuities (table 1). Five parameters are referred to as "the RMR<sub>b</sub>"<sup>2</sup>, and the value of it is between 0 and 100 [3]. The description of parameters and ratings as tabulated in table 1. An additional guideline for the classification of discontinuity condition was presented by Bieniawski [4] that is shown in Table 2. The orientation of discontinuities refers to the strike and dip of discontinuities that influence the direction of the tunnel drive, slope face orientation, or foundation alignment [5]. The value of discontinuities orientation is defined qualitatively as instead of quantitatively. Then, Bieniawski [2],[6] proposed a correction factor to evaluate the influence of discontinuity orientation on stability conditions for tunnel and dam foundations that is shown in Table 3. Moreover, He also suggested using the slope mass rating method (SMR) proposed by Romana [7] when considering the effect of discontinuity orientation on the slope stability of a rock slope. Finally, the summation of RMR<sub>b</sub> and orientations of discontinuity adjustment are called the “RMR<sub>f</sub>” that can be classified into five classes as shown in Table 4.

### Table 1. RMR classification parameters.

| Parameter | Ranges of values |
|-----------|------------------|
| 1. Strength of intact rock mineral | >10 | 4-10 | 2-4 | 1-2 |
| 2. Drill core quality RQD | >250 | 100-250 | 50-100 | 25-50 |
| 3. Spacing of discontinuities | >2 m | 0.6-2 m | 200-600 mm | 60-200 mm |
| 4. Condition of discontinuities (See Table 2) | 20 | 15 | 10 | 8 | 5 |
| 5. Groundwater | None | <10 | 10-25 | 25-125 | >125 |

### Table 2. Guidelines for classification of discontinuity conditions.

| Parameter | Ranges of values |
|-----------|------------------|
| 1. Discontinuity length (persistence) | <1 m | 1-3 m | 3-10 m | 10-20 m | >20 m |
| 2. Separation (aperture) | None | <0.1 mm | 0.1-1.0 mm | 1-5 mm | >5 mm |
| 3. Roughness | Very rough | Rough | Slightly rough | Smooth | Slickensides |
| 4. Infilling (gouge) | None | Hard filling <5 mm | Hard filling >5 mm | Soft filling <5 mm | Soft filling >5 mm |
| 5. Weathering | Unweathered | Slightly weathered | Moderately | Highly weathered | Decomposed |
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mode. in This (table the factors 0 -60. two of F 0 -2 rating the classification two of slope, joint is an adjustment factor that depends on the excavation method, as expressed in the following equation:

$$SMR = RMR_{basic} + (F_1 \cdot F_2 \cdot F_3) + F_4$$

(1)

Where RMR_{basic} is evaluated according to Bieniawski [3,4] by adding the five parameters. F_1, F_2, and F_3 are an adjustment factors related to joint orientation with respect to slope, and F_4 is an adjustment factor that depends on the excavation methods.

F_1 is an adjustment factor, which depends on the parallelism between the joint strike or the plunge direction of the intersection line of two planes and the slope face strike. It ranges from 0.15 to 1.0.

F_2 refers to joint dip angle in the planar failure or the plunge of the line of intersection of two planes in the wedge-type failure mode. Its value also varies from 0.15 to 1.0.

F_3 refers to the relationship between the slope face dip and the joint dip or the plunge of the intersection line of two planes. It ranges from 0 to -60. The adjustment factors for F_1, F_2, and F_3 are tabulated in table 5. F_4 is an adjustment factor that depends on the excavation method used in this project, which is either normal blasting or mechanical blasting, so the value of F_4 is none. The ranges of SMR values are 0 to 100. This range has been divided into five classes based on its stability (table 6). The suggested support to stability slope may only try to clarify the standard approaches for each type of support [5], as shown in table 7.

Table 3. Adjustment for joint orientation.

| Joint orientation assessment for | Very favorable | Favorable | Fair | Unfavorable | Very unfavorable |
|---------------------------------|---------------|----------|------|-------------|-----------------|
| Tunnels                         | 0             | -2       | -5   | -10         | -12             |
| Foundation                      | 0             | -2       | -7   | -15         | -25             |
| Slopes*                         | 0             | -5       | -25  | -50         | -60             |

* it is recommended to use slope mass rating (SMR).

Table 4. Classification of rock mass.

| Rating     | Class no. | Description |
|------------|-----------|-------------|
| 100-81     | I         | Very good   |
| 80-61      | II        | Good        |
| 41-60      | III       | Fair        |
| 40-21      | IV        | Poor        |
| <20        | V         | Very poor   |

2.2. Slope mass rating (SMR)

Romana [7] proposed a classification system called the "slope mass rating" (SMR) system. Later it was slightly modified by Anbalagan et al. [8] to incorporate wedge failure along with plane and topple failures. The SMR system is obtained from the RMR system, where adjustment parameters that represent the joint-slope relationship are added to the basic RMR that factor is depending on the excavation method, as expressed in the following equation:

$$SMR = RMR_{basic} + (F_1 \cdot F_2 \cdot F_3) + F_4$$

Where RMR_{basic} is evaluated according to Bieniawski [3,4] by adding the five parameters. F_1, F_2, and F_3 are an adjustment factors related to joint orientation with respect to slope, and F_4 is an adjustment factor that depends on the excavation methods.

F_1 is an adjustment factor, which depends on the parallelism between the joint strike or the plunge direction of the intersection line of two planes and the slope face strike. It ranges from 0.15 to 1.0.

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Table 5. Adjustment factors for F_1, F_2, and F_3.

| Case of slope failure | Very favorable | Favorable | Fair | Unfavorable | Very unfavorable |
|-----------------------|---------------|-----------|------|-------------|-----------------|
| \( P \) \[\alpha - \alpha_s \] | \( >30^\circ \) | 30-20'    | 20-10' | 10-5'       | <5              |
| \( T \) \[\alpha - \alpha_x - 180^\circ \] | \( \beta \) | \( <20^\circ \) | 20-30' | 30-35' | 35-45' | >45' |
| \( W \) \[\beta - \beta_s \] | \( F_1 \) | 0.15 | 0.40 | 0.70 | 0.85 | 1.00 |
| \( P/W/T \) \( F_2 \) | \( \beta \) | \( F_2 \) | 1.00 | 1.00 | 1.00 | 1.00 |
| \( P/W \beta \) | \( F_3 \) | 0.15 | 0.40 | 0.70 | 0.85 | 1.00 |
| \( T \) \( F_2 \) | \( \beta \) | \( >10^\circ \) | 10-0' | 0' | 0(-10') | <10' |
Where α is slope strike, α1 is joint strike, α2 is plunge direction of line of intersection, β4 is slope dip, βj is joint dip, and βi is plunge of line of intersection.

**Table 6. SMR classes and various stability of slope.**

| Class | SMR | Description   | Stability          |
|-------|-----|---------------|--------------------|
| I     | 81-100 | Very good     | Completely stable  |
| II    | 61-80  | Good          | Stable             |
| III   | 41-60  | Normal        | Partially stable   |
| IV    | 21-40  | Bad           | Unstable           |
| V     | 0-20   | Very bad      | Completely unstable|

**Table 7. Suggested supports for various SMR classes.**

| SMR classes | SMR values | Suggested supports                                      |
|-------------|------------|--------------------------------------------------------|
| Ia          | 91-100     | None                                                   |
| Ib          | 81-90      | None, scaling is required                              |
| IIA         | 71-80      | (None, toe ditch, or fence), spot bolting              |
| IIb         | 61-70      | (Toe ditch or fence nets), spot or systematic bolting  |
| IIIa        | 51-60      | (Toe ditch and/or nets), spot or systematic bolting,   |
|             |            | spot shotcrete                                         |
| IIIb        | 41-50      | (Toe ditch and/or nets), systematic bolting/anchors,  |
|             |            | systematic shotcrete, toe wall and/or dental concrete  |
| IVa         | 31-40      | Anchors, systematic shotcrete, toe wall and/or concrete |
|             |            | (or re-excavation), drainage                           |
| IVb         | 21-30      | Systematic reinforced shotcrete, toe wall and/or       |
|             |            | concrete, re-excavation, deep drainage                  |
| Va          | 11-20      | Gravity or anchored wall, re-excavation                |

2.3. Kinematic analysis

Kinematic refers to the motion of bodies without reference to the forces that cause slope to move. The kinematic analysis can be performed using the stereographic projection technique, which is a simplified method for discontinuity data collection and presentation. Dip and dip direction of all discontinuity are requested to perform this method, wish to analyse the potential of rock slope failure for using the cases of that in SMR classification. This research determined the structural control and the potential of slope failure by using DIPS 8.0 software. Dips is a well-known stereographic projection software for analyzing and presenting orientation-based data. In this multi-purpose tool, users may determine joint sets, perform kinematic analysis of slope stability, as well as more [9]. The display setting and application of that are depicted in figure 2.

3. Field studies and evaluation of data

Field data were collected from 3 sections of road cut slopes that are section 19, 20, and 21 along Bang Pa-In to Nakhon Ratchasima intercity motorway (M6) project. Each section of the road cut slope was collected field data by two sides are on the left-hand and the right-hand. The field study of section 19 is located between kilometres markers 77+600 and 77+800, that are four stations on the left and five stations on the right. Section 20 is located between kilometres markers 78+400 and 78+800, that is three stations on the left and five on the right. Section 21 is located between kilometres markers 85+400 and 85+600, that are two stations on the left and right sides, respectively. The data includes slope angle, rock type, joint orientation, joint set number, joint spacing, joint condition, joint roughness, joint alteration, rock mass structure and hydrological condition.
Point load strength index was applied to evaluate the compressive strength of intact rock. The number of joints per cubic meter was determined to estimate the RQD following Palmström [10] equation, in which RQD is estimated from the number of joints per unit volume, as expressed in the following equation.

\[ RQD = 110 - 2.5J_s \]  \hspace{1cm} (2)

where \( J_s \) is the total number of joints per m³.

Section 19 and 20 are slightly weathered dark grey sandstone interbedded with highly weathered shale. On the left-hand and right-hand sides of section 19, they show one direction that is dip and dip direction of bedding plane with two joint sets. The spacing between them is approximately 5 to 30 centimeters. Indeed, the joint's aperture is 2 to 10 millimeters on the left-hand side and 2 to 5 millimeters on the right-hand side. It is rough to rough planar and filled with soft and hard material of fewer than 5 mm. Similarly, section 20 has one direction of bedding plane on both sides. However, there are three joint sets on the left side and one joint set on the right. The distance between joints is 8 to 25 centimeters, and the persistence is 0.5 to 3.5 metres. The opening is 2 to 80 millimeters wide and filled with soft material less than 5 millimeters thick. They discovered the thickness of the soil layer at the crest of slope in this section. Section 21 is a slightly metamorphosed dark grey limestone with one bedding plane in one direction and two joint sets on both sides. In summary, the joint spacing ranges from 10 to 20 centimeters, with some reaching more than 300 centimeters. However, the joint surface is smooth and the persistence ranges from 0.2 to 2.5 meters. The joint openings are 2 to 10 millimeters in size, and they are filled with hard and soft material that is less than 5 millimeters thick. Certainly, the field observation found that the groundwater condition of all sections was completely dry. All of field data were collected to determine RMR and SMR of these slopes as tabulated in table 8 to 9. The orientation of joint or bedding plan and the figure of each section is depicted in figure 3.

The potential failure of the slope was analysed by using DIPS 8.0 software as shown in figure 4. Although the failures were found in the major plane of discontinuity, they are failures at the minor or some blocks too. As a result, the major wedge failure was found on the left side, but on the right side was found the major toppling failure and some block or discontinuity failure in the wedge of section 19. In section 20, the planar and wedge failures were found on the major plan of the left side, and it has one joint that makes the slope fail with toppling. Conversely, on the right side was found wedge and toppling failure, but it occurs in some of the joints. The wedge and toppling failures were discovered in section 21. However, it takes place in different joints, not on the major plane. On the right side, there are two types, while on the left, there is only wedge failure. Consequently, the adjustment parameters, \( F_1 \), \( F_2 \), and \( F_3 \), were evaluated and added to equation (1) for calculating SMR.
Figure 2. The display of DIPS 8.0 software.

Table 8. Data from field studies.

| Section | Slope height | Slope face | Station | Bedding or joint sets Dip (°) / dip direction (°) | RQD (%) | Point load strength index (MPa) |
|---------|--------------|------------|---------|-----------------------------------------------|---------|----------------------------------|
| 19      | 10           | 80/360     | L1      | 29/208                                        | 83/308  | 80/74                           |
|         |              |            | L2      | 29/215                                        | 68/310  | 80/82                           |
|         |              |            | L3      | 29/209                                        | 81/77   | 84/317                          |
|         |              |            | L4      | 29/207                                        | 86/70   | 69/312                          |
|         |              |            | Major joint sets | 28/210 | 76/310 | 81/75 | 91.50 | 1.04 |
| 15      | 80/270       |            | R1      | 28/213                                        | 77/308  | 67/72                           |
|         |              |            | R2      | 31/220                                        | 66/312  | 80/82                           |
|         |              |            | R3      | 31/214                                        | 81/307  | 80/80                           |
|         |              |            | R4      | 32/215                                        | 84/74   | 78/312                          |
|         |              |            | R5      | 32/213                                        | 80/79   | 85/305                          |
|         |              |            | Major joint sets | 31/214 | 79/76 | 78/309 | 93.85 | 1.10 |
| 20      | 10           | 80/180     | L1      | 40/208                                        | 83/110  | 70/250                          |
|         |              |            | L2      | 36/212                                        | 78/105  | 81/288                          |
|         |              |            | L3      | 38/209                                        | 82/109  | 72/248                          |
|         |              |            | Major joint sets | 82/110 | 40/209 | 85/163 | 70/247 | 89.50 | 1.01 |
| 12      | 80/360       |            | R1      | 78/304                                        | 26/211  | 72/248                          |
|         |              |            | R2      | 26/204                                        | 80/296  | 82/316                          |
|         |              |            | R3      | 78/310                                        | 40/190  | 84/210                          |
|         |              |            | R4      | 81/218                                        | 69/305  | 30/169                          |
|         |              |            | R5      | 28/169                                        | 80/280  |                                    |
|         |              |            | Major joint sets | 28/199 | 77/302 | 88.55 | 1.01 |
| 21      | 10           | 80/180     | L1      | 42/201                                        | 62/84   | 52/48                           |
|         |              |            | L2      | 40/203                                        | 40/86   | 51/320                          |
|         |              |            | Major joint sets | 39/203 | 51/88 | 43/331 | 97.84 | 1.39 |
| 9       | 80/270       |            | R1      | 83/241                                        | 40/204  | 71/54                           |
|         |              |            | R2      | 39/204                                        | 40/86   | 71/54                           |
|         |              |            | Major joint sets | 40/202 | 82/234 | 55/48 | 96.90 | 1.18 |

Table 9. Description of joint and joint condition from field observation.
| Section | Station | Spacing (cm) | Persistence (m) | Aperture (mm) | Joint condition |
|---------|---------|--------------|----------------|--------------|----------------|
| 19      | L1      | 10-25        | 0.5-2.5        | 2-10         | Rough to smoot, Hard filling < 5 mm, slightly weathered |
|         | L2      | 10-28        | 0.2-2.5        | 2-10         | Rough to smoot, hard filling < 5 mm, slightly weathered |
|         | L3      | 10-30        | 0.5-2.5        | 2-10         | Rough to smoot, hard filling < 5 mm, slightly weathered |
|         | L4      | 5-20         | 1.0-2.5        | 2-5          | Rough, Hard filling < 5 mm, slightly weathered |
|         | R1      | 5-25         | 0.3-2.5        | 2-3          | Smooth Undulating, soft filling < 5 mm, slightly weathered |
|         | R2      | 10-25        | 0.2-2.5        | 2-4          | Rough, soft filling < 5 mm slightly weathered |
|         | R3      | 5-25         | 0.2-2.5        | 2-5          | Rough planar, soft filling < 5 mm slightly weathered |
|         | R4      | 10-20        | 0.5-2.5        | 2-5          | Rough planar, soft filling < 5 mm slightly weathered |
|         | R5      | 5-15         | 0.5-2.5        | 2-5          | Rough planar, soft filling < 5 mm slightly weathered |
| 20      | L1      | 8-25         | 0.5-2.5        | 10-80        | Rough to smoot, hard and soft filling < 5 mm, slightly weathered |
|         | L2      | 10-25        | 0.5-3.5        | 2-40         | Rough to smoot, soft filling < 5 mm, slightly weathered |
|         | L3      | 12-16        | 0.5-2.0        | 2-5          | Smoot, soft filling < 5 mm, slightly weathered |
|         | R1      | 5-35         | 0.15-2.5       | 2-4          | Smoot, soft filling < 5 mm, slightly weathered |
|         | R2      | 10-25        | 0.5-3.0        | 1-7          | Smoot, soft filling < 5 mm, slightly weathered |
|         | R3      | 10-25        | 0.2-2.5        | 1-8          | Rough to smoot, soft filling < 5 mm, slightly weathered |
|         | R4      | 12-15        | 0.5-2.0        | 2-3          | Smoot, soft filling < 5 mm, slightly weathered |
|         | R5      | 10-25        | 0.5-2.0        | 1-5          | Smoot, soft filling < 5 mm, slightly weathered |
| 21      | L1      | 10-20        | 0.2-2.0        | 2-30         | Smoot, hard and soft filling < 5 mm, slightly weathered |
|         | L2      | 15-20        | 1.0-2.0        | 2-5          | Smoot, hard and soft filling < 5 mm, slightly weathered |
|         | R1      | 15-20        | 0.2-2.5        | 2-10         | Smoot, hard and soft filling < 5 mm, slightly weathered |
|         | R2      | 15-20        | 0.2-2.5        | 2-10         | Smoot, hard and soft filling < 5 mm, slightly weathered |
Figure 3. The sections of rock mass slope (a) section 19L, (b) section 19R, (c) section 20L, and (d) section 20R, (e) section 21L, and (f) section 21R.
Figure 4. Potential of the slope failure.
4. Results and Discussions

The results of rock mass classification are RMR, SMR, and the potential of the road cut slope failure from data evaluation were determined from table 1-3 and table 5-6, respectively. The RMR$_{final}$ adjusted the orientation of the slope after determination of the SMR. Of course, kinematic analysis of potential slope failure and excavation methods were considered. The excavation method of this project was normal blasting or mechanical excavation, so the value of the adjustment factor ($F_a$) is zero. Sections 19, 20, and 21 have RMR classifications of fair-good, fair, and good, respectively. The joint orientation adjustment for the right-hand side of section 20 is fair, while other parts are quite favorable. Furthermore, sections 19, 20, and 21 have SMR that are good-normal, normal, and good, respectively. As a result, the slope evaluated from SMR is stable-partially stable, partially stable, and stable, in either arrangement. The summary of rock mass classification is shown in table 10. The suggested support for various SMR and the suggested guidelines for excavation and support of rock tunnels in accordance with the RMR [4], [11] is also considered. The suggested support from table 2 is class IIb which is toe ditch or fence nets, spot or systematic bolting, and class IIIa is toe ditch and/or nets, spot or systematic bolting, and spot shotcrete. Meanwhile, RMR for rock tunnels recommended benching 1.5 to 3 meters and systematic bolts 4 meters long, spaced 1.5 to 2 meters, shotcrete 10 millimeters, as well as good rock class bolts 3 meters long, spaced 2.5 meters. As a result, the researchers propose categorizing the support into three zones: A, B, and C. Zone A consists of SRM classes II to III that are planar mostly along joints and many wedges or blocks. A benching slope with a width of 1.5 to 3 meters and a systematic bolt with a length of 4 meters and a spacing of 1.5 to 2 meters. Horizontal drainage is not required. Shotcrete with a thickness of 5 to 30 centimeters, on the other hand, should have been utilized. Because the rock is slightly weathered. Zone B is a minor zone in which RMR and SMR are not shown in the results. Because it is a slightly to highly weathered rock zone, it should be constructed immediately after the blasting operation. Zone B should also have a benching slope with a width of 0.5 to 1.5 meters and a systematic bolt with a length of 5 to 6 meters and a spacing of 1 to 1.5 meters. Furthermore, horizontal drainage with 0.75 meters spacing is required, and shotcrete with a thickness of 15 to 20 centimeters should have been applied. Zone C is a highly weathered rock zone on the crest of a slope that is suggested for excavating by mechanical technique or shotcrete with a thickness of 15 to 20 centimeters and horizontal drainage with 0.5 meters spacing is required. Figure 5 shows the cross-section of the slope and zoning of rock mass classification.

| Section | Side | RMR$_{final}$ | SMR | Class | Description          | Stability              |
|---------|------|---------------|-----|-------|----------------------|------------------------|
| 19      | Left | 60-64         | 60-64 | II-III | Good-normal          | Stable-Partially stable|
|         | Right| 57-60         | 57-60 | III    | Normal               | Partially stable       |
| 20      | Left | 59-60         | 59-60 | III    | Normal               | Partially stable       |
|         | Right| 56-57         | 53-54 | III    | Normal               | Partially stable       |
| 21      | Left | 64-65         | 64-65 | II     | Good                 | Stable                 |
|         | Right| 62-66         | 62-66 | II     | Good                 | Stable                 |
Figure 5. The cross-section of road cut slope.
5. Conclusions
The present study focuses on the engineering geological characteristics of rock mass discontinuities of road cut slopes in the construction of the Bang Pa-In-Nakhon Ratchasima intercity motorway (M6) project for rock mass classification and slope stability assessment. Two rock mass classification systems, Rock Mass Rating (RMR) and the Slope Mass Rating (SMR) systems, were comprehensively evaluated for rock mass characterization as kinematic as analysis for determine the potential of failure and adjustment the factor for SMR classification. RMR and SMR values were obtained from three sections, namely sections 19, 20, and 21. Both sides of these collected data from the field that was opened by the blasting method. The following conclusions can be drawn from this study. SMR values range between class II and class III, normal to good. The concern for slope failure was found in sections 19 and 20 that were partially stable, and stable. Not only wedge but also toppling failure were performed in section 19 on the right side, but three types of failure were performed in section 20 on both sides. In contrast, section 21 is a good class and stable. Moreover, all sections were performed with minor failure from some block or joint. The suggestions for stabilization of the slope are benching, installing of the systematic rock bolt and the horizontal drain, as well as shotcrete technique.

6. References
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