USER MANUAL

Release 1.1.2

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6th April 2023

Abstract

GeotekPPU is a mobile application (Android app) designed to assist geotechnical engineers in calculating Rock Mass Rating (RMR) and Slope Mass Rating (SMR) and other simple geotechnical analysis.

The user must specify all the necessary data such as strength of intact rock material (along with the corresponding the measurement method used, i.e point loads strength or uniaxial compressive strength), drill core Rock Quality Designation (RQD), spacing, discontinuity length, separation, roughness, infilling or gouge, rock weathering, and rock water condition to get the Rock Mass Rating (RMR) value.

GeotekPPU offers several functions to calculate RMR based on RMR classification methods such as RMR89 (ZT Bieniawski, 1989), RMR basic (Celada et al., 2014), RMR14 (Celada et al., 2014), RMR HLW (Tong et al., 2022) and RMR Sen-Bahaeldin (Şen & Bahaaeldin, 2003). Along with that it also offers function to calculate SMR based on (Romana et al., 2015).

GeotekPPU written in JavaScript and uses geotekppu-js package to calculate the classification of RMR and SMR. Besides GeotekPPU and geotekppu-js (https://www.npmjs.com/package/geotekppu-js), we also developed geotekppu, a Python module for simple geotechnical analysis (https://pypi.org/project/geotekppu/).

Content

Chapter
One

Introduction

1.1. Purpose

The purpose of this user manual is to introduce the new user to the Android application GeotekPPU as a simple geotechnical analysis tool, describe all features in this app and provides a step-by-step instructions for calculating rock mass rating (RMR) and slope mass rating (SMR).

The stable release of GeotekPPU is available in Google Play Store (https://play.google.com/store/apps/details?id=com.geotek_mobile).

Apart from GeotekPPU as a mobile app, we also developed a Python module `geotekppu` (https://pypi.org/project/geotekppu/) and an NPM package `geotekppu-js` (https://www.npmjs.com/package/geotekppu-js) which provide API for calculating RMR and SMR programmatically.

1.2. Scope

This manual covers only the instructions on how to use the software after installation and configuration. It does not contains additional information on the usage of `geotekppu` Python module and `geotekppu-js` NPM package.

1.3. Audience

Readers are assumed to be familiar with Android application and how to download and install it from Google Play Store.

Readers alse need to have a general understanding of Rock Mass Rating (RMR) as a classification system which is used to estimate the quality of the rock mass, and Slope Mass Rating (SMR) as a classification system which is used to estimate the quality of slope in the context of excavation, construction, or disaster preparedness.

1.4. Background

Interpretation of the quality of rock mass is one important and early step during a construction phase. A critical understanding about the rock mass classification system and how to put those system in a real field observation are also needed. However, not all field surveyor able to use this classification system to classify the rock mass quality consistently and able to propose a reinforcement strategy correctly.

The core part of GeotekPPU is `geotekppu-js`, which provide application programming interface (API) to classify the rock mass quality based on specific parameters as proposed in several literatures.

A core feature in GeotekPPU is that it can assist geotechnical engineers to classify rock mass quality and slope mass quality easily by providing several paramaters such as strength of intact rock material, drill core Rock Quality Designation (RQD), spacing, discontinuity length, separation, roughness, rock general condition and so on.

GeotekPPU release version 1.1.2 provides save/store feature so that user can create observation table in the database and save the calculation result. After that the user can export the data to a spreadsheet file called `ObservationData.xlsx` in the `/Android/data/com.geotek_mobile/files/Download` folder.

1.5. Restrictions and limitations of GeotekPPU

Although it has several powerful features, GeotekPPU has a number of limitations that any potential user needs to know. They are:

- It is assumed that the user of this app have general understanding about the rock mass classification system and slope mass classification system. The app gives only general guidelines on how to use all features, but does not give an exhaustive description about the detailed concept of RMR and SMR.
- GeotekPPU version 1.1.2 does not use location data from device's GPS, so the user should record the location data separately if they want to include this into their observation data.
- GeotekPPU version 1.1.2 does not have feature to include photo in the observation data.

1.6. Citing GeotekPPU

When citing GeotekPPU cite this manual:

Bibtext entry:

```
@manual{geotekppumanual,
      title={GeotekPPU User Manual},
      author={Daru Jaka Sasangka and Febri Fahmi Hakim},
      organization={Politeknik PU},
      year={2023}
}
```

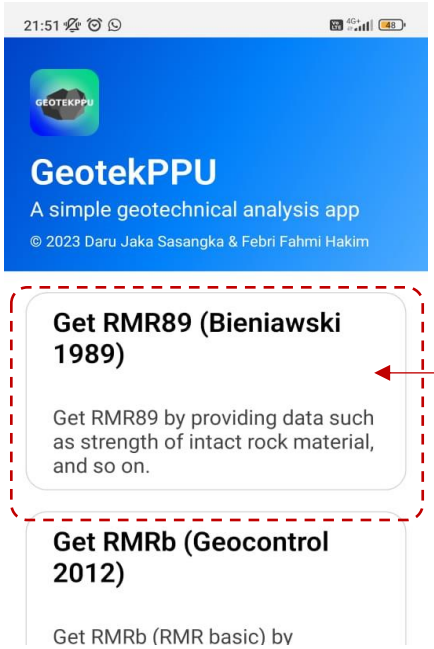
Chapter
Two

Getting Started

This section will gives you general information on how to quickly use GeotekPPU. By reading this chapter, you will be able to quickly set project/table name for storing observation data, using the available functions to calculate each aspects that contribute to the classification of rock mass or slope mass quality, save the result and export the data to a spreadsheet file for further analysis.

2.1. Creating project name/table to store the data

The first thing you will do after opening the GeotekPPU app is to select the RMR method that you will use in your project. Suppose that you will use RMR89 (ZT Bieniawski, 1989) to classify the rock mass quality, then in the Home Screen (the first screen that you will see after opening the app) you will select RMR89 card.



Accessing RMR89 by tapping/press this menu/card

Figure 1. GeotekPPU v1.1.2 Home Screen

You will then taken into the second page which contains all calculation aspects of RMR89.

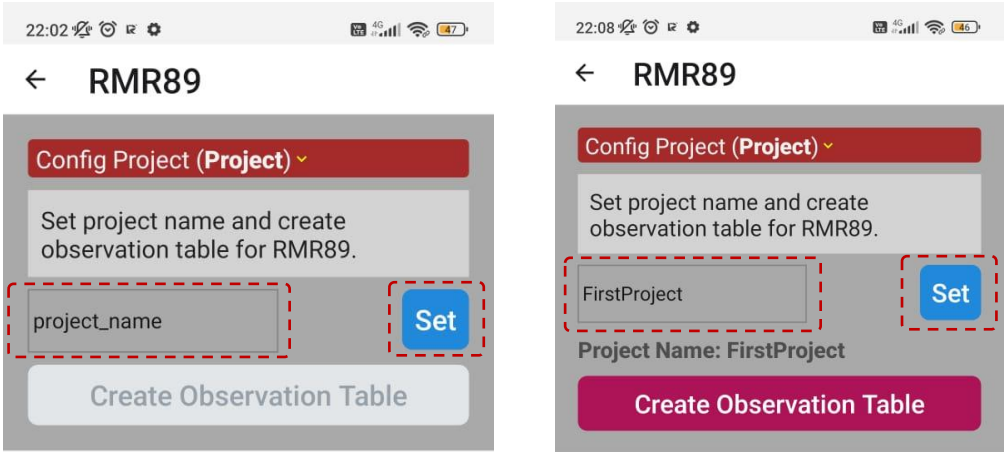


Figure 2. Create project or table name that will hold observation data and calculation result

To avoid problem when reading the data from this table later on, it is best to write the project name without `SPACE`, *i.e*: `my_project`, `MyProject`, `myproject` or something similar. To set this name, press `SET` button. The project name then will be displayed below the input form. To apply this project name and create a table in the database that will hold field observation data and calculation results, press button `CREATE OBSERVATION TABLE`.

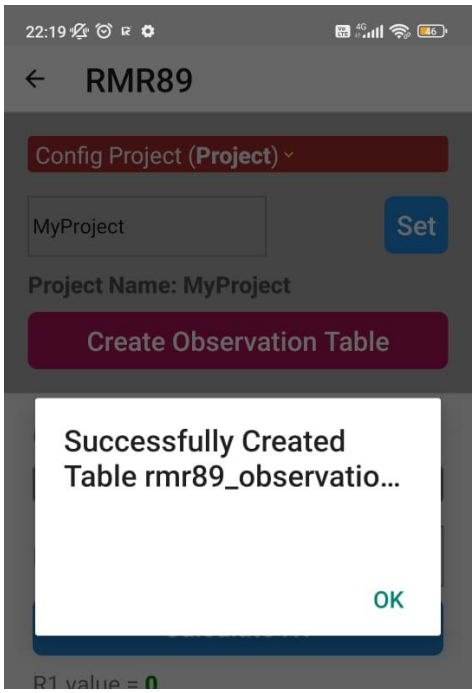
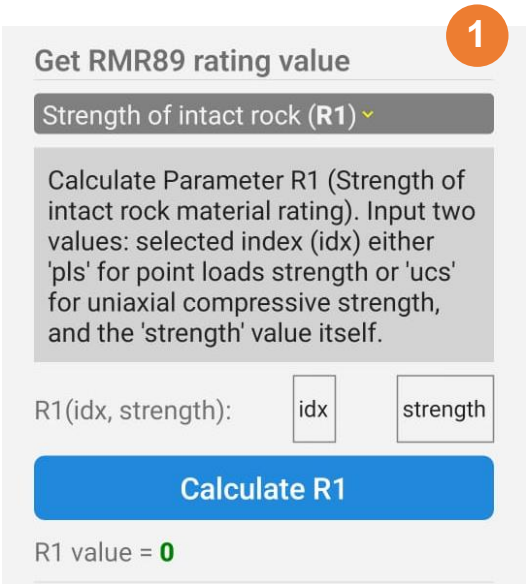
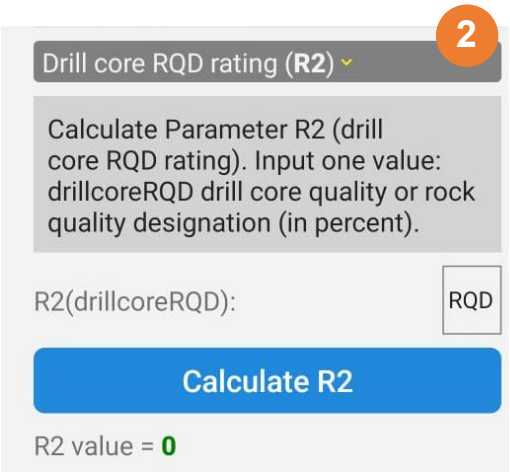


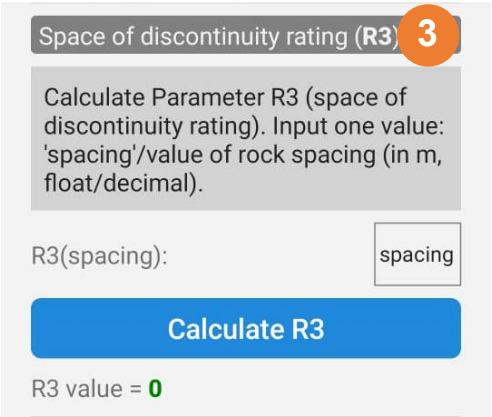
Figure 3. The app will show information if the table was created

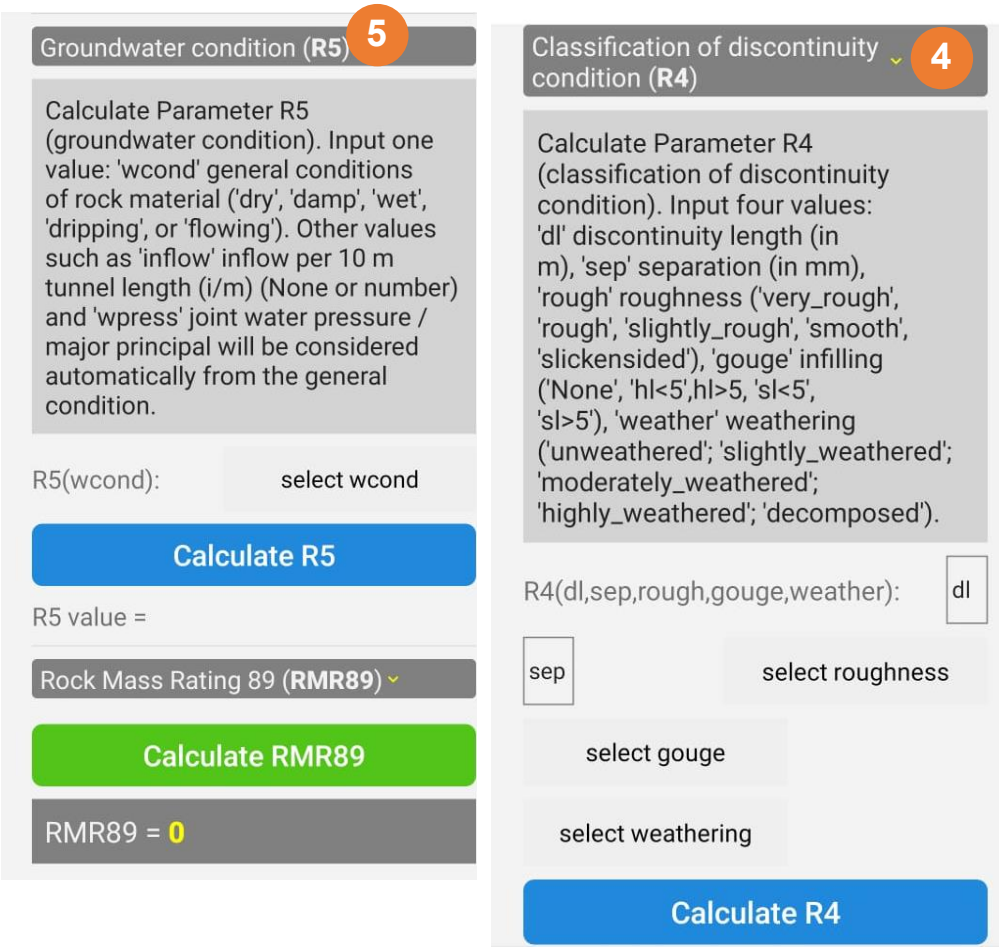
2.2. Calculating Rock Mass Rating (RMR) 89

The next thing you will do is to input several parameters that will help you to calculate the rating for each contributing aspects of RMR89.









To calculate Rock Mass Rating (RMR) 89, do the following:

1. For parameter in R1, when you observe the intact rock material, select the method you will use: point loads (`pls`) or uniaxial compressive strength (`ucs`). Then input the strength indicated either using `pls` or `ucs` method, then press `Calculate R1` button. The R1 rating will be displayed below the button.
2. For parameter R2, input the drill core rock quality designation (`drillcoreRQD`) value in percent, then press `Calculate R2` button. The R2 rating will be displayed below the button.
3. For parameter R3, input the space of discontinuity value or `spacing` of the rock material found in field observation, then press `Calculate R3` button. The R3 rating will be displayed below the button.
4. For parameter R4 or discontinuity condition, input four values: discontinuity length in meter (`dl`), separation in milimeter (`sep`), then select roughness (`rough`) condition from the avaliable options (`very_rough`, `rough`,

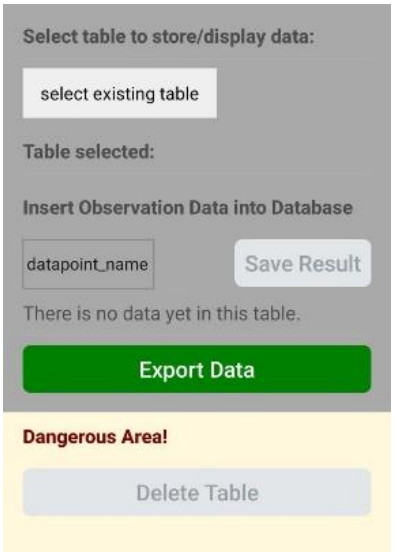
`slightly_rough`, `smooth`, `slickensided`), then select `gouge` condition from the option picker (`None`, `hl<5`, `hl>5`, `sl<5`, `sl>5`) and then input the weathering (`weather`) condition of rock material (`unweathered`, `slightly_weathered`, `moderately_weathered`, `highly_weathered`, `decomposed`). After that press `Calculate R4` button. The R4 rating will be displayed below the button.

5. For parameter R5 or general rock condition considering the water level in the rock material, select `wcond` from the options (`dry`, `damp`, `wet`, `dripping`, or `flowing`). After that press `Calculate R5` button. The R5 rating will be displayed below the button.
6. Last, press Calculate RMR89 button to get the RMR 89 rating value of the rock material being observed.

2.3. Save and export the calculation result

After the calculation finished, you can save your calculation into the table previously created. To save the data, follow these steps:

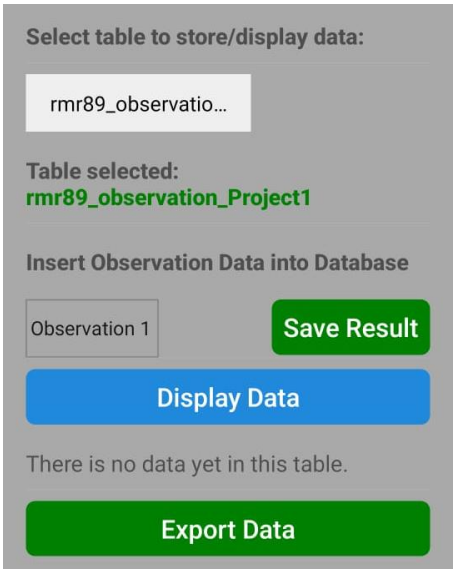
1. Before selecting any table, the user interface should look like this. The menu to save data located directly below the RMR89 calculation result text. It consist of four main smaller sections: a) section to select table to record the data and display the selected table name, b) section to input the `datapoint_name` and save the calculation result/insert the record into table, c) button for exporting the data to spreadsheet file, and d) the section to delete the selected table.



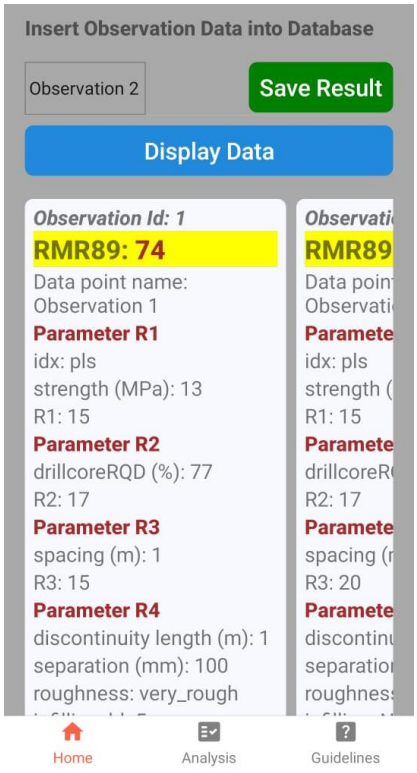
2. First, you need to select the table that you want to save the data to, then the selected table name will appear below the 'Table selected:' text in green color. If the table you want to select is not listed in the option picker, just press back button to the `HomeScreen` and then back to RMR89 screen to continue.

3. Then, input the `datapoint_name` that you want to record to your table. We encourage you to use consistent `datapoint_name` since it will be easier to track after exported to a spreadsheet for further analysis.

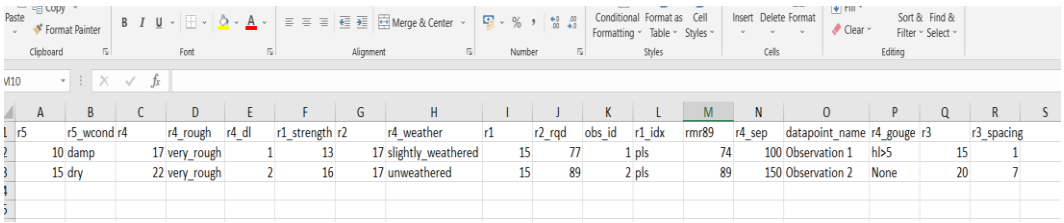
4. The '`Save Result`' button will turn to green after you input the `datapoint_name`, indicating that it is ready to save your data. Press the button once. The app will show alert message informing you that the data successfully saved in the table.



5. To verify that the data is successfully inserted into the table, press `Display Data` button. The app will show all available records save in the table.



6. To export data to a spreadsheet file, press `Export Data` button. The data will be available at `/Android/data/com.geotek_mobile/files/Download/ObservationData.xlsx`. You can use native file browser in your Android phone to browse and inspect the spreadsheet file.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	r5	r5_wcond	r4	r4_rough	r4_dl	r1_strength	r2	r4_weather	r1	r2_rqd	obs_id	r1_idx	rmr89	r4_sep	datapoint_name	r4_gouge	r3	r3_spacing	
2	10	damp	17	very_rough	1	13	17	slightly_weathered	15	77	1	pls	74	100	Observation 1	hl>5	15	1	
3	15	dry	22	very_rough	2	16	17	unweathered	15	89	2	pls	89	150	Observation 2	None	20	7	
4																			
5																			

Figure 4. Sample of data export result

Chapter
Three

Other RMR Classification

This section will gives you general information on the other RMR calculation/classification system. GeotekPPU offers functions to calculate five types of RMR classification, which are: RMR89 (ZT Bieniawski, 1989), RMR basic (Celada et al., 2014), RMR14 (Celada et al., 2014), RMR HLW (Tong et al., 2022) and RMR Sen-Bahaeldin (Şen & Bahaaeldin, 2003).

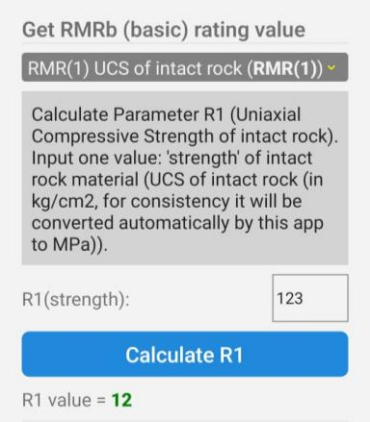
GeotekPPU v1.1.2 not provide functions to create and save observation data of the following RMR method. But we plan to add this feature for later release.

3.1. Calculating RMR Basic

Rock Mass Rating basic is an RMR system proposed by Geocontrol (2012) as cited in (Celada et al., 2014) that process several parameters, which are: rating of Uniaxial Compressive Strength rating of intact rock, rating of RMR RQD and spacing of joints, discontinuity condition as proposed in Bieniawski (1989), and general condition of water in rock mass.

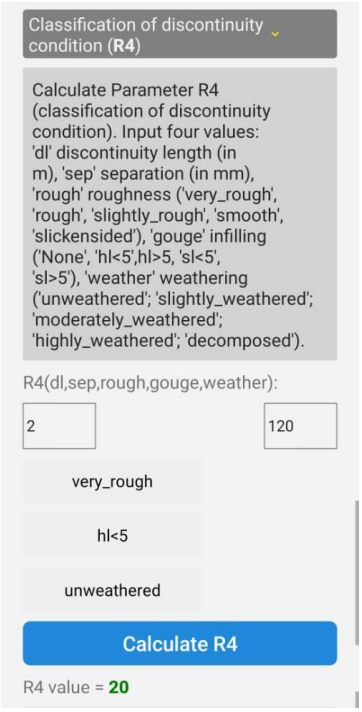
To calculate RMR Basic as proposed by (Celada et al., 2014), please follow these steps:

1. Prepare the intact Uniaxial Compressive Strength (UCS) of intact rock material strength (in kg/cm^2) for consistency it will be converted automatically to MPa by the app. Input the strength value to the text input field, then press `Calculate R1` button. The R1 rating will be displayed below the button.

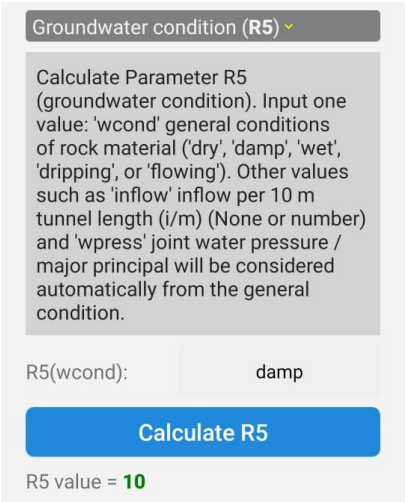


2. In second step, you will calculate R2+3 rating (RQD and spacing of joints). You need to input one value, which is number of `joints` per meter. Press `Calculate R2+3` button. The R2+3 rating will be displayed below the button.

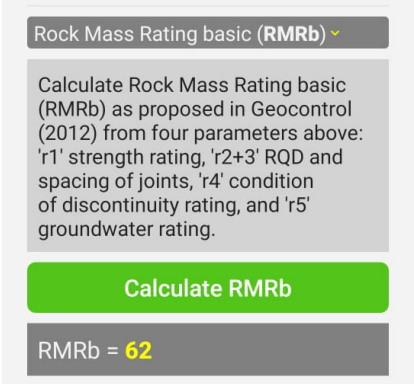
3. In third step, we calculate the rating for discontinuity condition of the rock mass similar with the step in RMR89. Input four values: discontinuity length in meter (`dl`), separation in milimeter (`sep`), then select roughness (`rough`) condition from the avaliable options (`very_rough`, `rough`, `slightly_rough`, `smooth`, `slickensided`), then select `gouge` condition from the option picker (`None`, `hl<5`, `hl>5`, `sl<5`, `sl>5`) and the last input the weathering (`weather`) condition of rock material (`unweathered`, `slightly_weathered`, `moderately_weathered`, `highly_weathered`, `decomposed`). After that press Calculate R4 button. The R4 rating will be displayed below the button.



4. The next step is to calculate the general condition in regard to water content of the rock material. Then select `wcond` from the options (`dry`, `damp`, `wet`, `dripping`, or `flowing`). After that press `Calculate R5` button. The R5 rating will be displayed below the button.



5. Then press Calculate RMR Basic button to get the RMR Basic rating value of the rock material being observed.



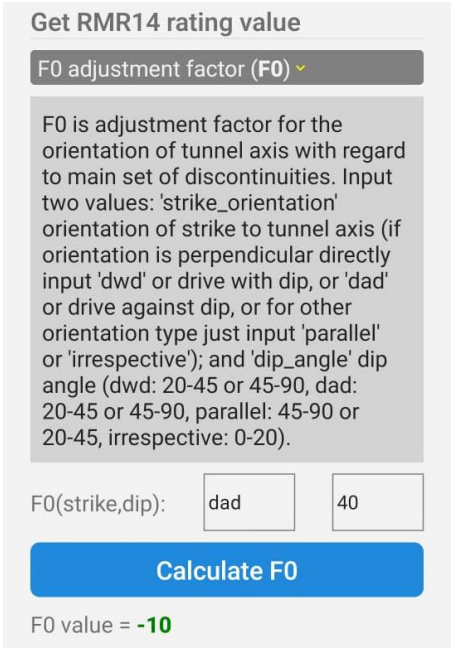
3.2. Calculating RMR 14 (Celada et.al, 2014)

RMR14 is used specifically for calculating the quality of rock mass for a tunnel project.

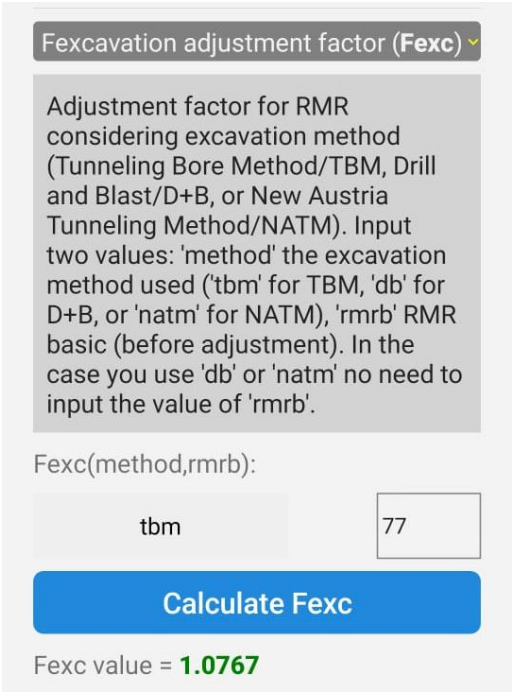
RMR14 proposed by Celada etal (2014) and has three adjusment factors applied, which are: RMRb adjustment factor for tunnel orientation, Fe adjustment factor for excavation, Fs adjustment factor for stress strain. Besides that, you should also provide parameter for calculating "*Índice de Comportamiento Elástico*" (ICE) as it is used to estimate the stress-strain adjustment factor, such as: value of original RMRb rating, uniaxial compressive strength of intact rock (in MPa), ratio of the horizontal to vertical virgin stress, tunnel depth (in meter), and shape coefficient (circular tunnel d = 6 m -> F 1.3 ; circular tunnel d = 10 m -> F 1.0 ; coventional tunnel 14 m wide -> F 0.75 ; caverns 25 m wide x 60 m high -> F 0.55).

To calculate RMR 14, follow these steps:

1. First, calculate `F0`. Factor `F0` is an adjustment factor for the orientation of tunnel axis with regard to main set of discontinuities. We need to input two values: `strike_orientation` of strike to tunnel axis (for perpendicular orientation plese select directly `dwd` or `dad`: '`dwd`' or drive with dip, '`dad`' or drive against dip, otherwise select '`parallel`' or '`irrespective`'), and `dip_angle` (with boundary value for `dwd`: 20-45 or 45-90 degree, `dad`: 20-45 or 45-90 degree, `parallel`: 45-90 or 20-45 degree, `irrespective`: 0-20 degree).

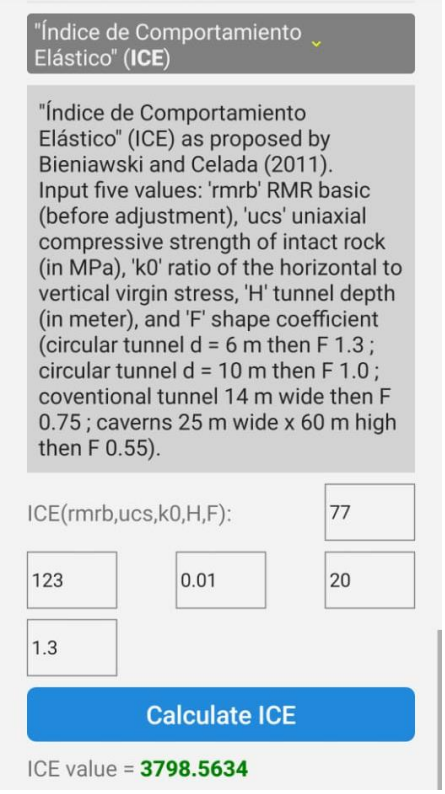


2. Second, estimating Adjusment factor for RMR considering excavation method (Tunneling Bore Method/TBM, Drill and Blast/D+B, or New Austria Tunneling Method/NATM). Input two values: '`method`' excavation method,and '`rmrb`' or RMRb rating value before adjustment. For `db` and `natm` method, no need to input `rmrb` value.

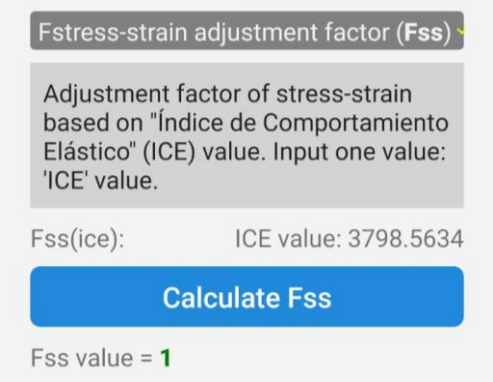


3. The next step is calculating the "*Índice de Comportamiento Elástico*" (ICE) value. Input five parameters: `rmrb` value of original RMRb, `ucs` uniaxial compressive strength of intact rock (in MPa), `k0` ratio of the horizontal to

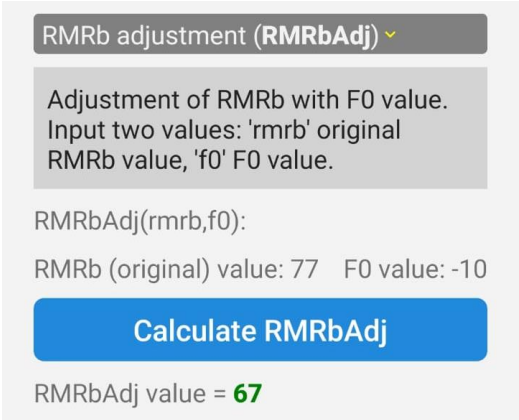
vertical virgin stress, H tunnel depth (in meter), and F shape coefficient (circular tunnel d = 6 m -> F 1.3 ; circular tunnel d = 10 m -> F 1.0 ; coventional tunnel 14 m wide -> F 0.75 ; caverns 25 m wide x 60 m high -> F 0.55).



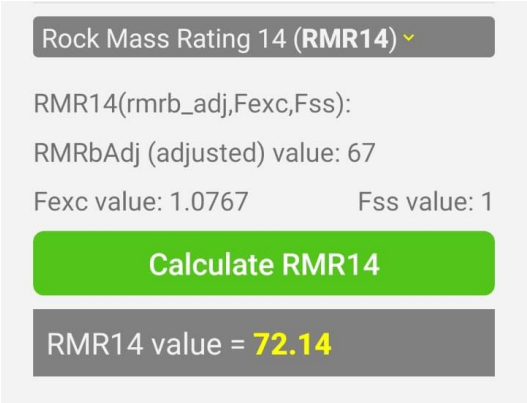
4. The fourth step is calculating stress-strain adjustment factor. You only need to input one value: ICE. Since the value of ICE already calculated in third step, it will be used automatically. Then we can press the `Calculate Fss` button to get the F-stress-strain rating.



5. The next step is calculating RMRb adjustment with F0 value. Input two values: `rmrb` original RMRb value, and `f0` factor F0 value.



6. The last step is calculating Rock Mass Rating (RMR14). To calculate RMR14, we need to supply three parameters: `rmrb_adj` adjusted RMRb value, factor `Fexcv` value and `Fss` value. Press `Calculate RMR14` to get RMR14 rating value.



3.3. Calculating RMR HLW (Tong et.al, 2022)

Rock Mass Rating (RMR) for high-level radioactive waste (HLW) disposal site is a modified rock classification system used to assist authorities to choose appropriate radioactivae waste disposal site as proposed in Tong et.al (2022).

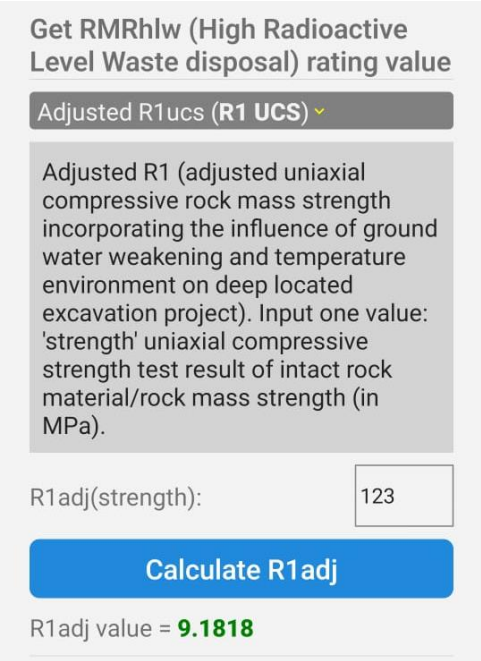
RMR HLW is the aggregate of nine rating aspects, namely:

- `r1` adjusted uniaxial compressive rock mass strength incorporating the influence of ground water weakening and temperature environment on deep located excavation project,
- `r2` adjustment of rock quality designation rating,

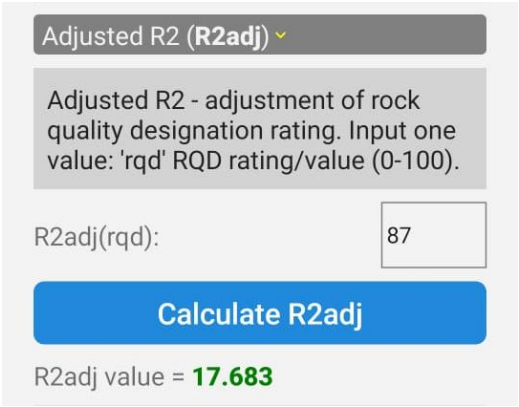
- `r3` adjustment of rating value based on joint spacing,
- `r4` classification of discontinuity condition as in RMR89,
- `r5` groundwater condition as in RMR89,
- `r6` adjustment rating for tunnel, foundation and slope based of favorability,
- `r7` geostress correction/strength-stress ratio index/in-situ stress modification index,
- `r8` Rock Mass Permeability Index,
- `r9` groundwater chemistry index.

To calculate RMR HLW, please follow these steps:

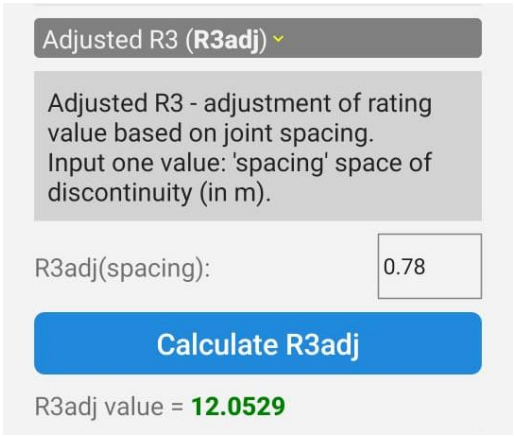
1. First, calculate adjusted R1 uniaxial compressive strength incorporating the influence of groundwater weakening and environment temperature on deep located excavation project. Input one value: `strength` uniaxial compressive strength test result of intact rock material (in MPa).



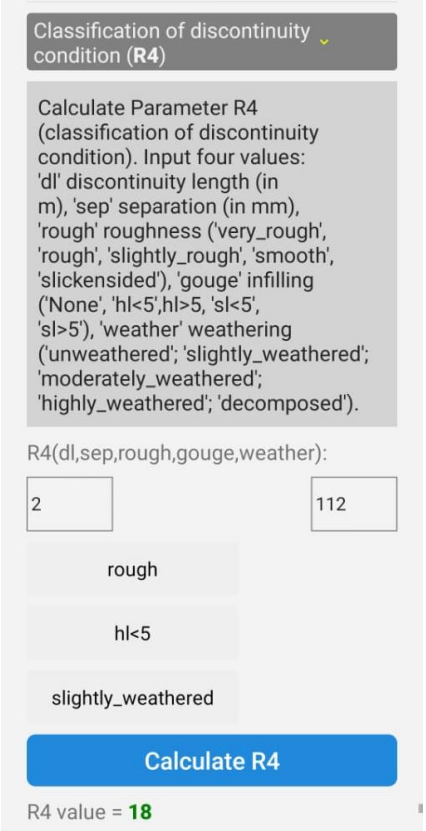
2. Second step, calculate adjusted R2 rating (adjustment of rock quality designation rating). Input one value `rqd` RQD rating/value (0-100).



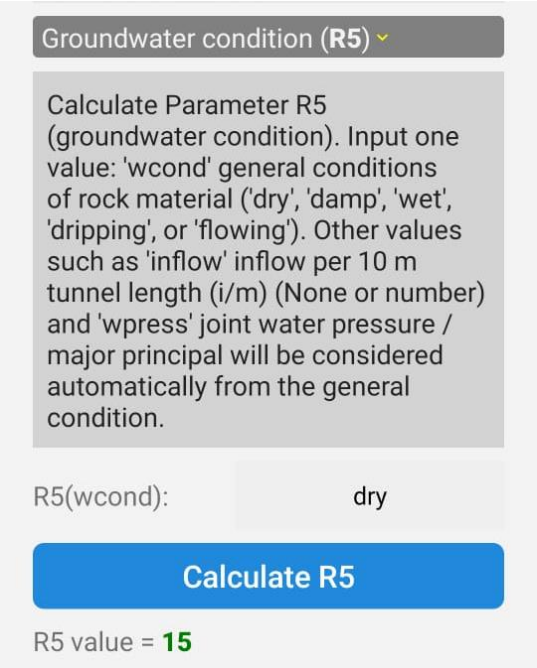
3. Third step, adjusted R3 based on joint spacing. Input one value: `spacing` or space of discontinuity (in meter).



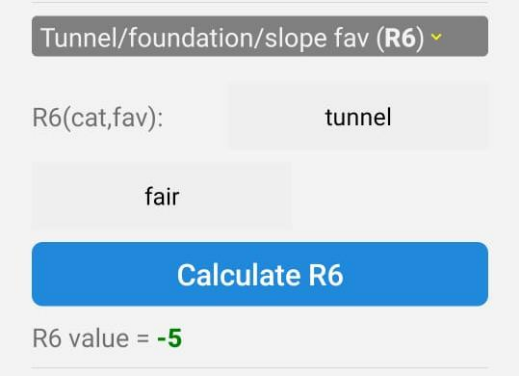
4. Fourth, calculate the rating for discontinuity condition of the rock mass similar with the step in RMR89. Input four values: discontinuity length in meter (`dl`), separation in milimeter (`sep`), then select roughness (`rough`) condition from the avaliable options (`very_rough`, `rough`, `slightly_rough`, `smooth`, `slickensided`), then select `gouge` condition from the option picker (`None`, `hl<5`, `hl>5`, `sl<5`, `sl>5`) and the last input the weathering (`weather`) condition of rock material (`unweathered`, `slightly_weathered`, `moderately_weathered`, `highly_weathered`, `decomposed`). After that press Calculate R4 button. The R4 rating will be displayed below the button.



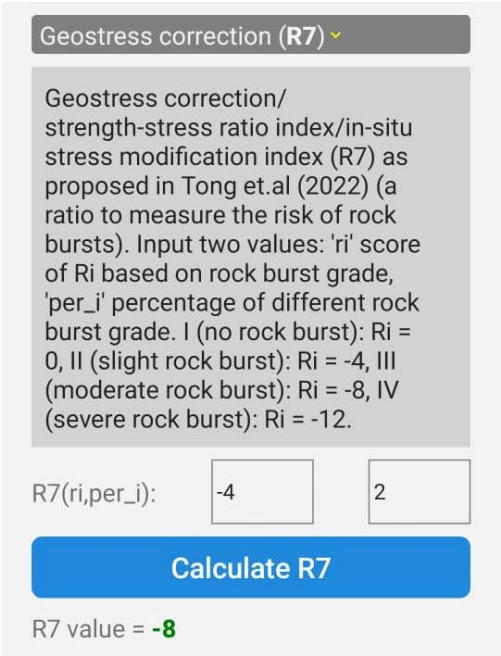
5. Fifth, calculate the general condition in regard to water content of the rock material. Then select `wcond` from the options (`dry`, `damp`, `wet`, `dripping`, or `flowing`). After that press `Calculate R5` button. The R5 rating will be displayed below the button.



6. Sixth, calculate R6 aspect based on tunnel/foundation/slope favorability. Input two values: `cat` or project category (tunnel/foundation/slope) and `fav` or favorability (the option includes `vfav` for very favorable, `fav` for favorable, `fair` for fair, `unfav` for unvaforable, and `vunfav` for very unfavorable).

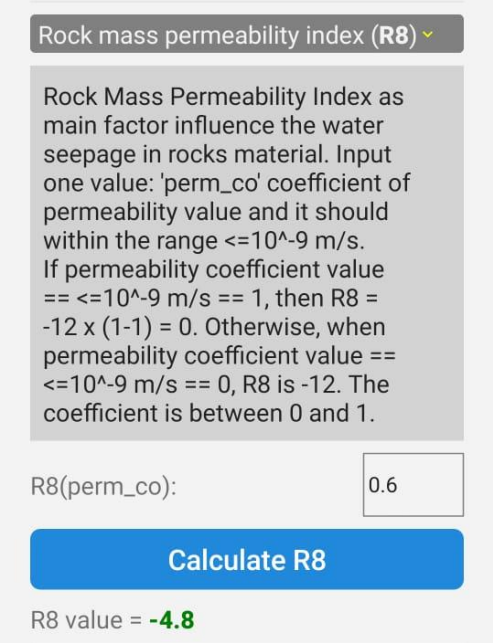


7. Seventh, calculate geostress correction aspect/strength-stress ratio index/in-situ stress modification index (R7) as proposed in Tong et al. (2022) (a ratio to measure the risk of rock burst). Input two values: `ri` score of Ri based on rock burst grade, and `per_i` percentage of different rock burst grade. Where Ri for specific rock burst grade: I (no rock burst) → Ri = 0, II (slight rock burst) → Ri = -4, III (moderate rock burst) → Ri = -8, and IV (severe rock burst) → Ri = -12.

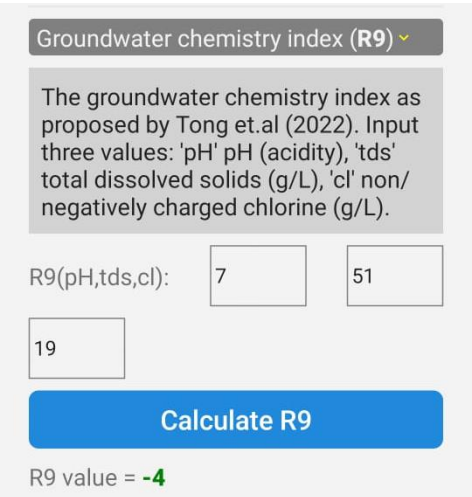


8. Next step is to calculate Rock Mass Permeability Index as main factor that influence the water seepage in rocks material. Input one value: `perm_co` coefficient of permeability value and it should within the range <=10^-9 m/s. If permeability coefficient value == <=10^-9 m/s == 1, then R8 = -12 x (1-1)

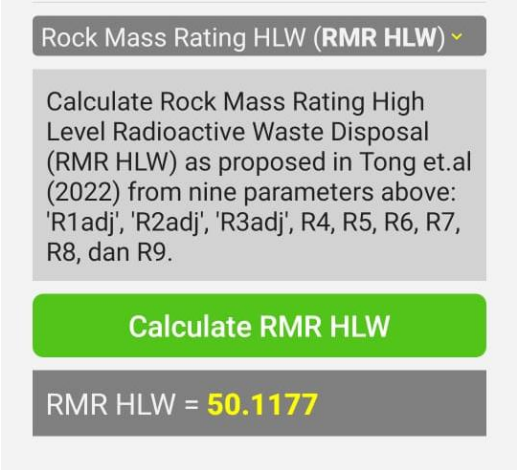
= 0. Otherwise, when permeability coefficient value == <=10^-9 m/s == 0, R8 is -12. The coefficient is between 0 and 1.



9. Then calculate the groundwater chemistry index. Input three values: `pH` pH (acidity), `tds` total dissolved solids (g/L), `cl` non/negatively charged chlorine (g/L).



10. Last, calculate RMR HLW by pressing `Calculate RMR HLW` button.

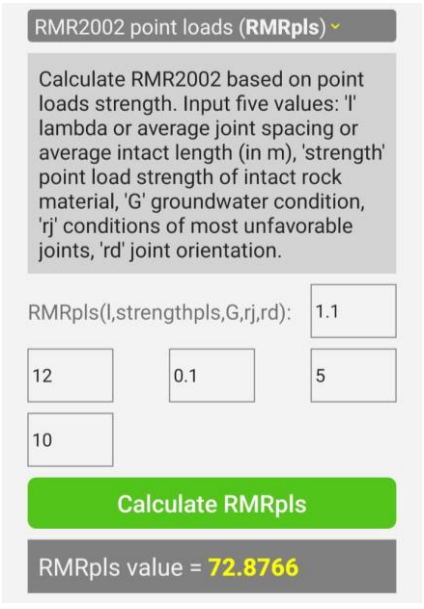


3.4. Calculating RMR Sen-Bahaeldin (Sen & Bahaaeldin, 2003)

RMR 2002 as proposed by Şen & Bahaaeldin (2003) is an improvement of original RMR system by incorporating only five basic parameters: RQD, ucs or point load strength of intact rock material, conditions of most unfavorable joints, groundwater condition, joint orientation.

For calculating RMR Sen-Bahaaeldin, follow these steps:

1. Both for RMR based on point loads strength (pls) or RMR based on uniaxial compressive strength (UCS), input these parameters: '`l`' average joint spacing or average intact length (in meter), '`strength`' point load or ucs strength value, '`G`' groundwater condition, '`rj`' condition of most unfavorable joints, '`rd`' joint orientation.
2. Press Calculate RMRpls or RMRucs button.



Chapter
Four

Calculating Slope Mass Rating (SMR)

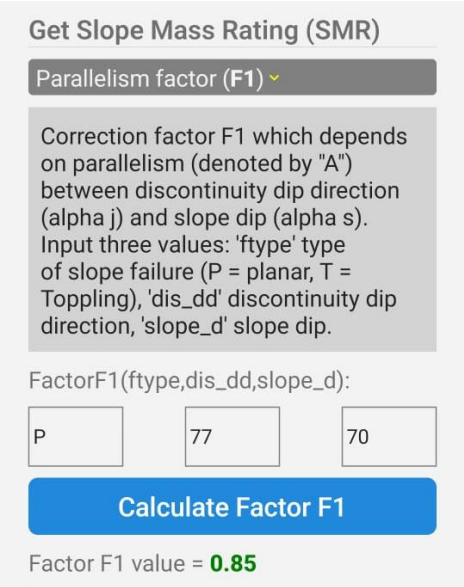
This section will gives you general information on how to perform Slope Mass Rating (SMR) classification/calculation using GeotekPPU.

Similar with RMR system, SMR is a system used to classify the slope mass quality. By classifying SMR the user now which slope treatment suits well for the specific slope in questions.

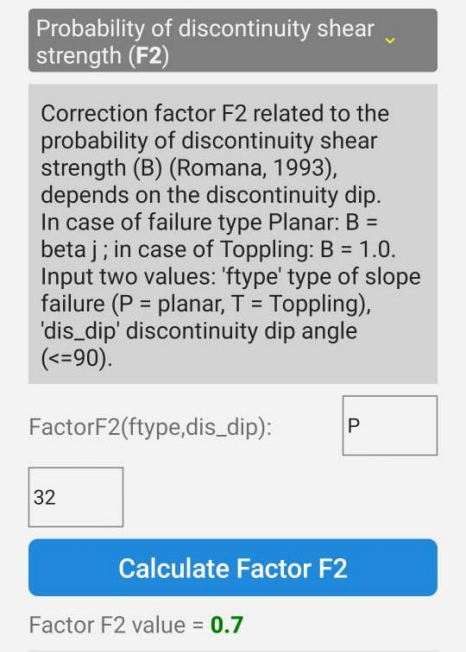
Function to calculate SMR is located in the middle tab menu of GeotekPPU, which titled Analysis. There are four factors that need to be determined to be able to calculate SMR, they are: parallelism factor (F1), probability of discontinuity shear strength (F2), slope and discontinuity dip (F3) and excavation method (F4).

To calculate SMR, follow these steps:

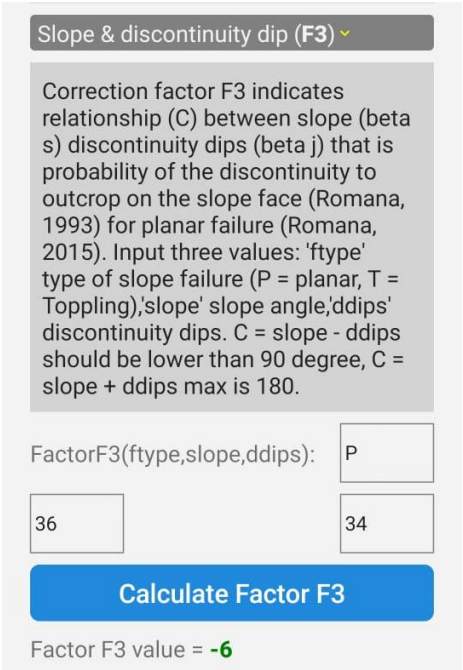
1. First, calculate parallelism (A) factor F1 which depends on paralellism between discontinuity dip direction (`alpha j`) and slope dip (`alpha s`). Input three values: `ftype` type of slope failure (`P` = planar, `T` = toppling), `dis_dd` discontinuity dip direction, and `slope_d` slope dip.



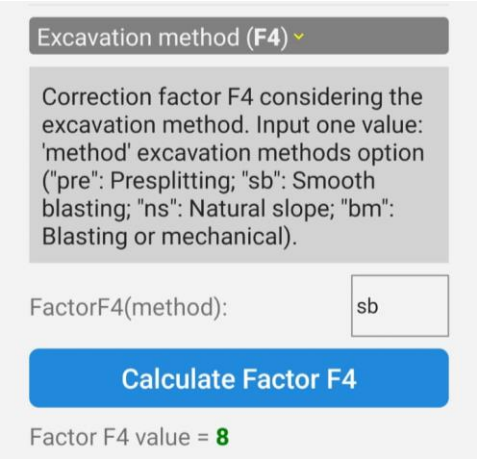
2. Second, calculate probability of discontinuity shear strength (B) factor F2 which depends on the discontinuity dip. In case of ftype Planar: B = beta j; in case of Toppling: B = 1.0. Input two values: `ftype` type of slope failure (`P` = planar, `T` = toppling), `dis_dip` discontinuity dip angle (≤90).



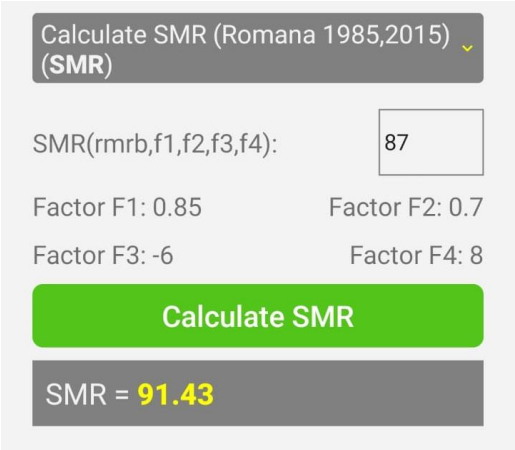
3. Third, calculate correction factor F3 indicates relationship (C) between slope (`beta s`) and discontinuity dips (`beta j`) that is probability of the discontinuity to outcrop on the slope face for planar failure (Romana et al., 2015). Input three values: `ftype` type of slope failure (`P` = planar, `T` = toppling), `slope` slope angle, and ddips discontinuity dips. C = slope – ddips should be < 90 degree. C = slope + ddips maximum 180 degree.



4. Then, calculate correction factor F4 considering the excavation method. Input one value: `method` excavation methods option (`pre`: Presplitting, `sb`: Smooth blasting, `ns`: Natural slope, `bm`: Blasting or mechanical).



5. Last, calculate SMR by pressing `Calculate SMR` button.



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Romana, M., Tomás, R., & Serón, J. (2015). *Slope Mass Rating (SMR) geomechanics classification: thirty years review*.

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ZT Bieniawski. (1989). *Engineering Rock Mass Classification*. John Wiley & Sons, Inc.