

# Fine quality evaluation of surrounding rock of an underground hydropower station

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**Abstract:** Using RMR surrounding rock classification method, the surrounding rock quality of underground main powerhouse of a hydropower station is evaluated with a small evaluation unit. The results of surrounding rock classification show that the surrounding rock of main powerhouse is mainly Grade III, and Grade II and IV surrounding rock develop intermittently with the depth of main powerhouse, and there is no Grade I or V surrounding rock distribution. Secondly, setting a smaller evaluation section is conducive to improve the accuracy of surrounding rock quality evaluation and better grasp the distribution of different grades of surrounding rock in the evaluation area.

## 1 Introduction

The quality of surrounding rock is an important factor affecting the design and construction process of underground engineering, especially water conservancy and hydropower engineering. The quality of surrounding rock directly affects the stability of surrounding rock and the design of excavation and support. It can accurately grasp the surrounding rock quality classification and its distribution in the project area, which plays a favorable role in ensuring the smooth progress of the project and saving the project cost [1-2].

In view of the importance of accurate evaluation of surrounding rock quality for underground engineering, there a lot of researches have been carried out at home and abroad, and many classification systems and methods have been put forward. Due to the complexity and particularity of rock mass itself, the natural characteristics of different rock mass, the suitability for engineering are different, and the suitability for different engineering is different for the same rock mass [3]. Therefore, unlike the early classification method which emphasizes single index or qualitative classification, the existing evaluation methods of surrounding rock quality basically need to refer to several indexes, and combine qualitative and quantitative evaluation to synthesize as many influencing factors as possible, so as to improve the accuracy of surrounding rock quality classification [4-6]. The most representative of these are RMR (1973) classification [7], Q-system classification (1974) [8]; At present, the most commonly used methods in China are national standard BQ method. In addition, various industries have set evaluation criteria for engineering surrounding rock quality close to the industry, such as HC method of domestic water conservancy and

hydropower, classification of railway tunnel surrounding rock, etc., whose purpose is to make the evaluation results of surrounding rock quality more accurate. In order to further improve the accuracy of surrounding rock quality evaluation, many studies have put forward corresponding correction methods in view of the shortcomings of the mainstream evaluation system. Taking the relevant research of RMR method as an example, the RMR method is amended by introducing the earth temperature and groundwater weakening coefficient [9]. The RMR rock mass classification method based on Mamdani fuzzy reasoning [10] and the revised RMR evaluation method [11] which increases the evaluation parameters to 15, etc. According to the above research, the existing research is mainly to improve the surrounding rock evaluation system itself on the one hand, and to upgrade the evaluation system with new theory and technology on the other hand, the purpose of which is to improve the accuracy of surrounding rock quality evaluation.

In order to obtain more accurate surrounding rock quality evaluation results, based on the above understanding of the existing surrounding rock classification system, this article combines a hydropower project example, using the RMR method and preliminary exploration flat tunnel structural surface data to evaluate the surrounding rock quality of the main underground powerhouse. Evaluate in a more refined evaluation unit, and grasp the distribution law of surrounding rock quality in the engineering area, and provide more reliable data support for underground engineering support design.

## 2 General situation and research plan of the project

## 2.1 General situation of the project

The project is located in the Middle-East of Qinghai-Tibet Plateau, with an average elevation of more than 4500m and a peak surface of more than 5000m. The overall geomorphic features are Mountain-Plain basin area in the West and north, alpine and deep valley area in the East and south. The hydropower station is located in the Naqu-Tengchong fold zone in the middle of Gangdisi-Nianqing Tanggula orogenic system (II), close to the front line of Bangong Lake-Dingqing-Nujiang suture zone. Therefore, the geological structure in the area is complicated and the faults are well developed.

The evaluation object of surrounding rock quality is underground powerhouse of a hydropower station, with a length of 221.8m, a width of 24.7m, a height of 57.6m and a maximum depth of over 300m. Surrounding rocks are mainly fresh sandy slate with medium-thin layered structure and well-developed interlaminar compression zones. The rocks are mainly medium-hard rocks. Statistical results of the occurrence of the sandy slate strata show that its strike is NW272°~NW300°, inclination is 60° ~89° and it belongs to medium-steep dipping layered rock mass. The axial direction of powerhouse is initially planned to be NE35° .

## 2.2 Research Program

The RMR method is used for surrounding rock quality evaluation of powerhouse. The RMR classification is widely used all over the world. Scholars and engineers from various countries have applied it to practical engineering and established a set of empirical relationship with rock mass mechanical parameters [12]. The correlation study of several main classification systems of surrounding rocks shows that RMR method has a good correlation with Q-value method and HC method, but HC method and BQ method are conservative compared with RMR classification [13]. RMR classifies rock mass quality by uniaxial compressive strength, rock quality index, spacing between structural planes, structural plane condition, groundwater condition and orientation of structural plane, and finally classifies rock mass quality into 5 grades.

According to the foregoing, the excavation scale of power house is large and the regional structure in the study area is complicated. The rock mass in the study area is affected by faults, interlayer faults, groundwater and other factors, and the rock formation conditions are general. Based on this, in order to truly reflect the quality distribution of the surrounding rocks in powerhouse and improve the accuracy of the surrounding rocks quality evaluation in the powerhouse, 2m is selected for this evaluation unit. Therefore, all evaluation indexes must be obtained according to 2m evaluation section. For the rock strength indexes, because there are too many groups and the rock in weak section of the exploration adit cannot be tested in laboratory, the field rebound test is carried out according to evaluation unit and its strength value is derived from equation (1) [14]. The other

indexes are scored according to the evaluation unit and the results of surrounding rocks are given according to RMR method.

$$R_b = 10^{0.000863\gamma_d R_c + 1.01} \quad (1)$$

In the formula,  $R_b$ -rock strength, Mpa;  $R_c$ -average rock rebound ;  $\gamma_d$ -rock bulk weight, kN/m<sup>3</sup>.

## 3 Quality Classification of Surrounding Rock

### 3.1 Rock strength and RQD results

The average strength of surrounding rocks of exploration Adit in powerhouse area is 99 MPa, which is higher. The variation law of rock strength with the depth of power house is counted, and the results are shown in Fig.1. It can be seen from Fig.1 that the rock strength decreases in a cliff like manner in some tunnel sections. The sudden decrease in strength in some sections is mainly affected by the local fault zone, which leads to serious compression and fragmentation of the rock stratum, and a large decrease in the strength. There are also underground water activities in some tunnel sections, which also degrades the rock strength. The integrity of surrounding rocks is evaluated by *RQD*, which means 77.3% for exploration adit of main powerhouse.

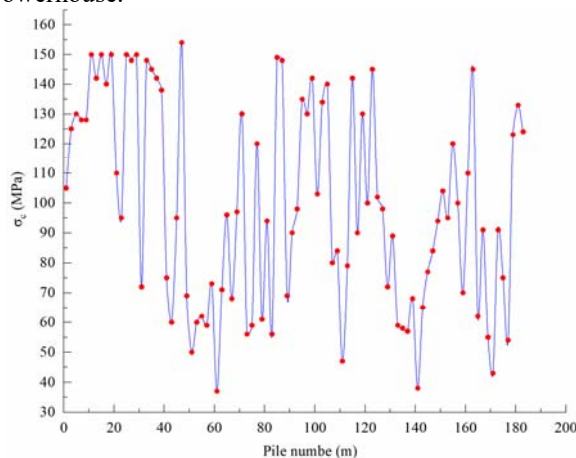
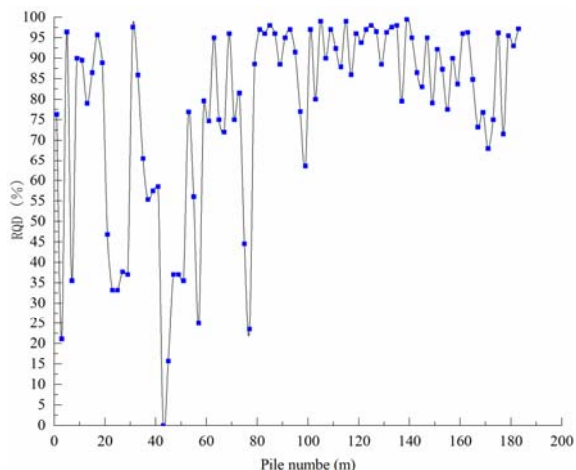


Fig. 1 Trend of rock strength changing with plant depth

The integrity of surrounding rocks is evaluated by *RQD*, which means 77.3% for exploration adit of main powerhouse. The changing trend of *RQD* with the hole depth is shown in Fig.2. Figure2 shows that the *RQD* is low in some sections, such as 21~29m, 42~61m, etc. These sections are affected by faults. Rock strata are strongly compressed and relatively fractured. After 79m, the *RQD* is in a high level in general and the integrity of surrounding rocks increases.



**Fig. 2** The degree of rock integrity changes with the depth of the plant

### 3.2 Quality classification results of surrounding rocks

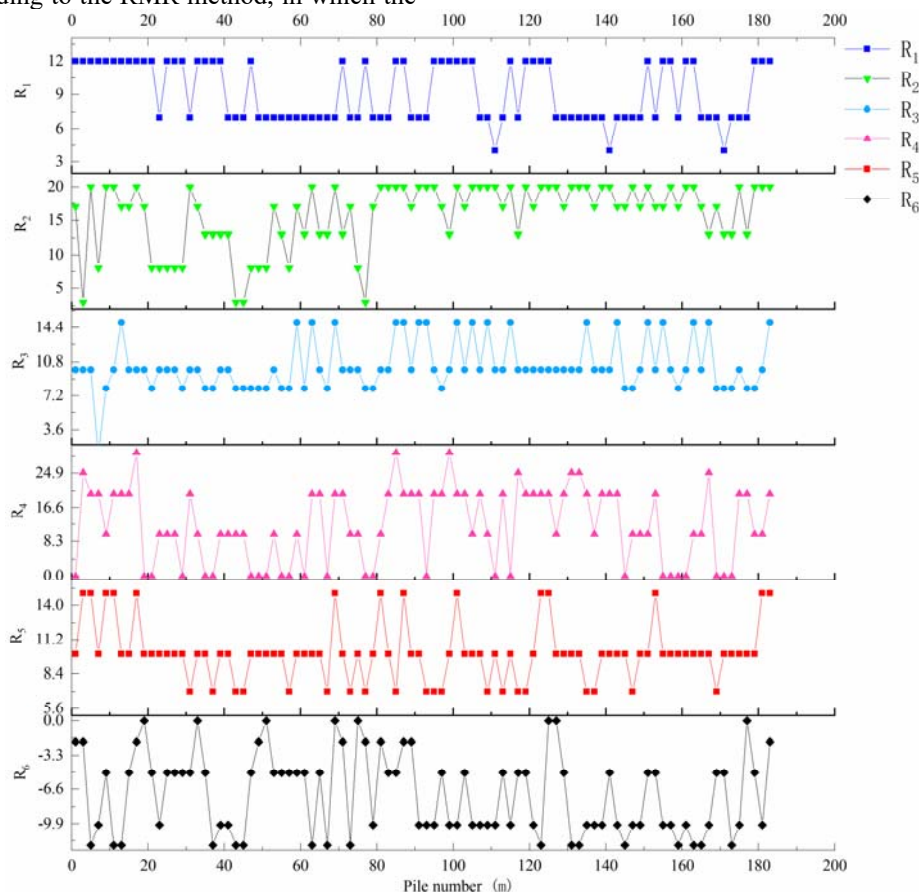
According to the parameters of surrounding rock strength and rock mass integrity (*RQD*) of the adit in Section 3.1, the two items are scored according to the RMR method. According to the investigation of the structural plane outcrop in the exploration adit, the statistics of the structural plane spacing, roughness and opening degree are made, and the scoring evaluation is conducted according to the RMR method, in which the

structural plane spacing is taken as the evaluation factor, and the score value is  $R_1$ , and the roughness and the opening of structural planes are combined to score  $R_4$ . The groundwater only drips in some evaluation sections and causes some tunnel sections to be wet. The impact is scored according to the field survey, and the score is  $R_5$ . The angle between the strike of the main structural plane and the axial direction of powerhouse is also an important factor affecting the stability of surrounding rock, and the score is  $R_6$ . The variation of  $R_1 \sim R_6$  with the plant depth is shown in Fig.3.

In summary, all index scores required by RMR method have been given. Based on these, RMR values are calculated and the results of surrounding rock quality classification are given. The results are shown in Table 3. From Table 3, it can be seen that there are 21 sections of Class II surrounding rock in the main power house, accounting for 22.8% of the total; the number of Class III surrounding rock is the largest, accounting for 51.1%; the number of Class IV surrounding rock is 24 sections in the vertical level evaluation, accounting for 24.1% of the total.

**Table 3** Quality classification results of surrounding rocks

Quality grade	II	III	IV
Percentage	22.8%	51.1%	24.1%



**Fig. 3** Variation of  $R_1 \sim R_6$  with Depth of workshop

The total RMR of surrounding rock quality and the change of surrounding rock quality with the depth of the tunnel as shown in Fig.4. From Fig.4, it can be seen that the exploration adit in the powerhouse area is mainly composed of Grade III surrounding rock, Grade II surrounding rock and Grade IV surrounding rock are locally distributed crosswise, and the Grade II surrounding rock distributes more centrally at the entrance of the powerhouse. This is due to the higher strength of the rock mass, relatively complete surrounding rocks and the less developed structural

planes; the development of Grade IV surrounding rock is relatively concentrated in the 20m~80m section, the faults in this section are closely developed. In particular, the F9,F10, F11, F12, F13, F14, f39 and F40 faults are all distributed in this 20m section. The rock mass in this section is severely crushed by the faults, the production and loading are distorted, the rock mass in some sections is crushed intensely, and groundwater is also active in this section. For example, there is linear drip along the fault in some areas of 41~58m and around it. The wall of the tunnel is also wet.

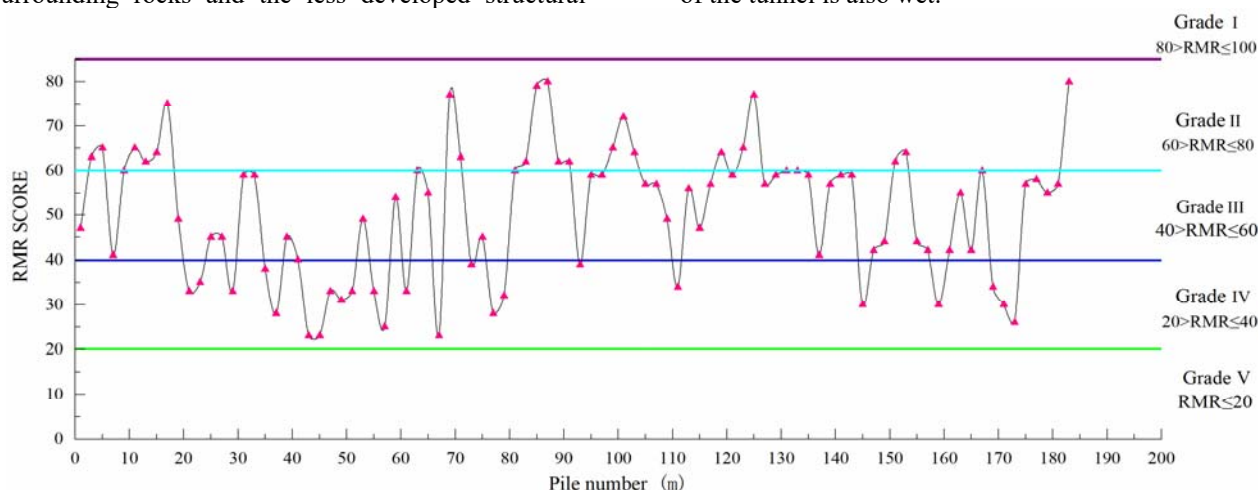


Fig. 4 Variation of RMR of surrounding rock quality with workshop depth

## 4 Conclusion

(1) The RMR method is used to classify the underground main powerhouse of the hydropower project as surrounding rock quality. The main powerhouse surrounding rock is mainly Class III surrounding rock, accounting for 51.1%, and the total proportion of Class III and II surrounding rock is 73.9%. Class II and Class IV surrounding rocks develop discontinuously with the depth of the main powerhouse, in which Class IV surrounding rock is mainly affected by fault development; there are no Class I surrounding rock and Class V surrounding rock distribution in the whole evaluation section. The quality of surrounding rocks is generally good and it is qualified to build large underground power house.

(2) The evaluation interval of surrounding rock quality for each 2m section improves the accuracy of the evaluation results of surrounding rock quality. Taking this study as an example, the influence of locally developed faults and groundwater activities will be reflected more finely in the corresponding evaluation section. Therefore, it avoids the influence of locally unfavorable geological phenomena on the quality of surrounding rock in the long evaluation section.

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