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ESTIMATION OF THE GEOLOGICAL STRENGTH INDEX SYSTEM FOR CAVITY LIMESTONE LAYER IN QUARRY AREA, REMBANG, CENTRAL JAVA PROVINCE, INDONESIA

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Abstract

Limestone mining needs a good mine design which is safe for the environment. Mine design is determined by the rock mass quality. The rock mass quality in each mine location is not necessary the same depending on the geological conditions. The research area is located in limestone quarry of Sale District, Rembang Regency, Center Java Province-Indonesia. In the limestone quarry area, there is cavity zone which consists of cavity limestone layer at the wall of quarry bench. This cavity layer in limestone quarry has occurred by solution process. The cavity layer zone is a potentially weak zone which has caused bench failures in the limestone quarry area. The objective of this research is to analyze the rock mass quality in the cavity limestone layer using Geological Strength Index (GSI) system. Final result of the research is a rock mass characterization, specifically for cavity limestone layer.

Keywords: *geological strength index, limestone, cavity layer*

1 Introduction

Limestone mining in *Sale District*, Rembang Regency, Center Java Province-Indonesia uses the quarry method, which is one of the surface mine methods. To apply this method, it must have mine design i.e. benchs with a safe slope at the wall (Hustrulid and Kuchta, 1995). Reliable estimates of the strength and deformation characteristics of rock masses are required for almost any form of analysis used for the mine design of surface excavations specifically for bench of limestone quarry. Hoek and Brown (1980a, 1980b) proposed a method to estimate the strength of jointed rock masses, based on an assessment of the interlocking of rock blocks and the condition of the surfaces between these blocks. This method was modified over the years in order to meet the needs of users who applied it to problems that were not considered when the original criterion was developed (Hoek 1983, Hoek and Brown 1988). The application of the method to very poor quality rock masses required further changes (Hoek, Wood, and Shah, 1992) which led to the development of a new classification called the Geological Strength Index (GSI) system (Hoek, 1994; Hoek, Kaiser, and Bawden, 1995; Hoek and Brown, 1997; Hoek, Marinos, and Benissi, 1998). The GSI system was also modified by Sonmez and Ulusay (1999). The GSI system is used in this research to determine rock mass quality of the surface mine, particularly limestone quarry.

The research area is located in limestone quarry of Sale District, Rembang Regency, Central Java Province, Indonesia. The research area is bounded by coordinates: 558000 mE – 558600 mE and 9240400 mN – 9241000 mN (Figure 1).

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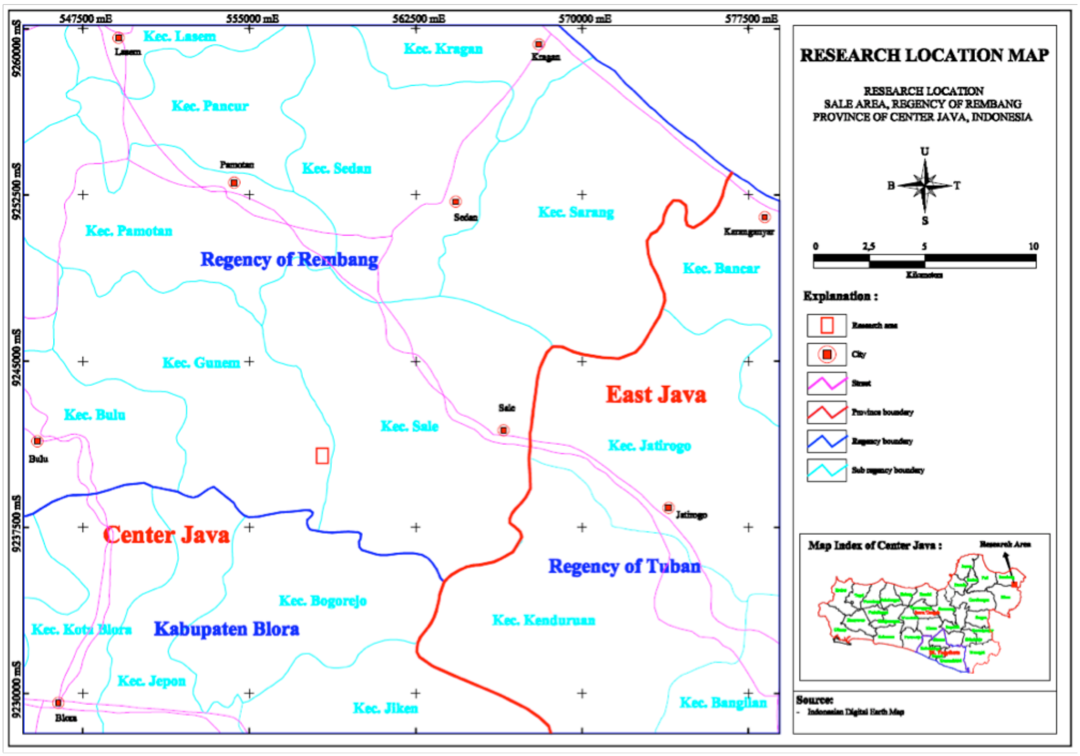

Figure 1: Location of the research area (red box).

2 Geological condition

Rembang Zone is part of the Northern East Java Basin that runs from Tuban eastwards through Lamongan, Gresik, and almost the entire island of Madura. The morphology of the Rembang Zone can be divided into three morphological units, namely lowland, undulating hills, and steep hills. Based on the geological map of Jatirogo (Figure 2), the research area is covered by Paciran Formation, which consists of massive limestone and dolomitic limestone (Situmorang, *et al.*, 1992). The rocks in the Rembang Zone have undergone intensive folding and faulting resulting in anticlines and synclines.

Table 1: Coordinates of cavity limestone layer outcrop observation.

Sampel Code	mE	mN
A	558358	9240927
B	558383	9240925
C	558404	9240928
D	558419	9240931
E	558433	9240936
F	558444	9240942
G	558459	9240952
H	558473	9240963
I	558487	9240975
J	558497	9240988

3 Solution cavity layer in limestone quarry

In some parts of the limestone quarry area, there is cavity zone, which is formed by solution of limestone, at the wall of quarry bench (Figure 3). The cavity zone is a potentially weak zone of bench failure. The cavity zone is from 50 to 300 cm wide and located at an elevation of approximately 389 m above sea level. The slope of quarry bench ranges from 60° to 75°. Observation of limestone cavity zone was conducted at 10 location points with A to J sample names (Figure 4). Location of each outcrop observation point in coordinates as follow (Table 1) and the cavity layer map (see Figure 5).

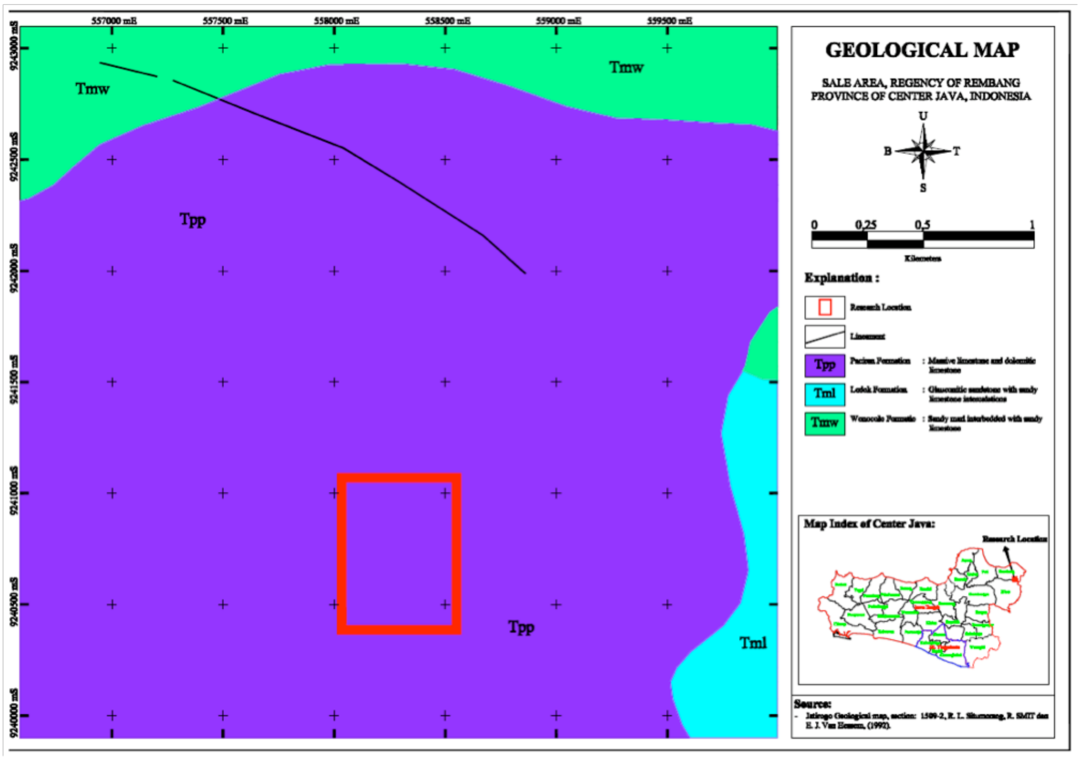

Figure 2: Geological map of the research area.

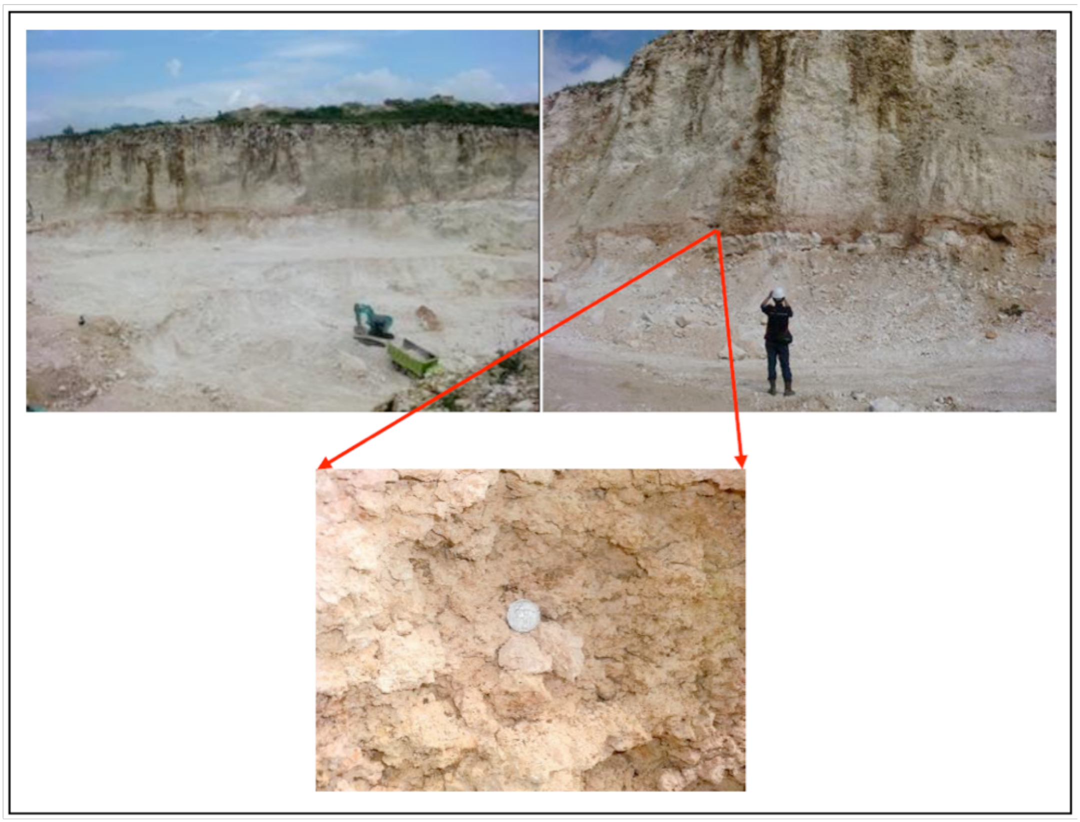

Figure 3: Cavity layer condition in limestone quarry .

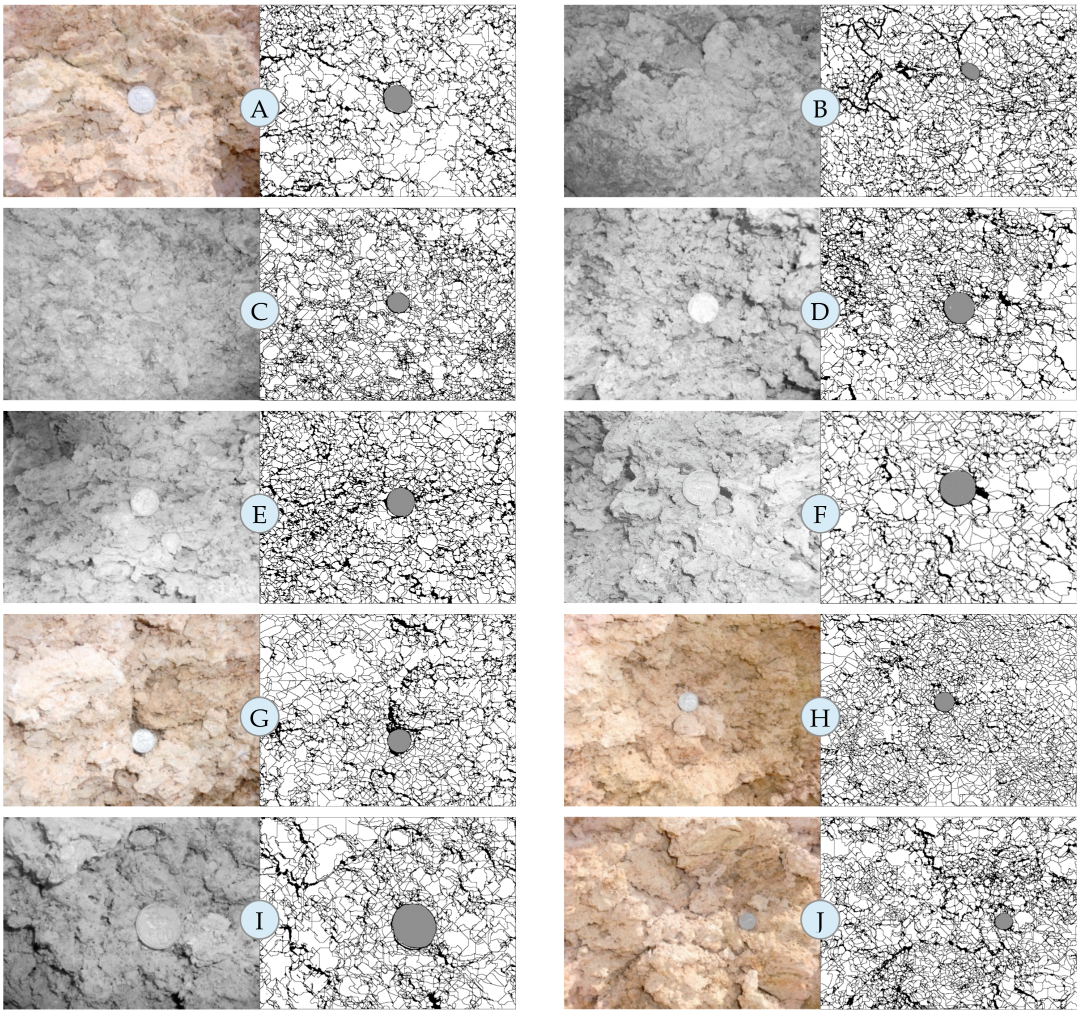

Figure 4: Limestone cavity layer outcrop.

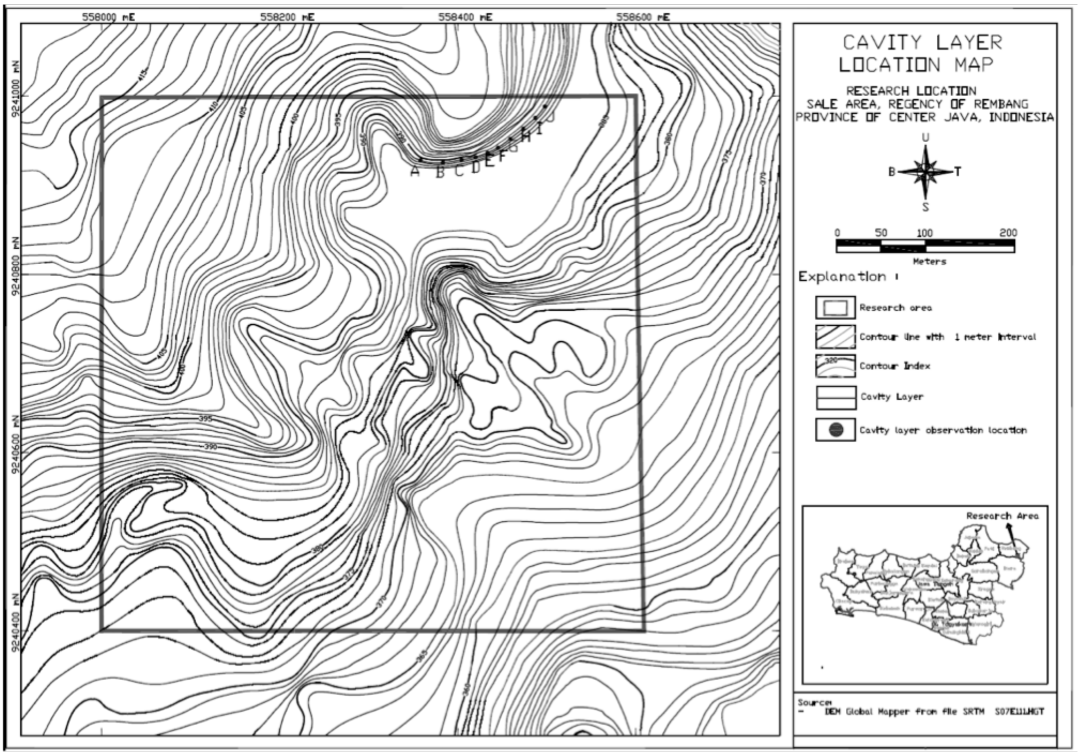

Figure 5: Cavity layer map.

4 GSI estimation for rock mass quality of cavity zone in limestone quarry

Identification of rock mass characteristic has been proposed to determine rock mass quality. This system provides a method for estimating the reduction in rock mass strength for different geological conditions as identified by field observations. Classification of rock mass quality based on the GSI, combined 2 (two) main parameters, i.e. structure rating (SR), in terms of blockiness and surface condition rating (SCR), in term of roughness, weathering and infilling. Based on outcrop observations in limestone quarry area, all structure condition of the cavity limestone layer are described by the term disintegrated as the rock masses are poorly interlocked, heavily broken rock mass with a mixture or angular and rounded rock pieces (see Figure 4). To obtain the structure rating (SR), volumetric joint count (Jv) is calculated as follow:

$$Jv = \left(\frac{M}{L}\right)^3 \tag{1}$$

Jv : Joint volumetric count
M : Amount of discontinuity
L : Scanline (m)

The surface condition rating (SCR) was estimated from the input parameters (e.g. roughness, weathering and infilling). The total rating for surface condition rating (SCR) is obtained using the following equation:

$$SCR = Rr + Rw + Rf \tag{2}$$

Rr : rating for roughness
Rw : rating for weathering
Rf : rating for infilling

Based on field observations, most of structure condition and surface condition are very small block, rough rock surface, slightly-moderately weathered and soft infilling. The scores of GSI estimation for rock mass quality of cavity layer zone in limestone quarry are between 32 and 39 (poor). Estimation of the structure rating (SR) and surface condition rating (SCR) is described in Table 2 and Figure 6.

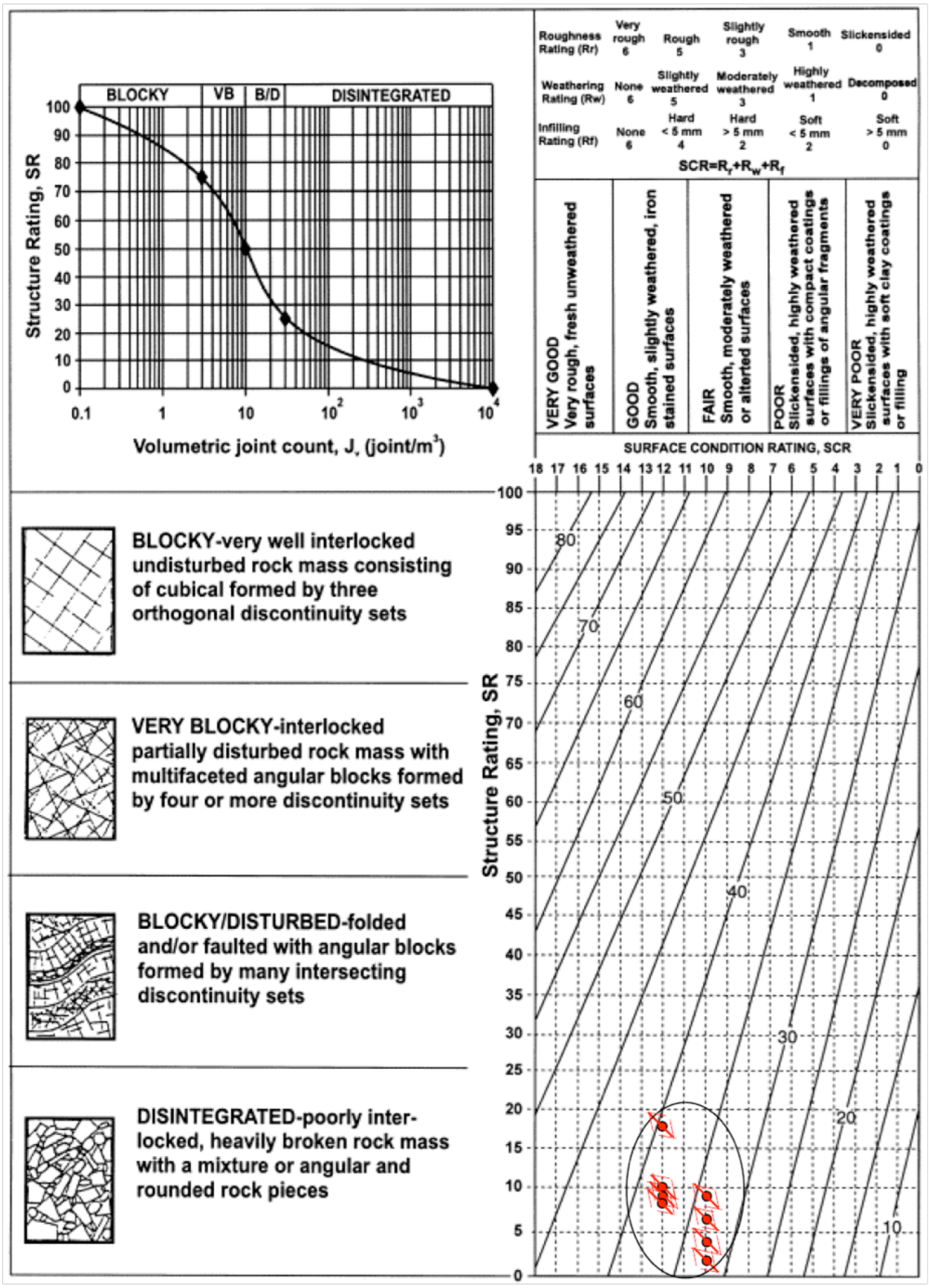

Figure 6: Field of GSI estimation for cavity limestone layer (After Sonmez and Ulusay, 1999).

5 Conclusions

The cavity limestone layer in the study area consist of very small blocks with rough surface, slightly to moderately weathered and soft infilling materials. The scores of GSI estimation for rock mass quality of cavity layer zone in the limestone quarry are between 32 and 39, indicating a poor rock mass quality. The cavity layer zone is a potential weak zone which has caused bench failure in the limestone quarry area.

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