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An extension of the stand-up time in the Q-system rock-mass classification up to 200 years based on the limestone mines in The Netherlands.

Une extension du temps de 'stand-up' dans le système 'Q' de la classification d'un massif rocheux basée sur les mines de calcaire au Pays-Bas.

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ABSTRACT: The stand-up times of room and pillar galleries in the limestone mines in the south of The Netherlands are calculated with the Q-system classification. A remarkable correlation seems to exist between calculated stand-up times and reality. Also the degree of fracturing of pillars can be related to Q-values, span width and the stand-up time.

RÉSUMÉ: Le temps de 'stand-up' des mines de calcaire au sud des Pays-Bas sont calculés avec le système 'Q' de la classification. Une corrélation frappante semble exister entre le temps de 'stand-up' calculé et la réalité. Ainsi le degré de la fragmentation des colonnes se relate au valeur 'Q', portées et le temps de 'stand-up'.

1 INTRODUCTION

Limestone calcarenite and calcisiltite formations outcrop in the south of The Netherlands. The formations are from Maastrichtian age. The limestones have been mined for building material since Roman times and mining stopped around the 1950's. Irregular rooms and pillars have developed as the result of sawing blocks out of the rock. The spans of the rooms approximately range from 4 to 7 m. Presently some of the mines are visited by tourists. Other areas are collapsed or are in a state which is not expected to be stable and where collapse is imminent.
A considerable amount of research has been done by the Delft University of Technology to establish stability criteria (Price, 1989, Steveninck, 1987, Bekendam, 1990). The data from this research have been used for assessing the stability and stand-up times according to the Q-system for rock-mass classification (Barton, 1976).

2 ROCK-MASS PARAMETERS

The limestone layers of the Maastrichtian in the south of The Netherlands are fairly massive. Tectonic faults are infrequent and jointing is virtually absent. Extensive laboratory testing on block samples has been executed. UCS values approximately range between 1 and 4 [Mpa] and Brazilian test tensile strength values range approximately from 0.1 to 1.2 [Mpa].

3 Q-SYSTEM PARAMETERS

The so-called Q-factor is calculated using eq.1. For the exact description of the parameters is referred to the literature by Barton (Barton, 1976).

$$Q = \frac{RQD}{J_n} \; x \; \frac{J_r}{J_a} \; x \; \frac{J_w}{SRF} \qquad \textbf{(1)}$$

For this study the parameters are as follows:
RQD = 100 %, J_n = 2.25, J_r = 4, J_a = 1

The rock-mass is massive and the rock-mass is virtually not jointed. Therefore RQD = 100 % and J_n is initially set to 0.75. The room and pillar mining method causes so many intersections that the multiplier of 3 for intersections is used for the J_n parameter which increases J_n to 2.25. For the joint roughness and joint alteration factors have been taken the maximum.

J_w = 1
The mines herein considered are all above ground water level.

SRF (The Stress Reduction Factor)
Weakness zones or shearzones occur only occasionally and are not expected to have
a serious influence on the rock-mass stability. Also the rock material is not expected to squeeze or swell so that the SRF parameter is determined by the strength - stress

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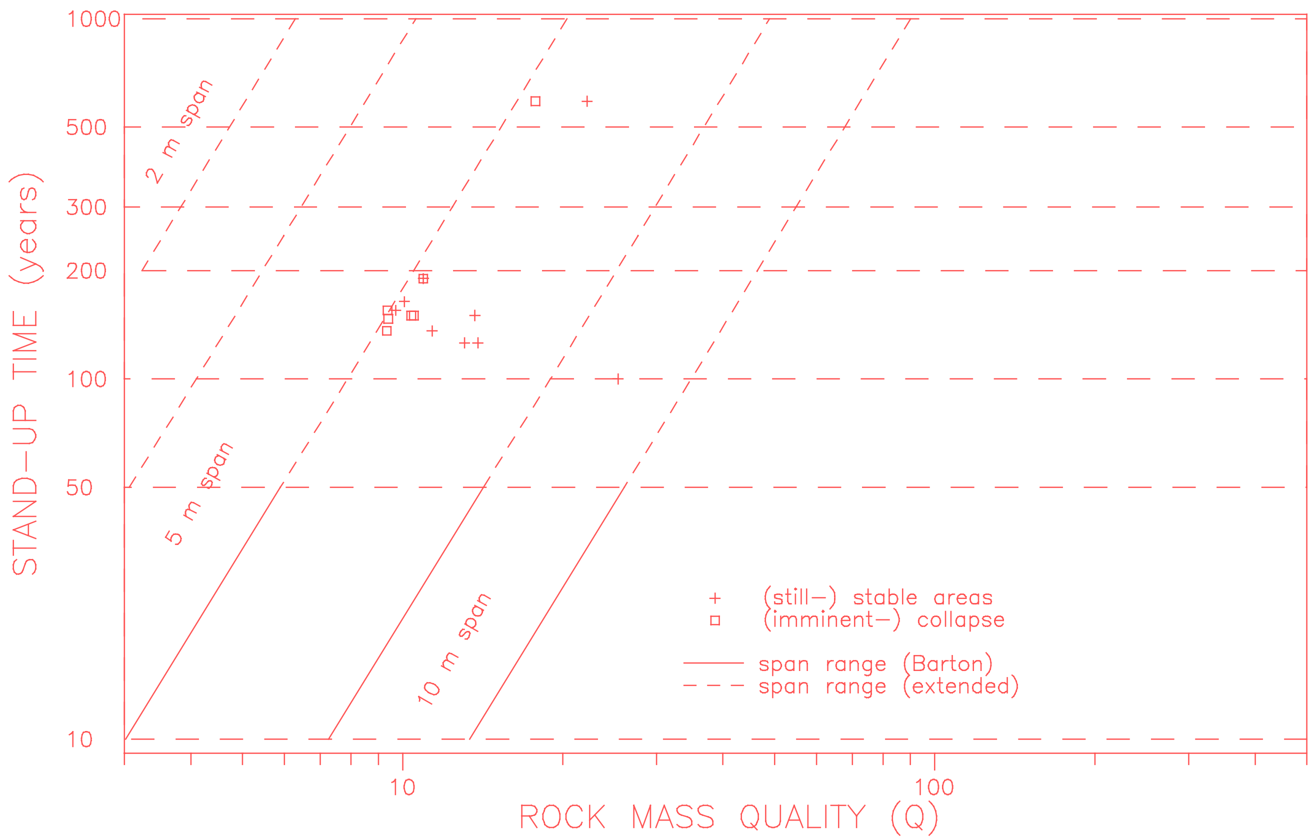

Figure 1: Stand-up time vs. Q-value for mine areas.

ratios. Two approaches for calculating the strength - stress ratios have been used:

1 For a preliminary general assessment of different mines and different mine areas (fig.1) the SRF has been determined by calculating the ratio of the laboratory UCS compressive strength to the overburden pressure, and the laboratory Brazilian test tensile strength value to the overburden pressure. The ratio which resulted in the lowest SRF value has been used for calculating the Q value.

2 For a more detailed assessment of different pillars in the 'Geulhem' mine (fig.2) the SRF value is based on the ratio of the pillar strength over the stress in the pillar (Steveninck, 1987). The strength of the pillar (σ_p) is calculated as follows:

$$\sigma_p = \sigma_c [0.935 + 0.690 * \log(\frac{w}{h})] \quad \textbf{(2)}$$

σ_c = UCS; w, h = pillar width, height

The stress in the pillars is calculated according the tributary area method (Goodman, 1980).

4 STAND-UP TIMES

Stand-up times have been achieved from historical sources and from dates written on the walls in the mines. Many of the stand-up times are rather minimum stand-up times because the dates do not necessarily reflect the building year of the mine.

5 RESULTS

Figure 1 shows clearly that mine areas which are collapsed or where collapse is imminent are on the boundary of the extended 5 m span range. This is in agreement with the actual span ranges of 4 to 7 m. The other points are visually described as stable but are in the same mines and although visually no damage has been established it might be that these areas are also in a nearly collapsing state.

Figure 2 shows the average Q-values against stand-up time of 331 individual pillars averaged according stand-up time and class in the 'Geulhem' mine. The 600 year old pillars are right on the edge of a collapsed area. From the figure it is clear that the nearly failing pillars or the

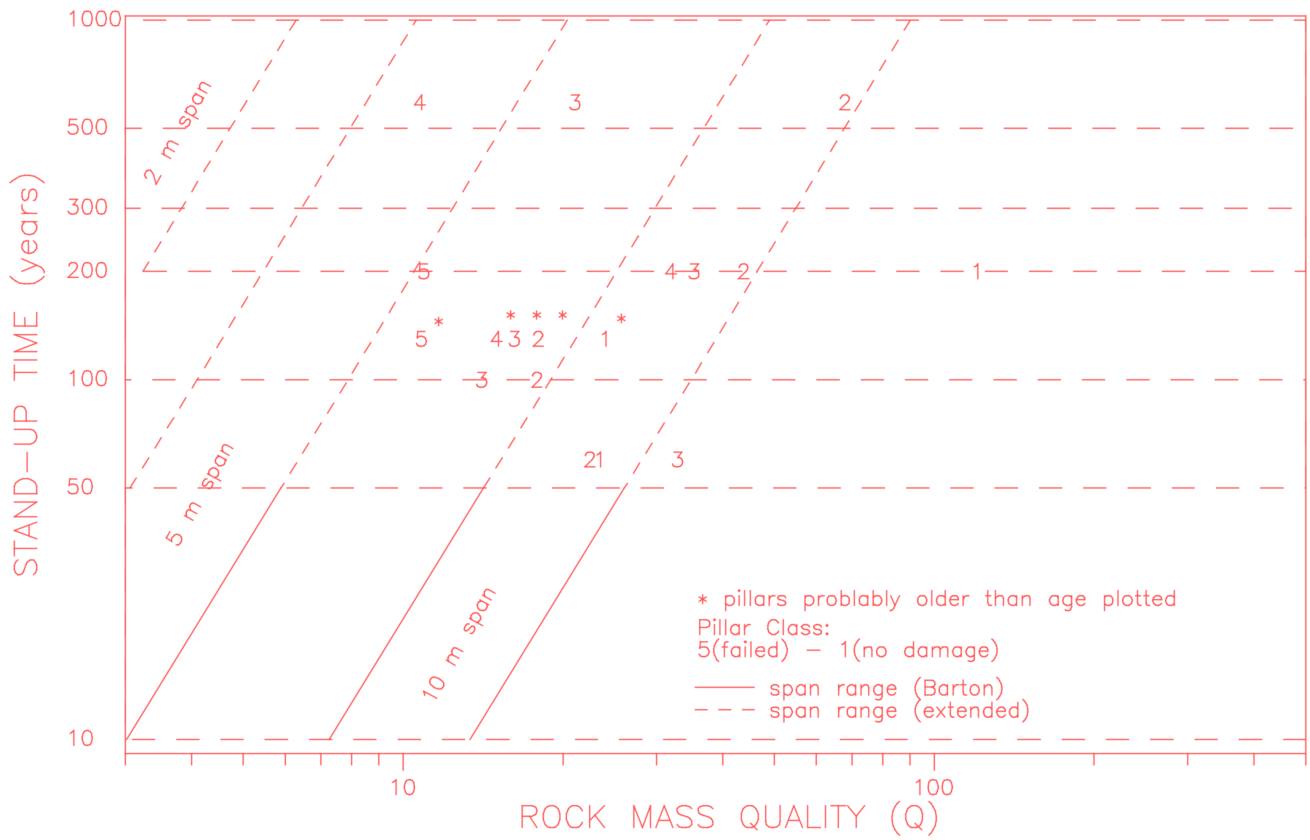

Figure 2: Stand-up time vs. Q-value for mine pillars.

pillars on the edge of a collapsed area are on the boundary of the 5 m span stand-up times.

6 CONCLUSIONS

It is of interest that the extension of the stand-up times which have been predicted by Barton only up to 50 years seem to reflect with reasonable accuracy the actual stand-up times up to 200 years and probably up to 600 years. Investigations and research on the above is still ongoing and further results will be reported.

REFERENCES

Barton, N. 1976. Recent experiences with the Q-system of tunnel support design. Pro. Symp. on Exploration for Rock Engineering, Johannesburg.

Bekendam, R.F. & W.G. Dirks 1990. Stability assessment of the Hoorensberg room and pillar mine, Southern Limburg. Proc. 6th Congr.IAEG, Vol 4, Amsterdam.

Goodman, R.E., Korbay, S. & Buchignani, A. 1980. Evaluation of collapse potential over abandoned room and pillar mines. Bulletin Association of Engineering Geologists 17, 27-37.

Price, D.G. 1989. The Collapse of the Heidegroeve: A case history of subsidence over abandoned mine workings in Cretaceous calcarenites. 'Chalk', Thomas Telford, London 1990.

Steveninck, R.van. 1987. Past mining in the Maastrichtian Limestone. Memoirs of the Centre for Eng.Geo. in The Netherlands, no 48.