Tutorial 4 Empirical Scaled Span Approach

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Introduction

There are three basic approaches for evaluating the stability of crown pillars or designing new ones: i) empirical methods; ii) analytical methods; and iii) numerical modeling. The Scaled Span method is an empirical method, separate from the analytical analysis used in the previous CPillar tutorials.

The scaled span empirical approach was initially developed for steeply dipping ore body geometries. The method requires the user to estimate crown geometry and assess whether the stope geometry is steep or shallow, in order to apply the most appropriate empirical relationships.

The user must also assess “controlling,” not average, rockmass quality (including assigning the stress and water terms within the estimated Q value). These are important considerations in correct application of the Method. Accordingly the user should familiarize themselves with the following critical limitations before applying the method.

Critical Limitations:

Each of the following critical limitations is described in more detail in the paper “Guidelines for use of the Scaled Span Method for Surface Crown Pillar Stability Assessment.” The links below go to the relevant sections of the paper.

• Revised Scaling Approach - Shallow Stopes (Section 6.1 - pg 14)
• Estimating controlling rock quality (Section 7.1 - pg 22)
• Assessing change in rock quality and failure risk with time (Section 7.2 - pg 23)
• Influence of Structure (Section 7.3 - pg 25)
• Optimizing definition of water and stress terms (Section 7.4 - pg 26)
• Accounting for overburden or lake bodies (Section 7.5 - pg 26)

Model Setup

In order to use the Scaled Span method, we must know the crown pillar geometry and the Q values of the rock mass.

It is important to note here that the Q value must be the “full Q” - the value must include the water and stress terms. This is imperative for considering the water and stress terms in the Scaled Span analysis.

We will consider a crown pillar with the following geometry and Q data:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qmin</td>
<td>1.9</td>
</tr>
<tr>
<td>Qmax</td>
<td>31.5</td>
</tr>
<tr>
<td>Thickness</td>
<td>32 m</td>
</tr>
<tr>
<td>Span</td>
<td>15 m</td>
</tr>
<tr>
<td>Length</td>
<td>35 m</td>
</tr>
<tr>
<td>Ore Dip</td>
<td>60 degrees</td>
</tr>
<tr>
<td>Rock Unit Weight</td>
<td>2.8 g/cm³</td>
</tr>
</tbody>
</table>
Select Analysis > Empirical Scaled Span Design Method

You will now see the Scaled Span dialog, as shown:

To illustrate the approach, we will first consider average geometry values, but will enter the range of rock quality. Enter the crown pillar data in the dialog and select “Compute Scaled Span.” Your dialog should look as follows:
Our $C_s$ value has been calculated and an area has been highlighted on the chart. The $C_s$ value is known as the Scaled Span. It is calculated using the equation shown in the dialog. This value characterizes the geometry of the crown pillar. The equation evolved from the simple “Rule-of-Thumb” methods of crown pillar evaluation. It was developed as a more accurate relationship which could be properly scaled to rockmass quality.

Once again it should be noted that $C_s$ only characterizes the geometry of the pillar, not taking into account the influence of clamping stresses or groundwater. This is why the full Q with water and stress terms must be used in the analysis.

**Results**

We can now interpret the results on the chart. The calculated $C_s = 4.15$ value is used to select the y coordinate of the highlighted box. The width of the box is defined by the $Q_{\text{min}}$ and $Q_{\text{max}}$ values, shown on the x-axis.

Our pillar is placed in the range of Classes B through F (noted in the white area), with a probability of failure ranging from ~1% to ~50% (red lines). We will click on the "Design Guidelines Chart" button to see what this information means. You will see the following table:
As expected ranges B through F constitute a probability of failure between 0.5% and 50%. In this case we will take the worst case scenario, B. This indicates that the life expectancy of the pillar is very, very short-term (~1 year), and that public access is "forcibly prevented." This would be acceptable in a mining block where surface risks can be mitigated perhaps by incorporating "continuous sophisticated monitoring" if critical surface infrastructure is sited over the crown area, but would not be acceptable for "mine closure" handover.

Since the Critical Scaled Span value for 50% Pf = FoS = 1 is defined as $S_c = 3.58Q^{0.44}$. For this example, we can take the $Q_{min}$ value = 1.9, and substitute in this expression to estimate the Critical Scaled Span giving $S_c = 4.75$. This value indicates the maximum stable scaled span at 50% Pf (FoS=1) for this rockmass quality.

While it is preferred that results of Scaled Span assessments be presented in terms of Probability of Failure (Pf), if desired, a crude estimate of the factor of safety can be approximated (Carter et al, 2008) from the following expression:

$$FoS = F_c^{0.6}$$

where $F_c = S_c/C_s = 4.75 / 4.15 = 1.14$, yielding an estimate of FoS = 1.08.

References

More information about the Scaled Span empirical method can be found in the paper "Guidelines for use of the Scaled Span Method for Surface Crown Pillar Stability Assessment." Additional information can be found in the Online Help at the link below: https://www.rocscience.com/help/cpillar/webhelp/CPillar/Empirical_Design.htm
