Verification following UNI 11211-4

If you have selected to follow the UNI 11211-4[3] design guidelines in the previous step, the recommended values to input for the parameters are listed below.

Impacted Rocks

Enter the design velocity (Vt) percentile (95% suggested [3] and also the default) here. Click on the **Rock Mass Selection** drop-down and choose which of the three options for mass and density you want to use. You can only edit the **Rock Mass** and **Rock Density** values below if you select "Manually enter rock mass and density". Otherwise, the values will be automatically filled in based on the rock properties defined in the model.

Installation Parameters

Enter the **Separation Distance** (minimum distance from the barrier to the infrastructure) and the **Free Border** (height of the barrier that you don't want to impact or safety zone, f_{min} in Figure 1 below). f_{min} is defined as the safety zone that cannot be impacted. It is at least 0.5m and at most half the average size of the block (for example, f_{min} = the radius for a circular rock).

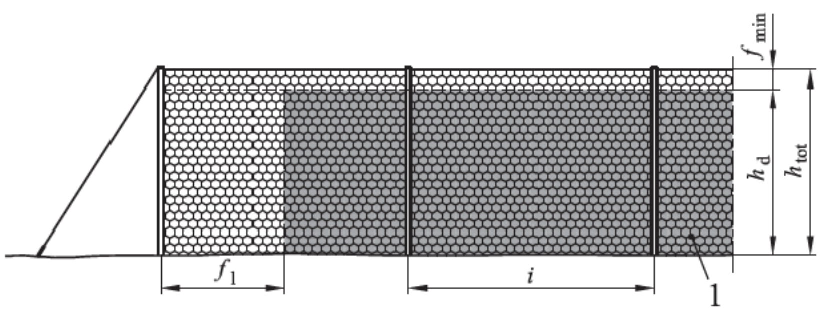

Figure 1: Main geometrical features of the barriers [3]

Barrier Design Coefficients

The design coefficients basically represent the level of confidence you have in the accuracy of each of the values.

Design Coefficient	Description	Value	Reference
Quality of topographic survey (γ_{dp})	safety coefficient related to quality of topographic survey	1.02 - high quality 1.10 - low quality	[3]
Precision of block survey (γ_{vol})	safety coefficient related to the	1.02 - high precision 1.10 - low precision	[3]

	precision of the design block survey		
Evaluation of the unit weight of rock (γ_γ)	safety coefficient related to the evaluation of the unit weight of the rock	greater than or equal to 1.0 (generally assumed to be 1.0)	[3]
Reliability of rockfall simulation (γ_{tr})	safety coefficient related to reliability of rockfall software simulation	1.02 - simulation with back analysis 1.10 - simulation based on bibliography of restitution coefficients	[3]
Impact energy (γ_i)	considers human risk. Varies from 1.0 to 1.2 depending on the degree of assessed risk	~~>1.0~~ 1.0 for assets with modest economic consequences 1.05 for assets with considerable economic consequences 1.10 for assets with significant economic consequences 1.20 for assets with significant economic and extensive or irreparable consequences (eg. hospitals, schools)	[3]
Barrier capacity (γ_e)	related to design energy level	1.00 - SEL for barriers with 3 or more spans: 1.20 - MEL for barriers with less than 3 spans 1.20 - MEL where two parallel barriers have to be placed 2.00 - MEL otherwise	[3]
		for energy level: >1.0 - MEL 1.0 - SEL for barrier length: >1.0 - barrier shorter than 30m 1.0 - barrier is at least 30m long	[1]
		1.00 - SEL 1.30 - MEL	[2]
Barrier elongation (γ_d)	related to barrier elongation	1.00 - SEL 1.30 - MEL 1.50 - MEL if free end spans are in impact area OR barrier has less than 3 spans	[3]
		for energy level: >1.0 - MEL 1.0 - SEL	[1]

		for barrier length: >1.0 - barrier shorter than 30m for barrier-span impacted by boulder >1.0 - if lateral span of barrier may be impacted	
Radius of block (γ_{Rb})	related to radius of block	= γ_{vol} above	[6]
		1.0	[2]

The Design Coefficients described above combine to give the Design Parameters for the Barrier Report. The Design Parameters are defined below.

Design Parameter	Equation	Reference
Design Mass (M_d)	$M\gamma_{vol}\gamma_{\gamma}$	
Design Velocity (V_d)	$V_t\gamma_{tr}\gamma_{dp}$	
Design Energy (E_d)	$(0.5M_dV_d^2)\gamma_i$	
Design elongation (Dd)	$D\gamma d$	
Design Height (Hd)	$Ht\gamma tr\gamma dp + R\gamma Rb$	[5] Ht = 95% impact ht. R = average rock equivalent radius
	95% impact height	[3]

Verification Equations

Verification Type	Equation	Additional Definitions
Energy	$E_d < E_{barrier}/\gamma_e$	$E_{barrier}$ – energy value of barrier (MEL or SEL)
Height	$H_{tot} >= H_d + f_{min}$	H_{tot} - nominal height of tested barrier f_{min} - safety zone that cannot be impacted (-see installation parameters)
Elongation	$D_A >= D_d$	D_A -minimum distance between barrier and protected zone

References

[1] Grimod, A. and Giacchetti, G. "High Energy Rockfall Barriers: A Design Procedure for Different Applications".

[2] Peila, D. and Ronco, C. (2009) "Technical Note: Design of rockfall net fences and the new ETAG 027 European guideline". Natural Hazards and Earth System Sciences. 9:1291-1298.

[3] UNI (2012) “UNI 11211-4: 2012 Rockfall protective measures. Part 4: Definitive and executive design”, UNI Ente Nazionale Italiano di Unificazione, Milano, Italia (in Italian), www.uni.com

[4] Giacchetti, G. and Zotti, I.M. (2012) "Design Approach for Rockfall Barriers". XI Congreso Nacional de Geotecnia, Congeo, Costa Rica. San Jose, Costa Rica. August 9-10, 2012.

[5] Giacchetti, G., Grimod, A. and Psimis, G. (2016) “Rockfall Barriers Design Approach at the Service or Ultimate Limit State”, 1st International Conference on Natural Hazards & Infrastructure, Chania, Greece. June 28-30, 2016.

[6] Grimod, A., Giacchetti, G. (2014); “Certified Deformable Rockfall Barriers: Tests, Design and Installation.” Proceedings of GeoHazard Conference, Canadian Geotechnical. Queen’s university in Kingston, Canada. June 15–18, 2014.