

## Rockfall Protection Systems



# Safety by Competence - *tried and true*

Trumer offers solutions based on decades of experience - both from testing and practical application - protecting life, urban areas and infrastructure from natural and anthropogenic induced hazards.



Tests following certification guidelines are carried out using standardized blocks to simulate impacts up to more than 5000 kJ.



The inclined test facility from Trumer is one of the largest and most modern in the world and can accommodate a large variety of types of fences as well as earth dams.

Trumer Schutzbauten has been at the forefront of the geohazard industry since the early 1990s, shortly there after developing proprietary systems now sold throughout the world. Our systems are the result of years of 1:1 scale testing at some of the most modern facilities. Combine this with real-world performance from systems installed across Europe, Scandinavia, Asia and Canada over the past two decades and you get rockfall catchment fences that have been fine tuned to be robust and reliable.

At Trumer, we take great pride in providing the best client support at all stages of projects, whether in the initial planning phases or on-site technical support. Through our highly capable team of engineers, geologists and technicians, you can be assured that full support is available when you need it and that the project has been designed for SAFETY BY COMPETENCE.



Two examples of hinged rockfall catchment fences impacted at and surrounding a post. Posts by Trumer are robust and can withstand direct impacts without compromising the systems integrity.



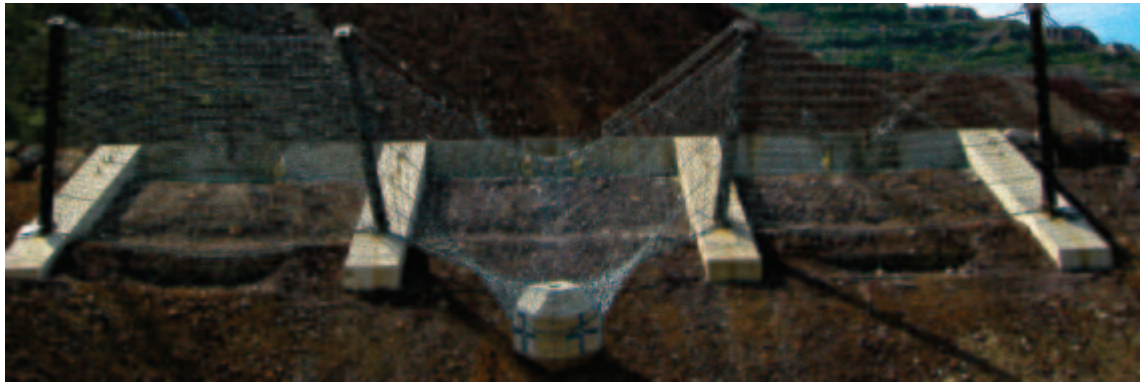
# Safety without Compromise - *because anything else isn't acceptable*

**Every system by Trumer is designed to perform with the highest level of safety during real-world events and not tailored just to meet certification guidelines.**

A pre-test photo of a 3000 kJ, hinged rockfall catchment fence. It is important to note that systems by Trumer do not use bypass or break-away elements as some manufacturers do in order to compensate for the lack of flexibility of the primary nets in the vicinity of posts. With such elements incorporated into the system, large openings can form in this area. Instead, the high strength and flexibility of the Omega-Net is utilized to provide a safe and secure barrier.



A test photo of the same system after a Maximum Energy Level test for certification. In this test, as with all tests certifying Trumer systems, there are no major damages to any components of the system, even though the certification guidelines allow certain damages. Also note that there are no openings of the nets near the post locations in not only the primary field but also end fields. If one were to compare this to photos of systems using break-away elements or bypasses, large gaps adjacent to posts, sometimes in the order of more than 2 m, would be apparent between the primary net and the bearing ropes.



At Trumer, it is not enough that a system simply passes the certification process where many components may be severely damaged but may still pass the certification process (as long as the test block is captured). This is because we believe that to design a system to pass an idealized event is not the same as to design a system to perform well under natural conditions. We expect more out of our systems and go above and beyond certification requirements to ensure that every primary component of the system is in a safe state following a Maximum Energy Level test, thus the motto: SAFETY WITHOUT COMPROMISE.



A completed Maximum Energy Level test for a 5000 kJ rockfall catchment fence.



An example of a tree stem impact on a rockfall catchment fence.



# Hinged Post Systems - *flexibility through tradition*

The hinged post system by Trumer is based on the same concept since its inception: a robust post and base connected by a pin that allows easy installation even in the most difficult terrain with minimal foundations, but which achieves the highest strength through flexibility.



Catchment fences with a hinged connection between the post and base plate require upslope anchors and retaining ropes. As such, large energies can be accommodated while minimizing forces on the foundation of the post.

Hinged post systems are the most common form of rockfall catchment fence. They can be easily installed in undulating or very steep terrain and require minimal foundations.

Two types of systems are available based on their certification ETAG 27 or 1:1 scale testing according to the Austrian WLV guidelines. Both are 1:1 scale tested but differ in their requirements for approval and construction.

## Available Systems Certified According to ETAG 27

System	Energy Rating	Approved Heights
TSC-100-ZD	100 kJ	2.0 - 2.5 m
TSC-250-ZD	250 kJ	2.5 - 3.0 m
TSC-500-ZD	500 kJ	3.0 - 3.5 m
TSC-500-ZD h4	500 kJ	4.0 - 5.0 m
TSC-1000-ZD	1000 kJ	4.0 - 5.0 m
TSC-1500-ZD	1500 kJ	4.0 - 5.0 m
TSC-2000-ZD	2000 kJ	5.0 - 6.0 m
TSC-3000-ZD	3000 kJ	5.0 - 6.0 m
TS-5000-ZD	5000 kJ	6.0 - 7.0 m

## Available Systems 1:1 Scale Tested Following WLV Guidelines

System	Energy Rating	Approved Heights
TS-150-ZD	150 kJ	2.0 - 3.0 m
TS-250-ZD	250 kJ	2.5 - 3.75 m
TS-500-ZD	500 kJ	3.0 - 4.5 m
TS-750-ZD	750 kJ	4.0 - 6 m
TS-1000-ZD	1000 kJ	3.0 - 4.5 m
TS-1500-ZD	1500 kJ	3.0 - 4.5 m
TS-2000-ZD	2000 kJ	4.0 - 6 m
TS-3000-ZD	3000 kJ	5.0 - 7.5 m
TS-5000-ZD	5000 kJ	6.0 - 9.0 m



Anchorage for base plates consist of one tension anchor and one compression anchor for ease of installation. Concrete foundations are not necessary though full support of the base plate is. As such, sometimes small pads are used when in soils.



Due to their light weight and minimal foundation requirements, hinged systems are suitable for installation in even the most difficult terrain, including on vertical walls.

# Fixed Rotation Systems - *brute strength with flex*

Where upslope retaining ropes are not desired or possible, fixed rotation systems provide an excellent alternative to rigid structures such as dams or walls that require more space and which are much more costly.

## Available Systems Certified According to ETAG 27

System	Energy Rating	Approved Heights
TSC-100-oA	100 kJ	2.0 - 2.5 m
TSV-500-oA	500 kJ	3.0 - 3.5 m
TSV-1000-oA	1000 kJ	4.0 - 5.0
TSV-2000-oA*	2000 kJ	4.0 - 5.0 m

\* pending

## Available Systems 1:1 Scale Tested Following WLV Guidelines

System	Energy Rating	Approved Heights
TS-100-oA	100 kJ	2.0 - 3.0 m
TS-300-oA	300 kJ	3.0 - 4.5 m
TS-500-oA	500 kJ	3.0 - 4.5 m
TS-1000-oA	1000 kJ	3.0 - 4.5 m
TS-2000-oA	2000 kJ	4.0 - 6.0 m



Fixed rotation systems are ideal for installing on walls or berms as well as in places where upslope anchors are either too difficult to install or where retaining ropes interfere with access requirements.

Fixed rotation systems are rockfall catchment fences that have no upslope anchors or retaining ropes and so must accommodate large forces in the post foundations. These systems are normally used where access to the back for the fence is required for either utility purposes or for cleaning out the system after an event. In general, the posts are more heavy than hinged systems of equivalent capacity but the system as a whole have much less anchors, ropes and brake elements.

As with hinged systems, two types of systems are available based on their certification: ETAG 27 or those tested in accordance with the WLV guidelines,



The lack of retaining ropes makes access and general maintenance of fixed rotation systems much more simple than for traditional hinged post systems.



Because of the large forces acting on posts and bases, steel profiles are much larger than their hinged post equivalents, as are the foundation requirements.



# Hybrid Rockfall Fences - *it's all about control*

Attenuators and hybrid rockfall fences by Trumer can absorb high amounts of energy while at the same time place debris at a more convenient location for maintenance.



Before photo of a 3000 kJ hybrid test. The system consists of 5 m high posts with 12 m of Omega-Net.



During the impact, the majority of the energy is absorbed during the initial contact with the upper section of the structure, but the projectile is allowed to progress through the system to the bottom portion of the net.

Hybrid and attenuator rockfall systems are those that absorb some or all of the energy of a rockfall but that allow the debris to move from an upper position to a lower position of the fence, thereby reducing the amount of effort for maintenance following an event.

Trumer provides lower energy hybrid systems as well as high energy. Two systems have been tested based on ETAG 27 guidelines where applicable: a 1000 kJ and 3000 kJ hybrid.

## Available Systems 1:1 Scale Tested Based on ETAG 27

System	Energy Rating	Approved Heights
TSC-1000-ZD Hybrid	1000 kJ	4.0 - 5.0 m
TSC-3000-ZD Hybrid	3000 kJ	5.0 - 6.0 m



Several adaptations are made to a standard catchment fence to reduce maintenance such as the brake locks pictured above.



A lower energy attenuator system composed of High Performance Netting in combination with standard hinged posts and base plates.

# Core Components - *simple design, simply the best*

Systems by Trumer are designed as simple as possible with regards to installation, maintenance and functionality. Why would you want it any other way?



The key component to all Trumer systems is the highly flexible Omega-Net that can be easily prepared with posts and ropes in compact packages for delivery by helicopter or crane. No shackles are required for attaching the net to bearing ropes.



The rope guidances on the posts and base plates are integrated and designed to be robust, giving the ropes smooth surfaces to glide over during an impact to help minimize fatigue. There is no assembly required.

One of our main goals when designing a rockfall mitigation structure is to make it as simple as possible, with as few components as necessary. Each component is designed to be robust and functional with safety in mind. Not only does this help create a system that will have optimal performance when needed, but also one that is simple to install and easy to maintain.

The design procedure is an ever evolving one, not just limited to Trumer's design team, but also including constant feedback from end-clients as well as contractors who install the systems and evaluate their performance in the field. It is only through such an interactive process that a high value product can be created.

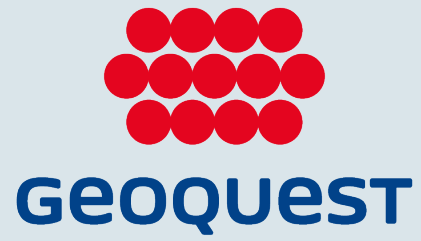


Brake elements are only found at the extremities of a system, directly at anchor points. All brake elements are connected with shackles to the ropes and can be easily changed. In this example, brake elements consist of large steel coils that unwind during impact.



A new generation of brake elements uses a roller to deform an angled steel strip in a very efficient and compact manner.





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