Debris flow barriers are designed on a site-to-site basis to protect infrastructure, utilities, buildings, and lives from debris flows and debris floods. Typical barriers are installed in run-out or deposition zones, close to the elements at risk that they protect or in series in the torrent channel. Each debris flow protection system is designed on a site-to-site basis, based on a thorough understanding of the debris flow characteristics.

Debris Flow Protection

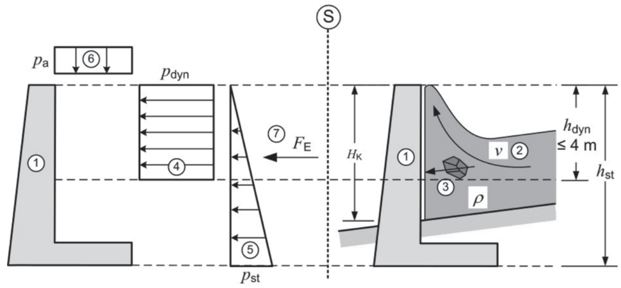
SAFETY WITHOUT COMPROMISE

Debris Flow Protection

The threat of climate change raising the global temperatures, potentially causes a change in weather patterns, thawing of permafrost areas, increasing wildfires, debris flows, and shallow landslide activity. The use of flexible-net barriers can be an efficient alternative to the other traditional and costly mitigation measures such as dams and other rigid barriers.

Unlike rockfall catchment fences, a technically correct solution involving flexible-net systems must be designed on a site-to-site basis. It should be based on a thorough understanding of the debris flow characteristics and loading parameters at any given site.

As there are currently no internationally accepted guidelines for the dimensioning of such barriers, designs are based on the state-of-the-art Austrian standard for debris flow mitigation structures entitled "ONR 24801: Protection works for torrent control – Static and dynamic actions on structures".



ONR 24801, Austrian Standards Institute 2013

1. Mitigation structure

2. Catching of debris flow

3. Impact of single blocks

4. Dynamic debris flow pressure

5. Static debris flow pressure

6. Dead load of settled debris

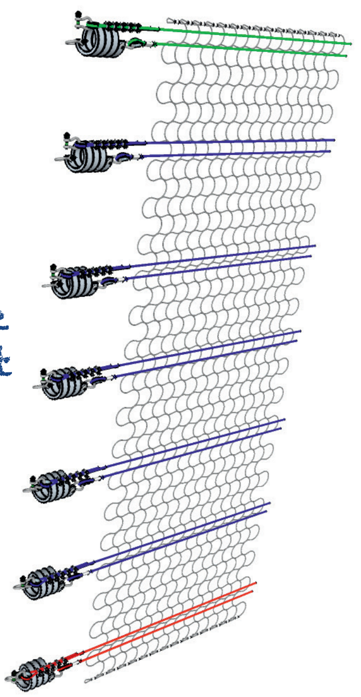
7. Impact load of single blocks

Gully Nets

Gully nets are the simplest style of debris flow barrier. They are designed to be installed in topographically confined channels, typically up to approximately 15 m in width. The shape and gradient of the channel have a large influence on the retention capacity of the system. When in steep terrain, they are often used in cascading series to help successively remove the debris along the transportation zone of the debris flow.

The system comprises of nets strung across the gully, perpendicular to the flow. Sets of bearing and middle ropes are attached to anchors, installed in the side slopes at approximately 1m intervals, depending on the loading parameters. Each rope has a brake element on opposing sides so that when they elongate, the net dœs not pull away from the sides of the channel.

Installation of gully nets can often be carried out using minimal equipment even in difficult terrain. As no posts are used, work is confined to the gully walls. However, if the ground is not scour resistant, it might be necessary to protect anchors through the use of riprap or concrete reinforcement.



Least invasive and very cost efficient

Gully nets have the following advantages after professional planning and installation:

- ☑ Low cost of materials
- ☑ Simple installation using minimal equipment
- ☑ Minimal disturbance of natural terrain
- ☑ Ability to reduce total debris volume in strategic positions along debris path
- ☑ Does not affect sediment flow under non-event conditions
- ☑ Low aesthetic impact on landscape

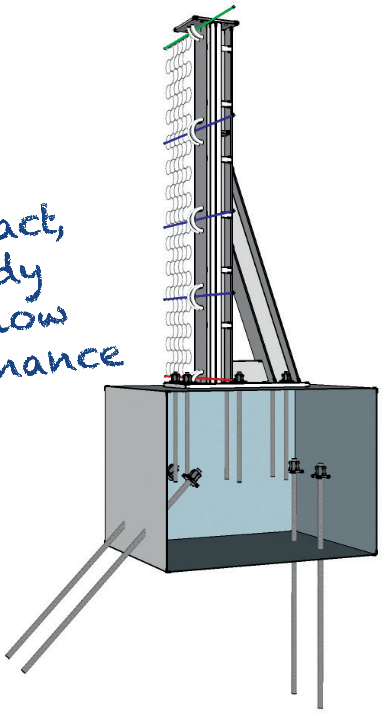
Debris Catcher
Delta Frame

The delta-frame Debris Catcher is a post-supported flexible-net barrier that can be installed in wide channels or along open slopes. The retention capacity of this system is controlled by the gradient of the slope and the height of the posts. An endlessly long system can be designed whereby independent sections are defined by internal anchoring of bearing ropes.

Nets are supported by the bearing and middle ropes that run through rope guidances on the posts. Nets are mounted on the upstream side of the posts, which are supported by a fixed brace on the downstream side. This means there is no need for retaining ropes to support the head of the post that would normally be found on the upstream side, directly in the path of the debris flow.

Posts have a fixed-rotation with respect to their base and hence require significant support to withstand the resulting bending moment. Typically, a reinforced concrete block is used to mount the post. The block is then independently anchored to the subsurface using soil anchors. In case the post is situated on bedrock or a man-made structure, it can be directly bolted to the surface.

Compact, sturdy and low maintenance



The delta-frame Debris Catchers have the following advantages after professional planning and installation:

- ☑ Cost efficient compared to similar rigid structures
- ☑ Not restricted to confined channels
- ☑ All support elements on downstream (protected) side of system
- ☑ Easy clean out and maintenance
- ☑ Does not affect sediment flow under non-event conditions
- ☑ Low aesthetic impact on landscape

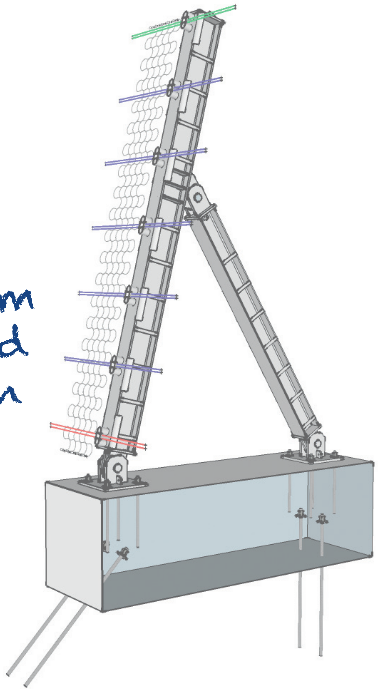
Debris Catcher
Lambda-Frame

The lambda-frame Debris Catcher is a post-supported flexible-net barrier that can be installed in wide channels or along open slopes. Functionally, it is similar to the delta-frame system but can be used for larger events. The retention capacity of the system is controlled by the gradient of the slope and the height of the posts. An endlessly long system can be designed whereby independent sections are defined by internal anchoring of bearing ropes.

Nets are supported by the bearing and middle ropes that run through rope guidances on the primary post beam at approximately 1 m intervals. Nets are mounted on the upstream side of the posts, which are supported by a removable brace on the downstream side. There is no need for retaining ropes to support the head of the post that would normally be found on the upstream side, directly in the path of the debris flow. Connections between posts, braces and base plates are made using a large diameter pin.

Posts have a fixed-rotation with respect to their base and hence require significant support to withstand the resulting bending moment. Typically, a reinforced concrete block is used to mount the base plates. The block is then independently anchored to the subsurface using soil anchors. In case the post is situated on bedrock or a man-made structure, it can be directly bolted to the surface.

Large system heights and easy clean out



The lambda-frame Debris Catchers have the following advantages after professional planning and installation:

- ☑ Cost efficient compared to similar rigid structures
- ☑ Not restricted to confined channels
- ☑ All support elements on downstream (protected) side of system
- ☑ Easy clean out and maintenance
- ☑ Does not affect sediment flow under non-event conditions
- ☑ Low aesthetic impact on landscape

Shallow Landslide Barriers

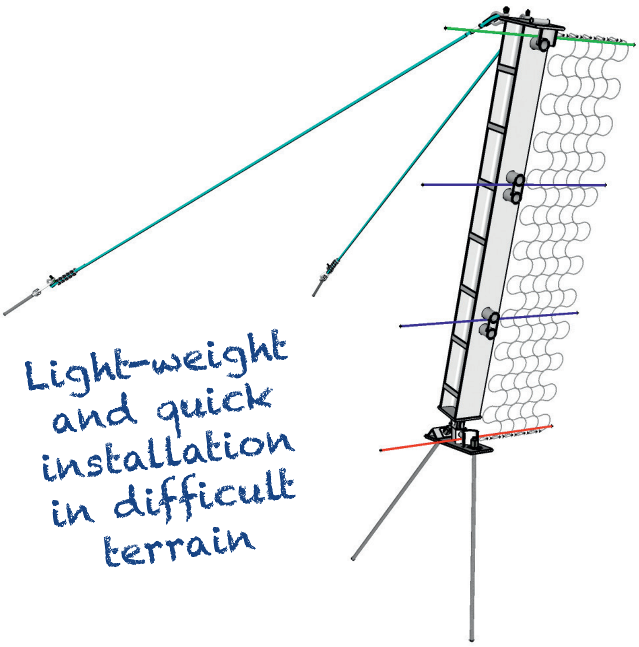
Shallow landslide barriers are systems evolved from rockfall catchment fences. As they are a post-supported system, they can be used in wide channels or along open slopes. These systems are especially suitable for the installation sites having difficult terrain.

The primary difference of this system from other debris flow systems is that the posts have a hinged connection to the base plate and hence, require upstream retaining ropes to support the head. The advantage is that this system can be built with lighter components. In addition, the anchorage requirements for the post base support are greatly reduced.

Nets are supported by the bearing and middle ropes that run through rope guidances on the posts and base plates. Nets are mounted on the downstream side of the posts. A small diameter pin is used to connect the post to the base plate.

Anchorage for the posts is typically provided using two soil or rock anchors: one on the tension side oriented at 45 degrees to the plate and the second anchor for compression at 90 degrees on the downstream side. Usually a micropile tube and/or small concrete pad are used to give additional support in soils.

In addition to shallow landslide barriers, traditional rockfall catchment fences can be adapted for debris flow and shallow landslide mitigation.



Light-weight and quick installation in difficult terrain

The shallow landslide barriers and modified rockfall catchment fences have the following advantages after professional planning and installation:

- ✓ Cost efficient installation
- ✓ Easy installation in difficult terrain
- ✓ Not restricted to confined channels
- ✓ Large variety of potential base systems
- ✓ Provides secondary protection against rockfall
- ✓ Does not affect sediment flow under non-event conditions
- ✓ Low aesthetic impact on landscape

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June, 2022