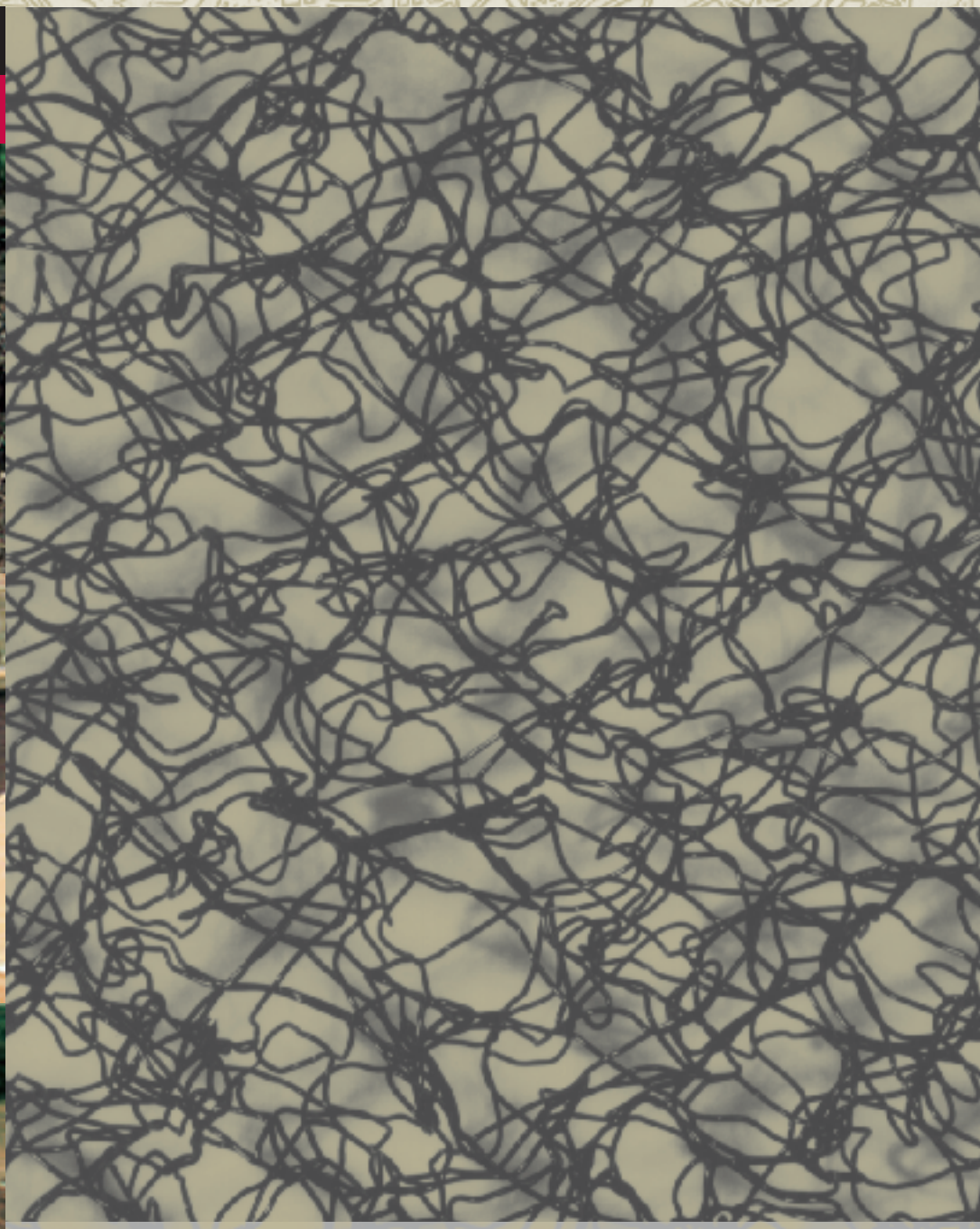
Enkamat®

Permanent Erosion Prevention Mat

EROSION CONTROL



COLBOND

Colbond

Colbond is a leading producer and supplier of high-quality synthetic nonwovens for flooring, automotive and construction applications and of three-dimensional polymeric mats and composites for civil engineering, building and industrial applications.

The company's production facilities are based in Emmen and Arnhem (NL), Obernburg (D), and Asheville (NC, USA). Regional sales offices are located all over the world. For product and application development, the company maintains a Development and Application Centre at the Arnhem head office and a Development Laboratory in Asheville.

Colbond is part of the Technical Textiles Division of Low & Bonar. Listed on the London Stock Exchange, Low & Bonar employs more than 2,700 people worldwide.

The range of specialty geosynthetic products for civil engineering includes Enkamat®, Enkadrain®, Enkagrid®, Colbonddrain® and Armater®. These products are used all over the world for erosion control, drainage, waste containment, soil reinforcement, stabilization and consolidation.

ISO 9001

The Quality Management System of Colbond at Arnhem, Emmen, Obernburg and Asheville has been approved by Lloyd's Register Quality Assurance to the NEN-EN-ISO 9001:2000 Quality Management System Standard (Certificate No. 935136).

Erosion - the problem

Erosion by wind and water often causes a great deal of inconvenience and considerable damage. Various erosion problems are too serious to be corrected by simple “natural” methods, such as planting vegetation, or using biodegradable products. Instead, an additional, permanent root reinforcement system is required that stops erosion, but is not in any way harmful to man or the environment.
This is where Enkamat comes in. It is designed for situations where nature alone cannot cope and where permanent erosion protection is essential.

Enkamat - the solution

Enkamat is a proven, lightweight, flexible alternative to rigid concrete, asphalt and stone riprap systems for controlling erosion. It is designed to help nature develop strong vegetation for permanent erosion protection of slopes, rivers, banks, ditches, channels, spillways, landfills, shorelines, and other vulnerable erosion-prone areas.

The structure

Enkamat is a dense three-dimensional permanent erosion prevention mat, made of thick polyamide filaments fused where they cross. Over 90% of the volume of the mat is available for soil filling, which ensures positive integration and immediate stabilization of slope surfaces, while providing an enhanced environment for seed germination. Once a layer of vegetation is established, Enkamat provides root systems with permanent reinforcement, resulting in an integrated, effective erosion control system. On steep slopes, Enkamat is sometimes used only with hydromulching acting as a protective layer.
Enkamat’s filament core structure slows down wind speed and percolating water, thus preventing erosion and even promoting sedimentation.

Enkamat -
keeping erosion under control

- **Integrated system**
  Enkamat has a three-dimensional structure which provides root systems with permanent reinforcement and offers an integrated, effective erosion control system.

- **Superior Area Holding Capacity**
  The quantity of soil which is retained in the mat is defined as Area Holding Capacity (AHC).
  Enkamat has a superior AHC. In addition, Enkamat's effective thickness is equal to its nominal thickness. The effective thickness indicates the AHC and can, as such, be considered as an indication of the performance of the mat.

- **Specific gravity**
  In contrast to mats of polypropylene or polyethylene, Enkamat's specific gravity exceeds 1.0 g/cm^3.
  (Erosion control mats with a specific gravity of less than 1 g/cm^3 will float in the water and are difficult to install.)

- **Multiwidth: economical installation**
  Enkamat can be supplied in widths up to 5.75 m and comes in different lengths. 5.75 m is the largest width available in erosion prevention mats and contributes to economical installation due to the reduced number of overlaps.
  The mats have to be pinned at the overlaps; the wider the mat, the less overlaps, and less pinning. Material cost savings can amount to 5% in dry applications with 100 mm overlaps and 15% in wet applications with 300 mm overlaps.
  It is only logical that less labour costs and faster installation go with the multiwidth.

- **Economies of scale**
  Enkamat is produced in large quantities because it is used all over the world. This allows for competitive prices, enabling selection of the best product for the various application areas at favourable costs.

Enkamat - the product range

The Enkamat range consists of various types of products.

Enkamat

A three-dimensional polyamide matting for immediate and permanent protection of all types of slopes. The open mat type, which has the same appearance on both sides, is particularly suited for use in erosion-prone situations where grass is also required. The tough filament core structure of Enkamat effectively prevents the soil from being eroded into a barren, channelled slope by rain and wind, but at the same time helps to reinforce the root system of the vegetation.

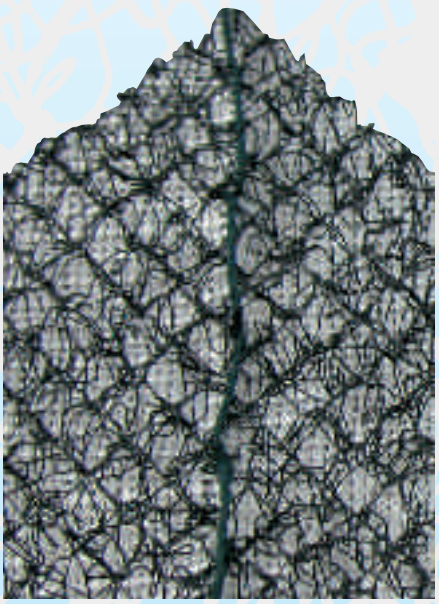
Enkamat flatback is a variant with a more closed, flat structure on the underside to enable 2 - 6 mm stone chippings (with which the mat is filled *after* installation) to be retained in the mat where no vegetation is present, usually below the water level and for low velocity streams and rivers or on reservoir banks. The filament core structure securely holds the stone chippings and provides protection below the water line.

Enkamat A

Enkamat A is a high performance special Enkamat, 22 mm thick, *prefilled* with a mineral filter of 2 - 6 mm chippings with a bitumen binder. The prefabricated permanent erosion mat is flexible and permeable and allows vegetation to grow through. Enkamat A is used where vegetation has little chance to develop, usually at and below the water level on the banks of watercourses.

Enkamat W

Enkamat W is a flexible lightweight geocomposite that consists of an Enkamat grip layer sewed to a reinforcing woven grid or fabric. The combination of the open-structured Enkamat and the high tensile strength woven grid or fabric renders Enkamat W very suitable for the use on steep slopes and slippery liners that require vegetation cover on a reinforced layer of soil.



Application areas

Enkamat is used in three main application areas.

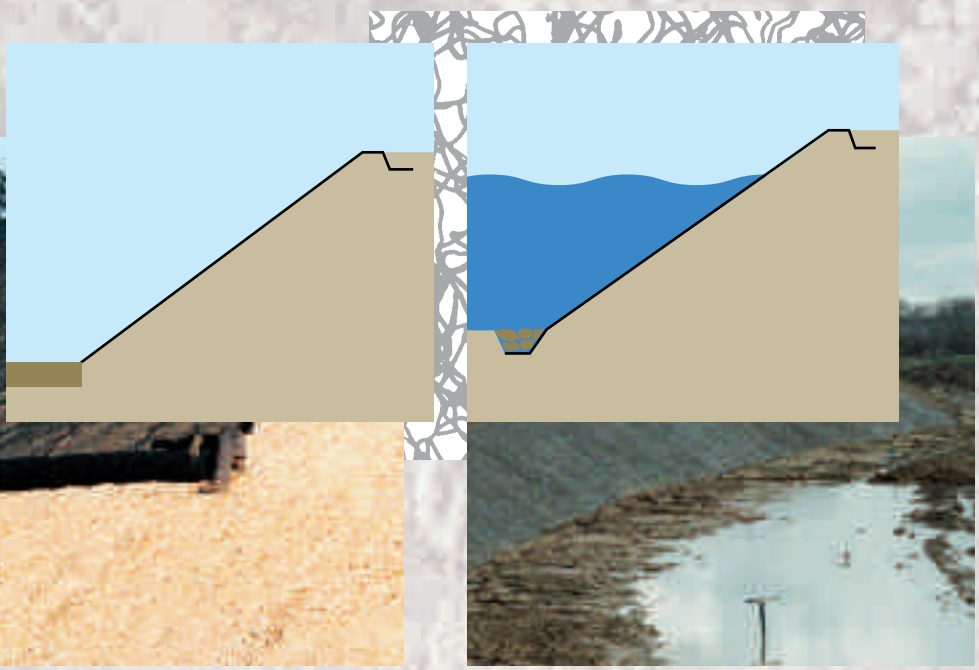
- **Erosion prevention for embankments and slopes**
- **Protection of river banks against erosion**
- **Support of vegetation on steep slopes and geomembranes**

Erosion control for embankments and slopes

Since **Enkamat** already offers adequate protection before any vegetation is established, it is often used to protect new or repaired embankments and slopes.
For example, road and railway embankments are protected by Enkamat, either seeded and filled with topsoil or hydroseeded after installation. Enkamat can keep the fertile soil fill and the germinating seeds in place, preventing the seeds from being washed out by heavy rain and encouraging active plant growth.
Although proper filling is most efficient, Enkamat may, under special conditions, be installed unfilled.
The matting must then be secured with extra pegs to ensure firm contact with the subsoil. When Enkamat is to be used to repair eroded banks, the surface has to be regraded. Any large holes must be filled and well compacted, and any potential surface water runoff channels should be diverted.

Protection of river banks against erosion

Dense vegetation is the basis of natural protection of banks against erosion. To achieve this, a strong root system is required, supported by an artificial root system or some other means. Green banks are an ecologically acceptable barrier which blends harmoniously into the landscape. This aspect is also increasingly being incorporated into the design and (re)construction of environmentally friendly banks for improving the habitat in residential and recreational areas.
On account of its high permeability, its weight (20 kg/m^2) and the immediate protection it offers with velocities up to approximately 2.5 m/s, the prefilled **Enkamat A20** is being widely used for bank protection, controlling erosive action at and below the waterline.
Standard **Enkamat** can be installed from approximately 0.50 m above the waterline. In this area, these types of Enkamat offer efficient protection.



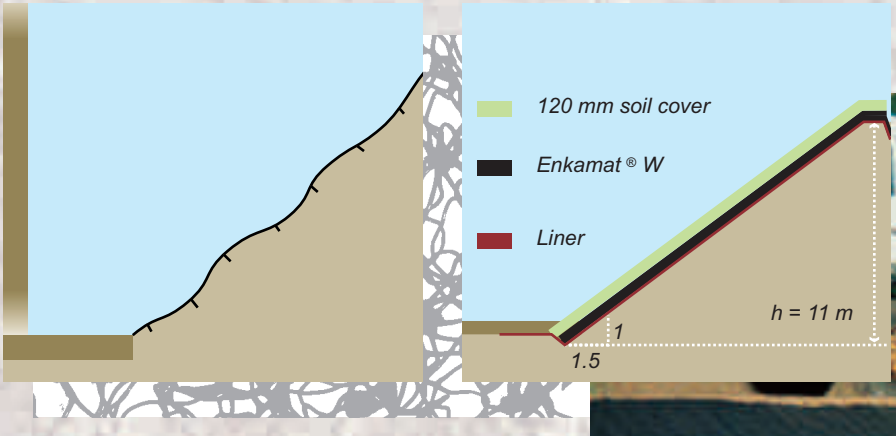
Support of vegetation on steep slopes and geomembranes

- **Vegetation on steep and rocky slopes**
  Enkamat 7010W/20PET is used for projects involving seeding on steep, rocky subsoil. Enkamat 7010W/20PET combines the mat's characteristic three-dimensional structure with an open PET reinforcing grid. This grid is made of high modulus polyester yarns, protected with a PVC coating. The combination of a matting structure with a high strength grid (18 kN/m) helps dense vegetation develop under the often unfavourable circumstances on rocky, eroded slopes. Enkamat 7010W/20PET forms a flexible grip layer in which soil is retained and seeds are encouraged to germinate.
  Enkamat 7010W/20PET is used on weathered rocky slopes in urban areas and on slopes in cut-and-fill situations in road construction.
  On very steep slopes, Enkamat 7010W/20PET is filled and seeded hydraulically.
  Creeping and climbing plants may also reinforce the vegetation.

- **Stabilization of earth on geomembranes and other smooth surfaces**
  Enkamat W is also used on slopes covered with geomembranes or which have other smooth surfaces that must be covered by a layer of soil upon which vegetation should develop. In such cases, a stable cover is established by the combination of the high tensile strength of the grid and the friction between Enkamat W and the soil. Enkamat W is anchored in a trench at the top of the slope.
  Examples of other applications of Enkamat W on slippery surfaces are rain and potable water reservoirs, lined with a geomembrane or geosynthetic clay liner.
  Enkamat W is also used on the inside of refuse dumps with geomembranes where durable protection against UV radiation and mechanical damage during tipping operations is required.

Special applications

Enkamat's vast potential also allows for applications other than erosion control and (re)vegetation, for example in playgrounds with natural grass and green parking areas. In these cases, Enkamat 7020 permits greater utilization. On soccer fields, for example, the use of Enkamat doubles or even triples the frequency in which the fields can be used.



Enkamat -
the right dimension in erosion prevention

- **Proven performance**
  Introduced in the Seventies, today over 18 million m^2 have been installed world wide.

- **International recognition**
  CIRIA (Construction Industry Research and Information Association), 1987
  Delft Hydraulics Lab, M 1421, report 116
  Karlsruhe University, 1983
  Silsoe University, 1984

- **Quality management**
  Colbond's materials are produced and supplied in accordance with the NEN-EN-ISO 9001:2000 Quality Management System Standard, certified by Lloyd's Register Quality Assurance under approval no. 935136.

- **Various types of products**
  Enkamat is available in various thicknesses. The range comprises several types, including Enkamat with a reinforcing grid and a type prefilled with 2 - 6 mm stone chippings bound with bitumen. It is available in various widths (1 - 5.75 m).

- **Permanent solution**
  Enkamat provides root systems with permanent reinforcement and offers an integrated, effective erosion control system.

- **Various application possibilities**
  Ranging from bank protection to stabilization of soil layers.

- **Tailor-made dimensions**
  For large quantities.

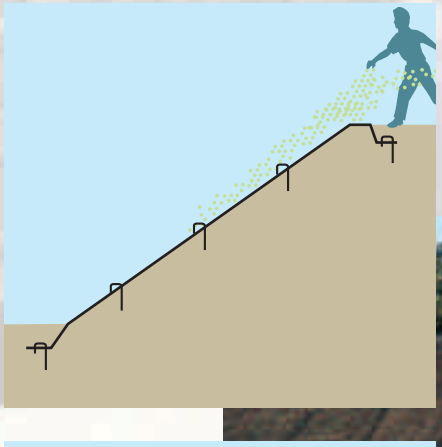
- **Excellent product properties**
  - light weight and high flexibility - thus easy to install
  - excellent bonding of the individual filaments
  - over 90% open spacing
  - non-toxic
  - high resistance to weathering and UV radiation
  - frost-proof
  - low flammability - does not support combustion

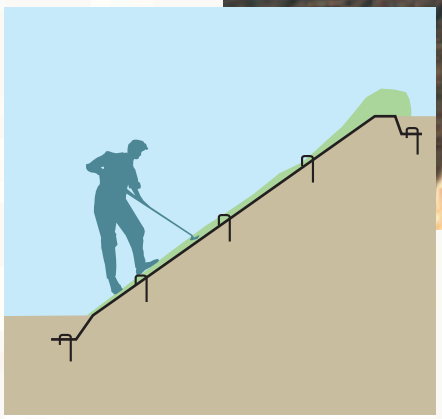
Installation

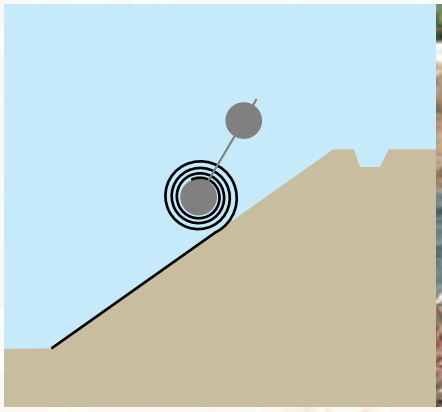
Integration of the roots with Enkamat's filament core structure provides the best possible protection for banks and embankments.
The embankment subsoil must be stable and the surface should be evenly graded. Cutting back is preferable to filling hollows in a slope, but large open areas and gullies need to be filled and well compacted.

After pinning Enkamat to the slope, the grass seed mixture selected should be placed into the matting at a rate of approximately 20-30 g/m^2.

Topsoil is then raked into the mat until the area is completely covered.
For the prefilled Enkamat A, the subsoil must be seeded before installation of the matting.
Enkamat flat-back below the water level is to be filled with stone chippings (2 - 6 mm) and also to approximately 0.5 m above the normal water level.
Always lay Enkamat from the downstream end with all overlaps upstream over downstream.
To ensure evenly distributed contact with the subsoil, Enkamat must be secured with pegs or pins. All edges (top, bottom and sides) should be firmly anchored in spade-deep trenches with pins. All overlaps should be pinned tightly. Any concentrated flow of surface runoff that could cause problems should be dealt with.
If rainfall causes some washout before vegetation has been established, replenish what is lost with friable topsoil.





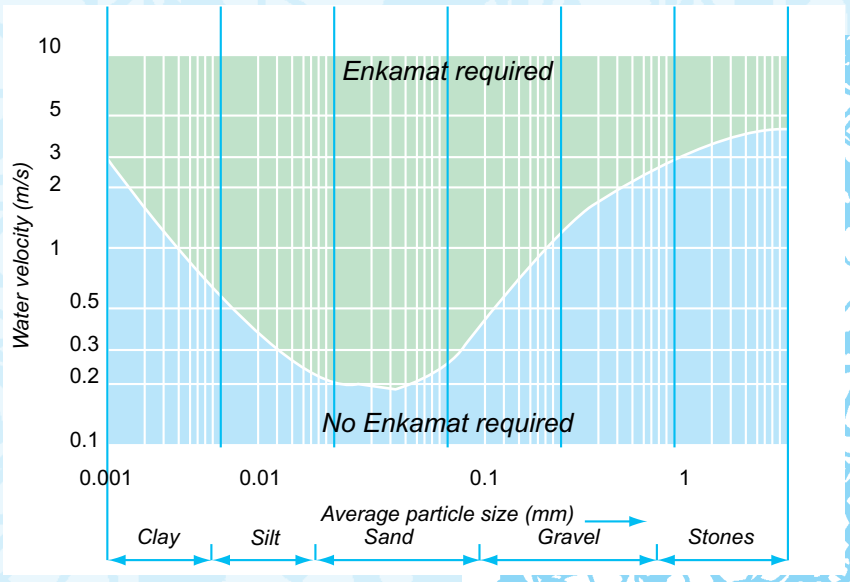


Design

In the simplified design method developed for the use of Enkamat, a distinction is made between use in wet and dry conditions.
***Wet conditions** are defined as applications where Enkamat is in contact with flowing water in streams, watercourses, ditches or waterstorm drainage channels.*
***Dry conditions** cover applications where no direct flow water along the mat occurs and erosion is only caused by rainfall.*

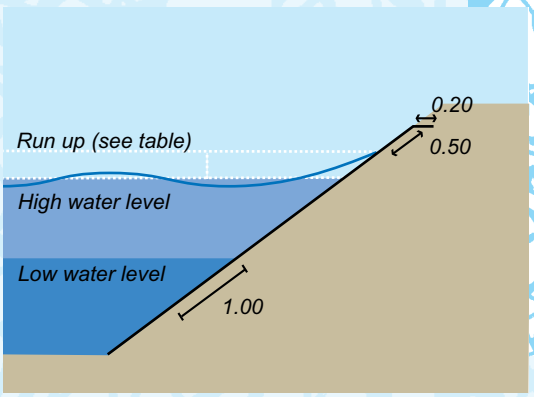
Wet conditions

1. Check the need for erosion protection with Enkamat.



2. Determine the length of the mat.

L = 0.20 + 0.50 + (run-up + (HW-LW) x conversion factor) + 1.00



Run up

Wave run up (m) *(measured vertically above the high water level)*, depending on significant wave height (Hs) and slope angle. The run-up height and the difference between HW and LW have to be multiplied by the slope conversion factor to find the length of the mat on the slope.

Wave height Hs (m) \ Slope	1 : 2	1 : 3	1 : 4
0.10	0.40	0.25	0.20
0.20	0.80	0.55	0.40
0.30	1.20	0.80	0.60

Conversion factor

Slope (v:h)	Conversion factor
1 : 1	1.40
1 : 2	2.25
1 : 3	3.15
1 : 4	4.10

3. Select mat type:

- determine the maximum flow in the period with **no** vegetation (v - no vegetation)
- determine the maximum time for this flow (t - no vegetation)
- determine the maximum flow in the period **after** permanent vegetation has developed (v - permanent)
- determine the maximum time for this flow in a condition of permanent vegetation (t - permanent)

The flow v can be calculated e.g. by using a channel design method, applying Manning's equation:

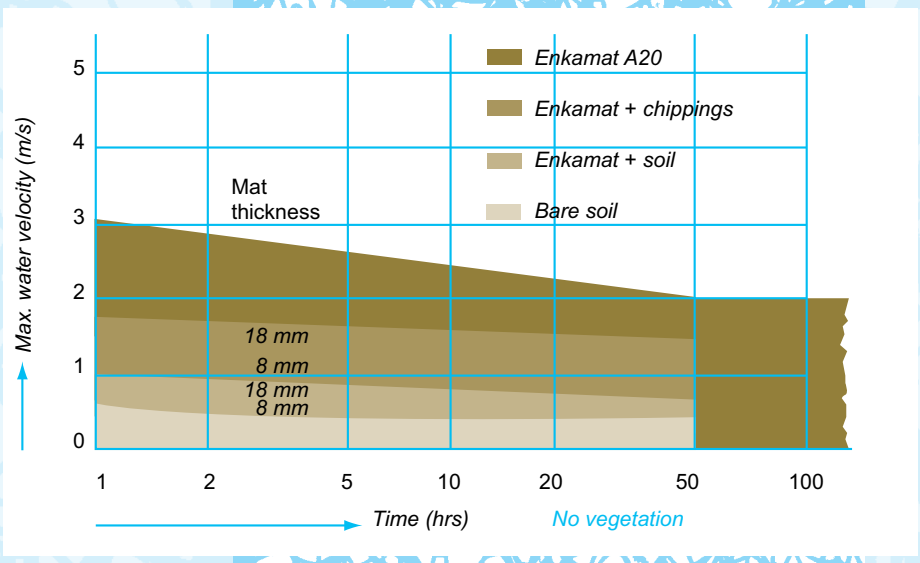
$$v = k_m \cdot r_{hy}^{2/3} \cdot i^{1/2}$$

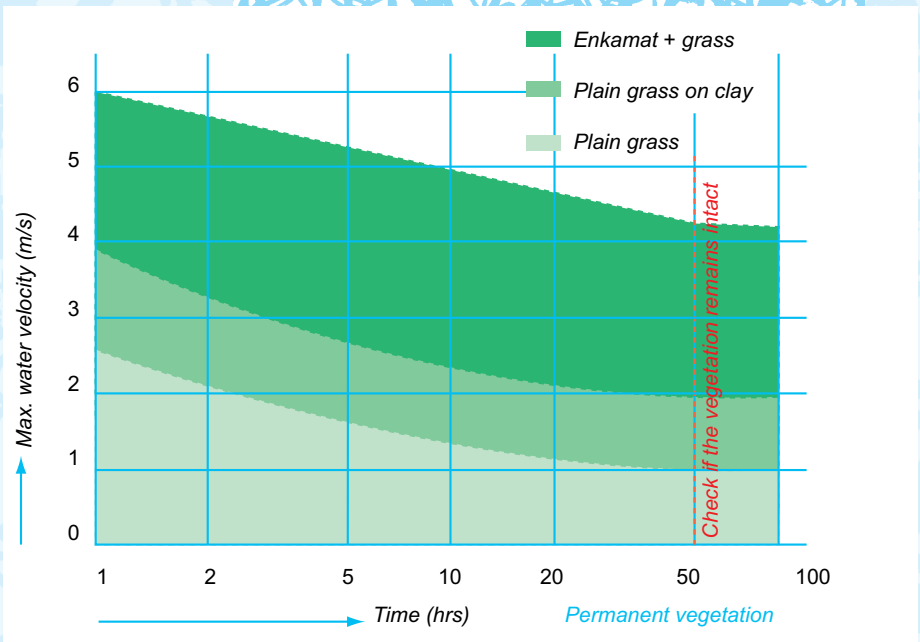
with

v	=	velocity (m/s)
i	=	hydraulic gradient
r_{hy}	=	hydraulic radius (m)
k_m	=	Manning's roughness coefficient ($m^{1/3}/s$)

For calculations with Enkamat $k_m = 52$ ($m^{1/3}/s$)

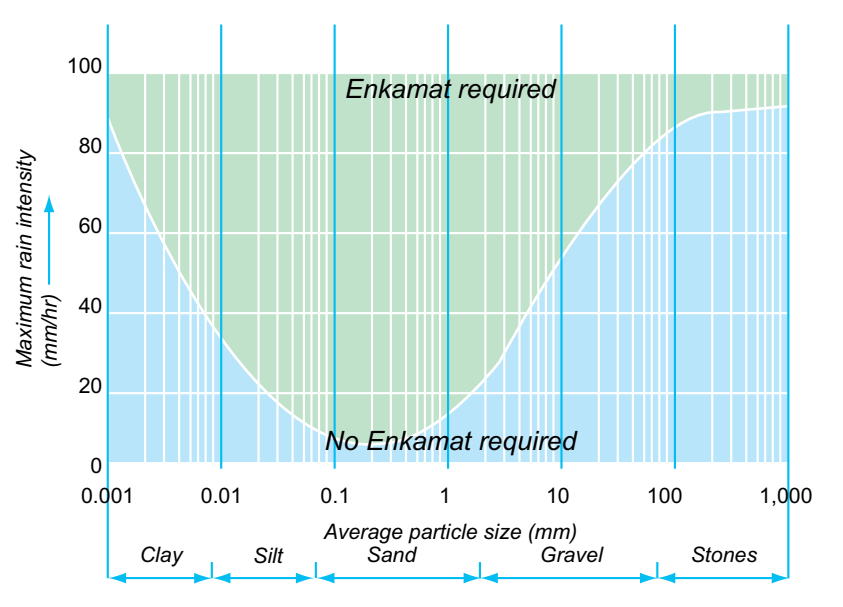
Select the mat types based on the most critical conditions using the following graphs.





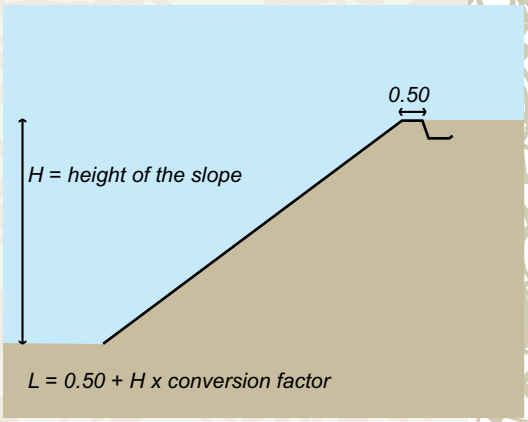
Dry conditions

1. Check the need for erosion protection with Enkamat.



2. Determine the length of the mat.

For anchoring details see installation manual.

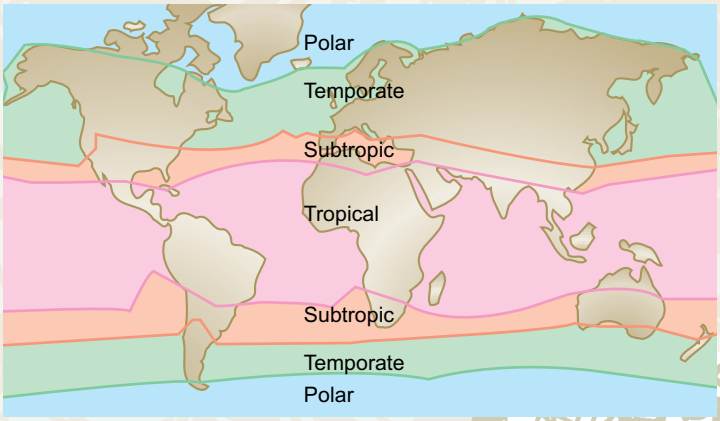


The height has to be multiplied by the conversion factor to find the length of the mat on the slope.

Slope (v:h)	Conversion factor
1 : 1	1.40
1 : 2	2.25
1 : 3	3.15
1 : 4	4.10

3. Determine the type of the mat.

Determine the required volume of rainfall in the month after installation for relatively rapid germination, related to the temperature and the climatic area.



Required, mean volume of rainfall (mm/month) necessary for vegetation.

Temperature °C Climate	**10-15**	**15-20**	**20-30**	**30-40**
Tropical **Humid** **Arid**			**90** **130**	**110** **165**
Subtropic **Humid** **Arid**	 **Winter** **Summer** **Winter** **Summer**	 **30** **75** **75** **90**	**90** **145**	**110** **200**
Temporate **Humid** **Arid**	 **30** **70**	 **70** **90**	**90** **110**	**130** **165**

Compare this volume of rainfall with what you expect to get.

A. Germination effects:
When you expect enough rainfall → "germination factor" = 2
In case you expect less rainfall or temperatures less than 10°C → "germination factor" = 3
If you do not know if you will get enough water → "germination factor" = 3

B. Slope angle effects:
Determination of the "slope effect factor":

Slope (v:h)	**"Slope effect factor"**
1 : 3 and smoother	**1**
1 : 2.5	**2**
1 : 2	**3**
1 : 1.5	**4**
1 : 1 and steeper	**5**

Select mat type:
"germination factor" + "slope effect factor" ≤ 5 → Enkamat with thickness of 8 mm
"germination factor" + "slope effect factor" > 5 → Enkamat with thickness of 18 mm

Enkamat - product details

Dimensions and weights

Enkamat	Type	Thickness mm	Tensile strength	
	Open matting			
	7010	10	1.6 kN/m	
	7018	18	1.8 kN/m	
	7020	20	2.0 kN/m	
	With flatback			
	7220	18	1.9 kN/m	
	With reinforcement (W types)		Characteristic strength	
	7010W/80.30PP	11	80 kN/m	
	7010W/200.50PET	11	200 kN/m	
	Prefilled			
	A 20	22	n.a.	Weight 20 kg/m^2

The above dimensions and weights are indicative values which can vary slightly.

Roll dimensions
Enkamat can be supplied in 1.0; 1.95 and 3.85 m wide rolls.
Enkamat 7010 is available in up to 5.75 m wide rolls.
Enkamat 7010W mattings are 4.90 m wide.
The length of the rolls varies between 50 and 150 m, depending on which type and width is selected.
Enkamat A20 mattings are 4.80 m wide and 20 m long.

Contact your national agent to obtain detailed product data sheets.

Material properties

Polymer type:
Polyamide 6

Enkamat density:
Approximately 25 kg/m^3

Strength at filament crossing points:
Excellent because of total fusion of the filaments where they cross.

Ageing:
Good resistance to weathering and UV radiation because of the addition of carbon black and UV stabilizers.

Chemical resistance:
Resistant to all chemicals in concentrations which are normally contained in the earth and surface water.

Temperature resistance:
From -30°C to +100°C; can easily be installed during winter periods.

Flammability:
Low flammability and low smoke formation; approved for use in tunnels.

Toxicity:
None; approved for use in potable water reservoirs; Enkamat is inert and not harmful to the environment.

Rodent damage:
No nutritive value; the tangled structure of the mat is unpleasant to burrowing animals and rodents.

Material specifications

Enkamat type 7010
The erosion prevention mats are a three-dimensional filament structure polyamide mattings with a thickness of 10 mm and supplied in rolls 1.00/1.95/3.85/5.75 m wide. The length of the mat is 150 m. The free volume is 95%, the AHC* 9.7 x 10^6 mm^3/m^2. The specific gravity of the polymer is 1.14 g/cm^3.

Enkamat type 7018
The erosion prevention mats are a three-dimensional filament structure polyamide mattings with a thickness of 18 mm and supplied in rolls 1.0/1.95/3.85 m wide. The length of the mat is 120 m. The free volume is 95%, the AHC* 17.7 x 10^6 mm^3/m^2. The specific gravity of the polymer is 1.14 g/cm^3.

Enkamat type 7020
The erosion prevention mats are a three-dimensional filament structure polyamide mattings with a thickness of 20 mm and supplied in rolls 1.0/1.95/3.85 m wide. The length of the mat is 100 m. The free volume is 95%, the AHC* 19.7 x 10^6 mm^3/m^2.
The specific gravity of the polymer is 1.14 g/cm^3.

Enkamat type 7220
The erosion prevention mats are a three-dimensional filament structure of polyamide mattings with a flatback and thickness of 18 mm.The rolls are 1.0 m wide.The length of the mat is 60 m. The free volume is 95%, the AHC 19.7 x 10^6 mm^3/m^2.The specific gravity of the polymer is 1.14 g/cm^3.

* AHC - Area Holding Capacity

Enkamat type A20
The erosion prevention mats are a three-dimensional filament structure polyamide mattings with a thickness of 22 mm and supplied in rolls 4.80 m wide. The length of the mat is 20 m. The mat is factory filled with 20 kg/m^2 of bilumen bound aggregate. The fill has a water permeability of 30 $l/(s \cdot m^2)$ at 100 mm head.

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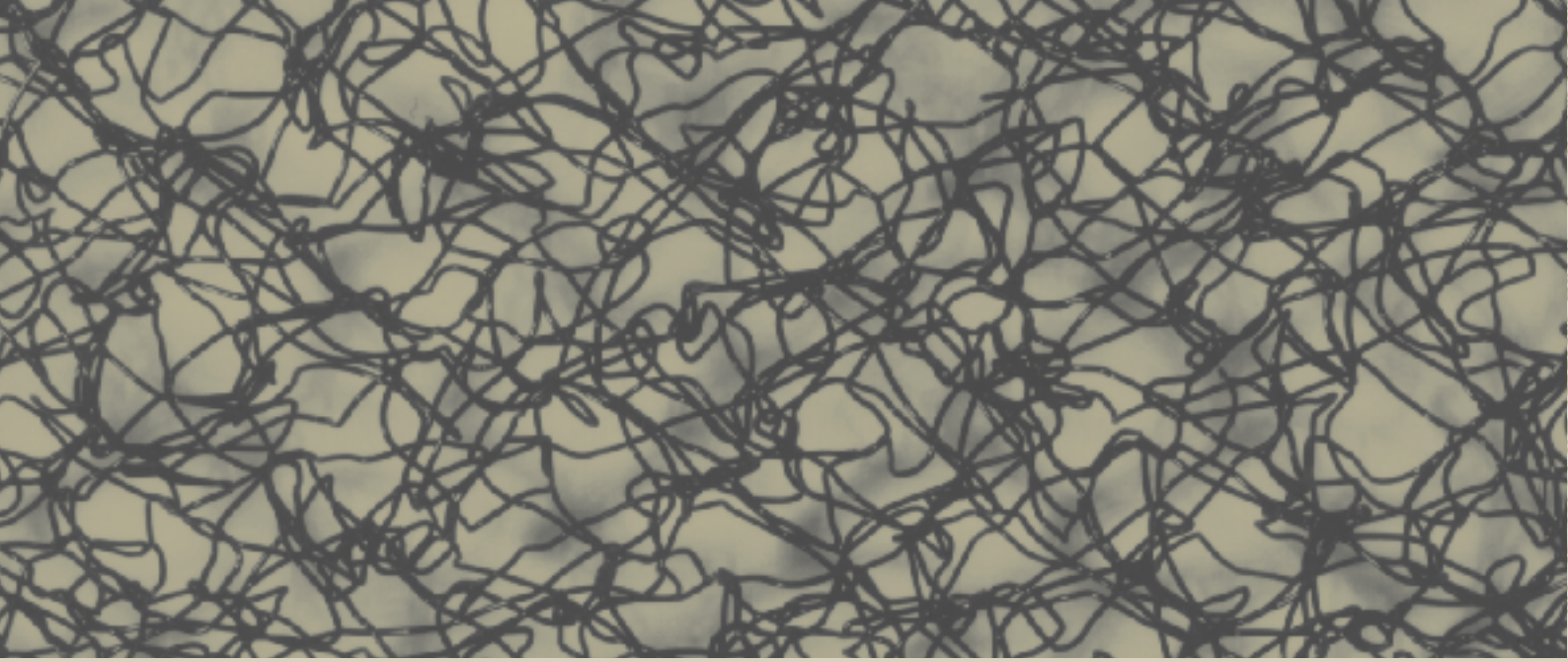

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