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Application of neoweb for landslide prevention in northern mountainous areas

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KEYWORDS

Retaining wall
Landslide
Neo - web materials
Pressure
Slope
Gravity

ABSTRACT

The northern mountainous region of Vietnam frequently faces severe landslides, especially during the rainy and stormy seasons. Provinces such as Lào Cai, Yên Bái, Hà Giang, Sơn La, and Hòa Bình are considered high-risk areas, with hundreds of landslides occurring each year. These events cause serious damage to lives, property, infrastructure, and disrupt transportation and the daily lives of local communities. The primary causes stem from steep mountainous terrain, weak soil structure, and prolonged heavy rainfall that saturates the soil, weakens its cohesion, and makes it prone to slipping. Given this reality, it is essential to research and apply effective and sustainable landslide prevention solutions. Therefore, the study on "Application of Neoweb for Landslide Prevention in Northern Mountainous Areas" plays a crucial role. Neoweb enhances slope reinforcement, distributes loads, and improves drainage efficiency. It helps stabilize slopes, reduce water pressure, and minimize surface erosion.

1. Introduction

According to statistics, from the beginning of 2024 until now, natural disasters have caused 104 deaths and missing persons, most of whom were victims of landslides or flash floods. The total estimated damage is around 2,000 billion VND. The northern mountainous region of Vietnam consists of 15 provinces, accounting for 28.8 % of the country's total natural area. This region is characterized by high mountain ranges, deep valleys, steep slopes, and weak geological foundations. In recent years, due to climate change, these provinces have frequently suffered damage from flash floods, mudflows, and landslides [1].

Figure 1. Image of unstable slope and talus.

In the context of increasingly complex natural disasters, the Government, along with relevant ministries, sectors, and local authorities, has actively implemented various measures to minimize loss of life and property caused by landslides, flash floods, and mudflows. Key efforts have focused on installing early warning systems in high-risk areas, developing landslide hazard maps, and placing warning signs in vulnerable locations.

To mitigate the damage caused by landslides triggered by flash floods-especially in the northern mountainous provinces-multiple solutions have been applied, such as the construction of retaining walls, gabions, ground anchors, anti-erosion grass cover, and surface and summit drainage systems along slopes and embankments. However, the effectiveness of these measures has not yet met expectations.

The underlying reasons lie in the complex geological, topographical, and hydrological characteristics of the region. These factors lead to changes in groundwater saturation paths, seepage pressure, soil mass weight, and flow hydraulics. As a result, swirling water currents erode weak soil areas, forming overhangs (undercuts) that trigger landslides. Additionally, construction activities increase the load on soil foundations, generating pressure that causes soil compression, upward heaving, instability, and ultimately structural failure.

That is the reason the author gives: *"Application of Neoweb for Landslide Prevention in Northern Mountainous Areas"*.

2. Experimental research

2.1. Research materials

Neoweb is an innovative material offering sustainable and efficient solutions in civil engineering, particularly in soil stabilization, erosion control, and infrastructure development. Its adaptability and high performance make it especially useful in challenging environments such as mountainous or flood-prone regions.

Neoweb material is a perforated and textured honeycomb-shaped cellular network, made from a new composite blend of multiple polymers arranged in a uniform structure. When filled with infill materials, it forms an integrated geotechnical system in which the cell walls and the confined materials work together to enhance the mechanical and geotechnical properties.

Neoweb is manufactured in panel form, with cell walls welded together. Each panel undergoes strict quality control during both the production and testing processes to ensure performance and durability.

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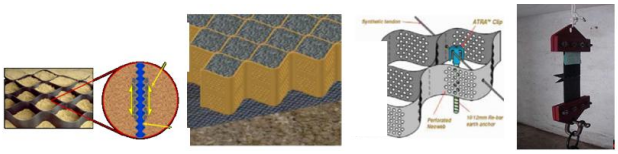


Figure 2. Neoweb material separation system.

The soil separation, stabilization and reinforcement system has been developed, manufactured and commercialized. The Neoweb material can be combined with a wide range of backfill materials. The soil separation holds and protects the backfill materials inside in three directions, providing high tensile strength in each direction. Its lattice-shaped cell structure and its synchronous polymer synthesis create the desired solid reinforcement.

The Neoweb material also has many different sizes. According to the size of the cell, Neoweb is divided into 3 types: Standard cell size (NWS) (21x25 cm), medium cell size (NWM) (29x34 cm) and large cell size (NWL) (42x50 cm). According to the height, Neoweb is divided into 5 commonly available types: 5, 7, 10, 15, and 20 cm. Depending on different design requirements, choose the type of Neoweb that is technically suitable [2][3].

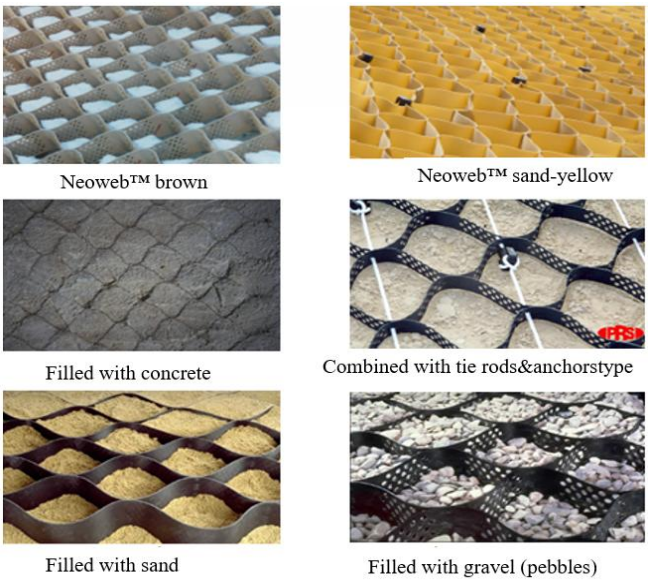


Figure 3. Neoweb combinations with other materials.

2.2. Specifications of The Neoweb material

The characteristic standards of Neoweb material are presented in Table 1, Table 2, Table 3.

Table 1. System of material property indices Neoweb material.

Nature	Temperature	Deformation			Experimental method	Unit, note
		1 %	2 %	3 %		
Tensile modulus	23°C	900	650	400	ISO 10319 ASTM D 4595	KN/m±5 %
	45°C	650	480	280		
Tensile stress	23°C	9	13	20		
	45°C	6.5	9.5	14		

Table 2. Technical specifications of Neoweb material.

Nature	Describe	Experimental method	Note
Tensile strength at yield limit	50 mm : 1.22 KN	ISO 10319	±5 %
	75 mm : 1.83 KN		
	100 mm : 2.44 KN		
	150 mm : 3.66 KN		
	200 mm : 4.88 KN		
Elongation at break	>600 %	ISO 10319	±5 %
Long term durability of joints	Obtain	ASTMST P 1437(1) (AAS HTOT-307-99)	1x10e7 overcome repetitive dynamic load 300 kPa
Joint strength	50 mm : 2.02 KN	ISO 13426-1	Angle 90±5 %
	75 mm : 3.10 KN		
	100 mm : 4.05 KN		
	150 mm : 6.06 KN		
	200 mm : 8.10 KN		

Nature	Describe	Experimental method	Note
Burst strength at 180	50 mm : 1.13 KN	ISO 13426-1	±5 %
	75mm : 1.70 KN		
	100 mm : 2.26 KN		
	150 mm : 3.39 KN		
	200 mm : 4.52 KN		
CTE (coefficient of thermal expansion)	160-200 deformation/0C	ASTM D 696-03	

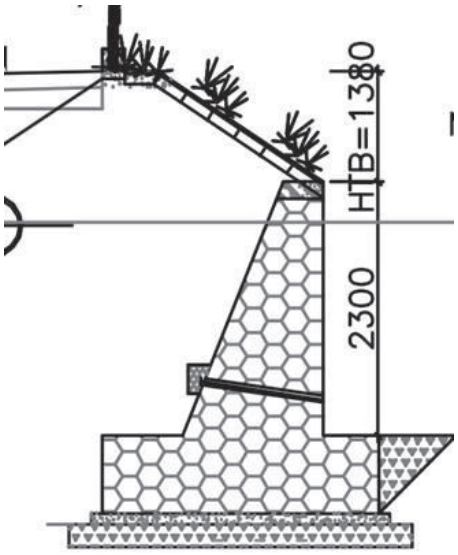
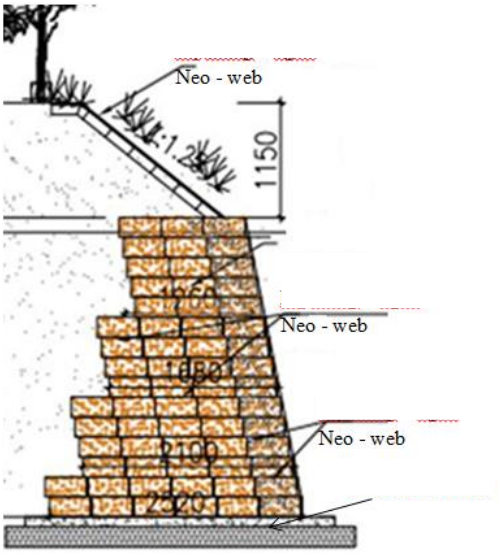
Table 3. Plate geometric characteristics – 3 types of: NWS, NWM, NWL.

Nature	Describe	Note
Height of the plate	50 mm, 75 mm, 100 mm, 150 mm, 200 mm.	For all types: NWS, NWM, NWL
Distance between joints	NWS: 330 mm ± 3 %	The plane being measured
	NWM: 445 mm ± 3 %	
	NWL: 660 mm ± 3 %	
Compartment size (according to standard opening)	NWS: 250 mm x 210 mm ± 3 %	Will change during opening
	NWM: 340 mm x 290 mm ± 3 %	
	NWL: 500 mm x 420 mm ± 3 %	
By Cell Density (standard aperture)	NWS: 39 cells/m^2 ± 3 %	Will change during opening
	NWM: 22 cells/ m^2 ± 3 %	
	NWL: 10 cells/ m^2 ± 3 %	
Compartment area (according to standard opening)	NWS: 265 cm^2 ± 3 %	Will change during opening
	NWM: 493 cm^2 ± 3 %	
	NWL: 1050 cm^2 ± 3 %	
Standard cross-sectional dimensions (according to standard open)	NWS: 2.5m x 8.0 m ± 3 %	Will change during opening
	NWM: 2.8 m x 10.7 m ± 3 %	
	NWL: 2.5 m x 16.0 m ± 3 %	
Standard cross-sectional area (according to standard opening)	NWS: 20 m^2 ± 3 %	Will change during opening
	NWM: 30 m^2 ± 3 %	
	NWL: 40 m^2 ± 3 %	
Other Sizes	Made to order	

3. Research results and discussion

3.1. Comparison of conventional retaining wall structure with retaining wall using Neoweb material

Content	Retention building wall solutions	Retention wall solution using neoweb material
Structural description	Overhead revetment structure: + No reinforcement, only grass to prevent erosion Revetment Structure Below: Rubble retaining wall + Retaining wall with slope 5:1, + Thick stone foundation 1 m. + High retaining wall 3 ÷ 4 m	Overhead revetment structure: + No reinforcement, only grass to prevent erosion Revetment Structure Below: wall solution using neoweb material 660-200 + Neoweb material 660-200; Cell height 200 mm + Nails consist of 2 thick layers 40 cm + High retaining wall 3 ÷ 4 m

Typical structure		
Technical requirements	+ Hard structure so prone to local damage. + Heavy structures can affect the bearing capacity of the ground. + Surface has low aesthetic value. 	+ Ensure technical requirements during both construction and operation phases. + Soft texture is flexible so the image is damaged locally. + Surface has high aesthetic value. 
Construction	+ Complex construction. + Construction time is long because of having to produce grass planting boxes and surface slats.	+ Simple construction. + Fast construction time.
Project life	+ Low construction life. Especially depends on construction quality.	High construction life. Neoweb materials are warranted for 30 years.
Quality control	+ Difficult to control quality, especially the quality of the connection between grass plots.	+ Easy to control material quality as materials are tested in the Factory.

3.2. Concept of retaining wall

A retaining wall is an engineering structure designed to stabilize embankments or excavation slopes, preventing landslides or soil erosion. These structures are widely used in civil construction, transportation, and irrigation works. In operation, the retaining wall is directly subjected to the pressure exerted by the soil mass behind it, primarily the earth pressure.

During the design process, accurately and comprehensively calculating the loads acting on the wall-especially the active earth pressure-is a critical requirement. This ensures not only the safety and stability of the structure but also contributes to reducing construction costs. [4].

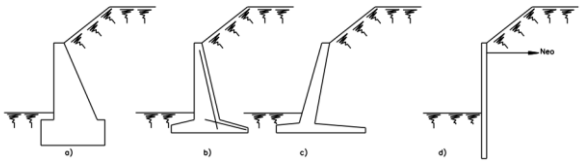


Figure 4. Types of retaining walls.

3.3. Technology of building retaining walls using Neoweb materials

The construction of retaining walls plays a crucial role in maintaining the stability of infrastructure in sloped and mountainous areas. This not only helps extend the lifespan of structures but also ensures safety and stability for surrounding communities. In this context, the application of Neoweb cellular confinement technology in retaining wall construction offers significant advantages in terms of technical performance, construction efficiency, and environmental impact.

Technical aspects: Neoweb retaining walls function similarly to gravity walls, providing overall slope stabilization. As a flexible retaining solution, they are highly adaptable and particularly effective in resisting localized settlement. This makes them well-suited for areas with weak soil foundations or seismic risk. Constructed using 20 cm thick Neoweb layers, the system enhances lateral drainage capacity, minimizing damage caused by internal water pressure.

Construction aspects: Neoweb retaining walls feature a simple construction process and can be implemented under a variety of weather conditions. Compared to reinforced concrete (RC) or rubble masonry retaining walls, construction time is reduced by approximately 30 %. The technology does not require specialized equipment and allows for the efficient use of local labor and materials.

Environmental aspects: By utilizing local fill materials, Neoweb walls help reduce emissions generated during material transport and construction. Additionally, the outer surface of the wall can be landscaped with grass or flowers, creating an environmentally friendly and visually appealing slope. This makes Neoweb an ideal choice for resorts, eco-tourism destinations, and nature-based developments.

Structural aspects: The perforated Neoweb panel system allows concrete to flow through the cells, increasing the friction between the concrete and the cell walls. This results in a more robust and stable structure for the wall's edge and improves overall integrity.

Figure 5. Neoweb combinations with other materials for road construction and slope protection.

3.4. Some applications of Neoweb material in retaining wall construction

+ This is the most common and typical type of retaining wall in applications involving Neoweb for wall reinforcement. The gravity retaining wall consists of 20 cm thick Neoweb layers stacked on top of each other. The wall slope ratio (vertical/horizontal) ranges from 1:1 to 6:1 (45°–8.1°). This type of wall is suitable for wall heights (H) ranging from 1 to 6 meters. For slopes higher than this range, the embankment should be divided into multiple smaller tiers, with each tier meeting the required height specifications mentioned above.

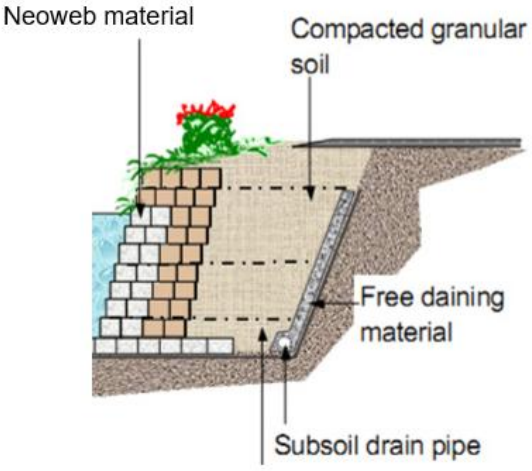


Figure 6. Structure of gravity retaining wall using Neoweb material to protect slopes.

+ The reinforced Neoweb retaining wall is suitable for locations with limited excavation space. It consists of equally sized 20 cm thick Neoweb layers stacked on top of each other, combined with geogrid reinforcement (or reinforced Neoweb layers). The wall slope ratio (vertical/horizontal) ranges from 1:1 to 6:1 (45 °– 8.1 ° relative to the horizontal). This type of wall can be used for heights ranging from 3 to 12 meters. For slopes exceeding this height, the embankment should be divided into multiple smaller tiers, with each tier conforming to the specified height requirements.

Figure 7. Structure of reinforced gravity retaining wall using Neoweb material.

4. Conclusion

Research: "Application of Neoweb for Landslide Prevention in Northern Mountainous Areas" some conclusions can be drawn as follows:

+) With high flexibility and the ability to resist local subsidence, the construction of retaining walls using layers of Neoweb material 20 cm thick significantly increases the horizontal drainage capacity, helping to increase the overall stability of the slope.

+) Neoweb retaining walls are simple and easy to construct in all weather conditions and can utilize local filling materials. Therefore, construction time is shortened and more economical.

+) Retaining walls using Neoweb materials use in-situ filling materials to help reduce emissions to protect the environment. In addition, the outer surface of the retaining wall using Neoweb materials can be planted with flowers and grass to create a green slope.

Thus, using Neoweb material combined with backfill material to overcome landslides in steep terrain areas in the north is a useful, safe and sustainable solution.

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