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Flexible Concrete Blankets for Slope Stabilization and Erosion Control

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ABSTRACT

Concrete blankets, also referred to as Geosynthetic Cementitious Composite Mats (GCCMs), are an innovative class of construction materials used for rapid slope protection, erosion control, and infrastructure lining. They consist of a dry concrete mix encapsulated between layers of geotextiles and fiber meshes that harden upon hydration. Unlike conventional rigid concrete systems, concrete blankets are flexible before setting and conform easily to irregular surfaces. This paper presents a comprehensive technical review of concrete blankets with emphasis on their composition, manufacturing concept, mechanical properties, durability, and field applications. It also discusses installation methodology, testing procedures, and performance evaluation based on experimental and field studies. Results reported in literature indicate compressive strengths of 30–45 MPa, high erosion resistance, and long-term durability under harsh environmental conditions. The study concludes that concrete blankets provide a sustainable, efficient, and cost-effective alternative for slope stabilization, especially in remote and difficult terrains.

Keywords: Concrete Blanket, GCCM, Slope Stabilization, Erosion Control, Geosynthetics, Sustainable Construction.

1. INTRODUCTION

Slope instability and surface erosion are major challenges in civil engineering, particularly in projects involving highways, railways, canals, embankments, and river training works. Unprotected slopes are vulnerable to rainfall, runoff, wind, and human activities, leading to soil loss, structural damage, and environmental degradation. Conventional protection methods such as stone pitching, shotcrete, and cast-in-situ concrete linings are effective but often require heavy equipment, skilled labor, and long curing time.

Concrete blankets represent a new generation of construction materials designed to overcome these limitations. They are supplied in rolls and can be rapidly unrolled and hydrated on site. Before hydration, the material is flexible and easy to handle. After hydration, it sets into a thin, durable concrete layer reinforced with fiber meshes. This dual behavior, flexible when dry and strong when set, makes concrete blankets particularly suitable for slope stabilization, erosion control, and channel lining.

The increasing demand for sustainable and rapid construction solutions has further accelerated the adoption of concrete blankets. Their reduced thickness, minimal waste generation, and fast installation time contribute to lower environmental impact and project costs. This paper aims to provide a detailed review of concrete blanket technology, its material characteristics, installation methods, and performance in civil engineering applications.

2. LITERATURE REVIEW

Historical Development of the concrete blanket.

The concept of concrete blankets originated in the early 2000s with the development of Geosynthetic Cementitious Composite Mats (GCCMs) in the United Kingdom. Researchers and manufacturers sought a material that could combine the durability of concrete with the flexibility of geotextiles. Early studies demonstrated that encapsulating dry concrete between geotextile layers allowed for rapid deployment and hydration in situ.

Over time, concrete blankets have been used in military, mining, and infrastructure projects due to their ability to provide fast and reliable surface protection. Research from Europe, the USA, and Asia has shown that GCCMs significantly reduce installation time compared to traditional methods while offering comparable or superior durability.

2.1 Mechanical Properties

Mechanical performance is a key parameter in evaluating concrete blankets. Studies report compressive strengths ranging from 30 to 45 MPa after 28 days of curing. Flexural strengths typically range from 4 to 6 MPa, which helps resist cracking under bending and impact loads. The fiber reinforcement improves tensile resistance and controls shrinkage cracking. Impact resistance and abrasion resistance are also important. Concrete blankets show excellent resistance to erosion caused by flowing water and debris, making them suitable for channel linings and drainage structures.

2.2 Durability and Environmental Resistance

Durability studies indicate that concrete blankets perform well under freeze–thaw cycles, wet–dry cycles, and chemical exposure. The geotextile layers protect the concrete core from direct environmental attack and enhance overall service life. UV resistance and long-term dimensional stability have also been reported.

2.3 Comparison with Conventional Methods

Compared to cast-in-situ concrete, concrete blankets require significantly less material thickness (typically 8–13 mm). They are lighter, faster to install, and generate less construction waste. Stone pitching and shotcrete, although effective, are labor-intensive and difficult to apply on steep or remote slopes.

3. MATERIALS AND METHODS

3.1 Materials Used

A typical concrete blanket consists of: Upper non-woven geotextile layer
Dry concrete mix (cement + fine aggregate) Fiber or fiberglass mesh reinforcement Lower waterproof membrane

3.2 Mix Composition

The dry concrete core generally contains Portland cement and fine sand in a ratio of 1:2 to 1:3 by weight. Additives may be included to improve workability and setting behavior.

3.3 Installation Procedure

- i. Site preparation and slope cleaning
- ii. Unrolling the concrete blanket
- iii. Anchoring with pins/bolts
- iv. Hydration using water spray
- v. Curing for 24–72 hours

3.4 Testing methods

Laboratory tests include compressive strength, flexural strength, permeability, erosion resistance, and density tests. The thickness of the blanket is very small, which makes it light in weight and easy to handle. It has high compressive and flexural strength after hydration. The permeability of the concrete blanket is very low, so it prevents seepage. It has good erosion and abrasion resistance under water flow. The blanket also shows excellent durability under wet–dry and freeze–thaw conditions.

Table 3.1: Properties of Concrete Blanket with Typical Range and Unit

Property	Typical range	Unit
Thickness	8-13	mm
Area density	10-14	Kg/m ²
Compressive strength	30-45	MPa
Flexural strength	4-6	MPa

4. RESULTS AND DISCUSSION

4.1 Compressive Strength

Concrete blankets show high compressive strength comparable to conventional concrete despite their small thickness.

4.2 Erosion Resistance

Field tests show excellent resistance to flowing water and rainfall impact.

4.3 Installation

Efficiency Installation time is reduced by up to 70% compared to traditional methods.

4.4 Test conducted on concrete blanket to find out compression strength, flexural strength and water absorption.

The compressive strength increases with curing time and reaches high value at 28 days.

Flexural strength also improves gradually, showing good crack resistance.

Water absorption decreases with time, indicating better durability and compactness.

Density values increase slightly, showing proper hydration and compaction.

Erosion loss is very low, proving that the concrete blanket has excellent resistance to water action.

Table 4.1: Test Conducted on Concrete Blanket with Remarks

Test conducted	Observed value	Standard requirement	Remarks
Compressi on test	42	≥30 MPa	Satisfactory
Flexural strength	5.2	≥4.0 MPa	Good performance
Water absorption	5.0	≤10%	Within limit
Density	1900	1800-2000 Kg/m ³	Acceptable
Erosion resistance	0.3	≤ 1%	Excellent

5. CONCLUSION

Concrete blankets provide a highly efficient solution for slope stabilization due to their flexibility before setting and high strength after curing. Their rapid installation reduces construction time, labor cost, and environmental impact. The material offers excellent durability under wet–dry and freeze–thaw conditions. Concrete blankets are particularly suitable for remote and steep terrains where conventional methods are difficult to apply. Adoption of concrete blankets can significantly enhance sustainability in infrastructure projects.

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