

**FOREIGN EXPERIENCE IN THE USE OF GEOSYNTHETICS IN AIRFIELD PAVEMENTS: A SCIENTIFIC AND ANALYTICAL APPROACH**

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**Abstract**

The article systematically analyzes the experience of the United States, Europe, and Asian countries in the application of geosynthetic materials in airfield pavements. Based on FAA and ICAO documents, scientific journal papers, and conference proceedings on airfield pavements, the separating, reinforcing, drainage, and crack-mitigation functions of geotextiles, geogrids, geocells, and geocomposites are discussed [1-5]. The evaluation criteria used in foreign studies are generalized, and analytical relationships associated with the Traffic Benefit Ratio, deformation moduli, and life-cycle costs are presented [4, 6, 7, 11]. It is noted that the Polish case of strengthening a natural airfield pavement with a geogrid system improved load-bearing capacity by approximately 30%, while full-scale FAA tests showed pronounced differences in TBR values among various geosynthetics [4, 7]. Based on this international experience, practical recommendations are formulated for the airfield infrastructure of Uzbekistan.

**Keywords:** Airfield pavement, geosynthetics, geotextile, geogrid, geocell, reinforcement, drainage, reflective cracking, TBR, performance.

**Introduction**

Airfield pavements include runways, taxiways, aprons, and shoulder zones, and these elements must satisfy significantly higher requirements than ordinary highways in terms of aviation safety, load-bearing capacity, and service life [1, 2]. ICAO Doc 9157 provides modern guidance on pavement design, evaluation, drainage, and the bearing capacity of prepared natural ground zones, whereas FAA documents regulate pavement structures, materials, and construction specifications in greater detail [1-3]. Under these conditions, geosynthetics are regarded as a promising solution for improving airfield pavement reliability, limiting the intermixing of granular layers with subgrade soils, reinforcing weak foundations, improving moisture conditions, and slowing reflective cracking during rehabilitation [3, 5, 6].

The relevance of the topic lies in the fact that, although geosynthetics have been widely studied in highway engineering, decisions on their use in airfield pavements are still made with considerable caution. The FAA construction specification gives explicit requirements for geotextiles, while geogrids may only be used when justified by a geotechnical engineer and

accepted by the FAA; moreover, the FAA emphasizes that the presence of a geosynthetic does not automatically justify reducing pavement thickness [3]. Therefore, analysis of international experience is an urgent scientific task for identifying the actual engineering effect of these materials.

### **Research objective and tasks**

The objective of this paper is to generalize international experience in the use of geosynthetics in airfield pavements on the basis of scientific sources, classify the principal application areas, and derive practical conclusions for Uzbekistan.

To achieve this objective, the following tasks were formulated: to analyze regulatory approaches to geosynthetics in FAA, ICAO, and other sources; to compare the functions of geosynthetics using scientific papers and practical case studies; to formalize the principal evaluation criteria; and to develop recommendations for the phased implementation of geosynthetics in Uzbekistan's airfield facilities.

### **Research methodology**

The study employs comparative analysis, literature review, engineering interpretation, and synthesis of secondary data. The source base includes official ICAO and FAA documents, Scopus-indexed journal papers, international conference proceedings, and technical industry presentations [1-10]. In the comparative analysis, the key criteria were the engineering function of the geosynthetic, the position of the layer within the pavement structure, the working mechanism, the technical effect obtained, and the practical limitations.

### **1. Engineering functions of geosynthetics in airfield pavements**

Analysis of foreign sources shows that geosynthetics in airfield pavements can be considered in terms of four main functions: separation, reinforcement, filtration-drainage, and crack mitigation [3, 5, 8]. FAA AC 150/5370-10H states that a separating geotextile may be used to prevent the intermixing of subgrade soil with granular base or subbase layers; for airport projects, Class 2 geotextile is generally considered adequate [3]. At the same time, a specific note is made for geogrids: their use requires geotechnical justification and does not automatically entitle the designer to reduce pavement thickness [3].

Geotextiles function primarily as separating and filtration media, whereas geogrids work as reinforcement elements that provide lateral confinement and distribute wheel loads over a larger area [5-7]. Geocells and geocomposites are especially important for stabilizing weak ground in natural airfield pavements, shoulders, taxiway zones, and apron foundations [7, 9]. In rehabilitation works, bitumen-impregnated geotextiles or woven-composite interlayers can act as stress-absorbing membrane interlayers (SAMI), slowing the propagation of reflective cracks from the existing pavement into the new overlay [8, 12].

### **2. Analysis of foreign regulatory approaches**

ICAO Doc 9157 generalizes international practice in the design and evaluation of airfield pavements and provides modern guidance for pavement bearing capacity, drainage, and the

assessment of prepared natural ground zones [1]. The introduction of updated material on the bearing capacity of natural ground areas expands the potential for geosynthetic applications, especially in shoulders and auxiliary zones [1].

FAA AC 150/5320-6G and AC 150/5370-10H reflect a more explicit and cautious position in the United States. The FAA construction specification defines requirements for geotextile permittivity, apparent opening size (AOS), and related ASTM and AASHTO properties [3]. In addition, the FAA has initiated full-scale evaluation of geosynthetics under aircraft loading and intends to integrate the results into future FAARFIELD design practice and construction specifications [4]. This demonstrates that theoretical advantages alone are not sufficient in foreign practice; full-scale field evidence is essential.

### 3. International practical cases

3.1. United States: FAA NAPTF tests. According to FAA presentations, geosynthetic materials were tested under aircraft loading conditions in the NAPTF Construction Cycle 9 program and evaluated by the Traffic Benefit Ratio (TBR) [4]. At the 1-inch deformation criterion, TBR values were reported as 32.0 for BX1200, 4.8 for TX140, 13.5 for Fornit 40, and 8.5 for RS580i [4]. These results indicate that geosynthetic type, placement, and foundation conditions have a strong effect on performance.

3.2. Poland: reinforcement of natural airfield pavement. In the study by Wesółowski and Kowalewska, the load-bearing capacity of a natural airfield pavement reinforced with a geogrid system was evaluated [7]. Field tests showed that the reinforced natural pavement exhibited an increase in load-bearing capacity of about 30% [7]. The authors also emphasized that this effect was due not only to the geogrid itself, but also to the contribution of mechanically stabilized cover layers [7].

3.3. Philippines: geotextile SAMI interlayer. In the rehabilitation works at Subic International Airport, a reinforced geotextile paving fabric was used, and a solution consisting of 50 mm overlay with paving fabric was compared with a conventional 75 mm overlay [8]. The study reports that the material simultaneously provided stress absorption, waterproofing, and reinforcement [8]. Laboratory testing and core analysis suggested that the interlayer delayed crack propagation and could extend the service life of the new overlay by more than twofold [8].

3.4. Belgium: Ostend airport apron. A 2024 GeoAmericas paper reported that in the construction of a new aircraft parking apron at Ostend airport, an appropriately selected woven geotextile allowed a significant portion of gravel to be replaced, generating both economic and environmental benefits [9]. The reduction of CO2 footprint, lower material consumption, and optimization of construction time were identified as major advantages of the geosynthetic solution [9].

### 4. Evaluation criteria and analytical relationships

Foreign studies use several indicators to assess the effectiveness of geosynthetics. One of the most common is the Traffic Benefit Ratio (TBR), defined as the ratio of the number of loading

cycles required to reach a prescribed deformation in the reinforced pavement to the corresponding number in the unreinforced control section [4, 11].

### **5. Discussion**

Based on the analyzed sources, several general regularities can be identified. First, in new construction geosynthetics are used most often as separating layers and as reinforcement for weak foundations, whereas in rehabilitation they are commonly employed as SAMI or crack-mitigating interlayers [3, 5, 8, 12]. Second, their effectiveness is highly sensitive to pavement thickness, base stiffness, aircraft tire pressure, material type, and placement depth [4-7]. Third, field performance is often associated with a combined structural solution - geosynthetic plus base layer plus drainage plus moisture control - rather than with a single material alone [7, 9]. Fourth, in developed countries the introduction of geosynthetics relies on an integrated mechanism of regulatory approval, pilot testing, and monitoring [1-4].

### **6. Practical recommendations for Uzbekistan**

Uzbekistan's dry-hot climate, the diversity of local soil types, and the uneven distribution of moisture conditions and loading at certain airfield locations indicate the need for targeted use of geosynthetics. The following phased approach is proposed: (1) establish pilot sections with separating geotextiles in aprons, taxiways, and shoulder zones; (2) build experimental structures with geogrids and geocells in weak-soil areas; (3) conduct comparative monitoring using HWD, FWD, DCP, and moisture observations; (4) introduce dedicated recommendations on geosynthetics for airfield pavements into local standards; and (5) make life-cycle cost analysis and safety-oriented project evaluation mandatory.

### **Conclusion**

International experience in the use of geosynthetics in airfield pavements demonstrates that these materials can be an effective means of increasing structural reliability, service life, and operational stability [3-9]. The FAA approach requires cautious, evidence-based implementation, while the cases from Poland and the Philippines confirm positive results both for strengthening natural pavements and for delaying reflective cracking during rehabilitation [4, 7, 8]. The Belgian case shows that geosynthetic solutions are also valuable from the standpoint of environmental and economic efficiency [9]. Consequently, for Uzbekistan the most appropriate path is not to adopt geosynthetics as a ready-made template, but to implement them step by step on the basis of pilot testing while accounting for local soil-climate conditions, loading regimes, and operational risks.

Table 1 - Comparative characteristics of geosynthetic applications in airfield pavements

Material	Main function	Location of use	Foreign example	Expected effect
Geotextile	Separation, filtration	Subgrade-base interface	FAA specification [3]	Reduces intermixing of materials
Geogrid	Reinforcement	Base/subbase or over weak soil	FAA and Polish experience [4, 7]	Load distribution and increase in modulus
Geocell	Confinement of layers	Natural pavement, shoulders	Polish natural pavement case [7]	Increase in bearing capacity
Geocomposite	Drainage	Aprons and shoulder zones	European practice [1, 9]	Reduces excess moisture risk
Paving fabric / SAMI	Crack delay	Under rehabilitation overlay	Philippine case [8]	Slows reflective cracking

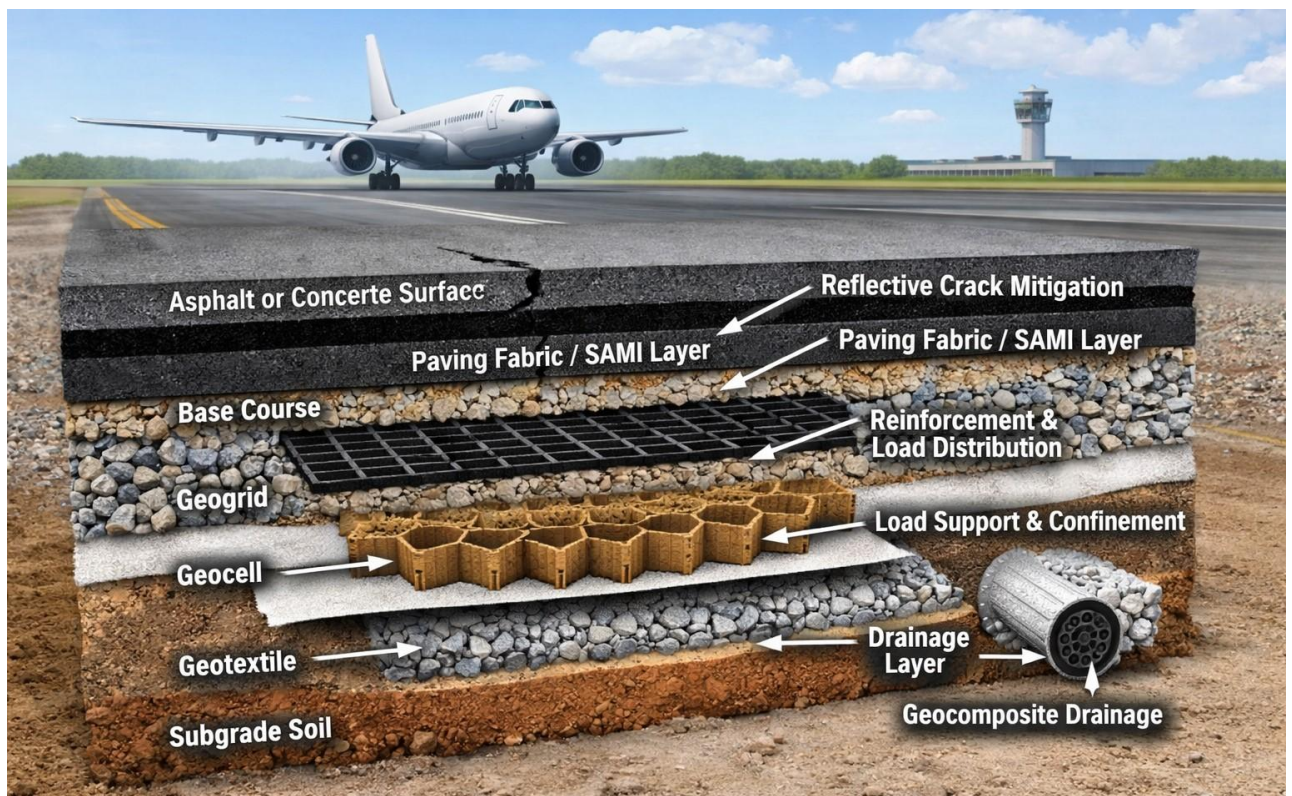


Figure 1 - Schematic view of geosynthetic layer placement and functions in an airfield pavement

The main analytical relationships used in the comparative review are given below.

$$TBR = N_r / N_0 \quad (1)$$

where  $N_r$  is the number of loading cycles required to bring the pavement with geosynthetics to the specified deformation;  $N_0$  is the corresponding number of cycles for the control section [4, 11].

$$k_{impr} = E_r / E_0 \quad (2)$$

where  $E_r$  is the deformation modulus of the reinforced layer;  $E_0$  is the deformation modulus of the unreinforced layer. In the Polish case study, this ratio showed a considerable increase relative to the natural pavement condition [7].

$$q = k * i * A \quad (3)$$

where  $q$  is filtration discharge,  $k$  is the coefficient of permeability,  $i$  is the hydraulic gradient, and  $A$  is the flow area. Geocomposites and filtration geotextiles help reduce excessive moisture [1, 3].

$$E_{LCC} = LCC_0 - LCC_g \quad (4)$$

where  $LCC_0$  is the life-cycle cost of the conventional structure and  $LCC_g$  is the life-cycle cost of the geosynthetic alternative. If  $E_{LCC} > 0$ , the geosynthetic alternative is considered economically preferable [5, 9].

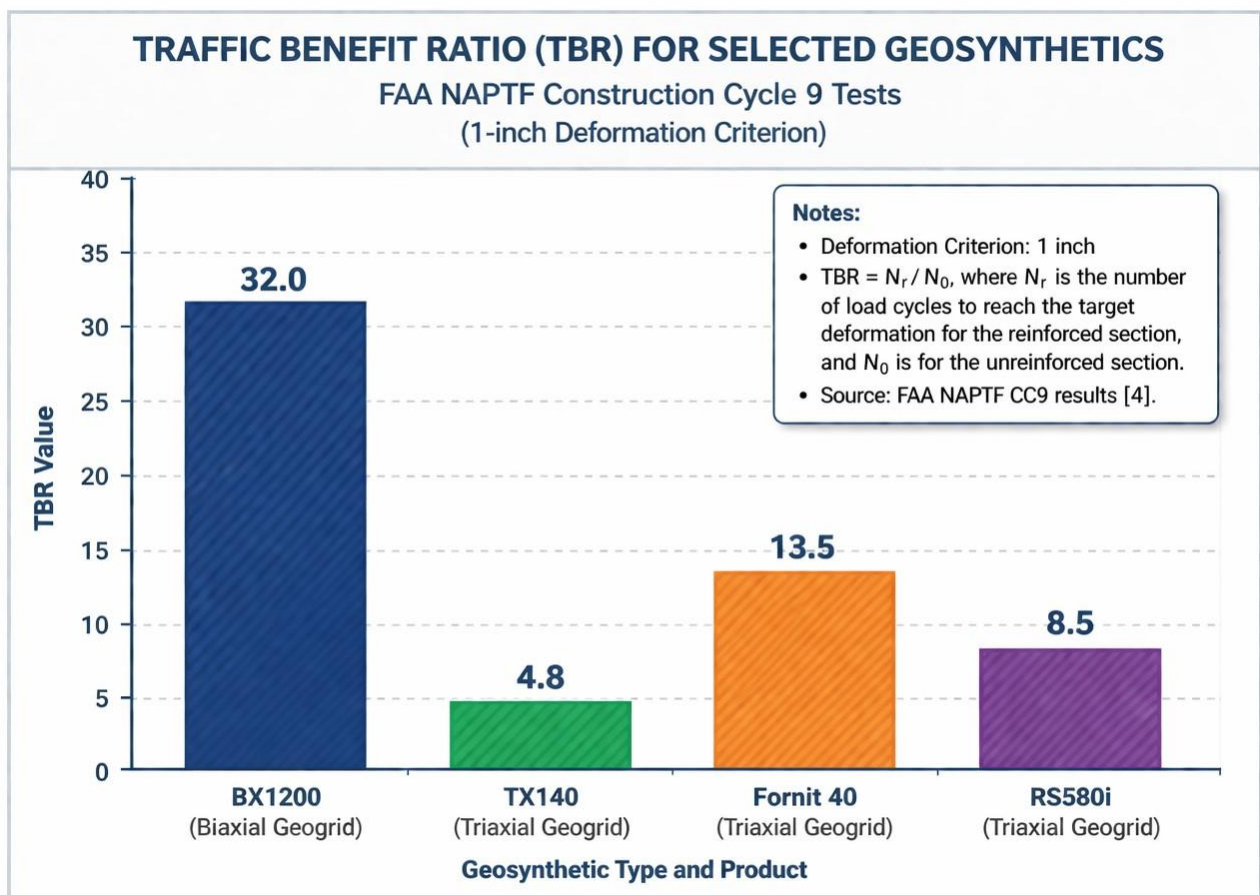


Figure 2 - TBR values for selected geosynthetics from FAA NAPTF tests (at the 1-inch deformation criterion) [4]

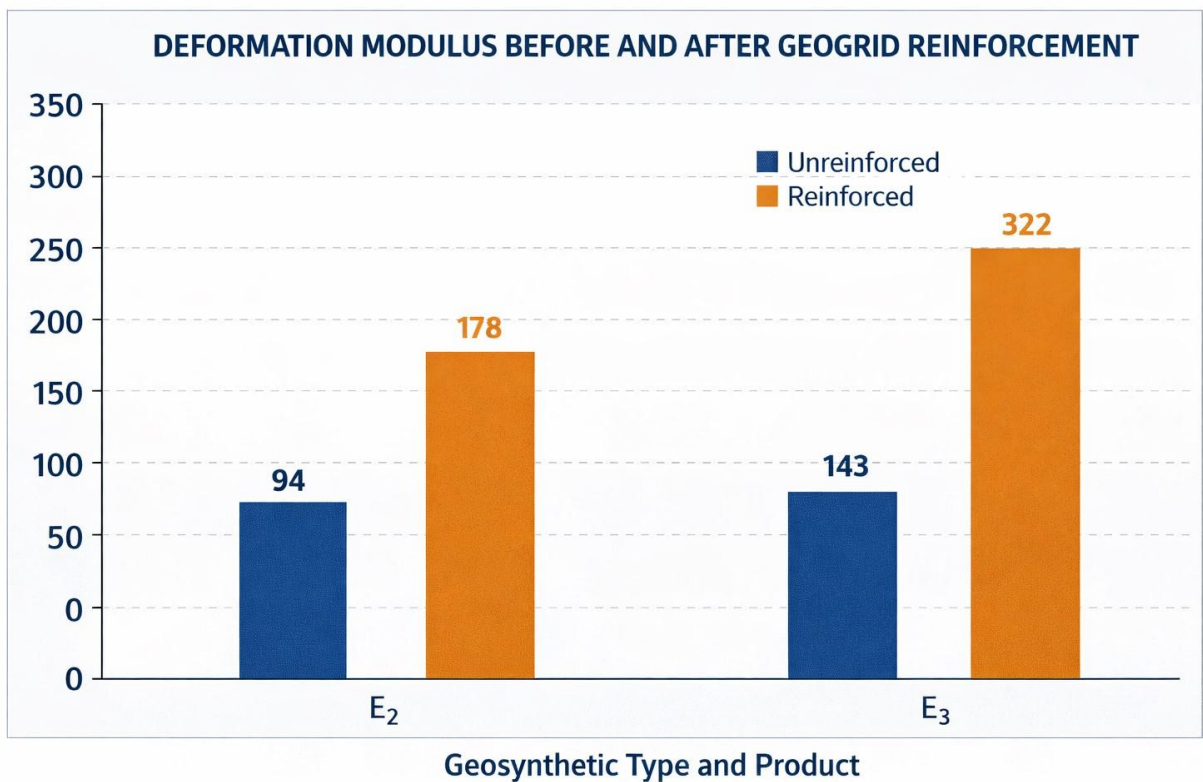


Figure 3 - Comparison of deformation moduli before and after geogrid reinforcement in the Polish case study [7]

Table 2 - Generalized comparison of technical results from foreign case studies

Case	Indicator	Value / result	Source
FAA NAPTF	TBR (BX1200)	32.0	[4]
FAA NAPTF	TBR (TX140)	4.8	[4]
FAA NAPTF	TBR (Fornit 40)	13.5	[4]
FAA NAPTF	TBR (RS580i)	8.5	[4]
Poland	Increase in bearing capacity	approx. 30%	[7]
Poland	Unreinforced modulus	54 MPa	[7]
Poland	Reinforced modulus (VSS)	81 MPa	[7]
Poland	Reinforced modulus (HWD)	128 MPa	[7]
Philippines	Overlay solution	50 mm paving fabric + overlay vs 75 mm conventional	[8]

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