USE OF GEOSYNTHETIC MATERIALS IN DAM CONSTRUCTION

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Geosynthetic materials in the form of geomembranes, geotextiles, geonets, geomats, geocomposites, etc., are used widely in modern dam construction. The article describes structural elements of dams in which various types of geosynthetics are used and those functions which geosynthetics perform in these elements.

Geosynthetic materials are presently used widely in international dam construction practice as watertight elements, filters, drains, reinforcing and separating members, and for protecting and revetting slopes of earth dams and surfaces of concrete dams.

The number of dams constructed in various countries with the use of geosynthetics is already many tens and is continuously increasing. Their height exceeded 100 m. Examples, in particular, are such dams as: Bend Boyd (30 m, Australia); Bolgenach, Bockhartzee, Greiferistein (92, 33, 31 m, Austria); Frauenau (86 m, Germany); Simbiriza (22 m, Italy); Ait Chouarit (144 m, Morocco); a number of dams and cofferdams of the La Grande complex (height up to 95 m, Canada); Atbash (76 m, USSR); Verney, Codol, Ospedal (42, 28, 26 m, France); Elandsprunt, Gedertrau, Hans Strigdom (95, 88, 56 m, South Africa), and many others.

Geosynthetics are polymeric materials with a high molecular weight, the macromolecules of which consist of a large number of repeating molecular links and include carbon atoms with covalent bonds. Such materials resist considerable tensile stresses, retain their strength even under large strains, are homogeneous in their quality, durable, adaptable to manufacture, and effective in construction [1].

The active use of geosynthetics in the construction of hydraulic and reclamation structures began at the end of the 1950s in various countries. These were originally geomembranes in the form of thin film coverings. Later, with development of production technology, improvement of the quality of geosynthetics, and increase of their durability, the manufacture of other types of products, in particular, geotextiles, began. Whereas the first are intended for antiseepage purposes \( (K_f = 10^{-12}-10^{-13} \text{ cm/sec}) \), geotextiles are permeable \( (K_p = 10^{-3}-100 \text{ cm/sec}) \). The very name geosynthetics (geomembranes, geotextiles, geodrains, etc.) was specially introduced in international practice for identifying polymeric materials used in construction and other areas with their combined use with soils, rock, etc. [2, 3, 4].

Geomembranes are flexible film materials. They are made from synthetic polymers or products on a base of bitumens mainly at factories, more rarely at construction sites. They can be reinforced and nonreinforced and should preserve their watertight capacity in the entire range of deformations under which the member works. The synthetic polymers most often used as the base products for manufacturing geomembranes are: thermoplastics (polyvinyl chloride); crystalline thermoplastics (polyethylenes of various densities, polypropylene); elastomers (rubber, isobutylene-isoprene), etc. Used as additives are: carbon, lime, clay shale powder, stabilizers, etc. A geomembrane is considered reinforced if the materials used for this cover it as a continuous layer. The reinforcing material can be woven or nonwoven geotextiles (made from polester, polypropylene, polyamide, fiberglass) and geonets made of polyamide or fiberglass. Geomembranes are usually made and shipped in rolls from 1.5 to 10 m wide. The thickness of factory-made unreinforced geomembranes varies from 0.25 to 4 mm and of reinforced, from 3 to 10 mm.

Geotextiles also represent a wide assortment of roll materials intended for various uses in construction, including hydraulic structures. Woven and nonwoven, as well as reinforced geotextiles are produced from polymer and synthetic fibers (polyethylene, polyamide, polypropylene, polyether, Orion, etc.) in the form of rolls mainly with a width up to 5 m, thickness up to 5 mm, mass 150-1500 g/m², tensile strength 30-500 N/cm with tensile elongation 10-200%. Woven geotextiles are produced

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Fig. 1. Designation of structural elements used in the construction of dams and functions of geosynthetics: a) water-tight barrier; b) filtering layer with separating function; c) transmission of force; d) intermediate layer; e) macroreinforcement; f) microreinforcement; g) surface reinforcement; h) structural element; i) double coating; drain; drain/covering.

by weaving two sets of filaments or tapes. Nonwoven is made from continuous or discontinuous filaments with random orientation. Joined by fused thermoplastic bonds. Nonwoven needling geotextile is a covering of randomly arranged short or continuous fibers, the interlacing of which is accomplished mechanically by serrated needles.

In addition to geomembranes and geotextiles, industry produces geonets, geodrains, geocomposites, etc. They are intended for performing special functions — watertight, filtering, drainage, reinforcing, anchoring, etc. A combination of two or more types of geosynthetics, for example, geomembrane on a layer of geotextile, are called geocomposites.

Considerable attention is presently being devoted to the use of geosynthetics in dam construction. These problems were discussed at the 16th and 17th Congresses of the International Commission on Large Dams in San Francisco (1988, issue 61) and in Vienna (1991, issue 67). The ICOLD Bulletin No. 55 "Geotextiles as Filter and Transitions in Fill Dams" was published in 1986 [5] and Bulletin No. 78 "Watertight Geomembranes for Dams" in 1991 [6].

The main trends in the use of geosynthetics in dam construction are described below on the basis of generalizing the ICOLD materials and data in domestic and international technical publications, particularly the works of J. Giroud, the president of the International Geotextiles Society. Figure 1 gives the conventional designations of geosynthetic structural elements.

Typical variants of using geosynthetics as drains and filter are shown in Fig. 2 [7].

In homogeneous earth dams (Fig. 2a), geosynthetics are used for constructing: horizontal drains (1) located in the upstream part of dams and intended for preventing the occurrence of pore pressure in the case of rapid drawdown of the reservoir level, and sometimes for accelerating consolidation of soils during construction; vertical drains (2) located under the upstream and downstream parts of dams and intended for accelerating the consolidation of foundation soils during construction and for removing uplift pressure; sloping drains (3) and drains along the base of the downstream part of the dam (4) intended for preventing an increase of pressure in pore water; horizontal drains (5) located in the downstream part of the dams and intended for preventing pore pressure occurring in the case of unsatisfactory work of the sloping drains, and sometimes for consolidation of the soil during construction.

In earth dams with various types of membranes, geosynthetics are used for constructing: drains located immediately behind the membrane (diaphragm wall, concrete wall, asphaltic concrete membrane) and intended for collecting water that seeped through the membrane and diverting it into the gallery (Fig. 2b, 1); horizontal drains intended for preventing the occurrence of pore pressure in the downstream part of the dam in the case of concentrated seepage through the membrane (Fig. 2b, 2).

Drains consisting of geocomposites with a geotextile filter and geonet or geomat transition layer having high permeability are used in the schemes shown in Fig. 2a and b. Also used are sand or a similar earth material with a nonwoven geotextile filter, or a thickened nonwoven geotextile which provides both filtration of water and transmission of loads. Figure 2c shows a gravel drain at the toe of the dam with a geotextile filter, and Fig. 2d shows a geocomposite drain or alternative gravel drain with a geotextile filter.