Geotextiles and Geomembranes 29 (2011) 415–424

Contents lists available at ScienceDirect

Geotextiles and Geomembranes

journal homepage: www.elsevier.com/locate/geotexmem

Feedback and guidelines for geomembrane lining systems of mountain reservoirs in France

Daniel Poulain [a,*], Laurent Peyras [b], Patrice Meriaux [b]

[a] Cemagref, 50 avenue de Verdun, 33612 Cestas cedex, France
[b] Cemagref, 3275 route de Cézanne, CS 40061, 13182 Aix-en-Provence cedex 5, France

ARTICLE INFO

Article history:
Received 4 January 2010
Received in revised form
24 October 2010
Accepted 7 November 2010
Available online 28 December 2010

Keywords:
Hydraulics works
Feedback
Reservoirs
Geomembrane
Mountain
Survey

ABSTRACT

Mountain reservoirs are hydraulic structures in mountains, used in ski resorts to store water, generally for producing artificial snow; there are about 120 of them in France. Despite their modest volumes (5000 −400,000 m^3) and dam heights of between 5 and 20 m, these structures do induce potentially high risks, due to their location in mountain at altitudes of between 1200 and 3000 m. These reservoirs are very often made watertight artificially by geomembrane. A survey conducted on about 70 of these reservoirs provided considerable information on their pathologies, incidents and even accidents and served as a basis for writing a set of guidelines for studying, designing, constructing, monitoring and rehabilitating. The paper is divided into two parts; the first based on an analysis of the 32 best documented structures is a feedback of water-tightness quality of Geosynthetic Liner Systems (GLS) at high altitudes; the second based on the guidelines above-mentioned, concerns the construction choices and behaviour of GLS at high altitudes. In particular, the guide advises using a cover layer in most cases to protect the geomembrane, and paying particular attention to the support layers and to drainage under the geomembrane.

1. Introduction

Mountain reservoirs are hydraulic structures in mountains, used in ski resorts to store water, generally for producing artificial snow. There are about 120 of them in France. These structures are relatively recent, most of them having been built in the last ten years. Their numbers are increasing rapidly, as projects in construction account for a third of the total amount of reservoirs in activity.

Despite their modest volumes (5000–400,000 m^3) and dam heights of between 5 and 20 m, these structures do induce potentially high risks, as they are usually located at higher altitudes than tourist areas and due to the risk of torrential flows that could arise in areas with strong slopes. Studies show that one in two reservoirs is of concern to public safety, in that if a severe breach were to appear or if the stored volume of water were to be expelled suddenly the consequences would be severe for people and installations located downstream. These reservoirs must therefore be highly reliable, to the same extent as civil engineering installations for which a rupture would have a huge impact on local populations.

They are considered as high-altitude installations as they are located in mountains at altitudes of between 1200 and 3000 m. This situation results in specific difficulties at every stage: design, construction, operation and, if necessary, rehabilitation. The greatest difficulties are complex geological and geotechnical contexts, hazards specifically related to mountain environments (avalanches, rockslides, landslides, erodible foundations), limited time-frames during the year for building, high stress linked to ice, structures subject to extremely cold temperatures, difficulties in monitoring in the wintertime, etc.

Mountain reservoirs are embankment installations that are often designed as cut-and-fill. Once the designers know the volume of water to be stored, the blueprint for the installations is created, which usually consists of excavations taken from the basin and fill materials erected from the excavated materials. These reservoirs are very often made watertight artificially by Geosynthetic Liner Systems (GLS) implemented over the entire surface: cut, fill and basin. There are two reasons for this. First, for geotechnical reasons: materials are the most often (60%) moraine and schist, containing rough elements and not naturally watertight. The second is related to the topographic and geological conditions that can be found in mountain environments: reservoirs are built on terraces and are generally designed as cut-and-fill basins, with the fill surrounding most of the reservoir. Under these conditions, the traditional solution to guarantee water-tightness on a classical dam – made up of foundation injections and a geomembrane on the upper bank – is not always adequate to intercept any leakages from the basin.

* Corresponding author. Tel.: +33 557890997.
E-mail addresses: daniel.poulain@cemagref.fr (D. Poulain), laurent.peyras@cemagref.fr (L. Peyras), patrice.meriaux@cemagref.fr (P. Meriaux).

0266-1144/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.geotexmem.2010.12.002