Geomembrane Liner to Control Water Loss and Create Conservational Lake - A Case Study

D. S. Saxena
Alamo/Saxena Consultants, Inc., Lakeland, FL, USA

ABSTRACT: A 1.2-hec man-made lake was initially constructed for an overall retirement community complex in northeast Naples, Florida, USA. Due to the presence of shallow weathered limerock overlain by sandy soils at the site, continual water loss occurred, thus jeopardizing lake use as an area for conservation. The lake geometry together with an island lined with rip-rap presented constraints during the selection process for an engineered liner.

Following an evaluation of various liner options, including compacted clays, GCLs, and geomembrane liners, a 40-mil thick geomembrane was selected to minimize water loss and to help contain water in the lake. Field monitoring during liner installation was provided by the geotechnical consultant. After an early delay in late-1991 due to an unusually severe rainy season, liner installation was completed in early 1992.

Construction considerations included proper diking, dewatering, excavation into shallow limerock, and anchoring of the geomembrane in a perimeter upslope trench. Localized unstable lake-bottom areas were stabilized by placement of gravel and a geotextile. Additionally, the geomembrane liner was overlain by a geotextile in the sideslope areas to provide stability during soil cover placement. Close coordination between the installer and the geotechnical consultant assured the quality of construction.

This engineered solution provided an effective method for the development of this water conservation facility. Additionally, the solution resulted in a substantial cost savings for the developer versus other evaluated solutions.

1. INTRODUCTION

The Piper's Pointe Development is a retirement community located in Naples, Florida. A 1.2-hec man-made lake was initially created as part of the development in 1990 to provide a conservation and recreational area for residents. However, continual water loss occurred thus jeopardizing lake use. The purpose of the work performed at Piper's Pointe Development was to aid in the restoration of the partially dried and useless lake to its originally intended form and purpose. The original C-shaped lake was 3.1 to 3.4 m deep and ranged in width between 24.4 m at its narrowest point to 59.1 m at its widest point. The lake bottom had an average width of 30.5 m. In the lake center, a circular island up to 2.4 m high was created together with access bridges. This island bank was lined with a combination of rock rip rap and a geotextile underneath.

The project site layout is shown in Fig. 1.

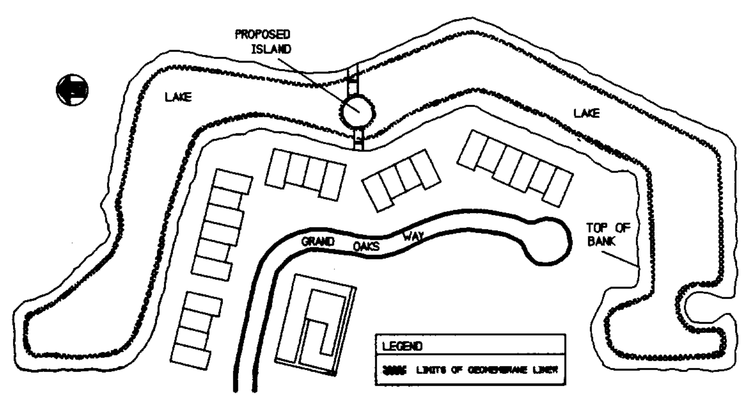

Fig. 1 Project layout

A typical lake cross-section and island detail are illustrated in Fig. 2.

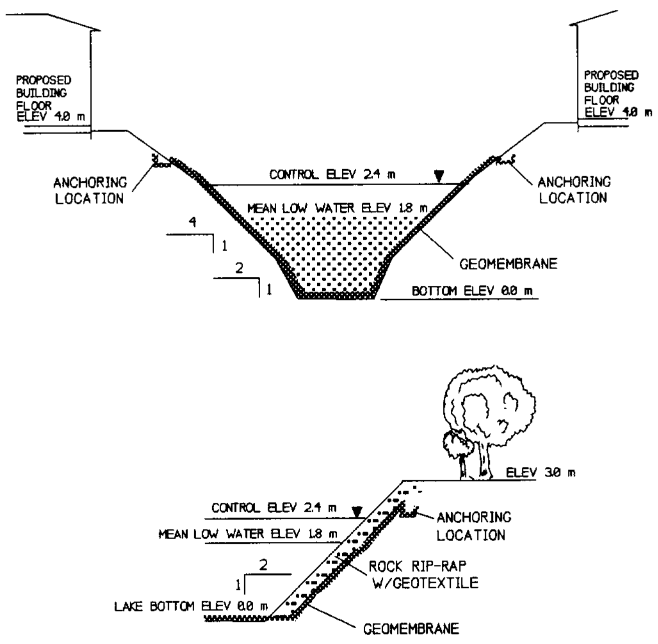

Fig. 2 Cross-section of lake and island detail

2. DESIGN DETAILS

The design process for this project consisted of reviewing generalized subsurface soil conditions which indicated shallow weathered limerock overlain by sandy soils at the lake site. Additionally, various types of sealing materials and other procedures were evaluated. These included sealing the lake bottom and sideslopes with a layer of compacted low-permeability clays from borrow pits in the area, utilizing geosynthetic clay liners (GCLs), or utilizing a geomembrane liner.

Project drawings and specifications were prepared including a permeability criterion of 1×10^{-9} cm/sec. Additional considerations included damming the lake near the island into 2 halves as well as anchoring of the liner into the lake sideslopes. Following a review of contractors' bids, qualifications, and alternates, a 40-mil thick HDPE geomembrane was selected and approved for installation by a geomembrane installer/contractor. A second contractor was selected to perform necessary earthwork and dewatering operations to prepare the pond bottom and sideslopes for proper installation of the geomembrane liner.

3. CONSTRUCTION AND LINER INSTALLATION

Construction was suspended during an unusually severe rainy season in late-1991 resulting in a high water table at the project site. In January 1992 earthwork was performed by a specialty contractor which consisted of: i) subgrade preparation and compaction in accordance with design specifications to provide a firm, unyielding foundation; ii) subgrade acceptance for installation of the geomembrane liner; iii) vegetative control; and, iv) anchor trench excavation. The geotechnical consultant's quality control team provided inspection of the prepared subgrade on a daily basis. Additionally, dry fill, rock, and geotextile were placed in the lake bottom to provide a dry working base in unstable areas which exhibited high moisture.

Installation of the geomembrane liner was performed by a second specialty contractor during the first quarter of 1992. Panel placement drawings identifying the panel configuration and seam locations were submitted, reviewed, and approved by the geotechnical consultant. Unrolling of panels was performed to minimize scratches, crimps, or wrinkles and sand bags were used to minimize uplift by wind. The geomembrane was protected underneath by a geotextile in areas where the prepared subgrade was deficient and in the center island area. Additionally, a 6.0 oz. nonwoven geotextile was provided over the 40-mil thick HDPE geomembrane liner on sideslope areas where a 15-cm thick compacted soil cover was placed. Along the top of the lake sideslope, the geomembrane liner was properly secured in a perimeter anchor trench.

The contractor's QA/QC program, which was approved by the geotechnical consultant, required testing of as much as 20 percent of factory fusion welds. Start-up tests were conducted at the beginning of each seaming period. All QA/QC testing procedures normally associated with this type of work were followed and documented.

An as built drawing showing panel configuration, seam locations, and destructive test as well as repair locations is included as Fig. 3.

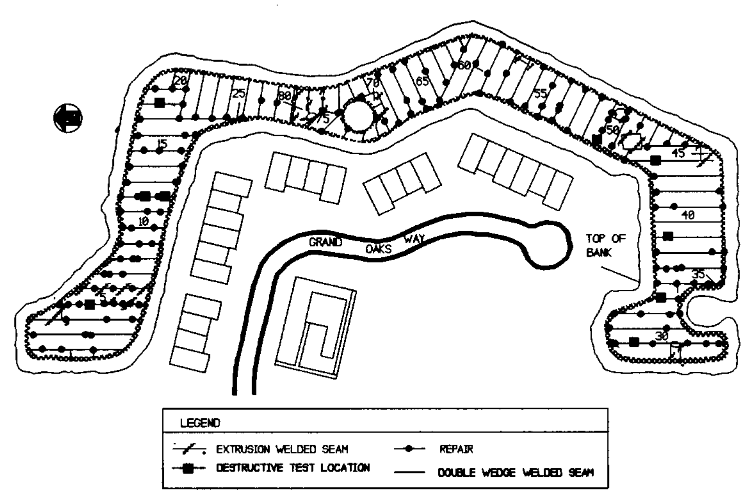

Fig. 3 As-built drawing showing test locations

Typical segments of the overall earthwork and liner installation processes are illustrated in Figs. 4 through 9.

Fig. 4 Installation of geomembrane in lake bottom

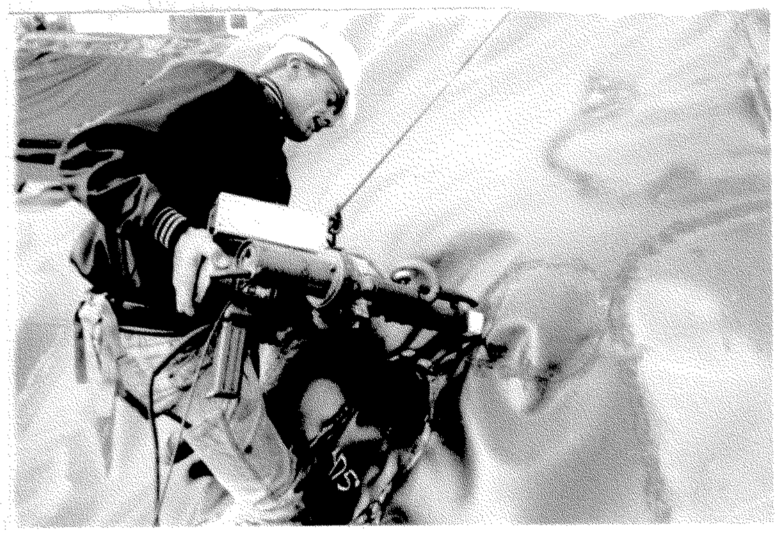

Fig. 5 Extrusion welding of seam with 10 cm overlap

Fig. 6 Damming lake into halves and bottom grading (note rear portion of lake full with water)

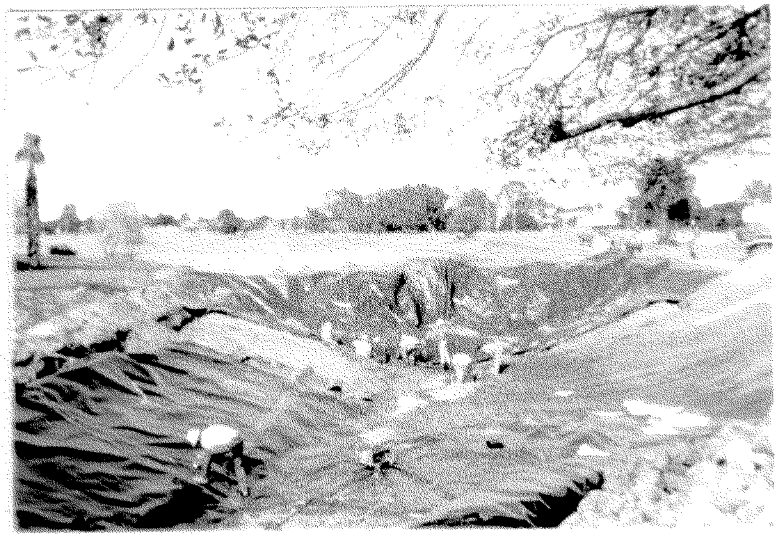

Fig. 7 Installation of geomembrane after damming of lake

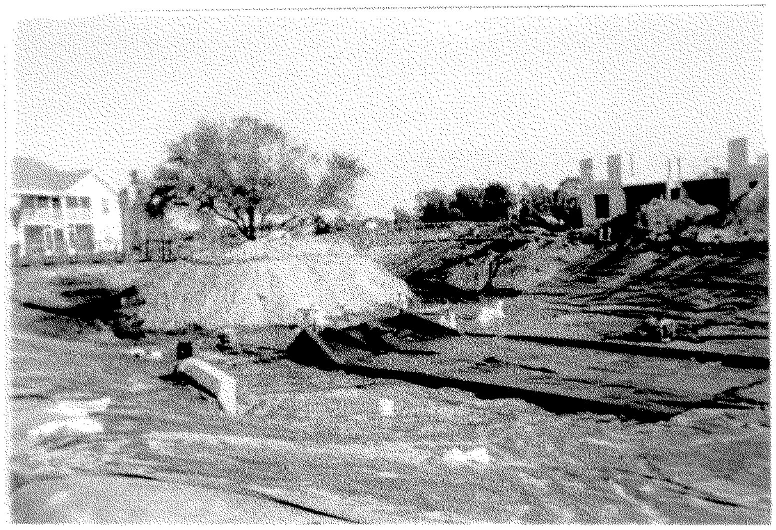

Fig. 8 Preparation of island slope with geotextile

Fig. 9 Installation of geomembrane on island slope

After another severe rainy season, some localized areas of geomembrane appeared at the lake surface as pressurized bubbles. The cause of this phenomenon was determined to be buildup of methane gas from decaying vegetation beneath the geomembrane liner. This methane gas was trapped by an extremely rapid rise in the ground-water table which inhibited dissipation of the gas through adjacent soil. After consultation with the geomembrane installer, pinholes were punched at the locations of pressure buildup to allow the gas to escape thus enabling the geomembrane liner to return to its originally installed position without any effect on its integrity.

Following close coordination between the geotechnical consultant and the geomembrane installer, the liner was satisfactorily installed in April 1992. This approach provided an effective and economical solution for the restoration of this conservational lake from a partially dried out and useless lake.

Figs. 10 and 11 illustrate BEFORE and AFTER views of the lake, respectively.

Fig. 10 Water loss and partially dried lake without liner BEFORE, June 1991

Fig. 11 Water retained in lake with liner AFTER, March 1994

4. ACKNOWLEDGEMENTS

Information presented in this paper is from a project in which the author and his firm, Alamo/Saxena Consultants, Inc. (ASC), were involved as the geotechnical consultant. ASC wishes to express its appreciation to the project owner Jim Wallace, Regal Housing Developers, Naples, Florida, USA. The data assimilation and technical assistance of Anu Saxena and Jeanne Berg are also acknowledged.