TWENTY YEARS OF POLYETHYLENE GEOMEMBRANE UTILIZATION IN QUEBEC

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ABSTRACT
A twenty year retrospective on the utilization of polyethylene geomembranes in Quebec is presented. Different applications and designs are discussed and commented along with lessons learned. Special consideration is given to the durability aspect of the materials throughout this first successful 20 year chapter of the geomembrane industry in Quebec.

RÉSUMÉ
Une rétrospective des vingt dernières années est présentée sur l'utilisation des géomembranes de polyéthylène au Québec. Différentes applications et conceptions sont discutées, accompagnées de leçons et expertises retenues. Une attention spéciale est prêtée à la durabilité des matériaux.

1. INTRODUCTION

Geomembranes are essentially bi-dimensional polymeric materials designed to reduce the hydraulic conductivity of in situ soils. Polymers come in different types, with polyethylene representing the bulk of the usage especially when corrosive contaminants are to be securely contained. Sparingly used for agricultural applications such as irrigation reservoirs and water conveyance structures as early as the 60's, it is truly only since the mid 80's that polyethylene geomembranes have revolutionized the waste containment industry in North America. Originally developed in Western Europe (Koerner 1997), polyethylene geomembranes were quickly endorsed by numerous governmental agencies, designers and users throughout the world as the materials of choice when it comes to environmental protection. This global and profound acceptance was basically achieved from the materials' intrinsic beneficial mechanical and physical properties in prolonged contact with a wide range of contaminants, along with their relatively low costs. From modest beginnings, polyethylene geomembranes are now being installed world-wide at an annual rate of over 300 million square meters. Canada is no exception to the rule, especially in the Quebec Province whereby polyethylene geomembranes have successfully been used since the mid 80's as well.

2. A SHORT HISTORY

In spite of the lack of properly documented and published case histories, it is still rather fairly safe to say that early uses of polyethylene geomembranes in the Quebec Province hail from the early 80's, more or less coincidental with the industry's official beginnings in North America as evidenced by what many consider as the first International Conference on Geomembranes held in Denver, Colorado in 1984 (Denver 1984). To that effect, internal documentation of one of the local industry's first polyethylene geomembrane commercial venture reports the installation of both Canadian and American-made polyethylene geomembranes for non-environmental protection applications such as small water tanks and reservoirs in the early 80's for both municipal and private clients.

Figure 1. Early non-environmental polyethylene geomembrane applications.

It is also the era whereby a large contaminated soil site (a former coke gasification plant) was rehabilitated using polyethylene geomembranes as one of the very first high profile geosynthetic environmental endeavours in Quebec. This event was then quickly followed in the mid 80's by Quebec's first polyethylene geomembrane municipal waste landfill lining system, the first hazardous waste landfill cover, the first geomembrane double-lined contaminated soil landfill, as well as the first large area secondary containment structure.

Figure 2. Quebec's first contaminated soil landfill.

Figure 3. Quebec's first municipal solid waste landfill.

Figure 4. Quebec's first large-scale secondary containment structure.

And then there was no turning back as polyethylene geomembranes have been used for all kinds of containment structures such as industrial sludge reservoirs, mine tailing dams, waste water reservoirs, etc… leading to MSW piggyback landfill extensions in 2001.

Figure 5. Industrial sludge reservoirs.

Figure 6. Contaminated soil cap closure.

Figure 7. Quebec's first MSW piggyback installation.

Endorsed from early on by local environmental regulators and engineers, polyethylene geomembranes in the Quebec Province have thus followed the same fast track evolutionary course as in the United States, covering a wide range of applications, both environmental and operational. Conservative estimates of the total amount of installed polyethylene geomembranes in the Quebec Province since their inception are over 50 million square meters.

3. 20 YEARS WITHOUT FAILURE

According to the authors' combined experience, none of the many polyethylene geomembrane projects in Quebec has ever been the subject of a claim pertaining to premature polymer degradation and/or ensuing leakage. This feat is further enhanced by the fact that twenty years ago, polymer resins were not as performing as they are today, installation equipment not as technically advanced, and that both manufacturing and installation quality control had not been as thoroughly industry-standardized as they are now. It is also noteworthy that many different manufacturers with different proprietary resin formulations have supplied the Quebec market for the past 20 years without a single failure case, reinforcing once again that all polyethylene geomembranes regardless of their origins have successfully performed as anticipated in the Province of Quebec. This feat is really not that exceptional as the whole industry can basically vouch for the same accomplishment during the same period.

4. QUEBEC INDUSTRY IDIOSYNCRASIES

Although very much closely in line with American industry developments, technology advancements and industry standards evolution throughout the years, the Quebec polyethylene geomembrane industry has had some notable differences and uniqueness of its own. It may claim for instance to have had three geomembrane manufacturers on its territory, even offering at one point fully automated extrusion pre-fabricated roll goods as an early effort to reduce the amount of on-site welds, a technology which obviously eventually became obsolete.

Figure 8. Prefabricated polyethylene geomembrane rolls with plastic spacers.

Another significant difference in the early years when hand-held extrusion welding was but the only game in town, was the extensive utilization of the so-called European automated hot air welding method which unfortunately never truly grabbed hold in America as a bonafide welding technique in spite of conclusive scientific studies (Marcotte et al. 1993). As a matter of fact, as of today automated hot air welding still hasn't graduated beyond an industry-approved tacking method for patch work.

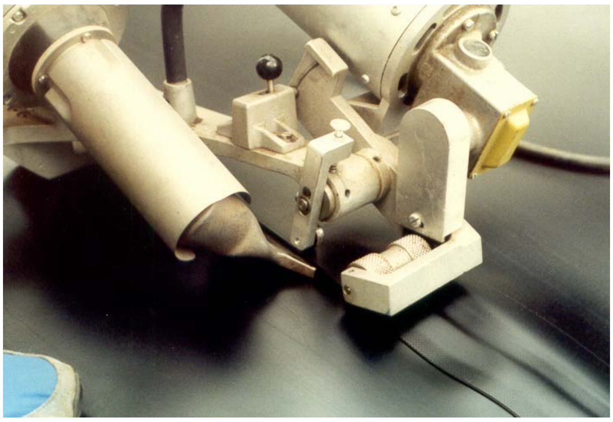

Figure 9. Automated hot-air welder.

Nowadays Quebec still distinguishes itself by proudly claiming the presence of the only Canadian polyethylene geomembrane manufacturer exporting to more than 40 countries throughout the world, as well as the home of a major polyethylene geomembrane resin supplier, of Canada's only exclusive geosynthetic design engineering firm, and of Canada's only fully GAI accredited laboratory. The industry is also greatly indebted to a few very distinguished emissaries such as Prof. André Rollin Ph.D. author of numerous technical papers and books on geomembranes (Rollin et al. 2002), and heavily instrumental into having École Polytechnique de Montréal offer intensive courses on the topic at graduate level for many years. The polyethylene geomembrane industry is thus truly well established in the Quebec Province, which is also a token of its historical success.

5. TYPICAL CROSS-SECTIONS

Different cross-sections of basal liner have been used throughout the years, from simplistic early beginning approaches to today's sophisticated double-lined multi-layered imperviating systems. While non-exhaustive, Figures 10. through 14. illustrate most of the different schemes utilized during the first 20 years of the industry in Quebec. Types "1" and "2" illustrate different variations of the same theme; type "2" using natural materials in lieu of geosynthetic versions. Individual composing elements are identified as follows;

GTX: Geotextile (filtrating function)
GMB: Geomembrane (imperviating function)
GCL: Geocomposite Clay Liner (imperviating function)
CCL: Compacted Clay Liner (imperviating function)
GNT: Geonet (lateral drainage function)
SP: Gravelly sand (drainage & puncture protection function, may also be replaced by a geotextile or geocomposite)

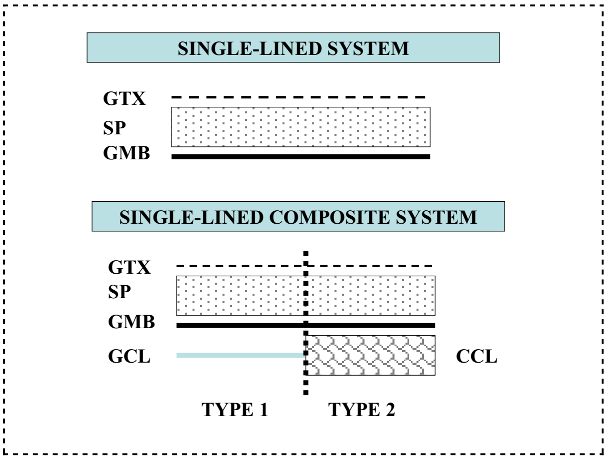

Figure 10. Typical geosynthetic single-lined systems.

Historically first to be designed and extensively used until the mid-80's prior to the advent of double-lined schemes, geosynthetic single-lined systems, are composed of a single geomembrane hydraulic barrier. Geomembrane thickness range between 1mm and 2mm. Usually directly installed on a compacted clayey subgrade free of puncturing elements, the geomembrane may also be protected from above by the addition of a so-called operational layer (in a liquid containment application) or by the addition of a drainage layer (in a solid containment application for the capture and removal of leachate). Further technological developments witnessed the coming of GCL products i.e. Geocomposite Clay Liners which may be used as a replacement for a clayey subgrade. Polyethylene geomembranes have also been left exposed without any protection or concern for their premature polymer degradation on account of their inherent carbon black UV inhibitor.

As previously mentioned, modern waste containment designs eventually evolved into so-called double-lined systems. A double-lined system is basically comprised of two hydraulic barriers separated by a drainage layer. To that effect it is important to understand how a double-lined system works, since contrary to popular misconception, the existence of a second barrier is not justified in case the first barrier fails (Denis et al. 1988). In other words, if the design engineer has reasons to believe that the first barrier may leak (which he should since nothing is never absolutely impervious), he needs to be consistent into believing that the second barrier may leak as well! The key imperviating element in a double-lined system is actually the drainage layer in between the barriers, as it will intercept any leaks through the first barrier and rapidly direct them to a sump area in order to be pumped out prior to the formation of any hydraulic head acting on the second barrier. Since no hydraulic head exists on the second barrier, no flow may develop through it and hence, the system taken as a whole is impervious although none of the composing elements are. So in essence, efficient pumping in between barriers i.e. pumping as fast as leakage develops between barriers, is the key into achieving impermeability.

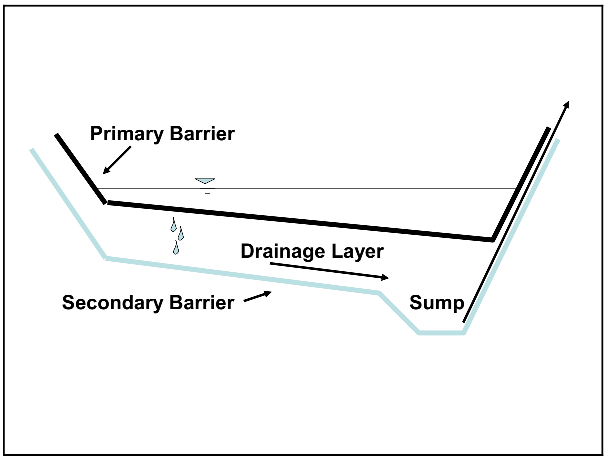

Figure 11. Schematic double-lined system.

As exemplified in the next figures, double-lined systems have also been designed using different versions of the same theme (GRI 1993). Some have exclusively used polymeric barriers, some have used so-called composite barriers (i.e. one part polymeric, one part natural materials), and some have also used GCL's as replacements for natural materials.

And finally, both hazardous and MSW landfill closures have also witnessed the numerous advantages of incorporating polyethylene geomembranes within their typical cross-sections such as their high elasticity and deformation to local subsidence, a phenomena associated with waste fermentation and consolidation.

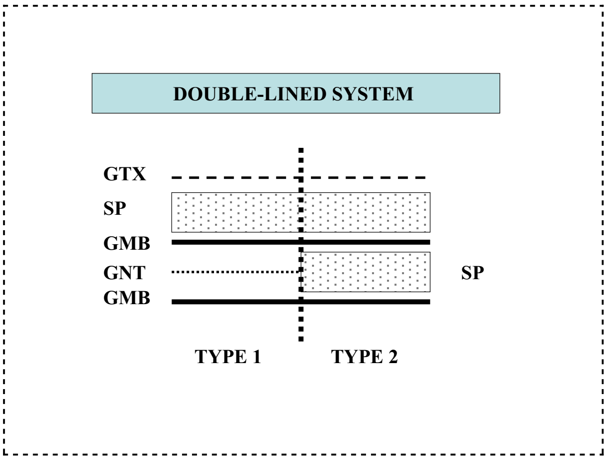

Figure 12. Typical geosynthetic double-lined systems.

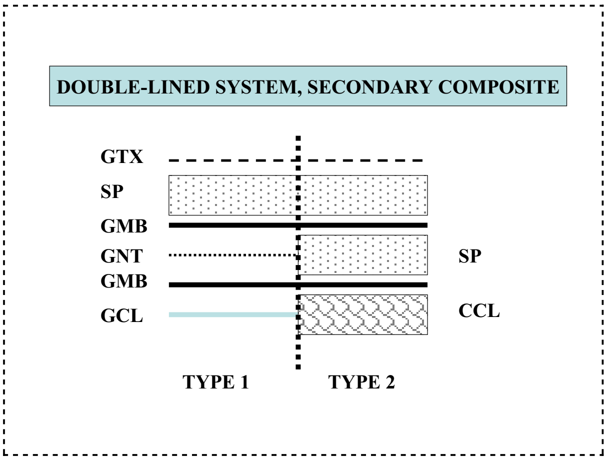

Figure 13. Typical geosynthetic double-lined systems with secondary composite liner.

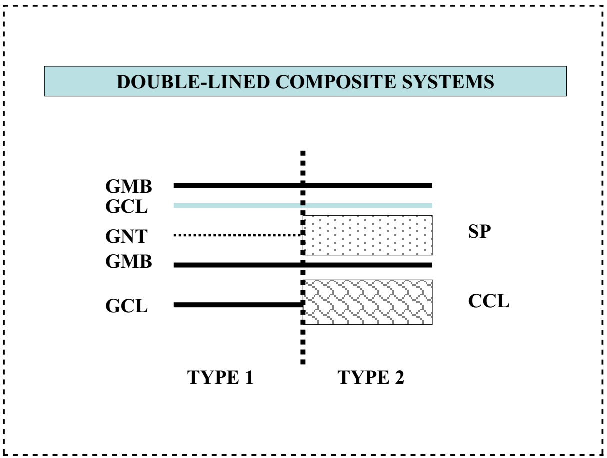

Figure 14. Typical geosynthetic double-lined composite liner systems.

6. THE NEXT TWENTY YEARS

It appears that the future of polyethylene geomembranes is very bright and secure for the next 20 years with increasing world demands especially in developing countries in conjunction for both water and waste management. Notwithstanding current and future polymer developments and save for some minor advancements, polyethylene as a primary geomembrane building material will be rather hard to dislodge for the same reasons it came to exist; excellent engineering properties at relatively low cost. New developments will probably be more along the lines of enhanced and modernized quality control and quality assurance methods such as the geo-electrical testing procedure (Rollin 2004). This procedure enables the identification and location of just about every geomembrane leak larger than 1mm in diameter, whether exposed or backfilled! This quality assurance procedure, although well proven and documented is unfortunately not currently made compulsory by governing bodies. Although it has already been used on a few projects in Quebec in recent years, it has yet to be considered as an inherent part of the geomembrane technology.

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