Discussion Session 5.3 / Séance de Discussion 5.3

New developments in containment techniques

Récentes mises au point dans les techniques de confinement

G. Baykal – *Boğaziçi University, Turkey*
A.Edinçliler – *Boğaziçi University, Turkey*

ABSTRACT: The objective of this session is to discuss the state of the art and future developments in containment techniques. The major development in containment techniques is in the area of new liner and cover materials. From modified clays to advanced polymers many developments became available. Prevention techniques of migration of flow and a new technology involving integrated glass sandwich panels have been presented. The new information related to fundamental behavior of composite liners, the developments in geosynthetic clay liners and alternative cover systems have been discussed.

RÉSUMÉ: L'objectif de cette session est de discuter l'état actuel et les futurs développements dans les téchniques de confinement. Le développement principal dans les téchniques de retenue est dans la domaine de nouveaux matériaux d' étanchement et de couverture. Beaucoup de développements, des argiles modifiés aux polymères avancés, sont devenus disponibles. Les téchniques d'empêchement du transfert de l'écoulement et d'une nouvelle téchnologie impliquant les panneaux de verre intégrés de sandwich ont été présentées. Le nouvel information pour le comportement fondamental des étanchements composés, les développements dans les étanchements argileux géosynthétique et les systèmes alternatifs de couverture ont été discutés.

Recent Developments in Liner Materials by G.Baykal

Due to the low hydraulic conductivity property of natural clay deposits, the landfills were constructed on them without any additional precaution. The effect of permeants on the diffused double layer thickness of the clay layer and the microfabric of the clay depending on the original depositional environment of the natural clay layer, serious leaching problems causing groundwater pollution were observed. Compacted clay liners were used as basal liner and cover material in the landfills for encapsulation. It did not take a long time to realize that the similar problems with natural clay deposits existed for compacted clay liners also. Every year more and more geosynthetic products became available for the construction industry.. The low hydraulic conductivity, flexibility, tensile strength properties of these materials made them very suitable for landfill applications. Holes and defective seams in goemembranes used as basal liner and cover showed that using a single geomembrane layer is not adequate. The benefits of compacted clay and geoemembrane were sinergized in composite liners. While the composite liners were performing well with inorganic leachates, in the case of concentrated organic leachates their performance were poor. This forced continuos research on development of new materials.; Organically modified clays (BTEA, DDTMA); Synthetically produced polymer addition (Metacrilates, polyaccrylammide etc). Innovative liners using bentonite sandwiched between geosynthetic layers became popular. Geosynthetic Clay Liners are available with many alternatives. Waste materials and byproducts are utilized as liner or cover material by mixing them either with clay or other materials or by stabilizing them with chemicals. New technologies have been developed for this purpose.

One example of these innovations is the Rubber fiber added clay liners and covers (waste of tire retread industry) which function well for organic contaminants as well as inorganic contaminants. This technology developed at Bogazici University reinforces the clay and decreases the crack propagation in liner and cover. By absorption it retards the leachate. The need for new technology development is to achieve: lower conductivity, full containment, compatibility, flexibility, stability, durability, equivalency, economy, ease of availability, implementability, compliance with regulations.

More and more manufactured products are used in liner design; concepts of modifying the clay or mineral liner by chemicals ; changing the leachate to viscous gel or by mixing the liner with inclusions; manufactured aggregates for leachate and gas collection.

New research tools like ESEM, Tomography, Hybrid devices, Miniature instrumentation and new research methods like modelling using neural networks, cellular automata etc. and improvements in material science especially in polymer science, intelligent materials and new developments in field instrumentation will help in the understanding of microfabric, the conduction phenomenon and other engineering properties.

It may be concluded that the trend in development in containment systems is towards manufacturing more and more geomaterials designed to fulfill special tasks. New technologies will help geotechnical profession to understand the mechanisms better so that long term performance of new containment systems will be assured.

New Developments in Containment Systems by R.D. Katzenbach

The migration of pollution could be prevented in two ways. One of them is providing containment by cutting of migration patways and the second one is by active and passive decontamination techniques. Cutting of migration pathways is achieved by encapsulation or immobilisation. Under the context of encapsulation, classical techniques covering vertical cut-of wall and bottom and surface liners and recent developments like capillary barrier systems and Integrated Glass Sandwich Sealing (IGSS) systems are presented.

A newly developed encapsulation technique is Slurry wall combined with glass elements that functions similar to classical slurry wall. Glass sheets are placed vertically in the slurry wall and the joints are sealed. Bentonite is used in the slurry. Double profile slurry walls are constructed using two glass sheets separated with a spacer.

Advantages of the IGSS system may be summarized as follows: Impermeability, chemical resistance to aggressive infiltration water, corrosion resistance and durability on long-term basis,

high bearing resistance, 100 % recycled glass can be used.

The cross section of basal liner made using Integrated-Glass-Sandwich-Sealing (IGSS) is composed of a drainage layer at the top which is underlain by a covering mineral layer. Flat glass elements are placed under the mineral covering layer on a foundation layer. Over the subsoil and under the foundation layer a sustaining mineral layer and a base layer are present. The sealing effect of IGSS is easily seen when its performance is compared to that of a standard 75 cm thick compacted clay liner with hydraulic conductivity of 0.5 10^{-10} m/sec. The stationary flow, q per area under 30-cm head of msw leachate is 220 m^3/ha.a. The q value decreases to a value of 1.5 m^3/ha.a for IGSS having 51-cm thickness.

Participant Contributions

Saglamer from Istanbul Technical University asked whether any data about the behavior of glass liners in the earthquake zones were available. Katzenbach stressed on the flexibility of the glass panels and stated that no problem is expected in the earthquake zones.

Jefferis from University of Surrey, UK contributed with his experience related to glass fibers used to reinforce concrete. He stated that they have used borax glass instead of soda glass. He wondered whether they were concerned with the durability of glass in such high alkaline environments. Katzenbach replied that classical commercial glass sheets were used and no consideration was given for the type of glass.

Hermanns-Stengele from Swiss Federal Institute of Technology commented on the joints and asked about the materials used in joints and their performance? Katzenbach mentioned that sealing materials are bentonite based. This is a problem because they do not have the same chemical resistance with glass.

Kamon from Kyoto University, Japan commented on the brittle behavior of glass sheets, and he asked why geomembranes were not used instead of glass? Katzenbach replied by stating that in the field tests they have learned that glass has high flexibility and only a few number of the glass elements was broken.

Edil from University of Wisconsin, Madison, USA asked the kind of joints that was used and the integrity of the joints against deformation and chemical contact. Katzenbach replied that the chemical resistance may be a problem in the long term and they are working on it in collaboration with the chemical industry.

Ozkul from Bogazici University, Turkey asked whether differential settlement be a problem in glass sheets? He replied that the results obtained from the field tests, and the computational research results show that differential settlement will not be a problem.

Baykal from Bogazici University, Turkey asked the effect of thermal stresses on the glass sheets especially when they are used in the cover layer. Katzenbach replied that the stress input on the glass elements were two to five times less than the bending capacity of the glass.

Recent Advances in Containment Techniques by T. Edil

The recent developments related to the fundamental behavior of composite liners may be outlined as follows: Chemical Transport through Compacted Clay Liners and Geosynthetic Clay Liners is affected by effective porosity and the chemistry of the leachate. For inorganic chemicals; partition and diffusion mechanismscontrol the flow of leachate. In the case of organic chemicals; partition, degradation, and diffusion mechanisms are involved.

Chemical Transport through Geomembranes are controlled by two mechanisms: diffusion and flux through defects (holes and seams).

Modeling of flux and chemical transport through composite liners is one of the research fields that attracts the interest of the researchers and recent models for inorganic chemicals and organic chemicals are presented.

Determination of the alternative liner equivalency is one of the important issues for the fundamental behavior of the composite liners.

Recent developments in liners include different types of geosynthetic clay liners which are manufactured materials composed of a bentonitic layer and geosynthetic layers. Swell and hydraulic conductivity of GCL are influenced by ionic strength and RMD (Ratio of Monovalent to Divalent cations) in multi-species solutions Swell tests are good indicators of hydraulic conductivity. Problematic leachates may cause up to several order of magnitude of increases in hydraulic conductivity; Especially for young MSW & mine wastes with an increase in ionic strength of the leachate, the hydraulic conductivity increases. For GCL` s the chemical compatibility with the leachate is very important.

Edil has presented a case history from Wisconsin State involving a sliding failure of a zone of saturation landfill. Effect of pore pressures should be considered when constructing landfills below the groundwater table, even in clayey soils. Effective stress parameters provided reasonable estimate of strengths mobilized during failure.

Some considerations related to alternative landfill covers are as follows: GCLs have some advantages over clay barriers, but should not be used without an overlying geomembrane. Composite covers work very well. They have very low percolation rates (1 - 3 mm/yr). They work well for mine wastes but they are costly. Alternative covers provide less costly alternative to composite covers in drier areas. Monolithic barriers, capillary barriers are some of the new developments. They require more testing for successfully design and analysis. Field performance data are being collected. Improved models for hydrological predictions are needed.

Participant Contributions

Chai from Saga University, Japan stated that Edil had emphasized the importance of flux through geomembrane defects. He asked whether some results were available? Edil replied that they have assumed either longitudinal or circular defects and in the case of inorganic chemicals water flow right through these defects. It can not go through the membrane and it would spread in the clay liner. In the case of organic chemicals primary transport would be diffusion through the membrane and then depending on the contact conditions between the geomembrane and the liner the flow will continue in the clay liner.

Jefferies from Surrey University, UK contributed with two comments: While plotting the results of the long term permeation tests it would have been better to plot with respect to pore volume permeated rather than time. If there will be interaction with the permeant and clay the test time may not be adequate. The origin of the clay used in GCL is important. It could be calcium bentonite converted from Sodium bentonite. Sources of bentonite is important for particularly in the early hydration stage. Edil stated that they have used a commercial bentonite and made a chemical analysis revealing that the clay used was 67% of Na bentonite.

Conclusions

The discussions reveal that more research should be carried out in understanding the long term contaminant transport mechanism and the interaction of these contaminants with new materials.