BENTOMAT® AS A LANDFILL LINER IN "SEISMIC IMPACT ZONES"

The shearing forces produced on a landfill liner system during an earthquake could be sufficient to threaten the stability of sloped areas and to thereby initiate a sliding failure on sloped areas of the liner. In recognition of this potential scenario, US EPA's recently promulgated solid waste landfill regulations contain certain design requirements for instances in which a new landfill is to be located in a "seismic impact zone." This technical reference examines these federal requirements and how they could be applied to a landfill design in which Bentomat is included in part of the liner system.

Section 258.14(a) of the landfill design requirements mandated under RCRA Subtitle D states that, "New MSWLF units shall not be located in seismic impact zones, unless the owner or operator demonstrates...that all containment structures, including liners...are designed to resist the maximum horizontal acceleration for the site." Section 258.14(b) then defines "seismic impact zones" as areas with a 10 percent or greater probability that the maximum expected horizontal acceleration as depicted on a seismic hazard map will exceed 0.10 g in 250 years.

Note that the design requirements in the new rules in no way prohibit or otherwise discourage the use of GCLs in landfills. Rather, the rules simply require the owner/operator to demonstrate that the maximum expected horizontal acceleration generated during an earthquake will not damage the liner system.

The first step toward achieving compliance with this requirement is to identify whether a proposed landfill site lies within a seismic impact zone as defined above. The preamble to the new rules (1) references a U.S.G.S. report, which contains maps showing acceleration isopleths for various return periods (2). CETCO maintains a copy of this report on file and can provide the relevant portions of it upon request. Assuming that the proposed landfill lies within a seismic impact zone, we next need to ask what effect, if any, would an earthquake have on the liner system. Answering this question requires many assumptions regarding the magnitude of the quake, the distance of its epicenter to the landfill site, the local geology of the landfill site, the degree of attenuation within the regional subsurface, and, finally, the translation of horizontal acceleration in the subsurface to a horizontal driving force within the liner system.

One method of incorporating many of these assumptions is provided by Huang (3). In this method, a seismic coefficient is calculated and then added to the driving force in a simple "infinite slope" or "sliding block" stability analysis. It is thereafter a relatively straightforward matter to incorporate the seismic force into the factor of safety for the sloping liner system, which would decrease as the seismic coefficient increases. Of course, the engineer must carefully evaluate the appropriateness of the many assumptions made by this method.

From a more general standpoint, it could be suggested that sodium bentonite itself is undesirable as a liner material due to its inherently low shear strength.

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This is not necessarily the case, however, if the bentonite is "reinforced," as in the case of Bentomat. Bentomat's needlepunched construction provides it with literally thousands of fibers, which connect the upper and lower geotextiles and thereby transmit shear forces through the bentonite layer. In this manner it is possible to safely utilize Bentomat for the design and construction a stable slope whose steepness exceeds the slope which would support a non-reinforced bentonite layer. Just as shear forces are transmitted downward in a typical design scenario, so, too, would they be transmitted upward through the liner in the event of an earthquake. In either case, the integrity of the liner is protected. Bentomat is totally unique in this regard.

Direct shear testing performed on the "internal" interface of Bentomat (i.e., the bentonite layer) indicates that it has an internal friction angle of 26 degrees. This is the lowest value we have yet obtained during testing of this interface. Others have obtained values as high as 39 degrees under different test conditions, yet CETCO recommends that the 26 degree value be utilized in slope stability analyses in order to be as conservative as possible. In comparison, the natural shear strength of bentonite by itself in these conditions is only 6-9 degrees; thus, it is evident that the needlepunched fibers in Bentomat adds significantly to its internal shear strength.

Another potential concern is that any vibrational movement of the subgrade during seismic activity could "mobilize" the hydrated bentonite and allow it to migrate downslope. However, the needlepunched construction of Bentomat not only transmits shear stresses but also serves to effectively confine the bentonite and prevent its movement. Bentomat is a three-dimensional matrix of bentonite and needlepunched fibers, which is highly resistant to this type of deformation under differential physical stresses.

To summarize, the new federal rules regarding new landfills located in seismic impact zones in no way restrict the use of GCLs such as Bentomat. Therefore, Bentomat can be safely designed into a Subtitle D-compliant landfill liner system, provided that the results of a seismic impact analysis and slope stability analysis do not indicate an unacceptable decrease in the factor of safety for the liner system.

References

1. 56 FR 50978 (October 9, 1991).U.S. Geological Survey Open File Report 82-1033. Probabilistic Estimates of Maximum Acceleration and Velocity in Rock in the Contiguous United States. U.S.G.S., Denver, CO.
2. U.S. Geological Survey Open File Report 82-1033. Probolistic estimates of maximum acceleration and velocity in rock in the contiguous Unites State. U.S.G.S., Denver, CO.
3. Huang, Yang H. 1983. Stability Analysis of Earth Slopes. Van Nostrand Rheinhold Co., New York.

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