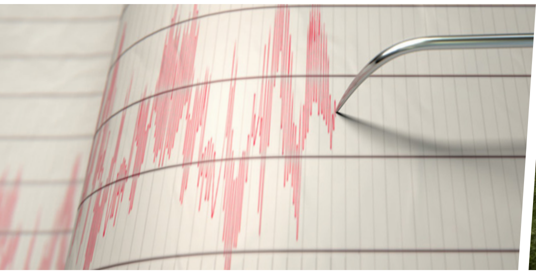
International Geosynthetics Society
Geosynthetics in Seismic Applications



Earthquake Disaster Prevention with Geosynthetics

Designing countermeasures for natural disaster, especially earthquakes, is a common task in the world. Earthquakes cause strong horizontal acceleration of structures. Table 1 presents the recorded Peak Ground Acceleration (PGA) values in recent notable earthquakes. This motion caused serious damage or failure in various structures. Geosynthetics play a major role in disaster mitigation and prevention due to earthquakes by retaining walls, embankments, and slopes.

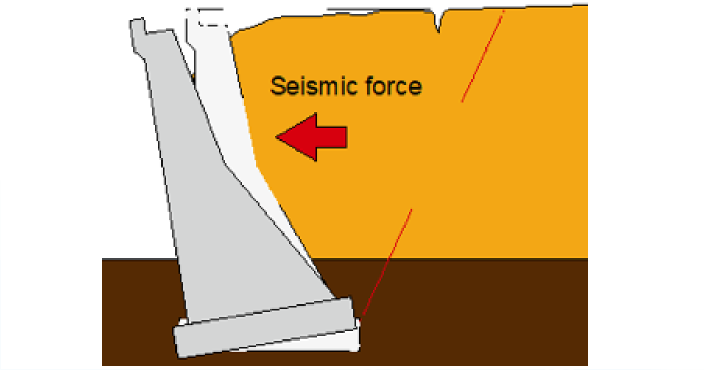
Table 1 PGA in Recent Notable Earthquakes

EARTHQUAKE	PGA
2011 Tohoku Earthquake & Tsunami	2.7g
2011 Christchurch Earthquake	2.2g
1994 Los Angeles Earthquake	1.7g
1999 Jiji Earthquake	1.0g
1999 Athens Earthquake	0.6g

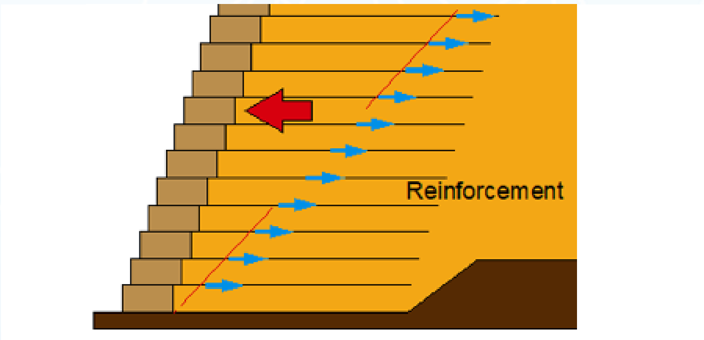
Why are Geosynthetics Beneficial in Seismic Applications?

Fig.1 shows the difference of seismic performance between gravity-type walls and geosynthetic- reinforced soil (GRS) walls. If seismic force is applied to the gravity type wall, the concrete structure part will rotate (Fig.1a) or sliding will occur owing to the lack of soil strength and inertia effect. Generally, in the gravity-type walls, failure occurs at a relatively low seismic force. In the case of GRS walls, additional reinforcement loads are mobilized owing to seismic forces. The reinforcement loads become an incremental resistance to stabilize the wall and the total resistance force of the wall increases. Hence, GRS walls can show good performance against high seismic forces.

The high seismic performance of GRS walls was evident by many earthquake experience. Fig.2 is a precious case history in Kobe earthquake (PGA 0.8g, 1995). A number of wooden houses, railway and highway embankments, and conventional types of retaining walls were seriously damaged and collapsed during this event. However, as shown in Fig.2, GRS walls having a full-height concrete facing performed very well even though the walls were located in one of the most severely shaken areas. At their location, only a slight deformation was recorded.



a) Poor performance of gravity-type walls.



b) Excellent performance of reinforced walls
Fig.1 Comparison of seismic performance of gravity- type and reinforced walls

Analysis Methods

The analysis of GRS structures can be classed into the following categories:

a) pseudo-static methods
b) sliding block methods
c) finite element/ finite difference methods.

Method a) is based on the Mononobe-Okabe method to calculate dynamic earth forces acting on the structure. Seismic force is treated as a static force and the stability of the wall is analyzed using limit equilibrium analysis with reinforcement loads. **Method b)** is based on Newmark's method to calculate the permanent displacement of geo-structures by integrating the calculated acceleration of the structure. **Method c)** is based on continuum mechanics based analysis. Soil, reinforcing materials, and the other materials are modeled by considering their elastic, plastic, and time-dependent properties and a discretized governing equation is solved by using the computer.

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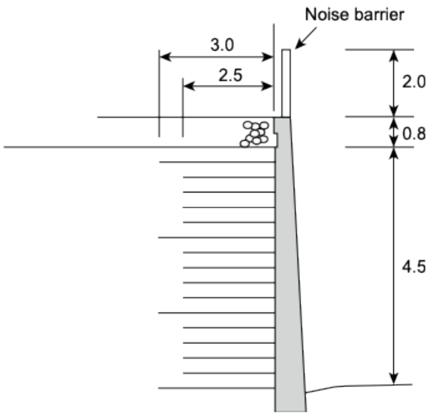
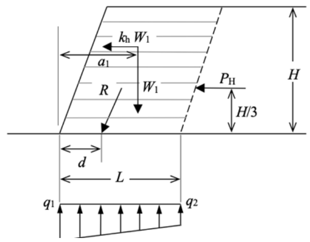


a) Poor performance of gravity-type walls.

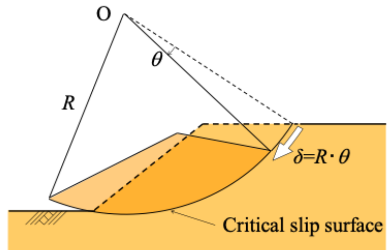
Fig.2 Surveyed reinforced wall during the Kobe earthquake (Tatsuoka et al: S&F, 1996)

Current Research and Future Techniques

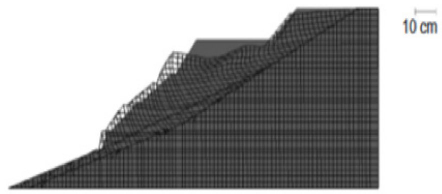
The high seismic performance of GRS structures is carefully being investigated by experimental tests using shaking table facilities or geotechnical centrifuges. In the tests, a reduced scale model of the GRS structure is subjected to an artificial excitation (input motion), simulating the ground motion induced by an earthquake. The mechanical behavior of geosynthetics under wide strain rate conditions is also being investigated. Analysis methods to determine the seismic performance of GRS structures are being updated by applying recent computer simulation techniques with their verification and validation. Some performance based design methods are proposed for GRS structures. The use of geosynthetics for seismic applications will increase owing these research activities.



a) Pseudo-static methods.



b) Sliding block methods.



c) Finite element / finite deference methods.

Fig.3 Analysis methods for determining seismic performance of geosynthetic-reinforced soil structures (Shinoda et al: GI, 2009).

About the IGS

The International Geosynthetics Society (IGS) is a non-profit organization dedicated to the scientific and engineering development of geotextiles, geomembranes, related products and associated technologies. The IGS promotes the dissemination of technical information on geosynthetics and their appropriate uses through a newsletter (IGS News), two official journals (Geosynthetics International and Geotextiles and Geomembranes), conferences and technical seminars, dedicated task forces, over 40 National Chapters, special publications, and multiple other communications and outreach methods.

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