

# Landslide hazard zonation in Campania - application and implementation in ArcGIS

Elin Skurtveit, Amir M Kaynia, Ellen E. D. Haugen and Gökhan Saygılı  
Norwegian Geotechnical Institute, Oslo, Norway

Displacement-based seismic slope stability methods are proven to be successful for studying the slope performance during an earthquake. Various methods have been tested for different earthquake case studies and a GIS based method have been applied for the Irpinia 1980 earthquake within the Destra Sele Region, Campania

## Empirical models tested

### ASCE Method

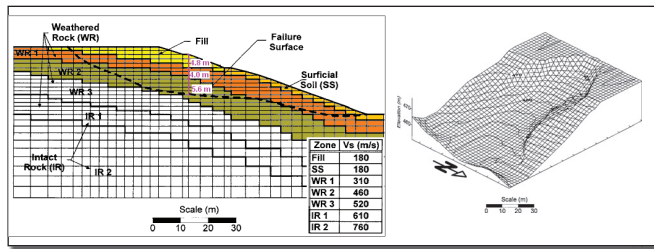
The ASCE method uses Newmark-type displacement analysis for calculation of earthquake-induced displacements. The analysis requires estimation of the slope yield acceleration  $a_y = k_y g$ . Parameter  $k_y$  is often referred to as yield seismic coefficient and can be estimated from the angle and safety factor of slope together with Horizontal Equivalent Acceleration, HEA.

$$u = k_{max} D_{5-95} \cdot 10^{\frac{1.87 - 3.477 \cdot k_y}{k_{max}}}$$

$k_{max} = MHEA/g$  is the peak acceleration demand coefficient, where MHEA is the maximum equivalent acceleration, and  $D_{5-95}$  is the significant duration of shaking (length of time between 5% and 95% of normalized Arias Intensity). More detailed models, including Saygılı and Rathje (2008) and Bray and Travasarou (2007) were used and the results compared.

Reference	Saygılı and Rathje (2008)		Bray and Travasarou (2007)	Blake et. al. (2002)
GM Parameters	PGA, M	PGA, PGV	PGA	PGA, $D_{5-95}$
Min Displacement	0 cm	0 cm	0 cm	0 cm
Max Displacement	76 cm	78 cm	97 cm	171 cm
0 - 5 cm	99.44%	99.44%	99.41%	99.37%
5 - 15 cm	0.31%	0.32%	0.34%	0.26%
15 - 30 cm	0.11%	0.10%	0.07%	0.12%
> 30 cm	0.14%	0.13%	0.18%	0.25%

Comparison of the distribution of landslides for varying displacement threshold using different empirical models.



The various empirical models have been compared with well described historical landslides after the 1994 Northridge Earthquake and the Yokowatashi landslide following the Niigata-Ken Chuetsu earthquake in 2004.

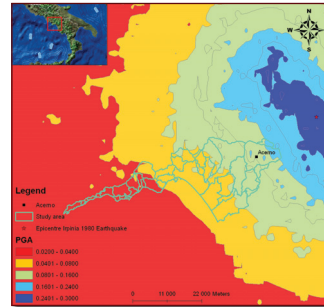
## References

Michellini, A., Faenza, L., Lauciani, V., & Malagnini, L., 2008. Shakedown Implementation in Italy, *Seismological Research Letters*, 79(5), 689-698.  
 Bray, J.D., Travasarou, T., 2007. "Simplified Procedure for Estimating Earthquake-Induced Deviatoric Slope Displacements", *J. Geotech. and Geoenviron. Engrg.*, Volume 133, Issue 4, 381-392  
 Saygılı, G. and Rathje, E., 2008. "Empirical Predictive Models for Earthquake-Induced Sliding Displacement of Slopes" ASCE *J. Geotech. Geoenviron. Eng.*, 134(6)  
 Blake, T., Hollingsworth, R., Stewart, J., D'Antonio, R., Earnest, J., Gharib, F., Horsman, L., Hsu, D., Kupferman, S., Masuda, R., Pradel, D., Real, C., Reeder, W., Sathilingam, N., and Smanthob, E., editors (2002). Recommended procedures for implementation of DMG Special Publication 117 guidelines for analyzing and mitigating landslide hazards in California. ASCE Los Angeles Section Geotechnical Group.

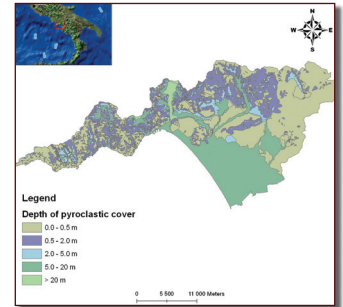
## Acknowledgements

Thanks to Eng. Angela Di Ruocco and Eng. Annamaria Criscuolo of the Amra Center for providing geological and geotechnical information from the Campania area and to Licia Faenza at INGV for providing the ShakeMap files from the Irpinia 1980 earthquake

## Application of ASCE Method to Destra Sele River Basin, Campania, Italy



Input PGA data for the Irpinia 1980 earthquake in the Campania region (Michellini et al 2008)

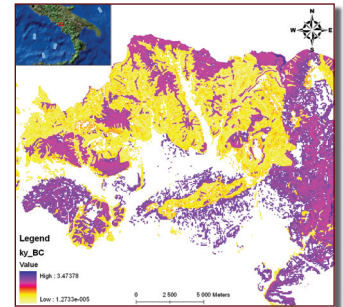


Thickness of pyroclastic cover in the Destra Sele River Basin. These data are used as the slab thickness in the soil stability model for the area.

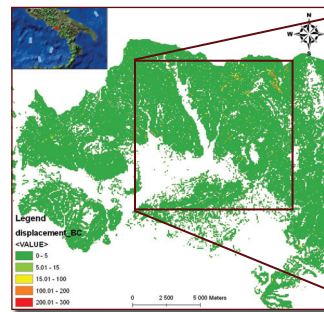
$$FS_{static} = \frac{c + (\gamma - \gamma_w)H \cos^2 \beta \tan \phi}{\gamma H \sin \beta \cos \beta}$$

$$a_y = k_y g = (FS_{static} - 1)g \sin \beta$$

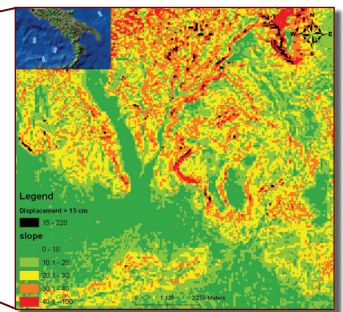
ArcGIS Raster calculation model for factor of safety and the yield acceleration of the soil.



The yield seismic coefficient,  $k_y$ , distribution (in g) for part of the Destra Sele territory. Low values are indicating the most critical areas for potential landslides.



Displacement in cm for part of the Destra Sele territory calculated for slopes steeper than 10 degrees.



Critical displacements above 15 cm compared with the slope map for a part of the Destra Sele River Basin Authority

## Results

The results show how a GIS-based method can be implemented for near real-time prediction and mapping of landslides. The model is based on the Shake Map and soil data collected available for the Destra Sele River Basin area.

Parameter studies show that the calculated displacement is more sensitive to the soil characterization parameters (shear strength) and resolution in topographical data than the type of empirical model or earthquake size.