

## Apply It.

# The math behind... Earthquake Simulations



### Math that is used to simulate earthquakes:

Numerical modeling, wave equations, time-series analysis, supercomputers, body waves, Rayleigh waves, Love waves

### Uses and Applications:

Predicting the amount of shaking from an earthquake, determining appropriate building codes, identifying dangerous areas

### How it Works:

When an earthquake occurs, it releases body waves that travel through the interior of the Earth. Upon reaching the surface, the body waves generate Rayleigh and Love waves that can damage engineered structures. Scientists use powerful supercomputers to simulate earthquakes in order to estimate the likely effects of such an event on people and infrastructure. This is done by approximating the solutions of sets of partial differential equations describing wave propagation (wave equations) through a visco-elastic medium, like the Earth.

The Earth is modeled as a set of elastic parameters, including seismic velocities, density, and attenuation properties. Simulations undertaken with sufficient computer resources can model the Earth in three dimensions so that the effects of complex geological structure on wave propagation can be investigated. Strong ground motion is modeled by recording time-series files at the "surface" of the simulated volume. Various parameters describing shaking can be calculated from these time series, such as peak ground acceleration and duration of shaking. These simulated quantities can be used to evaluate the seismic hazard in a region and building codes can be modified accordingly.

### Interesting Fact:

The Southern California Earthquake Center developed a very large-scale simulation project called TeraShake in order to evaluate the threat from earthquakes on the southern San Andreas fault.

TeraShake uses a supercomputer with 240 processors to solve wave equations in a 600 kilometer by 300 kilometer by 80 kilometer volume with 200 meter resolution. A simulation lasting three minutes generates almost 50 Terabytes of output, or enough data to fill about 75,000 CDs! Scientists use this data to conduct further research into understanding the earthquake process.

### References:

Southern California Earthquake Center website:

<http://epicenter.usc.edu/cmeportal/TeraShake.html>

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