Whose Fault Is It?

New Mexico

Supercomputing Challenge

Final Report

April 7, 2010

Team 16

Aspen Elementary

Team Members:

Talia Dreicer

Hunter Eaton

David Smith

Teacher:

Mrs. Zeynep Unal

Project and Team Mentors:

Jared Dreicer

Kathy Smith

Table of Contents

Executive Summary

Throughout North America there are numerous fault lines that cross through the United States with probably the most famous one being the San Andreas Fault in California. We were very interested in this area and decided to try determining which type of structural material for houses would withstand an earthquake better. Our interest became more important to us as we discovered Los Alamos sits on an active fault line called the Pajarito Fault Line. A large amount of our town was built during the 1940's when building codes did not seem to cover earthquake resistant materials.

By using StarLogo TNG we constructed a program in an attempt to demonstrate the amount of damage a house could withstand during an earthquake. We limited our research and programming to two different structural materials – wood and adobe.

Through our research and programming efforts we have learned there are many factors that can affect the amount of damage a house could withstand. Not only does the strength of an earthquake affect the houses, but also the distance the epicenter is from towns, the depth of the epicenter, and the surrounding terrain. Our programming model supports our research in that wood houses will withstand an earthquake better than adobe houses.

Statement of Problem Investigated:

We have been studying the effects of an earthquake using two different types of structural materials used in houses in our area. The two types of materials that we studied were wood and adobe. We understand that there are many factors that could affect the amount of damage done to the houses. Our main problem that we researched was which material, wood or adobe, is stronger and can resist some of the damage that might occur during an earthquake. The research we have conducted and the programming we have developed has helped us to answer this question.

Description of the Method Used to Solve the Problem:

We began solving our problem by conducting research on earthquakes and learning about the scales for measuring the magnitudes. The U.S. Geological Survey (USGS) web site provided many facts about the earthquakes and the different factors that could determine the amount of damage to a house. These factors are magnitudes, the epicenter's distance from a town, the epicenter's depth, the type of terrain, and the two types of waves (primary and secondary waves). We also understand that many wood and adobe houses of today have some type of reinforcements to them than in earlier times and in less developed countries.

Once we obtained this information, we started our programming in StarLogo TNG and decided what kind of logic we would use. We initially decided to set limits for our programming by focusing only on the magnitude and distance of an earthquake as shown in the table below:

Epicenter	Magnitude	Date	Affected Places	Distance	Damage Wood	Damage Adobe
15 miles WSW of PORT-AU-PRINCE, Haiti	7.0	Tuesday, January 12, 2010	Port-Au-Prince and surrounding towns	About 15 mi	Yes 95%	Yes 99%

Epicenter	Magnitude	Date	Affected Places	Distance	Damage Wood	Damage Adobe
Pacific Ocean 2 miles W of San Francisco	Around 7.8	April 18, 1906	San Francisco	About 2 mi	Yes 88.6%	?
Borah Peak, Idaho	7.3	Friday October 28, 1983	Challis, and Mackay	37 mi and 23.6 mi	Yes, small 15%	Yes 85%
Goshen, Utah	3.0	Saturday, January 23, 2010	Elberta, UT Provo, UT Salt Lake City, UT	4 mi 24 mi 56 mi	?	?
15 miles SSE of Golfito, Costa Rica	4.7	Tuesday, January 19, 2010	Golfito, Costa Rica David, Panama	35 mi 20 mi	No	No
15 miles) ENE of Isangel, Tanna, Vanuatu	5.6	Sunday, January 24, 2010	PORT-VILA, Efate, Vanuatu Isangel, Tanna, Vanuatu	140 mi 15 mi	No	No

We developed blocks to represent non-reinforced wood and adobe interior walls; however, when we began trying to create an agent we made some minor changes to our original programming.

The use of the Modified Mercalli Intensity Scale, Richter Scale, and the shake maps helped us to understand at what point damage could be identified. This helped us to set our magnitudes in our program.

Our Results:

Our initial results took on a logic based program, but we soon discovered that this type of program was overwhelming and began looking at it in a simpler form. We soon developed an agent based model using the logic program we had already developed.

During our testing, if we picked one hundred random magnitudes between 0 and 8 and one hundred random distances between 0 and 100, the damage count to an adobe house would be much higher than wood. In most cases adobe houses would have a likelihood of being damaged 2 to 3 times more often than wood. Our wood houses would have a probability of either receiving none or slight damage in most of our tests.

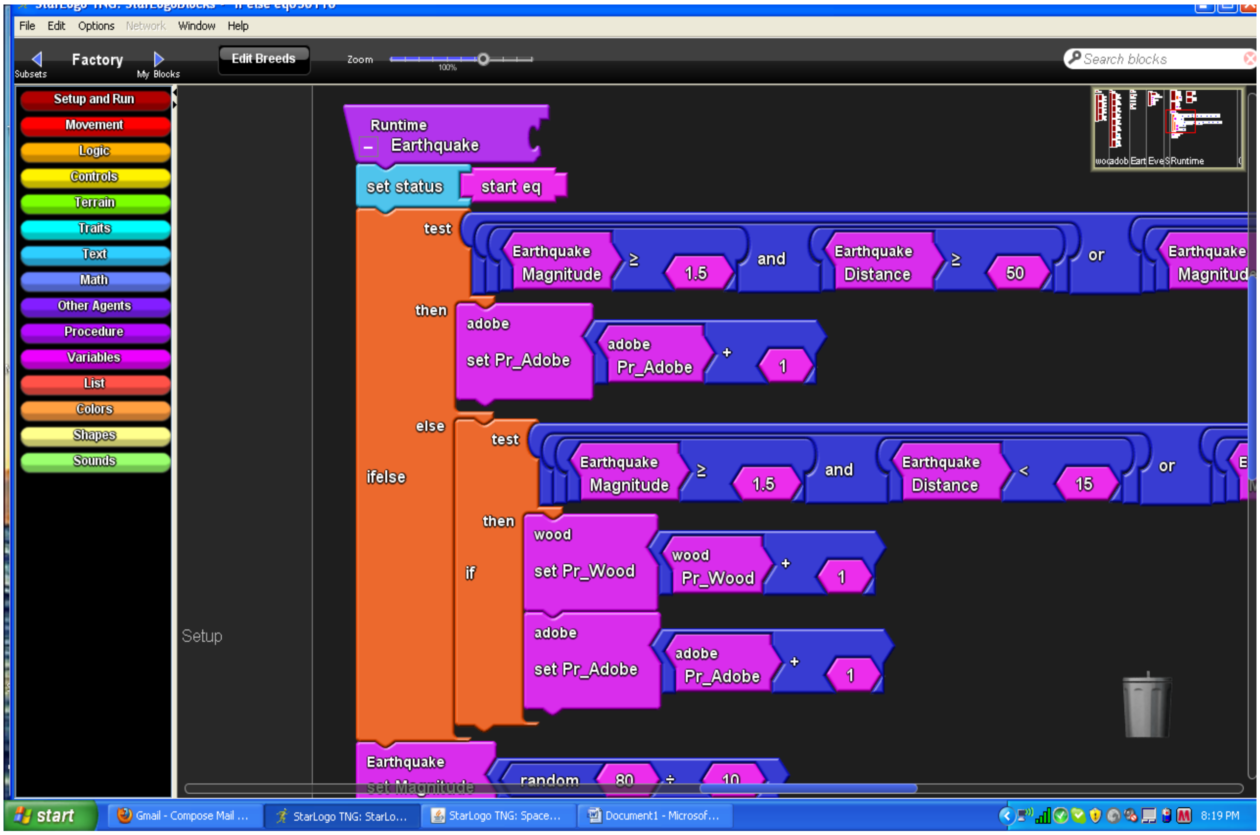
Our Conclusions:

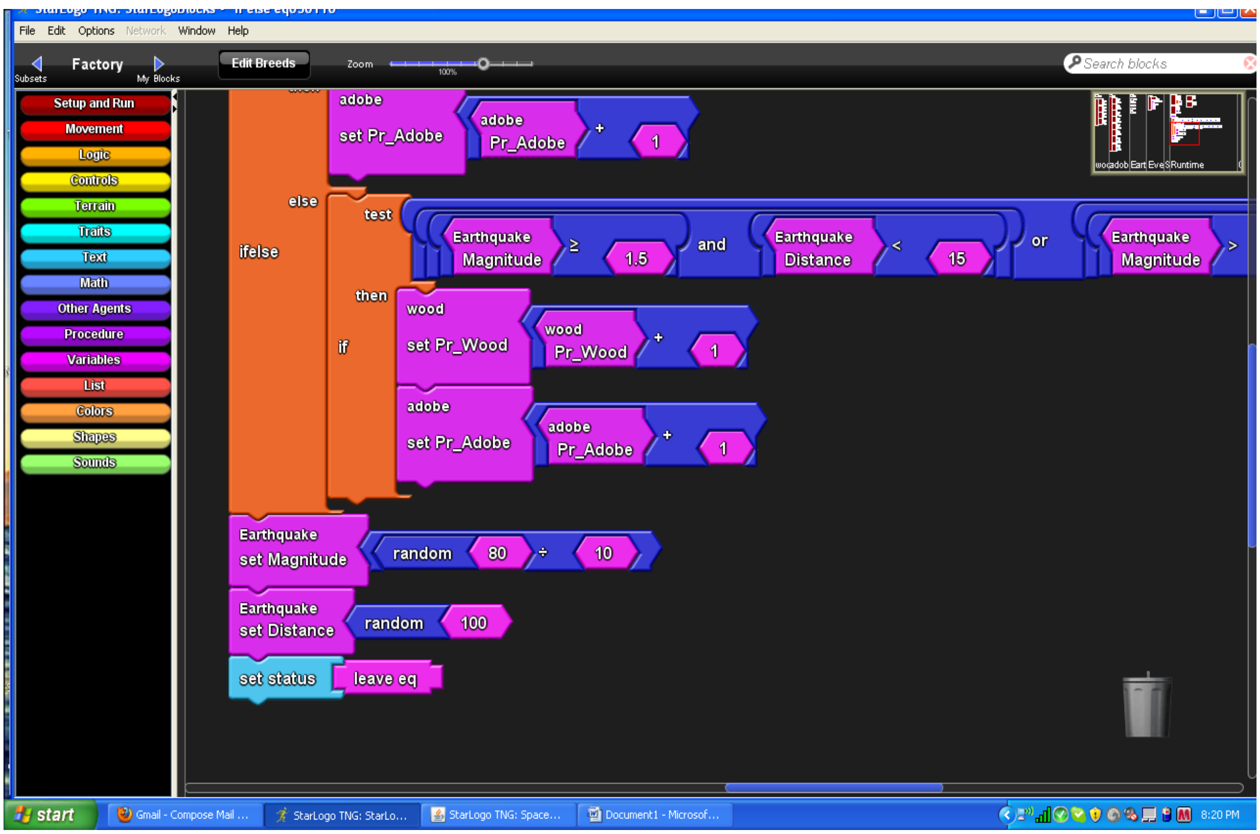
Overall, the research that we conducted and the testing of our programming efforts revealed that wood is more durable during an earthquake than adobe. We also believe that adobe will not withstand large earthquakes.

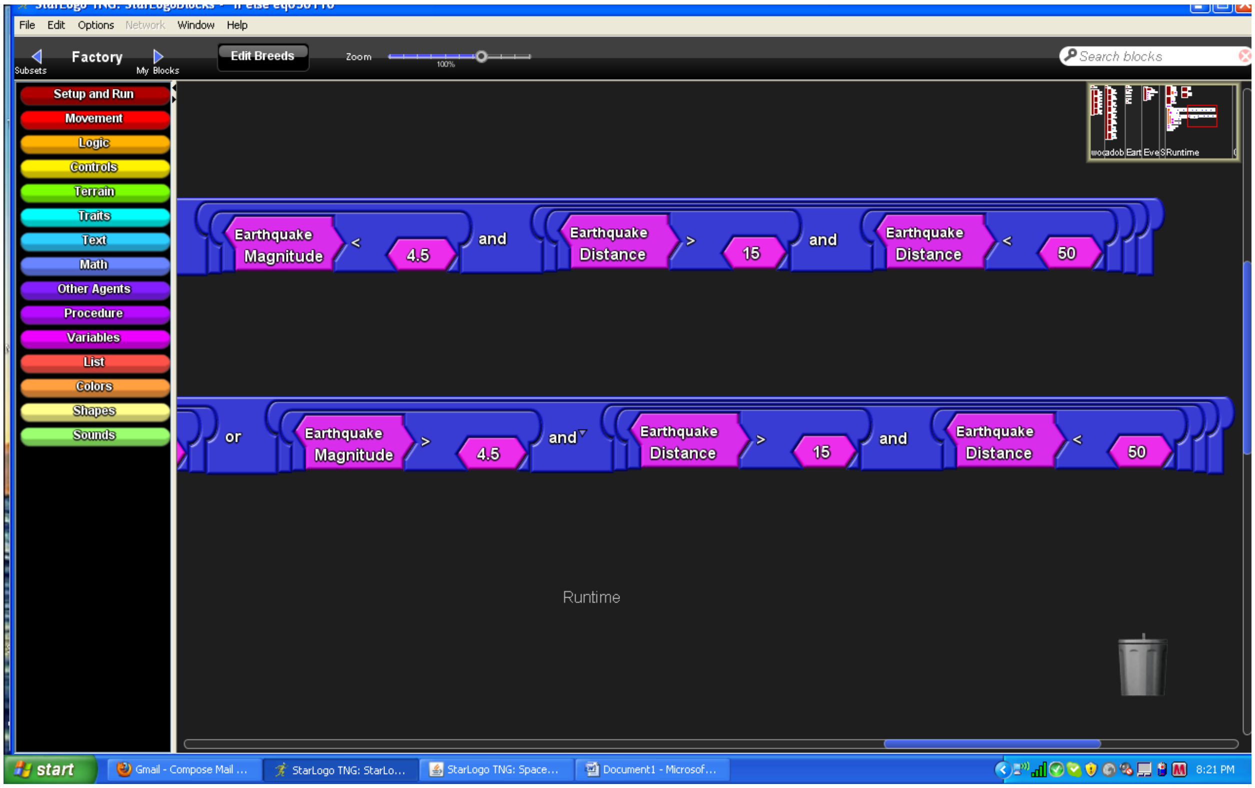
It also proved to us that our subject or problem to research and program was much more complex than we could have ever imagined.

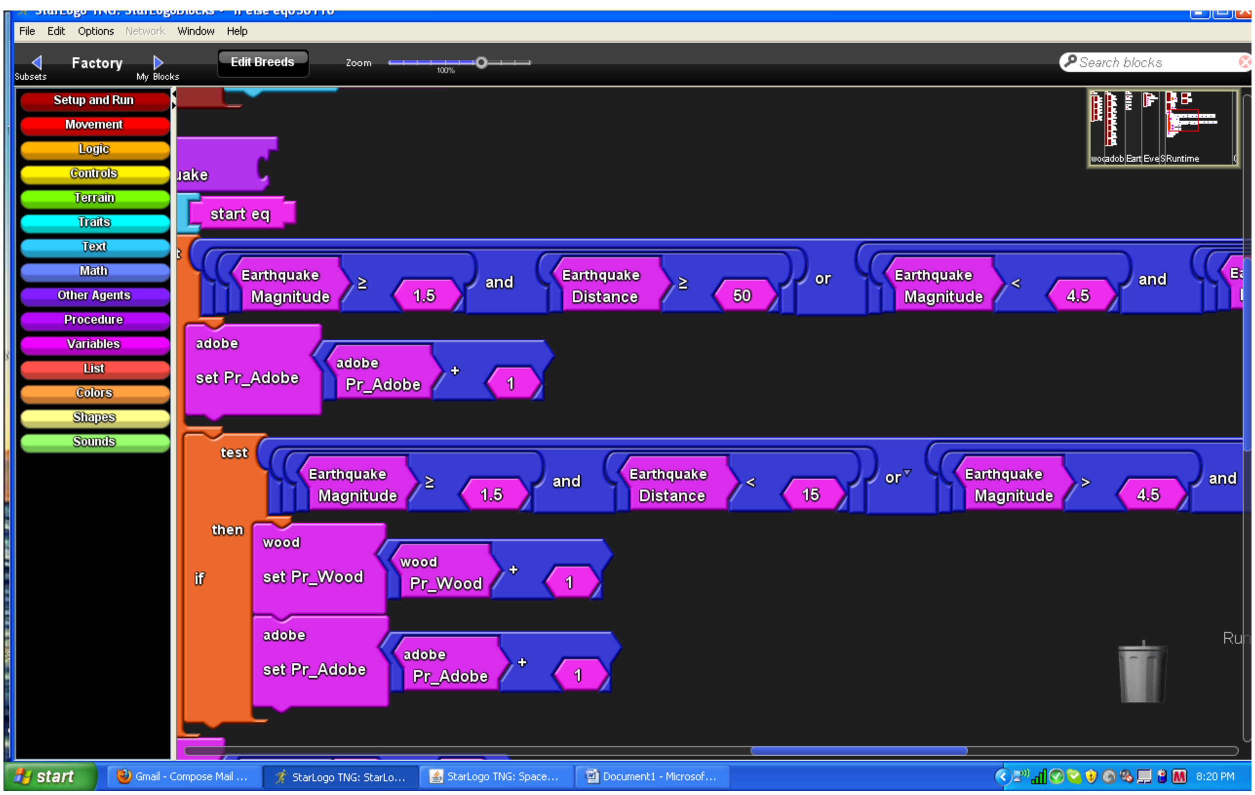
Software:

The software we used for our programming is StarLogo TNG. Shown below are screenshots of our program's logic.


Runtime
Earthquake
set status
start eq
test
then
else
ifelse
if
Setup


ifelse
else
test
then
if
Earthquake
set Magnitude
random
Earthquake
set Distance
set status
leave eq


File Edit Options Network Window Help
Factory
Edit Breeds
Zoom
Setup and Run
Movement
Logic
Controls
Terrain
Traits
Text
Math
Other Agents
Procedure
Variables
List
Colors
Shapes
Sounds
Earthquake Magnitude < 4.5 and Earthquake Distance > 15 and Earthquake Distance < 50
or Earthquake Magnitude > 4.5 and Earthquake Distance > 15 and Earthquake Distance < 50
Runtime
start
8:21 PM

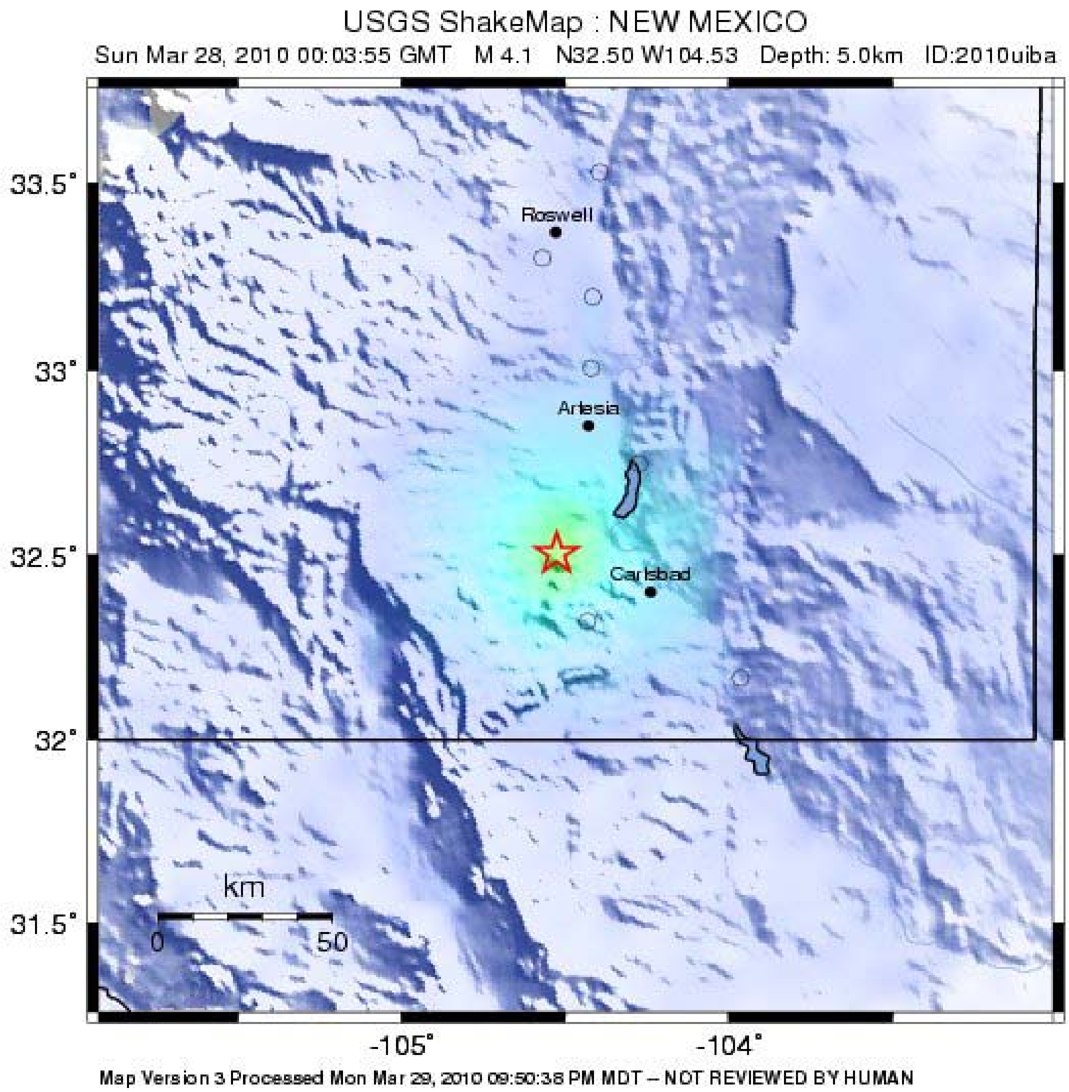

File Edit Options Network Window Help
Factory
Edit Breeds
Zoom
start eq
Earthquake Magnitude ≥ 1.5 and Earthquake Distance ≥ 50 or Earthquake Magnitude < 4.5 and
adobe set Pr_Adobe adobe Pr_Adobe + 1
test
Earthquake Magnitude ≥ 1.5 and Earthquake Distance < 15 or Earthquake Magnitude > 4.5 and
then
if
wood set Pr_Wood wood Pr_Wood + 1
adobe set Pr_Adobe adobe Pr_Adobe + 1
start
8:20 PM

References:

- Downs, Sandra. When the Earth Moves. Brookfield, Connecticut: Twenty-First Century Books, 2000.
- "Los Alamos-area historical earthquake activity" http://www.city-data.com/city/Los-Alamos-New-Mexico.html#ixzz0U9hlvcUp, October 2009
- USGS National Earthquake Information Center, http://earthquake.usgs.gov/regional/neic/, Earthquake Lists & Maps, November 2009
- New Mexico Tech, http://www.ees.nmt.edu/Geop/NM_Seismicity/, Seismic Activity and Risks in the Socorro Region of Central New Mexico, October 2009
- USGS Parkfield Interventional EQ Field work, http://www.allshookup.org/qukes/wavetype.htm, Types of Earthquake Waves, September 2009

Other Tables Used:

To help us in setting our magnitudes we viewed several shake maps from the USGS web site. Below is a sample of a shake map:



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Two additional tools we used with our programming were the Modified Mercalli Intensity Scale which has 12 levels of intensity and the Richter Scale. Both were used by us for identifying the strength of an earthquake and the potential damage it could cause.

Modified Mercalli Intensity Scale	
Level	**Description**
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake.
IV	Felt indoors by many, outdoors by few during the day. Sensation like heavy truck striking building.
V	Felt by nearly everyone, many awakened. Some dishes, windows broken. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures. Considerable damage in poorly built or badly designed structures.
VIII	Damage slight is specially designed structures. Considerable damage in ordinary substantial building with partial collapse. Damage great in poorly built or designed structures.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plum. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Richter Scale	
Magnitude	**Earthquake Effects**
2.5 or less	Usually not felt, but can be recorded by seismograph.
2.5 to 5.4	Often felt, but only causes minor damage.
5.5 to 6.0	Slight damage to buildings and other structures.
6.1 to 6.9	May cause a lot of damage in very populated areas.
7.0 to 7.9	Major earthquake. Serious damage.
8.0 or greater	Great earthquake. Can totally destroy communities near the epicenter.
Magnitude	**Magnitude Class**
8 or greater	Great
7 – 7.9	Major
6 – 6.9	Strong
5 – 5.9	Moderate
4 – 4.9	Light
3 – 3.9	Minor

Most Significant Original Achievement:

Overall our greatest achievement that we have accomplished is learning to work as a team. This was often difficult for us but allowed all of us to contribute to this project. Most importantly we learned that not only can wood houses do better in an earthquake, but.........

"Earthquakes have never caused a death,
but it was the poorly designed buildings that did."

Mike Salmon, Team Leader
Probablistic Structural Mechanics
Los Alamos National Laboratory

Acknowledgements:

There are a number of people we want to acknowledge and give thanks to for helping us every step of the way. They are:

- Our school sponsor, Mrs. Zeynep Unal. Mrs. Unal allowed us to come in twice a week and sometimes more if we needed it to work on our projects. She also helped us to find sources or people that could help us when we got stuck with a problem.
- For our earthquake research, we received help from Mr. Mike Salmon and Dr. Richard Lee. While both of these gentlemen are very busy LANL employees they took the time to help us in understanding earthquakes.
- We would not have been able to finish our agent based program without some special help from Mr. Duc Vo and his daughter, Kim.
- Finally our mentors who kept us on track and on schedule. Mr. Jared Dreicer and Mrs. Kathy Smith kept us moving in the right direction.