Building for the Quake

The scientific understanding of possible earthquake hazards in the Pacific Northwest has only recently become known. Because the Northwest has had very little seismicity over the last 200 years, cities in the area did not require buildings to be constructed with earthquakes in mind. Buildings built before 1974 did not account for earthquakes because we didn’t know we were at risk. Recent studies of plate tectonics, soils, faults, ancient and recent earthquakes in Oregon has informed us of the possible dangers which exist for the city’s buildings, bridges and roadways.

Portland is susceptible to three different types of earthquakes. A crustal earthquake could strike from a crack (crustal fault) in the North American Plate with an epicenter near the city; a subduction zone earthquake may rock Portland even though the fracture could be a hundred miles off-shore where the Juan de Fuca Plate slides beneath; or a deep Benioff earthquake could rattle the earth below our feet from the subducting plate being broken up as it melts. We must prepare our building to withstand any type of earthquake.

All building construction must conform to the Uniform Building Code (UBC). This code requires building designs to account for ground motion resulting from an earthquake. Extra supports will need to be added to ensure earthquake resistance. Each area of a state is appointed a UBC seismic code depending on its susceptibility to earthquakes. If an area is suspected or known to have earthquakes, it will be given a higher UBC value. The UBC seismic zones range from 0 to 4, 4 being the most hazardous area. In 1991, Earthquake Building Codes in western Oregon were upgraded from UBC seismic zone 2b to UBS seismic zone 3. The 2b code would require buildings to resist ground motions from an earthquake of approximately magnitude 5 to 6 (on the Richter scale), but the current building UBC seismic code for western Oregon requires that new buildings be able to withstand a magnitude 7 earthquake.

The January 1994 Oakridge earthquake in L.A. measured a magnitude 6.5. Your buildings will be tested to see if they meet or exceed this standard.

Team’s Mission: (Consists of an architect and a geologic engineer)

- Create a 250 foot building that is designed to resist earthquakes

Architectural Engineer’s Mission:

- Design, draw and describe the building in enough detail so it can be constructed and leased out to customers

Geological Engineer’s Mission:

- Select an exact location in Portland which minimizes damage due to an earthquake, while adhering to the city codes and restrictions

There are several steps and responsibilities each of you must take during this project. Be sure to go through and check off each step as you go along. You may put this together as one project rather than two individual projects with the same information.

Building Proposal

Each group must construct a building proposal BEFORE construction can begin. The building proposal will include the following information:

- **Background Information:** A 1/2 page description of Portland’s location and earthquake threats. Talk about possible earthquake threats. What is an earthquake? Why must Portland prepare for one? What other threats are there as a result of an earthquake in the Portland area?

- **Building Design:** Two drawings of the building (front view and top view) drawn to scale on graph paper with dimensions shown and earthquake devices drawn and labeled.
**Building Description:** Building type (what is it going to be...ex. Hotel, bank, industrial, etc.), give the building a name, total height, area of base, and number of floors.

**Site Description:** Maximum height zone, base zone, and soil type your building is located on. Explanation of how soil types behave during earthquakes and any possible landslide hazards. (at least 2/3 of a page)

**Seismic Requirements:** UBC seismic zone requirement for the Portland area. How are you going to design the building to resist an earthquake? Describe the structural techniques, or additional materials used and explain how these will help the building survive. Use your experience with load paths to describe how your building design will handle a load in any direction. Use the handout, “What Causes Damage?” to explain your reasoning (at least 2/3 of a page)

**Construction Budget:** Create a material list for the construction of the building (what are you going to use?). Create a budget describing the amount of each material used for the completion of the building, cost for each material, total for each material and the total cost of the structure.

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**Designing Your Building**

Your building will be awarded points on us ability to withstand an earthquake, as well as following the building requirements described below. The challenge is to get the most strength for the least cost.

**Design Specifications:** Your building must be a 250 foot high rise, which could be a huge industrial building, office skyscraper, tall apartment complex, government building (such as City Hall or Police Department), or public entertainment building (such as Memorial Coliseum, the Rose Garden, Schnitzer Concert Hall, etc.). The scale of your building model will be 1” = 10 feet. Therefore your building must be 25 inches tall (MINIMUM).

**Lot Size:** In order to construct a building, you will be given a 12” X 12” piece of wood or particle board which resembles your land. (the scale of your model is 1” = 10 feet, so your building could have a maximum width of 120 feet) You will need to think about the building’s general shape, earthquake resistance and process of construction given this tot size.

**Building Materials:** Your building must be at least 90% toothpicks. Additional materials may be added for earthquake resistance (rubber bands, straws, Popsicle sticks, string, rubber, plastic, etc.), any materials other than toothpicks MUST BE APPROVED by your friendly neighborhood teacher before ills constructed. Your teacher will inform you of the cost for each additional material so you can calculate that into your construction budget. The additional materials must also be shown and labeled in the scale drawing of the building. No metal or wood larger than the diameter of a round toothpick may be used! (With the exception of wood skewers, not to exceed a maximum of 10% of the total building.

You will construct your building using glue guns in class. Points will be taken away from students who are not ready to work in class. You will most likely need to spend time outside of class to work on this project so be prepared. Architectural and Geological Engineers should have each other’s phone numbers and addresses so they can coordinate with each other. Absences will result in working at home extra.

You will want to make arrangements to take your buildings home over the weekends to continue progress.
The wooden base for your building and glue used in class will be provided for your construction, but materials for your building and extra glue sticks will have to be purchased by you and your partner. Maximum budget for materials is $7.50 (not including glue). Glue is cheap at craft stores like Joann’s Fabrics or the Dollar Tree in the Milwaukie Marketplace (you can get toothpicks at the dollar tree as well).

Note: Any changes you make to your building must also be changed in your building design on paper.

**Testing Your Building**

Buildings will be tested for their strength and judged by their beauty of design and cost. Your building will be tested on the earthquake table at three different strengths of earthquake, low, moderate, and severe, for a duration of 30 seconds. More points will be awarded to a building that withstands a severe earthquake.

**Building for the Quake Evaluation**

You will put together a comprehensive report with all the following information included:

- All handouts given out in class
- ½ page describing background information
- 2/3 page selected building site description
- 2/3 page resistance explanation (seismic requirements)
- Building drawings and description
- Four site possibilities (see Geological Engineer Handout)
- Construction Budget data table expected and actual (See Geological Engineer Handout)

On the next page you will see the actual evaluation sheet that we will use for this project.
### Building for the Quake Evaluation

**Name:** ____________________________

### Phase I Building Proposal

<table>
<thead>
<tr>
<th>Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Drawings &amp; Description</td>
<td>(30 pts)</td>
</tr>
<tr>
<td>Earthquake Resistance Explanation</td>
<td>(15 pts)</td>
</tr>
<tr>
<td>Construction Budget</td>
<td>(5 pts)</td>
</tr>
<tr>
<td>Construction Timeline</td>
<td>(5 pts)</td>
</tr>
<tr>
<td>Four Site Locations &amp; Requirements</td>
<td>(10 pts)</td>
</tr>
<tr>
<td>Selected building Site Description</td>
<td>(20 pts)</td>
</tr>
<tr>
<td>Detailed description of the Geology</td>
<td>(30 pts)</td>
</tr>
</tbody>
</table>

**Total Phase I** ____________________________ (/90 pts)

### Phase II Construction

<table>
<thead>
<tr>
<th>Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building constructed to design specs</td>
<td>(20 pts)</td>
</tr>
<tr>
<td>Wise use of Class Time for Construction</td>
<td>(20 pts)</td>
</tr>
<tr>
<td>Aesthetics of design (how does it look?)</td>
<td>(20 pts)</td>
</tr>
</tbody>
</table>

**Total Phase II** ____________________________ (/60 pts)

### Phase II Testing Building for Earthquake

<table>
<thead>
<tr>
<th>Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building constructed to design specs</td>
<td>(30 pts)</td>
</tr>
<tr>
<td>Low Magnitude (4-5) major damage</td>
<td>10 pts</td>
</tr>
<tr>
<td>Mod Magnitude (5-6) minor cracks</td>
<td>20 pts</td>
</tr>
<tr>
<td>High Magnitude (6-7) no damage</td>
<td>30 pts</td>
</tr>
</tbody>
</table>

**Total Phase III** ____________________________ (/30 pts)

### Phase IV Final Report

<table>
<thead>
<tr>
<th>Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete, all questions answered</td>
<td>(20 pts)</td>
</tr>
</tbody>
</table>

**Total Phase IV** ____________________________ (/20 pts)

**Total Score:** ____________________________ (/200)
Building Proposal Format (Must be word processed)

“Proposal for the Construction of the (Building Name) located at (Building Address)”

Building Description & Characteristics
- Building Type (ex: Hotel, bank, factory, apartment, etc.)
- Total Height
- Area of Base of building (ex: 2600 square feet)
- Number of floors (estimate, average ceiling is 8 feet)
- Total amount of floor space in your building (square feet)
- Volume of building in cubic feet
- What additional features does your building provide (elaborate on any extras: public services, shops, pools, spas, ballrooms, conference rooms, presidential suites, etc.)
- Why this building would benefit the Portland Area, what does it have to offer at this location
- Drawing of building plaque

Building Site Description
- Location of Building, include city, state, and zip code
- Site Elevation above sea-level (see geologic map and look for contour lines)
- Zoned Maximum Height for Location
- Base Zoning, explanation of what it means and how your building applies
- Geology of Site, soil type abbreviation with brief explanation (ex: Qal — Alluvium — river and stream deposits of silt, sand and gravel)
- Printed Names and Signatures of the Architectural and Geological Engineer toward the bottom of the page

Building Site Selection Process
- Explanation concerning the final location (explain why you chose this site, referring back to information found from all the maps (maximum height, base zoning, etc.); as well as the location in terms of business potential ($$$) — maybe the building is in the heart of downtown where foot traffic is high and tourists are abundant?
- Reference to the Relative Earthquake Hazard Map (DOGAMI) (ex: we selected this site because it was in Zone C on the Relative Earthquake Hazard Map prepared by the Department of Oregon Geology and Mineral Industries, zone C is NOT the least hazardous, but it is the least hazardous of the four selected sites. Two other sites were Zone A, which is the most hazardous, and the other was zone B, which is still more hazardous than our preferred site.) It does not have to be located on the least hazardous site, but you MUST include a detailed description of what your building has designed in it to prevent hazards.
- Explanation of Geologic Earthquake Hazards for the selected location. How does the geology behave in the event of an earthquake? (ex: soil type may be prone to liquefaction, amplification, or landslides/location could be hit by seiches from the Willamette, or landslides from the West Hills)

Earthquake Resistance Design
- UBC Seismic Zone for the Portland Area (See map of Oregon with Seismic Zones)
- How building is designed to withstand earthquakes. You need a thorough description, probably 1/4page in length describing all the ways your building is designed to resist earthquakes (ex: foundational support, material slab, drilling into geology, rollers, structural support- corner braces, cross beams, flexible beams, shear walls, solid walls, steel cables, strengthening welds, interior support, etc.)

Construction Budget
- Quantity of material used
- Type of materials
- Cost for each type of material
Construction Timeline
- Date individual jobs are to be completed
- Date typed proposal will be completed and turned in (must be completed before 50 foot level, or construction will be stopped, City will place a stop work order on your project!)
- Dates for completion of the 50 foot, 100 foot, 150 foot levels.
- Date of Completed Construction

Architectural front and top Drawings
- Attach both scale drawings to your proposal

Final Report (Written in class the last day of testing, written in paragraphs in essay format answering the following questions)
- During construction, what problems did you run into? Did you have to make modifications to your design and why? How did you solve your problems? Look at your journal for ideas.
- What parts of the project do you think will help you later in life?
- What was the most difficult part of this project - be specific and give an example of a situation (ex: working with your partner, map reading, drawings, proposal writing, budget, construction, etc.)
- After we shake your building, evaluate your design. Describe how your building reacted to the shaking and if you could build it all over again, what would you change so that it’s more earthquake resistant?
- Attach Daily Construction Journal with this report.

Good Luck !!!!!!