Seventh Annual Competition

2010 Undergraduate Seismic Design Competition

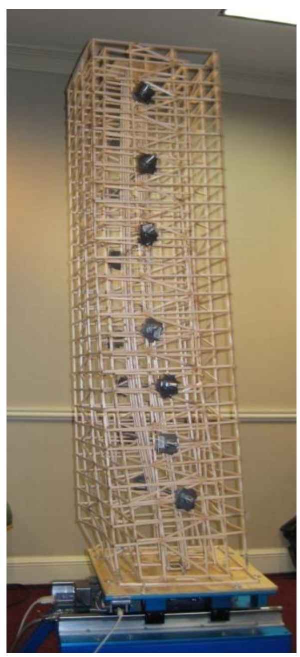
Rules

Organized and Run by:

EERI Student Leadership Council (SLC)

Competition Website: http://slc.eeri.org/seismic.htm

Email: seismic.design.competition@gmail.com



Sponsored by:

- Earthquake Engineering Research Institute (EERI)
- Federal Emergency Management Agency (FEMA)

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1. Introduction

The competition will be held February 3-6 at the Parc 55 Hotel in San Francisco, California. This event will be held in conjunction with the EERI Annual Meeting. More information about this conference is available online at:

http://www.eeri.org/site/meetings/2010annual-mtg

1.1 Competition Objective

The objectives of this Seventh Annual Undergraduate Seismic Design Competition sponsored by EERI are:

- To promote the study of earthquake engineering amongst undergraduate students.
- To provide civil engineering undergraduate students an opportunity to work on a hands-on project by designing and constructing a cost-effective frame structure to resist earthquake excitations.
- To build the awareness of the versatile activities at EERI among the civil engineering students and faculty as well as the general public and to encourage nation-wide participation in these activities.
- To increase the attentiveness of the value and benefit of the Student Leadership Council (SLC) representatives and officers among the universities for the recruitment and development of SLC, a key liaison between students and EERI.

1.2 Summary of Rule Changes from 2009

1.2.a The maximum weight of the structure has been reduced from 6.61lb (3 kg) to 4.85 lb (2.2 kg).

1.2.b The total weights to be attached to the structure have been increased from 23.3 lb (10.57 kg) to 26.9lb (12.2 kg).

1.2.c Floor plan areas may exceed the floor plan area of the level beneath.

1.2.d The earthquakes have been updated; they are now EQ1, EQ2, and EQ3. EQ1 is relatively mild while EQ2 and EQ3 are expected to exert higher demands on the structures.

1.2.e The rentable income per floor area has been decreased from $250/$350/$450 to $125/$175/$225.

1.2.f The Engineering Demand Parameters (EDPs) have been updated. The mean and standard deviation for EDP1 are now 0.02 and 0.0075. The mean value for EDP2 is now 1.75g.

1.2.g A bonus Analysis Prediction Score (APS) has been introduced to the scoring system to reward teams predicting the maximum roof drift and acceleration for EQ1.

1.2.h A penalty structure has been introduced for violations of the limitations for the structural dimensions.

1.3 **Structural Design Objective**

Your team has been hired to submit a design for a multi-level commercial office building. To verify the seismic load resistance system, a scaled model must be constructed from balsa wood. It will be subjected to severe earthquake excitations. The time histories are available online at the website of the competition:

http://slc.eeri.org/seismic.htm

The seismic performance of the structure will be evaluated according to the rules described in the following sections of this document.

1.4 Important Dates

Registration deadline	November 20th
Design proposal deadline	December 4th
Release proposal comments	December 22nd
Provide predictions of the structural performance	February 2nd
Competition	February 3rd-6th

1.5 Financial Assistance

Some amount of financial support from EERI SLC will be available to help offset the cost of attending the competition. Financial assistance is not intended to cover all expenses, but will at a minimum provide a hotel room to each participating team. In the past, has been able to subsidize a second room and a number of plane tickets as well. However, the exact amount each team will receive cannot be known until the lists of participants and sponsors have been finalized. Teams will be notified of their exact assistance amount closer to the competition. Each team is *strongly encouraged* to seek additional funding from local sources.

1.6 Support

Questions should be directed only to the EERI Student Leadership Council (SLC) via email to: seismic.design.competition@gmail.com

2. Eligibility Requirements

2.1 **Eligibility:**

The following rules shall be strictly followed:

- 2.1.a Participants must be currently enrolled undergraduate students and may come from any university in the USA or abroad.
- 2.1.b Teams may have as many undergraduate student participants as they wish
- 2.1.c Each competing university can enter one student team and one structure at the competition.

2.2 The university name should be placed at the top of the structure, on a banner or paper (non-structural element). The size of this banner shall not exceed a length of 6 inch and a height of 1 inch.

2.3 If financial assistance is provided by external sponsors, their names and/or logos may appear on the structure or on any clothing worn by the team. However, the sponsors should be named below the school name.

2.4 The structure shall be constructed prior to the competition. No structural modifications will be allowed beyond **noon of February 4th, 2009**. If a structure is damaged during transportation, it may be repaired to its original design at the competition before this deadline.

2.5 Participating teams are responsible for transportation of their structure to and from the competition venue. See the Appendix for transportation details.

2.6 SLC will be selecting three to five judges from the earthquake engineering community to score all aspects at the competition.

2.7 Judges will determine the direction of shaking on the structure.

3. Structural Model and Testing

This section describes the rules and limitations to be followed for the structural model. Any violation of the materials or dimensions listed in this section will result in Structural Dimension Penalty factor (M) which is described in a following section.

3.1 Structure Dimensions

The structure must comply with the following dimensions. For penalties refer to Section 7.2.

Max floor plan dimension:	15”x15” (38.1 cm x 38.1 cm)
Min individual floor dimension:	6”x6” (15.2 cm x 15.2 cm)
Max number of floor levels:	29 levels
Min number of floor levels:	15 levels
Floor height:	2” (5.08 cm)
Lobby level height (1^{st} level):	4” (10.2 cm)
Min building height:	32” (81.28 cm)
Max building height:	60” (153.4 cm)
Max total floor area (including all floors):	4650 in^2 (3 m^2)

Structural height shall be measured from the top of the base floor to the uppermost beam member of the top level. The base floor is defined as the top of the base plate.

Total floor area includes the core of the structure. Counting total floor area starts from the base floor and stops when reached to the maximum value mentioned above. The floor area above this point will not be included in the calculation of the rent income.

3.2 Structural Model Base Plate

A square plywood base plate will be used to attach the structure to the shake table. Each team will be responsible for manufacturing their base plate. An engineering diagram depicting the manufactured base plate can be found in Figure 3-2.

3.3 Structural Model Roof Plate

A square plywood roof plate is needed to attach the accelerometer to the structure. Teams are responsible for fabricating and installing their roof plates according to committee requirements. An engineering diagram depicting the desired roof plate can be found in Figure 3-3.

The roof plate needs to be centered and aligned with the base plate. It is the responsibility of each team to ensure total access to all four holes to allow installment of nuts and washers.

3.4 **Structural Frame Members**

Structures shall be made of balsa wood and the maximum members cross sectional dimensions are:

Rectangular column:	1/4” x 1/4” (6.4 mm x 6.4 mm)
Circular column:	1/4” (6.4 mm) diameter
Beam:	1/8” x 1/4” (3.2 mm x 6.4 mm)
Diagonal:	1/8” x 1/4” (3.2 mm x 6.4 mm)

3.5 **Shear Walls**

Shear walls constructed of balsa wood must comply with the following:

Max thickness:	1/8” (3.2mm)
Min length:	1” (25.4mm)

Columns can be attached to the ends of a shear wall.

3.6 **Structural Mass**

The total mass of the structural model, including the base and roof plate and any damping devices, should not exceed **4.85 lbs (2.2 kg)**.

3.7 **Column Connections**

All columns on the first floor must be connected directly to the base board. No base isolation of any kind is permitted.

3.8 **Fabrication Details**

3.8.a Laser cut members from balsa plywood are permitted, however they must meet the limitations described above.

3.8.b An interior three dimensional brace will result in no income for the space occupied by the brace.

3.8.c The height and length of moment frame connections shall not exceed 3 times the maximum cross sectional dimension (width or thickness) of the members being joined, as shown in Figure 3-1. The thickness shall not exceed the minimum cross sectional dimension of the members being joined.

3.8.d The interior building core usually reserved for elevators, emergency exit staircases, and utilities, etc, should not be blocked by braces, shear walls and columns. For each floor, access openings in both the E-W and N-S direction are required. Each access opening should have, as a minimum, the following dimensions:

Width:	1” (25.4mm)
Height:	1.5” (38.1mm)

3.8.e Floor level diaphragms need not be constructed. Weights, to be attached at the competition, will simulate the dead load and the inertia mass of floor diaphragms, office walls, furniture, and live load.

3.9 **Innovative Damping Devices**

Structural damping devices, such as viscous dampers, are allowed in the design. However, unconventional dampers need to get the approval of the competition committee before the construction to avoid disqualification of the structure.

3.9.a Any material is allowed to manufacture a damper; however, the dampers must be homemade. The implementation of such a device needs to allow for the placement of weights as discussed in Sections 3.11.

3.9.b Teams should consider that damping devices installed in 3-dimensional space (not in the same plane as an existing wall) will reduce rentable floor space as the dampers render the space unusable.

3.9.c Damper attachments to the structure may not reinforce any other structural connections. If a damper is connected to a column or a beam, the member's cross-section may not be increased beyond twice the limits listed earlier. For example, if a column is constructed of 1/4" x 1/4" (6.4 mm x 6.4 mm) balsawood section; the damper connection may expand the cross-section of the column to 1/2" x 1/2" (6.4 mm x 6.4 mm). The length of the connections along the direction of the connected beam or column may not exceed 1" (25.4 mm).

3.10 **Structural Connections**

Connections of structural members can be made only from wood glue. Connections of structural members to the base plate or to the roof plate can be made using wood glue or hot glue. Failure to comply with this requirement will result in the disqualification of the structure.

3.11 **Structural Loading**

Dead loads and inertia masses will be installed through threaded bars loaded with washers. These will be firmly attached to the frame in the direction perpendicular to shaking.

Floor mass:	2.6 lbs (1.18 kg)
Roof mass:	3.5 lbs (1.59 kg)
Mass spacing:	Increments of 1/10th the height (H/10)
Threaded bar length:	36" (914 mm)
Threaded bar diameter:	1/2" (12.7 mm)

The dead load will be placed at nine floor levels in increments of (H/10), corresponding to (1/10)*H to (9/10)*H. In cases where a floor does not exist at an exact increment of (H/10), the weight will be attached to the nearest higher floor.

Weight connection members (columns) will be needed on all sides of the structure, since the judges will decide on the direction of shaking. Weights will be secured to the structure using nuts and washers. **Weights cannot be secured to the beam alone.** See Figures 3-4 and 3-5 for a typical weight attachment. It is strongly recommended that each team purchases a sample weight to try out and ensure proper attachment.

Note that some moderate compressive force is required to secure the weights from sliding with respect to the structure during shaking. The design should accommodate these compressive forces and prevent sliding of the rods during shaking.

The roof dead load weight will consist of a steel plate with dimensions of 6” x 6” x 1/2” (15.24 cm x 15.24 cm x 1.27 cm), and an accelerometer, which weigh 3.5 lbs (1.59 kg) in total. See Figure 3-3 for roof configuration.

3.12 The structural finish must be bare wood. Paint or other coatings will *not* be allowed on the structure.

3.13 **Scaled Earthquakes**

Structures will be subjected to 3 scaled and modified ground motions named EQ1, EQ2, and EQ3. Team’s “Performance Prediction” (section 7.1.c) will be only based on EQ1 which is a scaled and heavily modified version of the 1940 El Centro earthquake. EQ1 is a relatively mild earthquake and the structure is expected to remain nearly linear-elastic during the motion. EQ2 and EQ3 are also scaled and modified ground motions based on historic earthquakes and designed to be more intense motions than EQ1.

It is imperative for teams to download all the ground motions from the SLC website and not from any other sources, since the records have been compressed in time and scaled to meet the limits of the shake table.

The ground motion records are available at:
http://slc.eeri.org/seismic.htm

3.14 In the Spirit of the Competition, the Judges and/or SLC may take disciplinary action, including warnings, point deductions, or disqualification of a team or entry for inappropriate use of materials, language, alcohol, uncooperativeness, or general unprofessional behavior of team members or persons associated with a team. The judges have the final authority to determine what constitutes a violation of the “spirit of the competition” and may take appropriate action towards point deduction or disqualification.

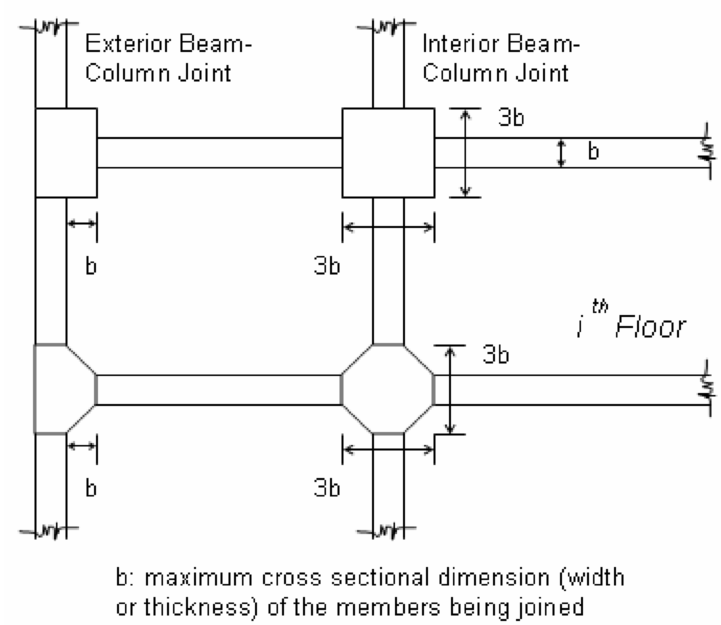


Figure 3-1: Allowable Moment Frame Connection Detail

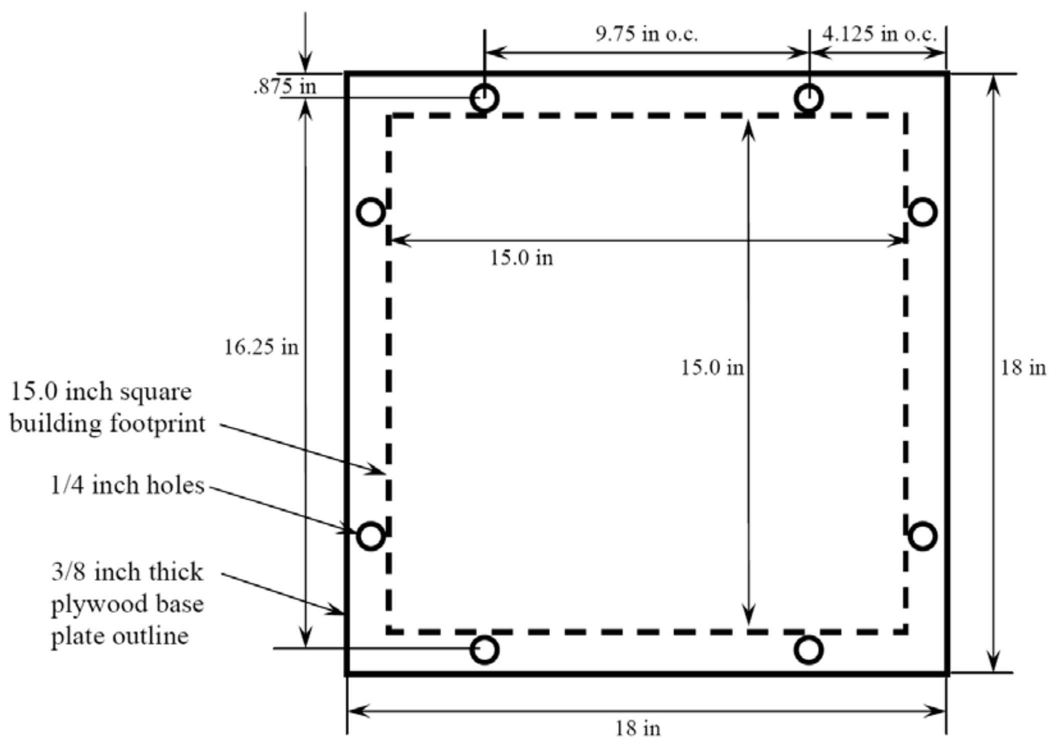


Figure 3-2: Engineering drawing of base plate (to be fabricated by each team)

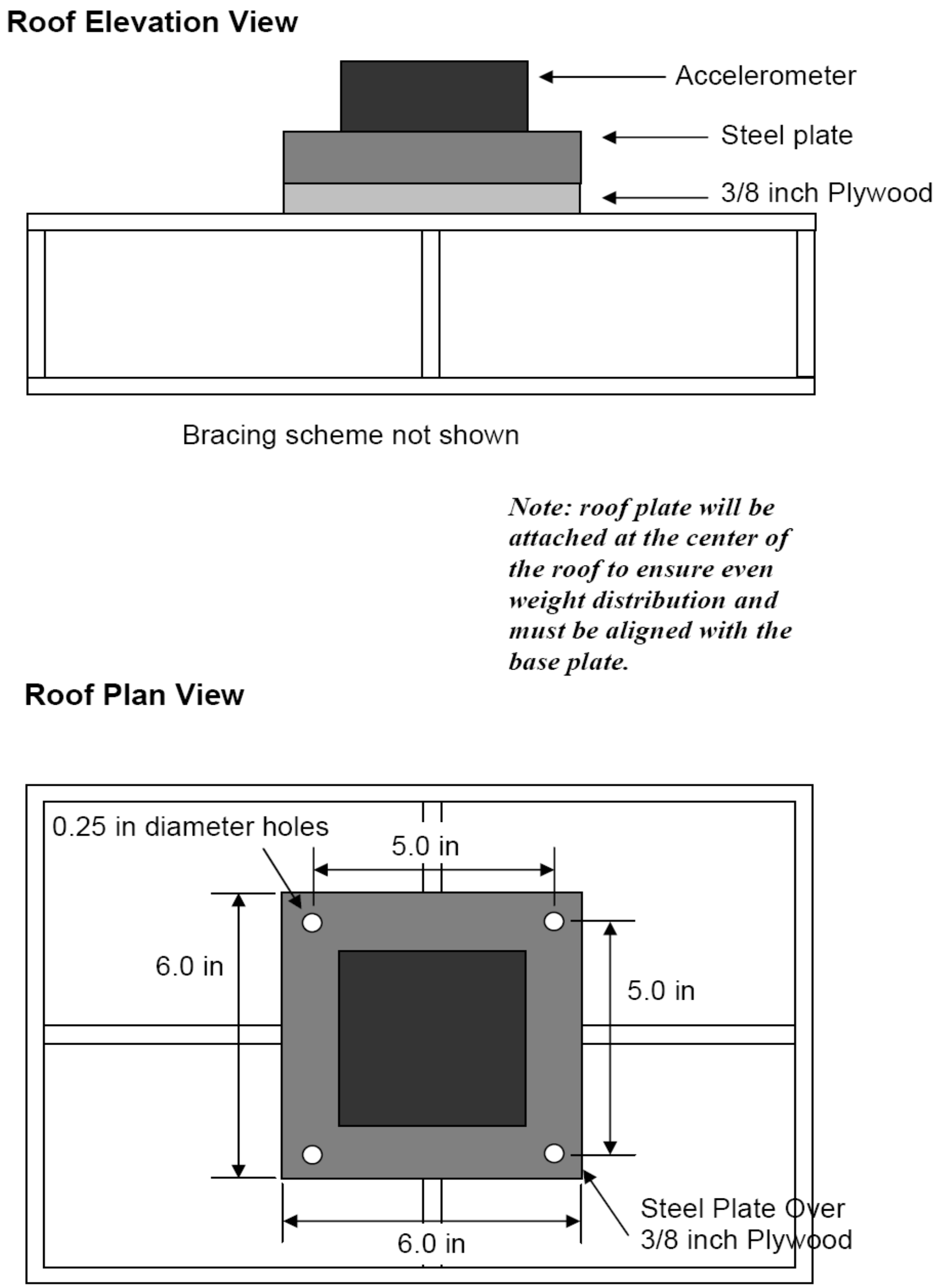


Figure 3-3: Weight and Accelerometer at Roof Level

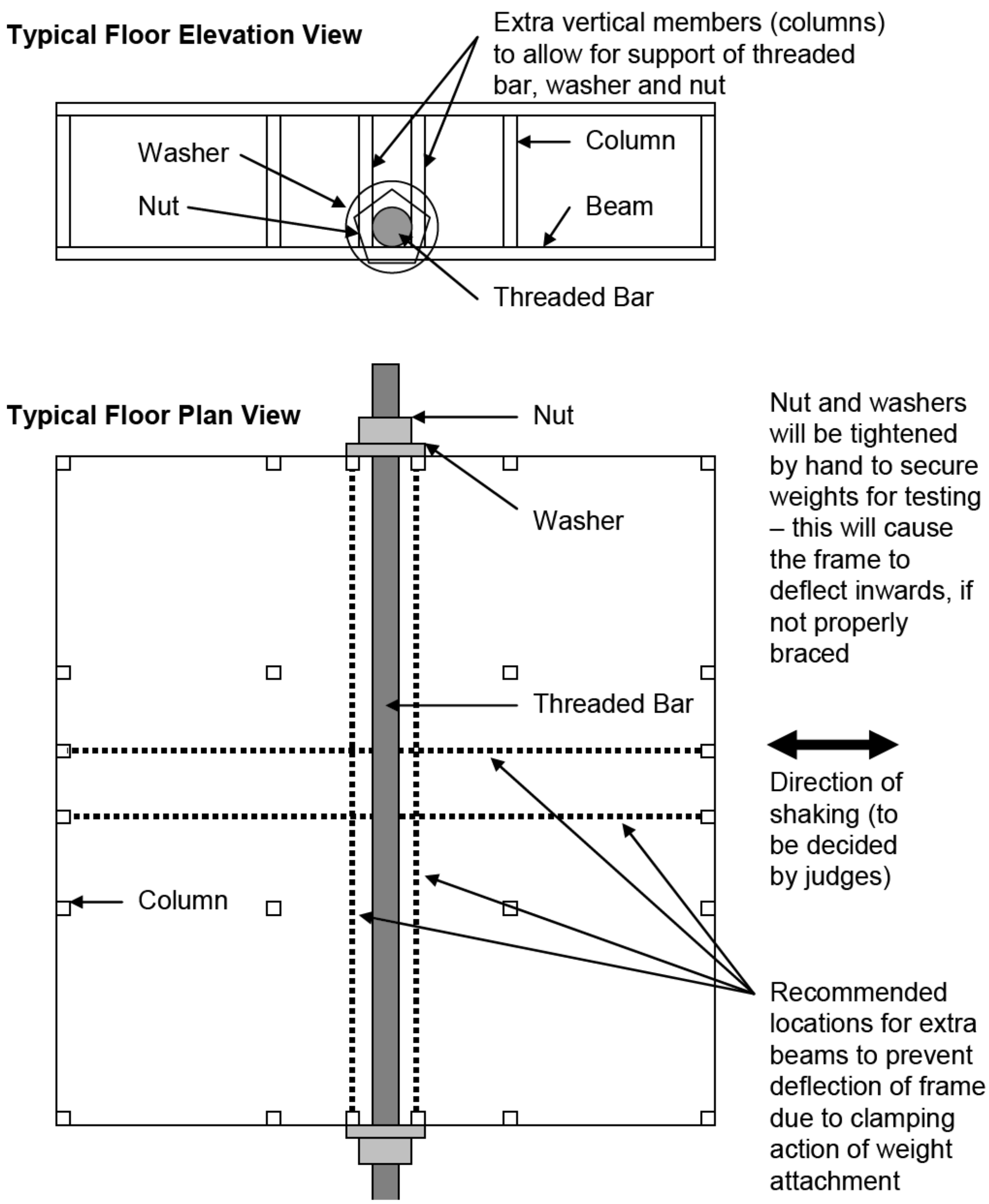
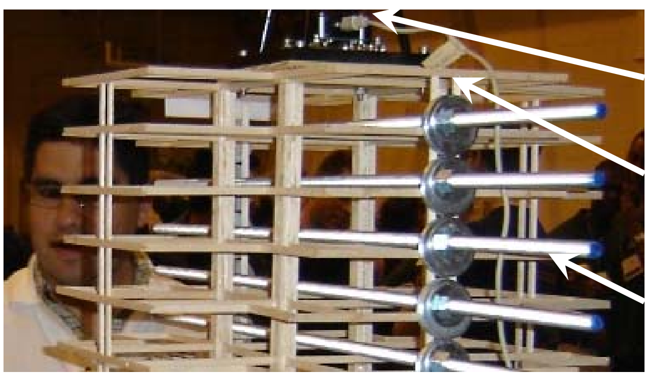


Figure 3-4: Anchorage of Weights to Structure

(a.) Example of insufficient support for threaded bars preventing the requisite tightening of the nuts, thereby permitting the bars to slide with respect to the structure during shaking. (The photo was taken at the 2003 competition, when weight distribution differed from this year's configuration.)



(b.) Example of an ideal support for threaded bars. Vertical columns facilitate the weight attachment, and prevented rolling and sliding of the bars during shaking. (The photo was taken at 2005 competition, when weight distribution differed from this year's configuration.)

Figure 3-5: Typical Weight Attachment

4. Additional Considerations

4.1 Oral Presentation

4.1.a Each team will give a five-minute oral presentation to a panel of judges. Judges will have three minutes to ask questions following the presentation. The presentations will be open to the public.

4.1.b A projector and laptop, running Microsoft Windows XP, and PowerPoint (Office 2003) will be provided. The presentation files should be uploaded on the competition laptop by **2 pm on February 4th, 2009**. Teams are responsible for the software compatibility and will not be allowed to run presentations from their own laptops. Teams can email their presentations to organizing committee; however, it is strongly recommended that presentations be brought on a USB memory stick and/or CD-ROM in case of technical difficulties with the projector.

4.1.c Scoring will be based on the scoring sheet provided in the Appendix.

4.2 Poster

4.2.a A poster shall be displayed providing an overview of the project. Each poster shall have a height of 42 inch (1.1 m) and a width of 36 inch (0.91 m).

4.2.b The university name and EERI logo should appear at the top of the poster and a font size of 40 is recommended.

4.2.c Scoring will be based on the scoring sheet provided in the Appendix.

4.3 Architectural Form

A unique architectural form and quality workmanship is highly desired by the owner and will be evaluated by the judges.

5. Instrumentation and Data Processing

Horizontal acceleration will be measured in the direction of shaking using accelerometers mounted on the roof of the structure and on the shake table as shown in Figure 5-1. Technical specifications of the shaker table, data acquisition system, the accelerometers and the data processing can be found at the appendix.

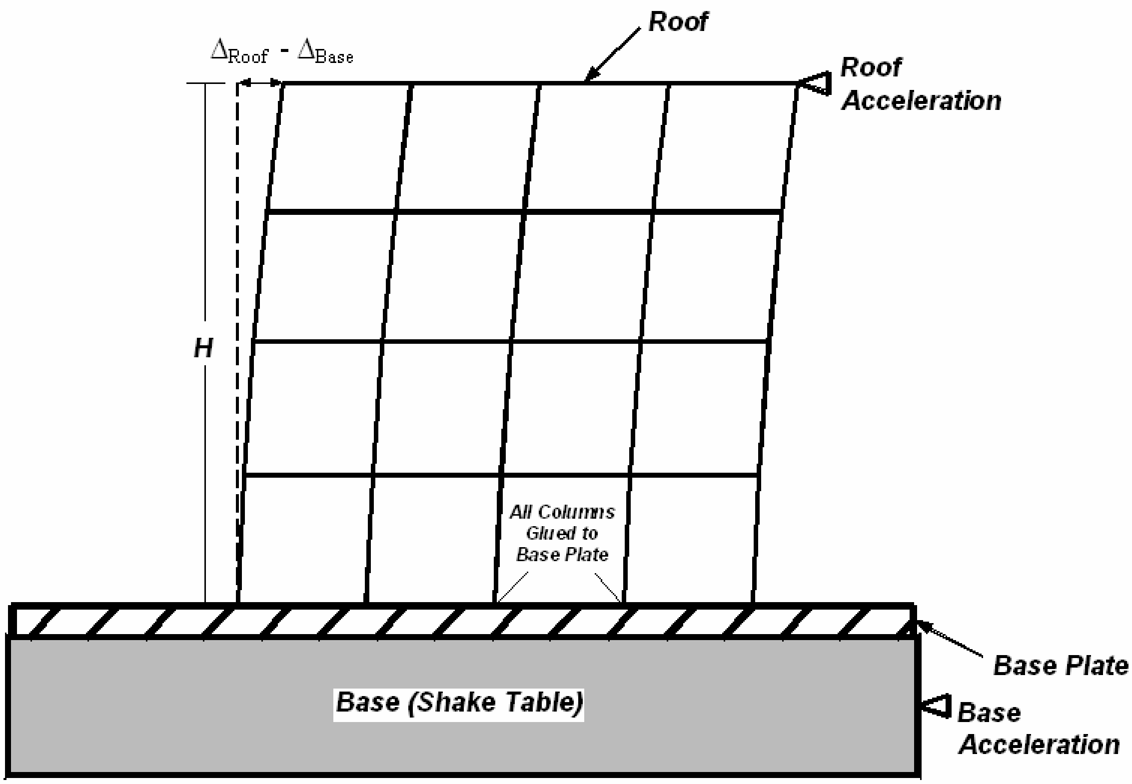


Figure 5-1: Schematic of instrumentation layout and measured engineering demand parameters for structure without base isolation.

6. Scoring Method

This section describes the method used to score the seismic performance of the structures in the seismic competition. Scoring is based on three primary components: 1. Annual income, 2. Initial building cost, and 3. Annual seismic cost. The final measure of structural performance is the annual revenue, calculated as the annual income minus annual building construction cost minus annual seismic cost. An example problem in the Appendix demonstrates the scoring method.

6.1 Annual Income

Annual building income will be based on total floor area, with higher floors bringing in more income than lower floors as follows:

$125 per year per square inch for floors 1 through 15
$175 per year per square inch for floors between 16 through 24
$225 per year per square inch for floors 25 and above

The floor area will be counted from the bottom up. If the maximum allowable height is exceeded, any floors above will not be counted. The total floor area includes the core of the structure but excludes areas occupied by diagonal members such as braces or dampers.

6.2 Initial Building Cost

The cost of the building is calculated based on the cost of the land beneath the building footprint and the initial construction cost as well. The land costs $35,000 per square inch of building footprint, which is defined as the maximum floor plan area.

The initial construction cost of the building is $10,000,000 per kilogram of building mass. The building mass includes the mass of the base and roof plate, but not the mass added during shaking with the threaded bars. The annual building cost will be computed by dividing the cost of land and the initial construction cost of the building by the design life of the building (100 years).

6.3 Annual Seismic Cost

The structures will be subjected to a series of three ground motions with increasing intensity. If time does not allow, only two of the ground motions will be used for the tests. The decision will be made by SLC the day of the competition based on the time constraints and the number of teams that will participate in the competition.

Economic damage from each earthquake will be assessed using loss functions that relate financial loss to two Engineering Demand Parameters (EDPs) that will be measured during shaking. The EDPs are:

EDP1 = Peak absolute value of drift ratio between the roof and the foundation of the structure.
EDP2 = Peak absolute value of the roof acceleration.

Annual economic damage for a given motion will be computed by summing the economic loss for each EDP for that motion, and then dividing by the return period of the imposed earthquake, which is indicated in Table 6-1. Annual seismic economic damage will be computed by summing the annual economic damage for all ground motions imposed. Each loss function is discussed in detail in the sections that follow.

Table 6-1: Return periods for ground motions used in competition.

Motion	Return Period (Years)
EQ1	50
EQ2	150
EQ3	300

6.3.a Economic loss due to structural damage (EDP1)

Structural damage to the buildings is correlated with the peak drift ratio between the roof and the foundation level [Drift Ratio = $(\Delta_{Roof} - \Delta_{Floor})/H$]. The maximum cost of repairing structural damage is assumed equal to the initial construction cost of the structure. The loss function relating cost of structural damage to drift ratio is defined as a cumulative normal probability density function with mean drift ratio of 0.02 and a standard deviation of 0.0075.

Tip: The distribution function can be computed using many commercially-available software packages (e.g. the NORMDIST function in Microsoft Excel, with the 'cumulative' field set to TRUE). The function is plotted in terms of normalized cost in Figure 6-1.

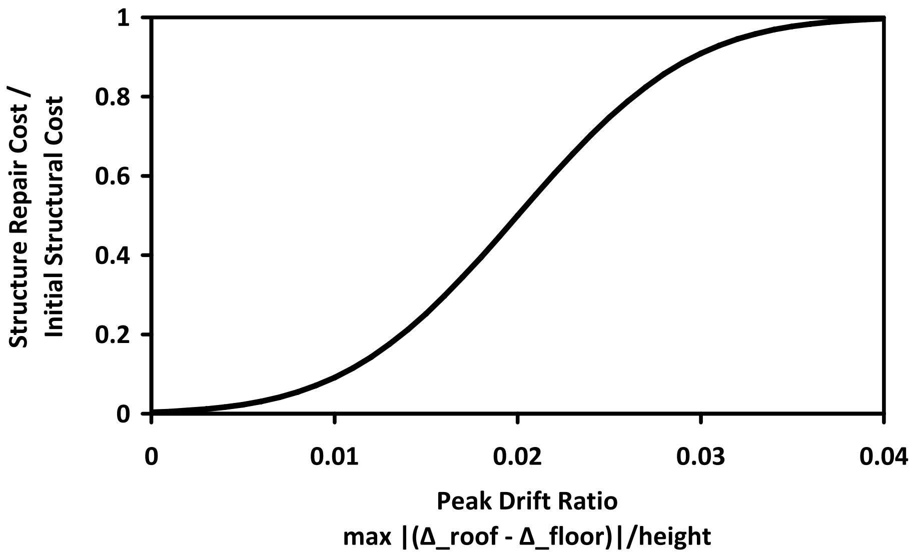


Figure 6-1: Loss function relating structural replacement cost to peak drift ratio (EDP1)

6.3.b Loss Caused by Equipment Damage (EDP2)

The structure will house equipment with a total value of \$20,000,000 that is sensitive to the floor acceleration. Damage to this equipment will be related to the peak absolute value of roof acceleration using a loss function that is a cumulative normal probability density function with mean peak roof acceleration of 1.75g, and standard deviation of 0.75g. The loss function is plotted in Figure 6-2.

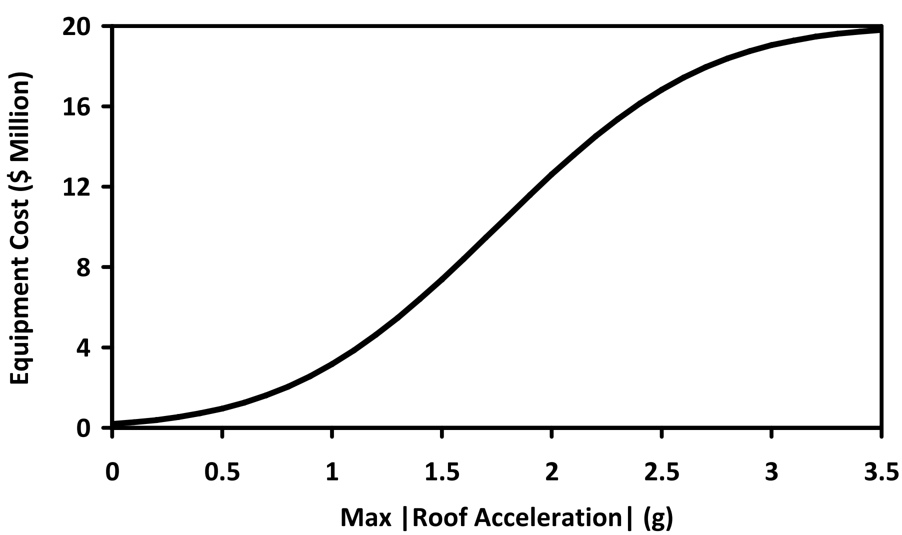


Figure 6-2: Loss function relating equipment cost to peak roof acceleration (EDP2)

7. Scoring Multipliers

The following section describes the calculation of the overall final score for each team. The final score will be equal to the annual revenue and will depend on:

- the annual income, as determined from Section 6.1,
- the oral presentation,
- the poster,
- the aesthetics and architecture of the structure.
- the possible applied penalties
- the structural performance under earthquake excitation

The prediction of the structural response under EQ1 is not mandatory. However, bonus will be awarded to eight teams with the most accurate predictions of the structural response

The team with the greatest annual revenue will be the winning team. Structures that "collapse" during the shaking will be disqualified from the competition. The state of collapse may include the inability of the structure to carry the vertical loads, toppling over, etc, and will be determined by the judges.

7.1 Increase in Annual Income

The Annual Income will be increased by scores assigned for the:

7.1.a Oral Presentation and Poster

The oral presentation and the poster will each be evaluated by the judges. A team with an excellent poster and a remarkable presentation may receive 10% increase for each component and increase their annual income by 20%.

7.1.b Architecture

An aesthetically pleasing structure is easier to sell to the client and can raise the rent. This is reflected in the scoring method by a percentage increase of the annual income. Avery appealing structure can get the annual income increased by 20%.

7.1.c Performance Predictions (optional for extra bonus)

Each team is encouraged to conduct analysis and predict the performance of the structure for EQ1. This can be done with or without any structural engineering software. Each team is asked to report the expected maximum roof drift (roof displacement with respect to the base divided by the building height) and the peak roof absolute acceleration (g). The accuracy of the predicted performance (taken to two significant figures) is taken as the Analysis Predicted Scores (APSs). APS1 is for the roof drift prediction while APS2 is for the roof acceleration prediction.

$$APS_i = abs\left(\frac{predictedEPS_i - measuredEPS_i}{measuredEPS_i}\right)$$

Each team will be ranked based on the accuracy of the prediction of EDP1 and EDP2 for the EQ1, i.e. the lowest APS (APS1+APS2) wins. Bonus percentage increase of the Annual Income will be awarded to the top 8 teams based on Table 7-1.

Table 7-1: Annual Income Increase for APS

Rank	Annual Income Increase, Z
1st	20%
2nd	17.5%
3rd	15%
4th	12.5%
5th	10%
6th	7.5%
7th	5%
8th	2.5%
>9th	0%

Although it is not required, each team is strongly encouraged to predict the structural behavior for all three ground motions. This may get some extra points from the judges if included in the presentation. The existence and accuracy of the predictions will be used as a tie-breaker.

7.2 Increase in Initial Building Cost due to Violations of Rules

All penalties due to rule infractions are given by the sole discretion of the judges, and will follow the guidelines below. Initial Building Cost, as determined by Section 6.2, will be increased by the workmanship factor which includes:

7.2.a Penalty for the violation of the structural dimensions (N)

Structural dimension penalty, factor N, reflects the violation of the allowable dimensions described in Section 3. Failure to comply with the dimensions will result in added percentage to factor N according to the following criteria.

7.2.a.1 Any deviation in any direction from min/max floor dimensions specified in section 3.1 will result in 2% penalty per 1/4” of deviation.

7.2.a.2 Maximum and minimum number of levels is 29 and 15 (including the base floor). There will be 10% for any floor deviating from the above limits.

7.2.a.3 Penalties for deviations in floor and building heights:
Each 1/4” deviation in individual floor height gets 2% penalty (lobby floor height is 4” and other floor heights are 2”.)

Each 1/4” deviation in total building height gets 5% penalty (total building height should be 2*(number of floors)+2.)

7.2.a.4 Penalties in deviations in column, beam, and diagonal sizes. For each 1/8” increment exceeding beyond the specified dimension there will be 1% penalty per element, per story. For example if there are 4 columns that are built 1/4” x 3/8” and go through 20 floors, there will be 20*4*1%=80% penalty. If the columns were 1/2” the penalty would have been 2% per element per story.

Note: In calculating all types of penalties, dimensions between the increments will be rounded up to the next increment.

7.2.a.5 For any moment frame connection longer than the maximum allowable dimension there will be a 1% penalty per each 1/8” deviation added to factor N.

7.2.a.6 Failure to provide access points to the core of the building as described in Section 3.8.d will result in 2% penalty for each floor.

7.2.a.7 If dampers are to be used, SLC approval is required to ensure compliance with the rules.

7.2.a.8 All the dampers’ connections should be in accordance to Section 3.9. Any discrepancy will result in 2% penalty for each connection.

7.2.b **Penalty for violation of the building mass (M)**

Maximum total mass of building, including dampers, base plate and top floor plate, is **4.85 lbs (2.2 kg)** with a tolerance of **0.10 lb (0.045 kg).** There will be 10% penalty for each 0.10 lb going above the tolerance.

7.2.c **Penalty for insufficient structure-to-weights connections (L)**

Additional weights will be connected to the structure in accordance to Section 3.11. Weights should be firmly secured against horizontal translation by the means of beams and columns. After each earthquake the judges will inspect the structure for failed connections. There will be a 5% penalty for each threaded bar that has loosened; this state is determined by the judges.

7.3 Final Scoring

The final score for each team will be calculated in terms of the annual revenue. The team with the greatest Final Annual Building Revenue (FABR) will be the winning team. FABR is equal to the Final Annual Income (FAI) minus the Final Annual Building Cost (FABC) and Final Annual Seismic Cost (FASC).

Final Annual Income (FAI) can be expressed as:

$$\boxed{FAI = (1+X+Y+Z+APS) * AI}$$

Where:

AI: Annual Income
X: Annual Income increase from presentation
Y: Annual Income increase from poster
Z: Annual Income increase from architecture
APS: Annual Income increase from performance prediction

Final Annual Building Cost (FABC) can be expressed as:

$$\boxed{FABC = (1+N+M+L) * ABC}$$

Where:

ABC: Annual Building Cost
N: Annual Building Cost increase from inadequate tolerances on structural dimensions
M: Annual Building Cost increase from inadequate tolerances on structure's mass
L: Annual Building Cost increase from inadequate tolerance on Weight-to-Structure connection

Final Annual Seismic Cost, FASC, can be stated as:

FASC = Annual Seismic Cost

The Final Annual Building Revenue (FABR) can be expressed as:

$$\boxed{\begin{aligned} FABR &= FAI-FABC-FASC = \\ &= (1+X+Y+Z+APS) * AI - (1+N+M+L) * ABC - FASC \end{aligned}}$$

8. Special Awards

8.1 Charles Richter Award for the Spirit of the Competition

The most well known earthquake magnitude scale is the Richter scale which was developed in 1935 by Charles Richter, of the California Institute of Technology. In honor of his contribution to earthquake engineering, the team which best exemplifies the spirit of the competition will be awarded the Charles Richter Award for the Spirit of Competition. The winner for this award will be determined by the judges.

8.2 Egor Popov Award for Structural Innovation

Egor Popov had been a Professor at UC Berkeley for almost 55 years when he passed away in 2001. Popov conducted research that led to many advances in seismic design of steel frame connections and systems, including eccentric bracing. Popov was born in Russia, and escaped to Manchuria in 1917 during the Russian Revolution. After spending his youth in China, he immigrated to the U.S. and studied at UC Berkeley, Cal Tech, MIT and Stanford. In honor of his contribution to structural and earthquake engineering, the team which makes the best use of technology and/or structural design to resist seismic loading will be awarded the Egor Popov Award for Structural Innovation. The winner for this award will be determined by the judges.