Ninth Annual Undergraduate Seismic Design Competition (SDC)

Memphis, TN

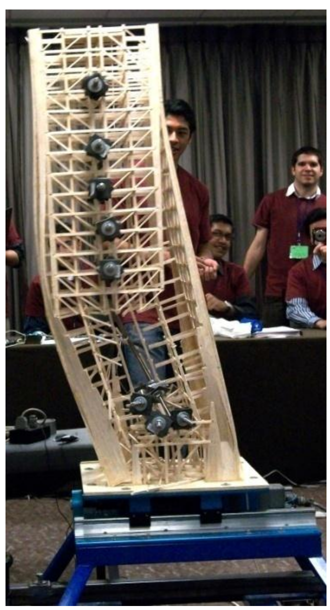
Rules

Organized and Run by:

EERI Student Leadership Council (SLC)

Competition Website: *http://slc.eeri.org/SDC2012.htm*

Email: *seismic.design.competition@gmail.com*



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1. Introduction

The competition will be held in conjunction with the 64th Earthquake Engineering Research Institute (EERI) Annual Meeting on April 10th through 14th 2012 at the Peabody Hotel in Memphis, Tennessee. More information is available online at:

http://2012am.eeri.org/

1.1 Competition Objectives

The objectives of the Ninth Annual Undergraduate Seismic Design Competition sponsored by EERI are:

- To promote the study of earthquake engineering among undergraduate students.
- To provide civil engineering undergraduate students with an opportunity to work on a hands-on project designing and constructing a cost-effective frame building to resist seismic loading.
- To promote EERI activities among civil engineering students as well as the general public, and to encourage nation-wide participation in these activities.

1.2 Summary of Rule Changes from 2011

1.2.a Each team must have a registered EERI Student Chapter at its respective campus.
1.2.b Only 35 teams will advance to the competition; those teams will be selected based on their design proposals.
1.2.c The design proposals will not be used to evaluate for penalty violations.
1.2.d The base and roof plates will be mailed to the teams; those exact plates must be used.
1.2.e The maximum member size is 1/4 in; there is no beam, column, or diagonal designation.
1.2.f Notching the base and roof plates is permitted; however, trimming to reduce weight is not.
1.2.g All types of glue are permitted.
1.2.h Floor isolation of any kind is not allowed.
1.2.i The parameters defining the loss function related to peak drift ratio have been modified.
1.2.j The estimation of the economic loss due to collapse has been modified.
1.2.k Factors that modify the Annual Revenue and Annual Seismic Cost have been adjusted.
1.2.l The architecture award has been removed.
1.2.m The spirit of the competition award will be determined by the participating teams.
1.2.n Honorable mentions will be awarded to the best architecture, best communication skills, and best seismic performance. These awards will be determined by the judges' scores.

1.3 Important Dates

Pre-registration	November 18th
Design proposal	December 2nd
Selection of 35 teams	December 16th
Registration	March 9nd
Performance predictions and floor area calculations	April 6th
Structure arrival to competition	April 10th
Presentations and poster session	April 11th
Shaking	April 12th
Award Ceremony	April 13th

Only **eligible** teams are allowed to submit a design proposal. For eligibility requirements, refer to Section 1.7.

1.4 Design Objectives

Your team has been hired to submit a design for a multi-story commercial office building. Your task is to design and construct a cost-effective structure to resist seismic loading.

To verify the seismic load resistance system, a scaled balsa wood model must be constructed and tested. The model will be subjected to three ground motions, which represent different return period earthquakes. In order to ensure life safety the building model must not collapse during shaking. In addition, the response of the model in terms of roof drift and roof acceleration will be measured during the shaking. For each ground motion, the value of the roof drift will be used to estimate the monetary loss due to damage in the structural and non-structural building components. Likewise, the roof acceleration will be used to estimate the monetary loss due to damaged equipment that is contained inside the building. If collapse occurs, the monetary losses will account for demolishment, reconstruction, and downtime. Finally, the annual seismic cost will be obtained as the sum of the economic loss estimated for each of the earthquakes divided by its return period.

A cost-benefit analysis will be carried out to determine the most cost-effective building. This will be done by balancing the revenue with the initial building cost and seismic cost.

- The revenue will be computed as a function of the floor area to be sold or rented. Bonuses in revenue will be given to those teams with the best architecture, presentation and poster. These bonuses account for the positive effect quality architecture and effective communication skills can have on increasing the value of the floor to be sold or rented.
- The initial cost will be obtained as a function of the weight of the building model. Penalties that increase the initial cost will be applied to those models that exceed the maximum permitted weight and dimensions.

- The seismic cost will be based on the building's seismic performance. A bonus will be given to the teams with the best performance predictions. This bonus will reduce the seismic cost of the building. This accounts for the fact that a detailed structural analysis can improve structural design leading to better seismic performance.

The winner of the competition will be the team whose building survives the shaking with the highest cost-benefit balance. Teams whose buildings collapse will be ranked in a lower category than teams whose buildings survive. More details about the model requirements, testing procedure, and scoring method are provided in Sections 2 through 6.

1.5 Design Proposals

Due to limited resources, only 35 teams will be able to participate in the seismic design competition. If more than 35 teams register, those with the best design proposals will be selected to compete. The design proposal should highlight the structural and architectural concepts of the design; it is not a detailed blueprint. Teams should communicate their design in a 5 to 10 page document. The proposal must be in PDF format and be emailed to:

seismic.design.competition@gmail.com

Design proposals are not being evaluated for rule violations. Selected designs are still subject to penalization. Damping devices are the only item that must be pre-approved; they are approved during the design proposal selection. Teams are allowed to deviate from their original designs, but any major revisions are prohibited. Teams are responsible for ensuring that their buildings follow the competition rules. For any clarification, please contact us at the above email address.

1.6 Team Registration

All teams interested in participating in the competition are required to pre-register. The pre-registration form will be available online. The 35 teams selected to compete will be required to complete a final registration prior to the competition. The final registration form will be sent via email 4-6 weeks prior to the competition.

1.7 Eligibility

The following rules shall be strictly enforced:

1.7.a Teams **must** be affiliated with a registered EERI student chapter. To start a student chapter, please reference the following website:
http://www.eeri.org/about-eeri/student-chapters/how-to-start-an-eeri-student-chapter/

1.7.b Teams may have as many undergraduate student participants as they wish; Graduate students are welcome to assist undergraduate student participants in the competition; however, they **cannot** register as team members.

1.7.c Each competing university can enter only one student team and one structure at the competition

1.8 Company Sponsorship

If financial assistance is provided by external sponsors, their names and/or logos may appear on the building or on any clothing worn by the team.

1.9 Structure Transportation

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

1.10 Financial Assistance

Some financial support from SLC will be available to help offset the cost of attending the competition. The exact amount allotted to each team 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. Henceforth, every team is strongly encouraged to seek additional funding.

1.11 Contact Us

Questions should be directed only to:

seismic.design.competition@gmail.com

2. Structural Model and Testing

This section describes the rules and limitations to be followed for the structural model. Any violation will result in building dimension penalty factor (N) or building weight penalty factor (M); both are described in Section 6.2. Failure to comply with any of these requirements may result in penalization or even disqualification.

2.1 Building Dimensions

The building must comply with the following dimensions. For penalties refer to Section 6.2.

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

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

Each individual floor area is calculated using the total plan area. Columns, shear walls, and the core are **not** subtracted from the floor area. The total floor area will be calculated by summing the individual floor areas from the bottom up. The individual floor area of any story that exceeds the maximum allowable height will not be counted.

2.2 Weight of Scale Model

The total weight of the scale model, including the base and roof plates and any damping devices, should **not** exceed**4.85 lbs (2.2 kg)**. Any violation will result in building weight penalty factor (M), which is described in Section 6.2.

2.3 Structural Model Base Plate

A square continuous 3/8 in thick plywood base plate will be used to attach the building to the shake table. One base plate will be provided to each team at no expense, and they will be mailed out in December. Each team must use the base plate provided. An engineering diagram depicting the manufactured base plate can be found in Figure 2-2. The approximate weight is 1000 grams.

2.4 Structural Model Roof Plate

A square continuous 3/8 in thick plywood roof plate is needed to attach the accelerometer to the building. One roof plate will be provided to each team at no expense, and they will be mailed out in December. Each team must use the roof plate provided. An engineering diagram depicting the desired roof plate can be found in Figure 2-3. The approximate weight is 100 grams.

2.5 Structural Frame Members

Structures shall be made of balsa wood. The maximum member cross section dimensions are:

Rectangular member:	1/4 in x 1/4 in (6.4 mm x 6.4 mm)
Circularmember:	1/4 in (6.4 mm) diameter

2.6 Shear Walls

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

Maximum thickness:	1/8 in (3.2mm)
Minimum length (plan view):	1 in (25.4mm)

Shear walls must span at least one floor. Structural members can attach to the ends of a shear wall.

2.7 Floors

2.7.a Floor isolation of any kind is not allowed.

2.7.b Each floor must be labeled. The floor at the base of the building will be labeled ground, and the floor above the lobby 2nd.

2.7.c Each floor must have a system of perimeter and interior beams to clearly define the floor area. The system of interior beams must run perpendicular to each other and have a minimum of 2 beams in each direction.

2.8 Fabrication Details

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

2.8.b 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 connected, as shown in Figure 2-1. The thickness shall not exceed the minimum cross sectional dimension of the members being joined.

The interior building core should not be blocked by frame members or walls. 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 in (25.4mm)
Height: 1.5 in (38.1mm)

2.8.c Floors do not need to be sheathed.

2.9 Innovative Damping Devices

All dampers must be approved. Any material is allowed to manufacture a damper. The implementation of such a device needs to allow for the placement of weights as discussed in Section 2.15.

2.10 Structural Connections

Connections of structural members can be made only from glue. All members and walls must frame directly into the base plate. Notching the base plate and roof plate is allowed, but only if it is to frame members and walls; that is, you cannot trim the base plate or roof plate to save weight.

2.11 Structural Modifications

The structure shall be constructed prior to the competition. If a structure is damaged during transportation, it may be repaired to its original design at the competition after this deadline.

2.12 Building Finish

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

2.13 University Banner

The university name should be placed at the top of the building, on a banner or paper (non-structural element). The dimensions are restricted to a width of 6 in and depth of 1 in.

2.14 Scaled Ground Motions

Structures will be subjected to 3 scaled and modified ground motions named GM1, GM2, and GM3.

It is imperative for teams to download all the ground motions from the competition 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 the competition website:

http://slc.eeri.org/SDC2012.htm

2.15 Structural Loading

Dead loads and inertial masses will be added through steel threaded bars tightened with washers and nuts. These will be firmly attached to the frame in the direction perpendicular to shaking.

Floor weight:	2.6 lbs (1.18 kg)
Roof weight:	3.5 lbs (1.59 kg)
Weight spacing:	Increments of $1/10^{th}$ the height (H/10)
Length between weights on bar:	16 in (406mm)
Threaded bar diameter:	1/2 in (12.7 mm)

The dead load will be placed at nine floor levels in increments of (H/10), corresponding to (1/10) x H to (9/10) x 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.

Weights will be secured to the structure using nuts and washers; they cannot be secured to the beam alone**.** See Figures 2-4 for their dimensions and Figures 2-5 and 2-6 for a typical weight attachment. It is *strongly* recommended that each team purchase a sample weight to try out and ensure proper attachment.

The roof dead weight will be 3.5 lbs (1.59 kg) in total, and will consist of a steel plate with dimensions of 6 in x 6 in x 1/2 in (15.24 cm x 15.24 cm x 1.27 cm) and an accelerometer. See Figure 2-3 for roof configuration. The direction of shaking will be determined by the judges.

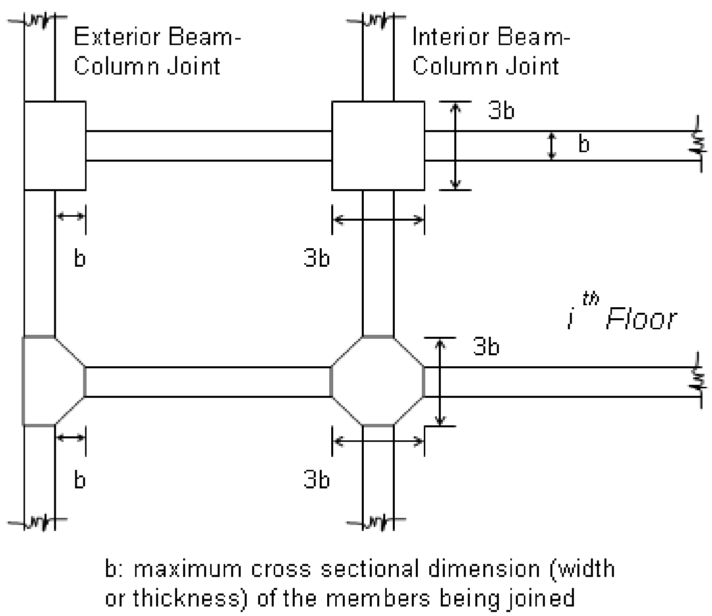


Figure 2-1: Allowable Moment Frame Connection Detail

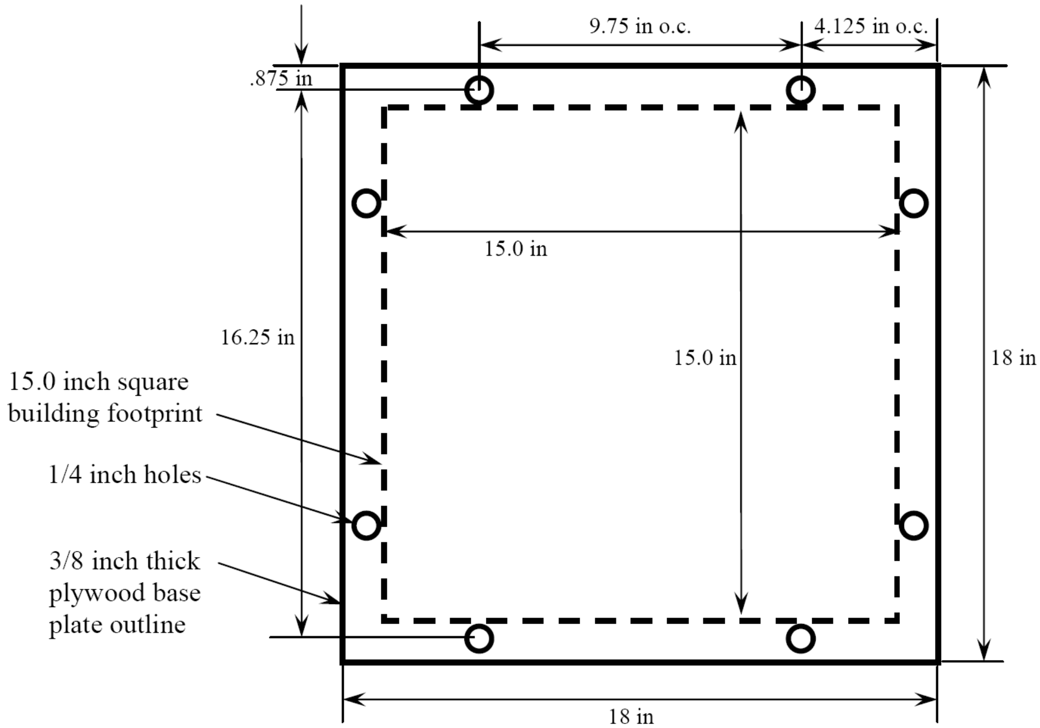
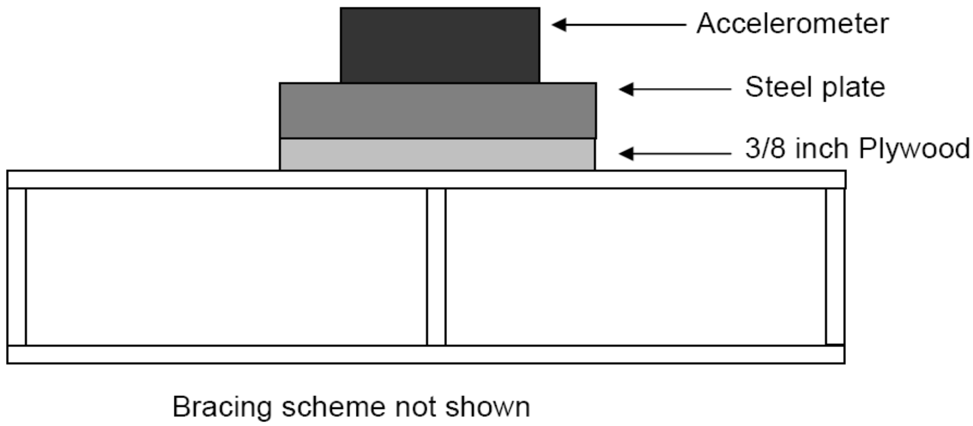


Figure 2-2: Engineering drawing of base plate

Roof Elevation View



Note: roof plate will be attached at the center of the roof to ensure even weight distribution and must be aligned with the base plate.

Roof Plan View

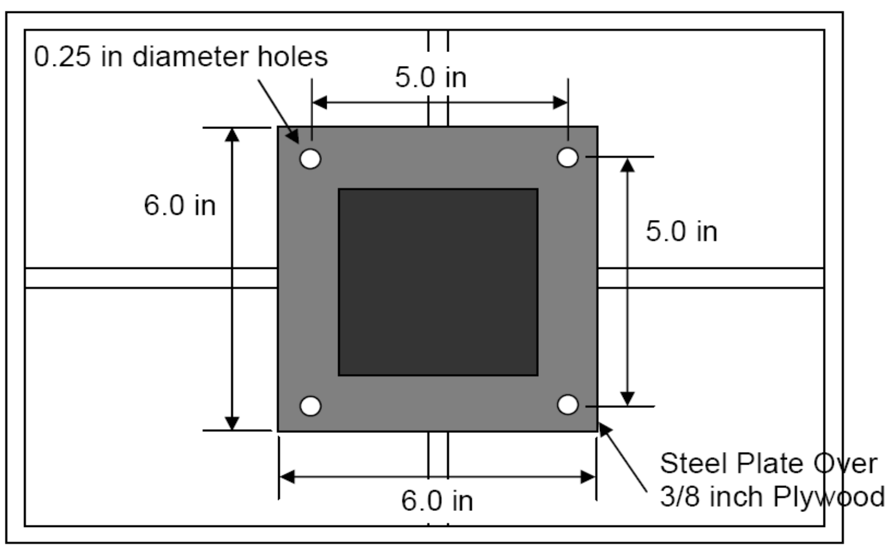


Figure 2-3: Weight and Accelerometer at Roof Level

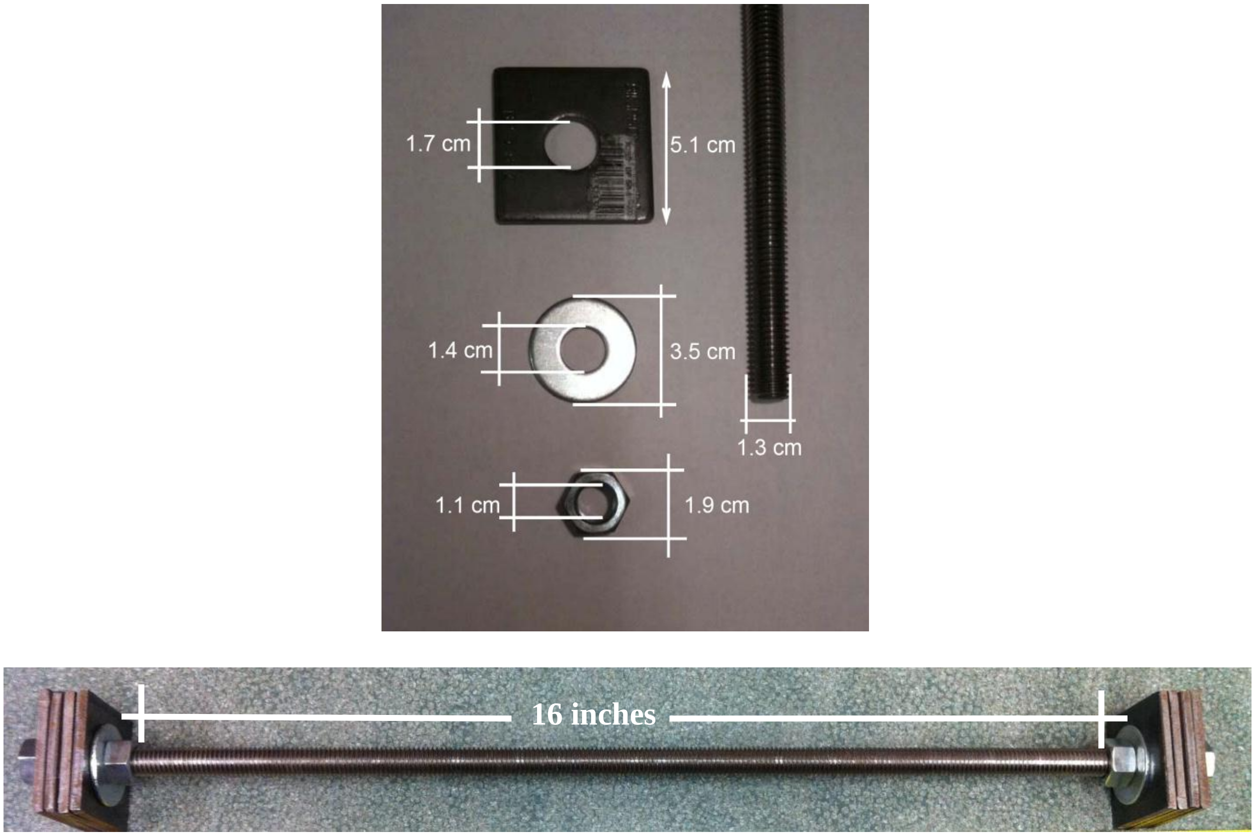


Figure 2-4: Dimensions for the Anchors used to Attach Weights

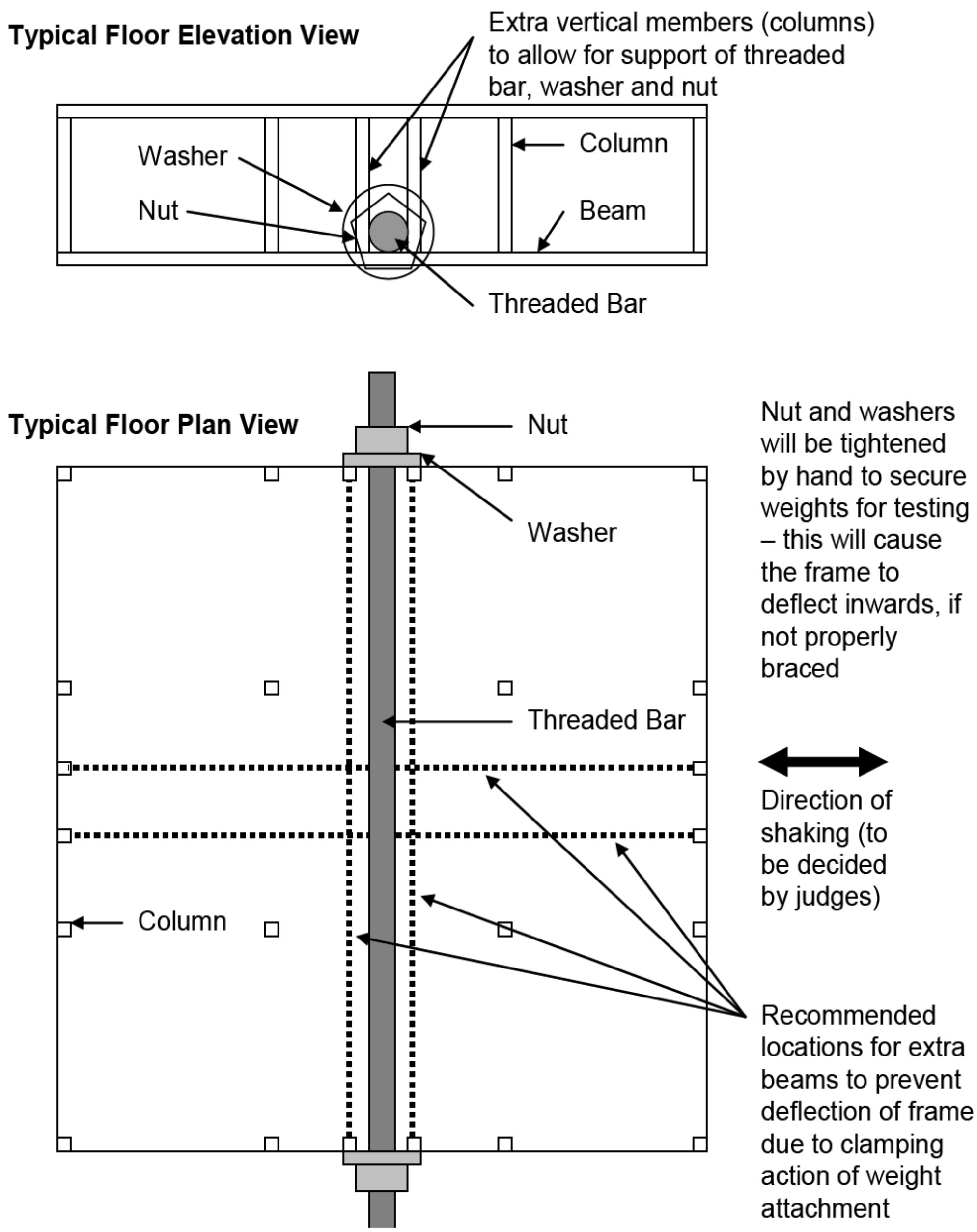
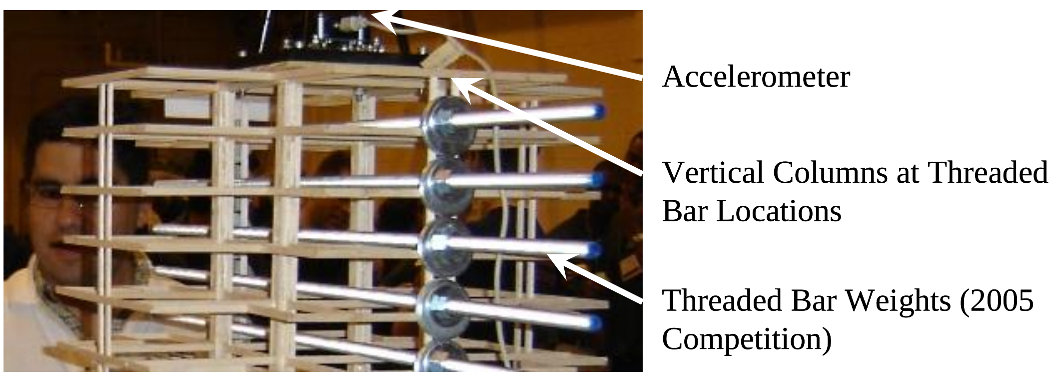


Figure 2-5: Anchorage of Weights to Structure

(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 frame members 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 2-6: Typical Weight Attachment

3. Additional Requirements

3.1 Oral Presentation

3.1.a Each team is required to 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.

3.1.b A projector and laptop, running Microsoft Windows 7, and PowerPoint (Office 2007) will be provided. The presentation files should be uploaded to the competition laptop before the first presentation. Teams are responsible for software compatibility. Teams can email their presentations to the organizing committee; however, it is recommended to bring a USB memory stick as well.

3.1.c See Appendix for the judge's score sheet that will be used.

3.2 Poster

3.2.a Teams are required to display a poster providing an overview of the project. The dimensions of the poster are restricted to a height of 42 inch (1.1 m) and a width of 36 inch (0.91 m).

3.2.b The university name and EERI logo should appear at the top of the poster and a font size of 40 is recommended. The font size shall not be less than 18.

3.2.c See Appendix for the judge's score sheet that will be used.

3.3 Performance Predictions

3.3.a Teams are required to predict the peak roof drift and the peak roof absolute acceleration for all three ground motions. Although performance predictions for all three GM's are required, only the performance predictions for GM1 will affect the annual income.

3.3.b The performance predictions must be sent in before April 6th.

3.3.c See Section 6.3 for scoring details.

4. 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 4-1. Technical specifications of the shake table, data acquisition system, the accelerometers and the data processing can be found in the appendix.

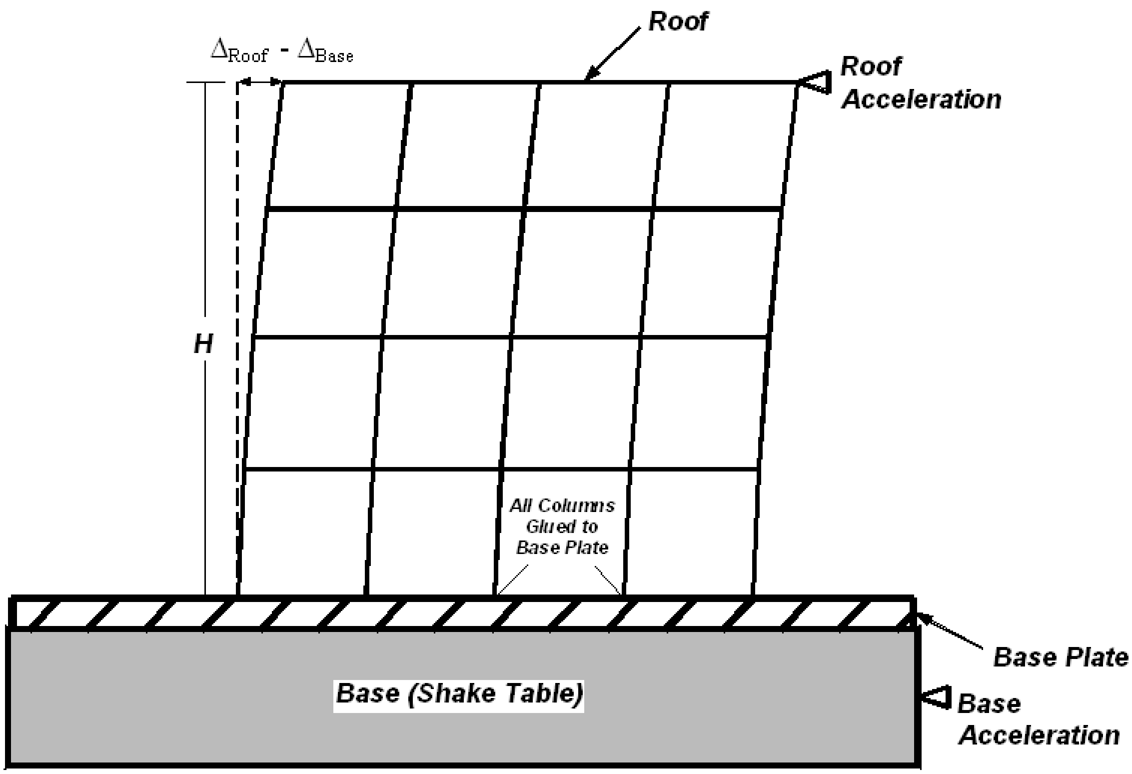


Figure 4-1: Schematic of instrumentation layout and measured engineering demand parameters.

5. <u>Scoring Method</u>

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

5.1 Annual Revenue

Annual building revenue will be based on the total floor area, with higher floors commanding more revenue per square inch than lower floors:

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

See Section 2.1 for floor area calculations.

5.2 Initial Building Cost

The initial building cost consists of land and construction costs.

$35,000 per square inch of building footprint
$10,000,000 per kilogram of building weight

The building footprint is defined as the maximum floor plan projected onto the base plate. The building weight includes the weight of the base and roof plates, but it does not include the weights added during shaking. The annual building cost will be computed by dividing the cost of land and construction by the design life of the building (100 years).

5.3 Annual Seismic Cost

The building will be subjected to three ground motions of increasing intensity. The structural response to all three ground motions will contribute to the annual seismic cost. If time does not allow, only two of the ground motions will be used for the competition. The decision will be made by the SLC on the day of the competition based on time constraints and the number of teams.

The annual economic damage for a given ground motion will be computed as the economic loss for that motion divided by its return period, which is indicated in Table 5-1. Annual seismic economic damage will be computed by summing the annual economic damage for all ground motions imposed.

Table 5-1: Return periods for ground motions used in competition.

Motion	Return Period (Years)
GM1	50
GM2	150
GM3	300

The economic loss for collapse and non-collapse is computed differently, as defined below.

5.3.a If collapse occurs, the economic loss corresponding to this ground motion will be equal to the sum of the following: the equipment cost, twice the construction cost of the building, and three times the annual revenue. A panel of judges will decide if a building is classified as collapsed. If collapse occurs during GM1 or GM2, collapse will be assumed to happen for the subsequent ground motions for loss calculation purposes.

Collapse is considered if the judges deem that the building has failed. This includes, but is not limited to, a significant portion of the building falling from the shake table, and the pancaking of one or more stories.

If no collapse occurs, the economic damage from each ground motion will be assessed using loss functions that relate financial loss to two engineering demand parameters (EDPs) measured during shaking. The EDPs are:

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

The economic damage for a given motion will be computed by summing the economic loss for each EDP.

a) Economic loss due to structural damage (EDP1)
Structural damage to the building will be assessed using the peak drift ratio between roof and the foundation level [Drift Ratio = $(\Delta_{Roof} - \Delta_{Floor})/H$]. The maximum cost of repairing structural damage is equal to the initial construction cost of the building. 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 0.015 and a standard deviation of 0.005. The loss function is plotted in terms of normalized cost in Figure 5-1.

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).

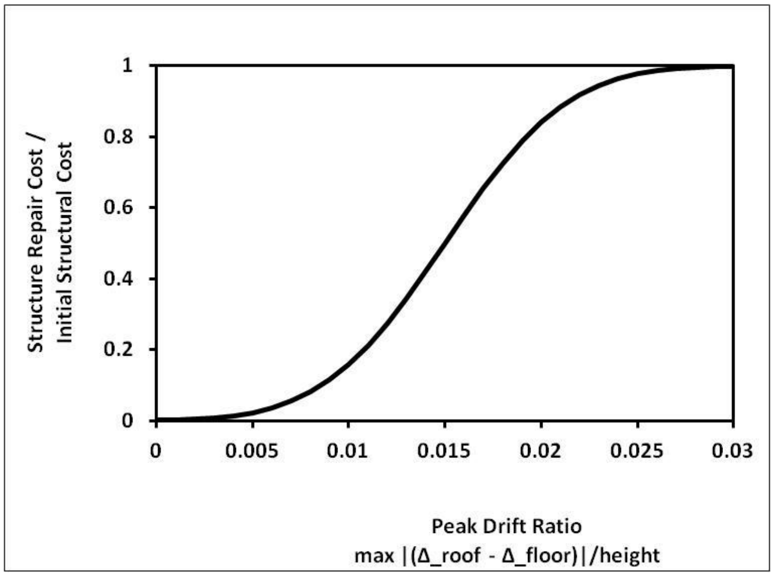


Figure 5-1: Loss function relating relative structural repair cost to peak drift ratio (EDP1)

b) Loss Caused by Equipment Damage (EDP2)
The building is assumed to house equipment worth $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 0.7g. The loss function is plotted in Figure 5-2.

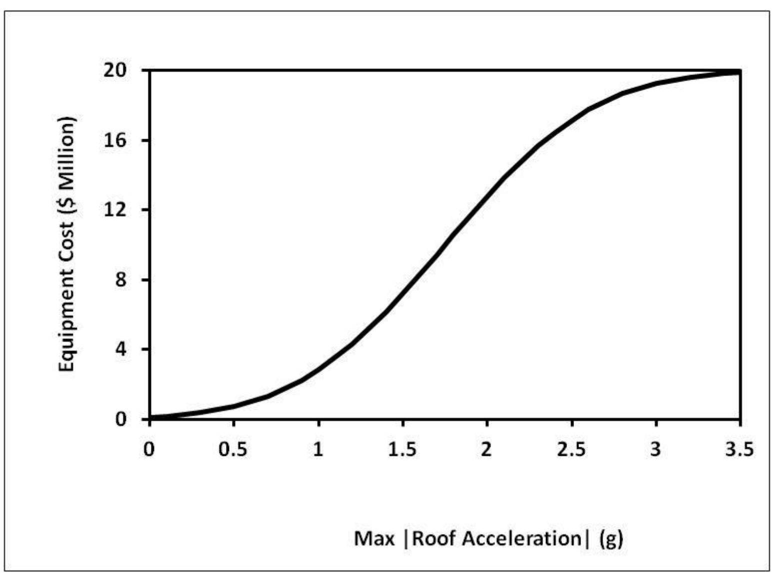


Figure 5-2: Loss function relating equipment cost to peak roof acceleration (EDP2)

6. Scoring Multipliers

The following section describes the calculation of the final score for each team. The final score will be based on the annual income affected by bonuses and penalties based on the following:

- Oral presentation
- Poster
- Architecture
- Violations of weight and dimension
- Failed connections during shaking
- Performance predictions

The team with the greatest annual income will be the winning team.

6.1 Increase in Annual Revenue

The increase in Annual Revenue will be determined by the team's rank in the oral presentation, poster, and architecture. Only the top 10 teams in each category will receive this benefit. See Table 6-1 for the percentage increase per rank.

6.1.a Oral Presentation, Poster, and Architecture

These components will be evaluated by the judges, and each team will be ranked by the scores. The scoring sheets that will be handed to the judges are found in the appendix.

Table 6-1: Annual Revenue Bonus

Rank	Presentation and Architecture	Poster
1^{st}	15%	10%
2^{nd}	12%	9%
3^{rd}	10%	8%
4^{th}	8%	7%
5^{th}	6%	6%
6^{th}	5%	5%
7^{th}	4%	4%
8^{th}	3%	3%
9^{th}	2%	2%
10^{th}	1%	1%
$11^{th}>$	0%	0%

6.2 Increase in Initial Building Cost

Rule infractions will be penalized by an increase in Initial Building Cost. Penalties will be given at the discretion of the judges and will follow the guidelines below.

6.2.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 2.Failure to comply with the dimensions will result in added percentage to factor N according to the following criteria. Note: In calculating all types of penalties, dimensions between the increments will be rounded up to the next increment.

6.2.a.1 Deviation in any direction from min/max floor dimensions specified in Section 2.1 will result in 2% penalty per 1/4in of deviation.

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

6.2.a.3 Penalties for deviations in floor and building heights:

6.2.a.4 Each 1/4 in deviation in individual floor height gets 2% penalty. Each 1/4 in deviation in total building height gets 5% penalty (total building height should be 2 x (number of floors) +2). Story heights are measured from the top of one floor beam to the top of the next floor beam.

6.2.a.5 Penalties for deviations in the frame member size: For each 1/8 in increment exceeding beyond the specified dimension there will be 1% penalty per element, per story. For example, if there are 4 frame members that have 1/4 in x 3/8 in cross sections and span 20 floors, there will be 20x4x1%=80% penalty. If the frame member were 1/2 in the penalty would have been 2% per element per story.

6.2.a.6 For each moment frame connection longer than the maximum allowable dimension there will be a 1% penalty per each 1/8 in deviation added to factor N.

6.2.a.7 Failure to provide access points to the core of the building as described in Section 2.8.c will result in 2% penalty for each floor.

6.2.a.8 If dampers are to be used, SLC approval is required to ensure compliance with the rules.

6.2.b Penalty for violation of the building weight (M)

The maximum total weight of building, including dampers, base plate and top floor plate, is **4.85 lbs (2.2 kg)**. There will be a 10% penalty for each 0.10 lb increment over the allowable weight.

6.3 Modification of the Annual Seismic Cost

The Annual Seismic cost will be modified based on the bonus for performance prediction and penalties due to insecure weight-to-building and accelerometer-to-building connections after shaking.

6.3.a Failed connections (D)

After each ground motion the judges will inspect the building for failed connections. Failed connections are deemed any weight that have fallen off or significantly detached from the original floor structural system. There will be a 5% increase for each loosened threaded bar.

6.3.b Performance Predictions (APS)

The seismic cost will be reduced based on the team's rank in the performance predictions. Each team is required 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 (proportion of g). The Analysis Predicted Scores (APSs) are used to evaluate the accuracy of the predicted performance (taken to two significant figures). 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 GM1, i.e. the lowest APS (APS1+APS2) wins. Only the GM1 predictions contribute to the APS.

Table 6-2: Analysis Prediction Score Bonus

Rank	APS
1st	15%
2nd	12%
3rd	10%
4th	8%
5th	6%
6th	5%
7th	4%
8th	3%
9th	2%
10th	1%
11th>	0%

6.4 Final Scoring

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

Final Annual Revenue (FAR) can be expressed as:

$$FAR = (1+X+Y+Z) \times AR$$

Where,

AR: Annual Revenue
X: Presentation Bonus
Y: Poster Bonus
Z: Architecture Bonus

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

$$FABC = (1+N+M) \times ABC$$

Where,

ABC: Annual Building Cost
N: Building Dimension Penalty
M: Building Weight Penalty

Final Annual Seismic Cost (FASC) can be expressed as:

$$FASC = (1+D-APS) \times ASC$$

Where,

ASC: Annual Seismic Cost
D: Failed Connections Penalty
APS: Analysis Predicted Score Bonus

The Final Annual Building Income (FABI) can be expressed as:

$$FABI = FAR - FABC - FASC$$
$$= (1+X+Y+Z) \times AR - (1+N+M) \times ABC - (1+D-APS) \times ASC$$

7. Competition Awards

7.1 Competition Winner and Ranking

7.1.a The team that designs the building that survives all three ground motions with the highest Final Annual Building Income will be the winner of the competition.

7.1.b Teams whose buildings collapse will be ranked in a lower category than teams whose buildings survive. Within each category, teams will be ranked based on the Final Annual Building Income.

7.1.c The teams ranked 2^{nd} and 3^{rd} will also be awarded.

7.2 Honorable Mentions

Three honorable mentions will be awarded for the best teams in individual aspects of the competition:

7.2.a An Honorable Mention for Best Architecture will be awarded to the team ranked 1^{st} in architecture.

7.2.b An Honorable Mention for Best Communication Skills will be awarded to the team with the highest combined presentation and poster score.

Total score = 1.5 x Presentation score + Poster score

7.2.c An Honorable Mention for Best Seismic Performance will be awarded to the team with the lowest final seismic cost.

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 participating teams.

8.2 Egor Popov Award for Structural Innovation

Egor Popov had been a Professor at the University of California, Berkeley for almost 55 years before 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 SLC members.