# *Eighth Annual Undergraduate Seismic Design Competition*

*San Diego, CA*

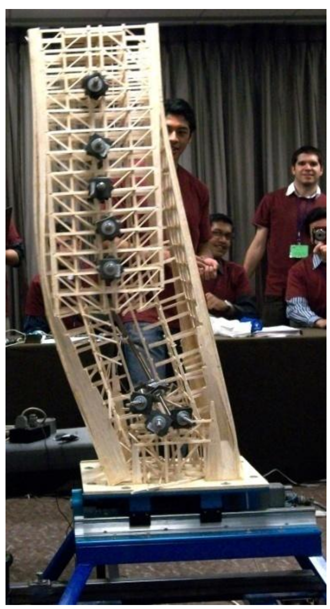
# *Rules*

**Organized and Run by:**

**EERI Student Leadership Council (SLC)**

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

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



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## 1. Introduction

The competition will be held in conjunction with the 63rd EERI Annual Meeting on February 10th and 11th 2011 at the Hyatt Regency La Jolla, Aventine in San Diego, California. More information about this conference is available online at:

http://www.eeri.org/site/2011-annual-meeting-home

### 1.1 Competition Objectives

The objectives of the Eighth 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 2010

1.2.a The base plate must be continuous and made of plywood. Balsa wood base plates of any kind are not permitted. Any team violating this requirement is subject to disqualification.

1.2.b Floor requirements have been added. Floor isolation is permitted in the middle-third of the building, every floor must be numbered, and every floor must have a system of interior beams running perpendicular to each other with a minimum of 2 beams in each direction.

1.2.c Premanufactured dampers are now permitted; however, they still require approval from the committee.

1.2.d The engineering design parameters have been readjusted.

1.2.e Scoring for the oral presentation, poster, and architecture are now rank-based.

1.2.f Factors that increase the Annual Seismic Cost have been added.

1.2.g An award will be granted to the second place team.

1.2.h An award will be granted to the team with the best architecture design.

### 1.3 Structural Design Objectives

Your team has been hired to submit a design for a multi-story 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 ground motion excitations. The time histories and response spectrums are available online in the competition website.

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

## 1.4 Important Deadlines and Dates

### 1.4.a **Important Deadlines**

| | |
|---|---|
| Registration | November 19th |
| Design proposal[1] | December 3rd |
| Release proposal comments | December 21st |
| Performance prediction | February 6th |
| Final floor area calculation | February 6th |
| Structure arrival to competition | February 9th |

### 1.4.b **Important Dates**

| | |
|---|---|
| Presentation | February 10th |
| Shaking | February 11th |
| Award Ceremony | February 12th |

Both the registration form and the design proposal shall be PDF and less than 500kb (multiple files are OK). The filenames should read:

- School name + registration + 2011
- School name + proposal + 2011 + part # (if multiple files are used)

The registration form and a sample design proposal can be downloaded from the competition website.

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[1] The design proposal must include the following:

1. Plan view for the first level, showing column layout, and any braces and/or walls
2. Plan view for typical levels (with rentable floor area shaded)
3. Plan view for the roof level
4. Elevation view (N-S) and (E-W)
5. Floor area calculations (in a separate excel sheet)

It is also very important to show the location and details of the weight attachment and the damping devices used.

## 1.5 Eligibility

The following rules shall be strictly followed:

1.5.a Participants must be currently enrolled undergraduate students and may come from any university in the USA or abroad.

1.5.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.

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

## 1.6 Company Sponsorship

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.

## 1.7 Structure Transportation

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

## 1.8 Financial Assistance

Some financial support from EERI-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 from local sources.

## 1.9 Support

Questions should be directed only to the EERI Student Leadership Council (SLC) via email 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 of the materials or dimensions listed in this section will result in Structural Dimension Penalty factor (M) which is described in a following section. Failure to comply with any of these requirements may result in ***disqualification***.

### 2.1 Structure Dimensions

The structure 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 top of the base floor to the top of 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.

### 2.2 Weight of Scale Model

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

### 2.3 Structural Model Base Plate

A square ***continuous*** 3/8 in thick plywood base plate will be used to attach the structure to the shake table. A balsa wood base plate will ***not*** be permitted, and any violation to this requirement subjects the team to disqualification. An engineering diagram depicting the manufactured base plate can be found in Figure 2-2.

### 2.4 Structural Model Roof Plate

A square ***continuous*** 3/8 in thick plywood roof plate is needed to attach the accelerometer to the structure. Teams are responsible for fabricating and installing their roof plates according to the requirements. As with the base plate, a balsa wood roof plate will ***not*** be permitted and any violation to these requirements subjects the team to disqualification. An engineering diagram depicting the desired roof plate can be found in Figure 2-3.

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.

## 2.5 Structural Frame Members

Structures shall be made of balsa wood and the maximum member cross section dimensions are:

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

## 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: | 1 in (25.4mm) |

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

## 2.7 Floors

2.7.a Floor isolation in the horizontal and vertical planes is allowed in the middle third of the building.

2.7.b Every floor must be labeled. There is no requirement on where the floors are labeled; however, the floor at the base of the structure will be labeled ground, and the floor above the lobby will be labeled 2$^{nd}$.

2.7.c Every floor must have a system of interior beams running perpendicular to each other with 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.

2.8.c The interior building core usually reserved for elevators, emergency exit stairwells, 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 in (25.4mm)
Height: 1.5 in (38.1mm)

2.8.d 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 loads.

## 2.9 Innovative Damping Devices

Structural damping devices, such as viscous dampers, are allowed in the design. However, unconventional dampers require ***approval*** from the competition committee before construction.

2.9.a 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 Sections 2.15

2.9.b 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 in x 1/4 in (6.4 mm x 6.4 mm) balsa wood section; the damper connection may expand the cross-section of the column to 1/2 in x 1/2 in (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 in (25.4 mm).

## 2.10 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. All columns must frame directly into the base plate.

## 2.11 Structural Modifications

The structure shall be constructed prior to the competition. No structural modifications will be allowed beyond ***noon of February 10th, 2011***. If a structure is damaged during transportation, it may be repaired to its original design at the competition after this deadline.

## 2.12 Structure Finish

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

## 2.13 University Banner

The university name should be placed at the top of the structure, 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.

## 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 mass: | 2.6 lbs (1.18 kg) |
| Roof mass: | 3.5 lbs (1.59 kg) |
| Mass spacing: | Increments of $1/10^{th}$ the height (H/10) |
| Threaded bar length: | 36 in (914 mm) |
| 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 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, which weigh 3.5 lbs (1.59 kg) in total. See Figure 2-3 for roof configuration. The direction of shaking will be decided by the judges. Therefore, it will be prudent to design structures that are symmetric in both directions.

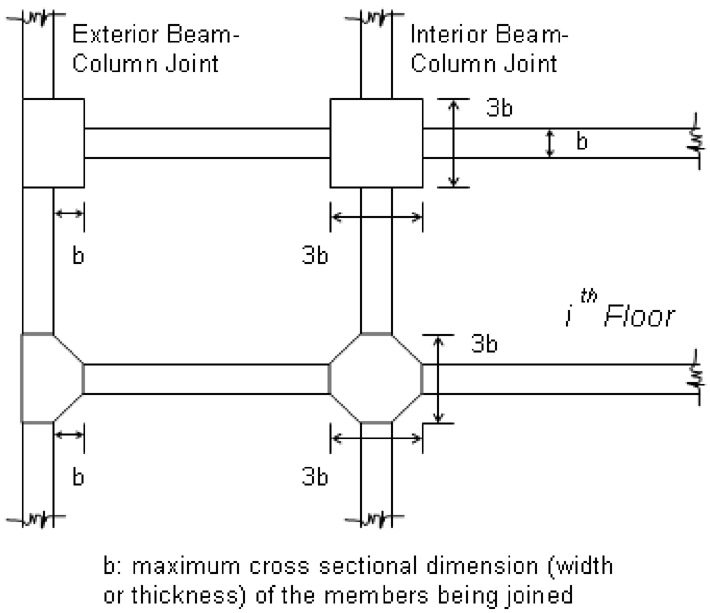


Figure 2-1: Allowable Moment Frame Connection Detail

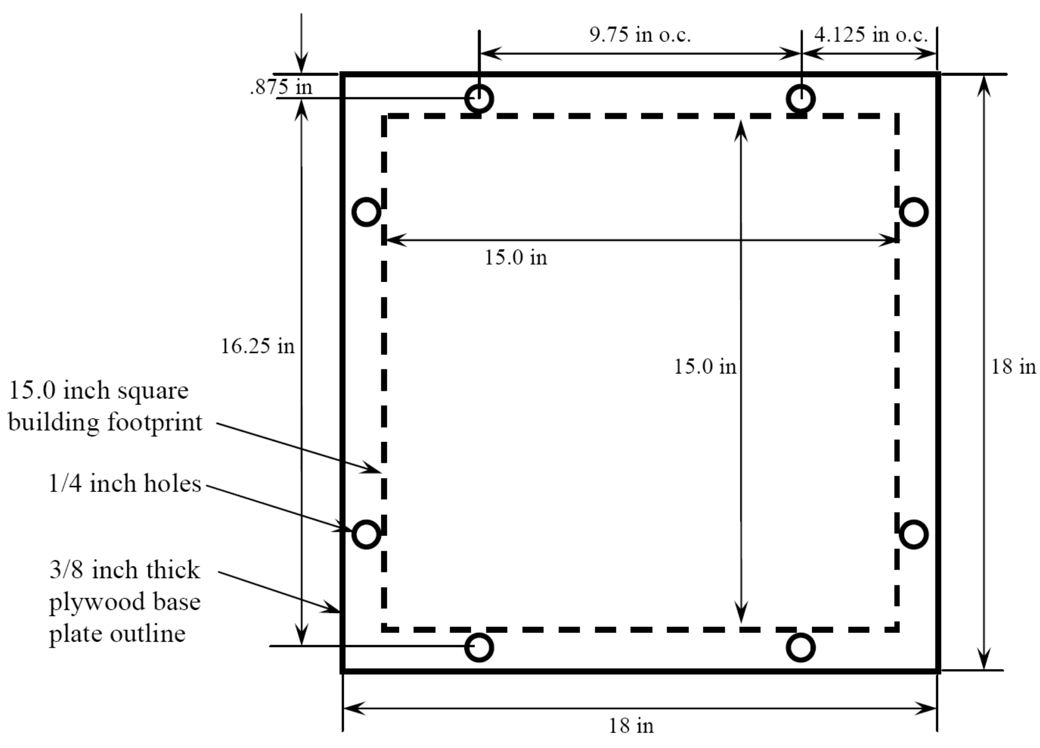
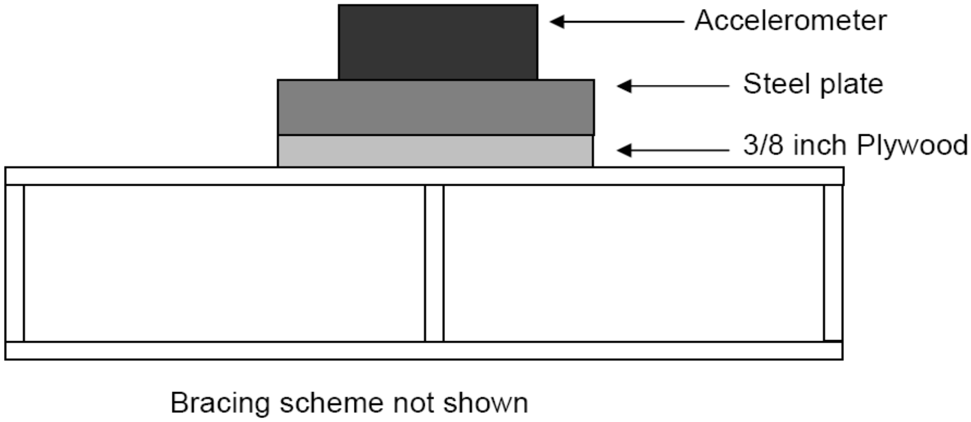



Figure 2-2: Engineering drawing of base plate (to be fabricated by each team)

**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**

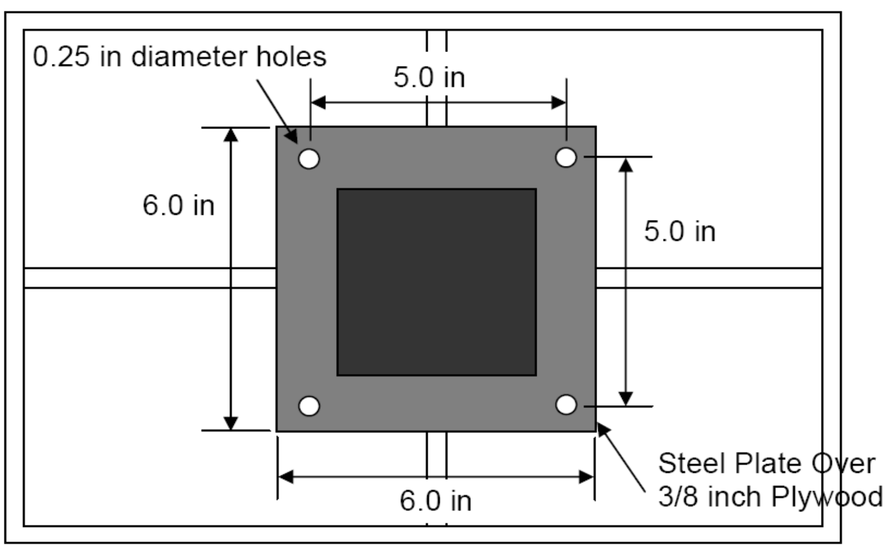



Figure 2-3: Weight and Accelerometer at Roof Level

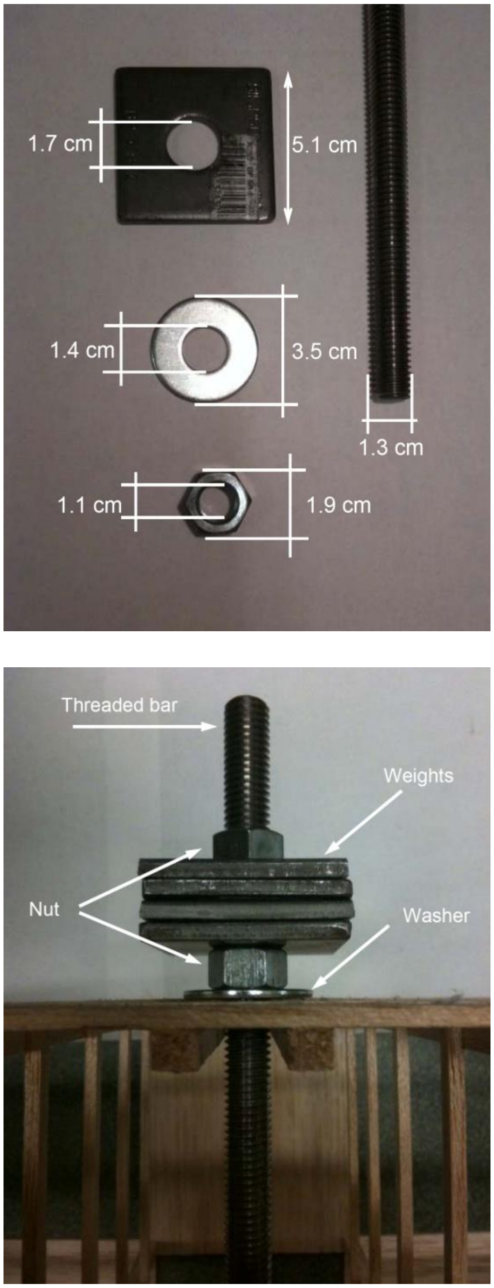



Figure 2-4: Dimensions for the Anchors used to Attach Weights

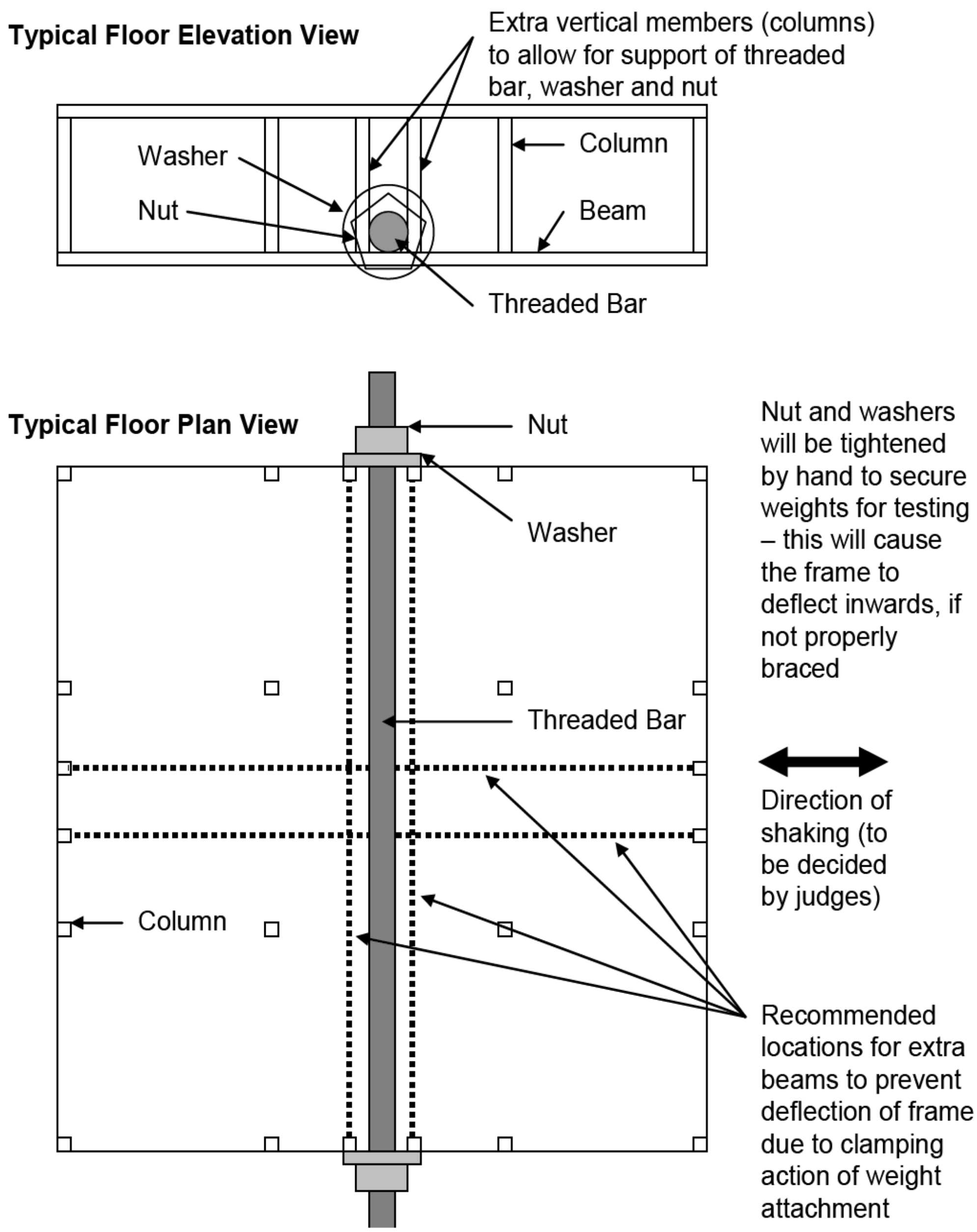
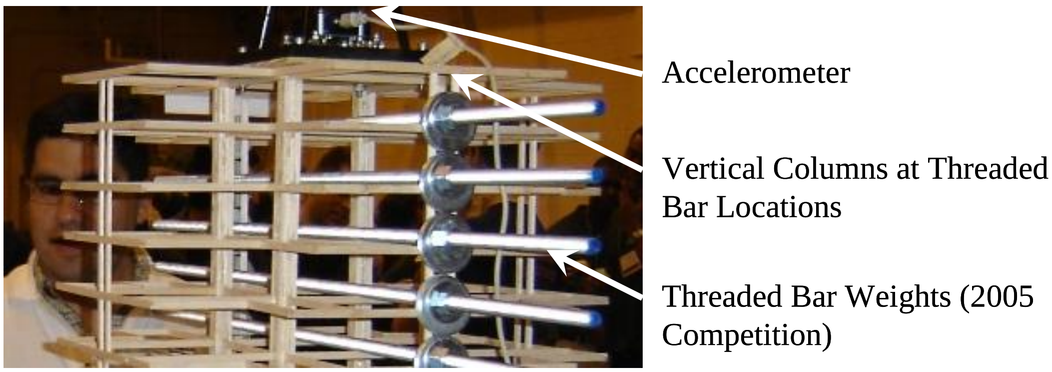



Figure 2-5: Anchorage of Weights to Structure


(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 different 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 different 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 on the competition laptop by ***9am on February 11$^{th}$, 2011***. 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 in case of technical difficulties with the projector.

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

## 3.2 Poster

3.2.a The 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 Scoring will be based on the scoring sheet provided in the Appendix.

## 3.3 Performance Predictions

3.3.a The 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 February 6$^{th}$, or the score they will not be counted.

3.3.c See section 6.1 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.

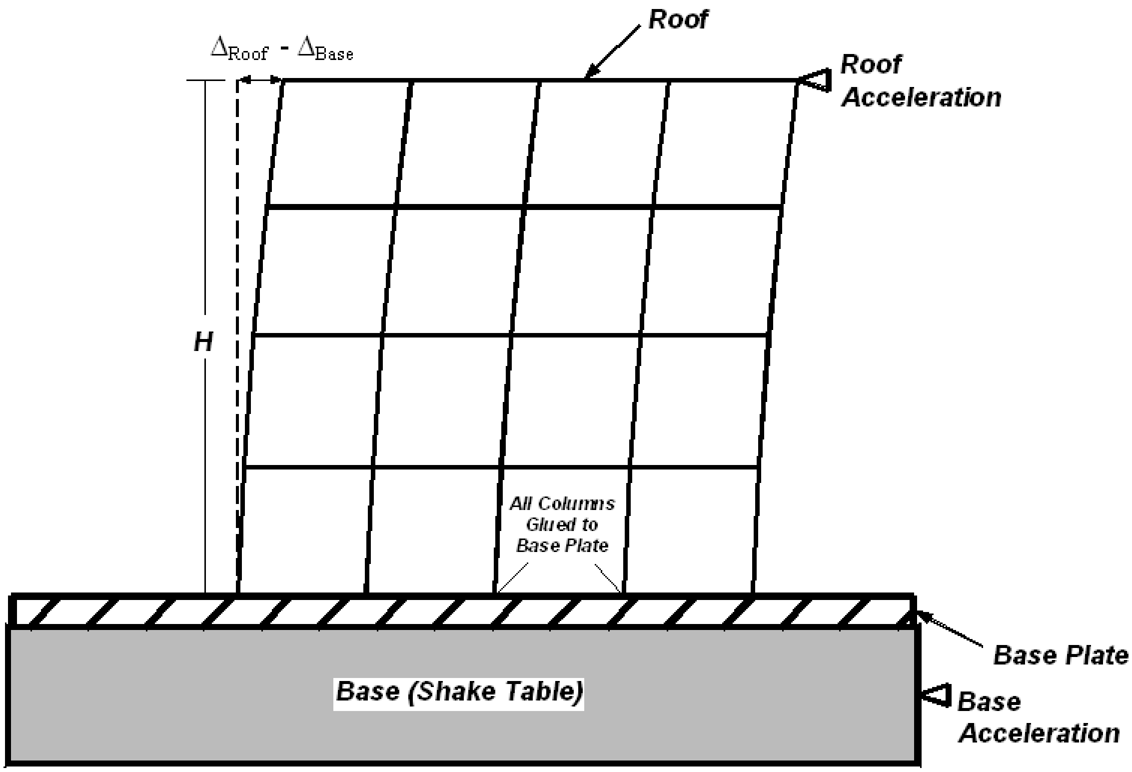



Figure 4-1: Schematic of instrumentation layout and measured engineering demand parameters for structure without base isolation.

# 5. Scoring Method

This section describes the method used to score the 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.

## 5.1 Annual Income

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

$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.

## 5.2 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).

## 5.3 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 on the day of the competition based on time constraints and number of teams participating in the competition.

Economic damage from each ground motion 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 ground motion, 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. Each loss function is discussed in detail in the sections that follow.

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

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

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

Structural damage to the buildings is correlated with 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 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 0.01 and a standard deviation of 0.004.

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 5-1.

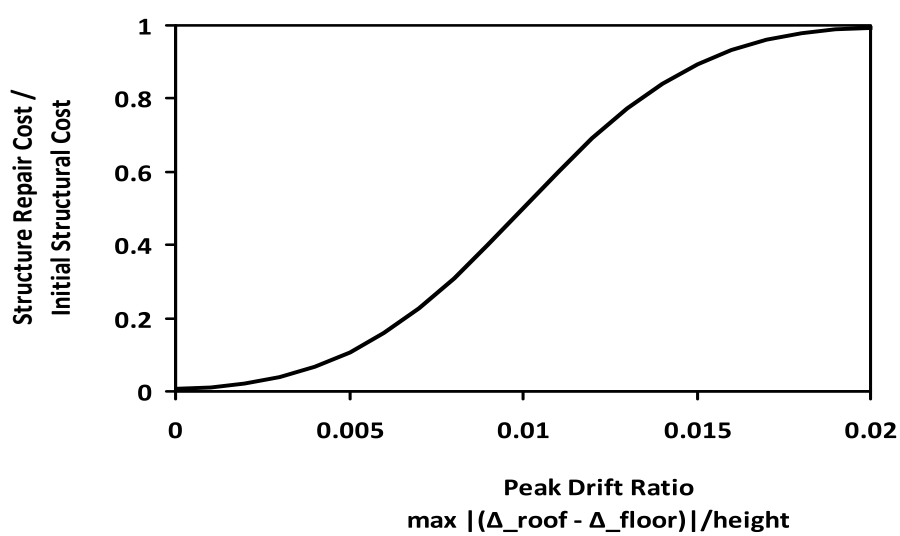



Figure 5-1: Loss function relating relative structural replacement cost to peak drift ratio (EDP1)

5.3.b Loss Caused by Equipment Damage (EDP2)

This is to simulate a scenario for equipment damage. The structure 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 which 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.

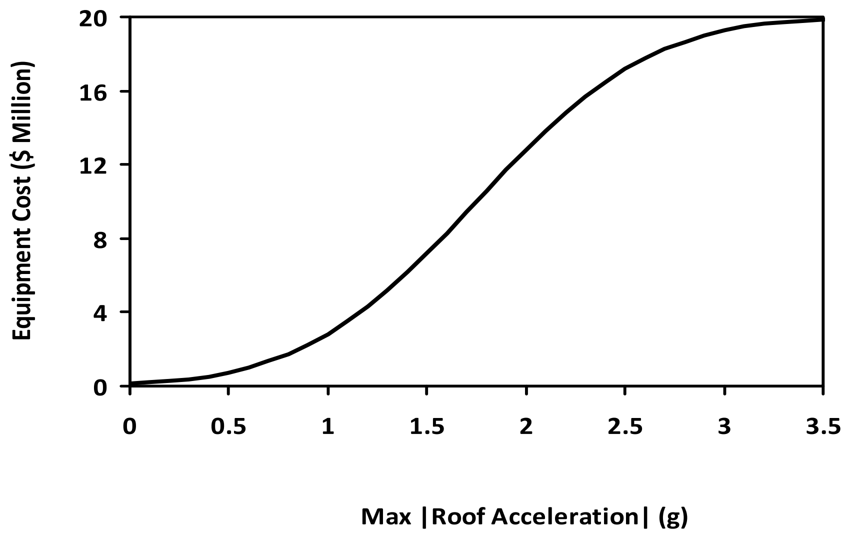



Figure 5-2: Loss function relating equipment cost to peak roof acceleration (EDP2)

# 6. Scoring Multipliers

The following section describes the calculation of the overall final score for each team. The final score will be based on the annual revenue and will be a function of:

- Annual Income
- Oral Presentation
- Poster
- Architecture
- Penalties
- Structural Performance
- Performance Predictions

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

## 6.1 Increase in Annual Income

The increase in Annual Income will be determined by the team's rank in the oral presentation, poster, architecture, and performance predictions. 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 (X,Y,Z)

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

### 6.1.b Performance Predictions (APS)

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 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.

$$APS_i = abs\left(\frac{predictedEDPS_i - measuredEDPS_i}{measuredEDPS_i}\right)$$

Each team will be ranked based on the accuracy of the prediction of EDP1 and EDP2 for the GM1, i.e. the lowest APS (APS1+APS2) wins.

Table 6-1: Annual Income Increases

| Rank | X, Y, Z | APS |
|---|---|---|
| $1^{st}$ | 10% | 25% |
| $2^{nd}$ | 9% | 20% |
| $3^{rd}$ | 8% | 18% |
| $4^{th}$ | 7% | 16% |
| $5^{th}$ | 6% | 14% |
| $6^{th}$ | 5% | 12% |
| $7^{th}$ | 4% | 10% |
| $8^{th}$ | 3% | 8% |
| $9^{th}$ | 2% | 6% |
| $10^{th}$ | 1% | 4% |
| $11^{th}$> | 0% | 0% |

## 6.2 Increase in Initial Building Cost

Increase in Initial Building Cost will be due to penalty rule infractions which are given by the sole 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.

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

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

6.2.a.3 Penalties for deviations in floor and building heights:
Each 1/4 in deviation in individual floor height gets 2% penalty (lobby floor height is 4 in and other floor heights are 2 in). Each 1/4 in deviation in total building height gets 5% penalty (total building height should be 2 x (number of floors) +2)

6.2.a.4 Penalties in deviations in column, beam, and diagonal sizes: 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 columns that are built 1/4 in x 3/8 in and go through 20 floors, there will be 20x4x1%=80% penalty. If the columns were 1/2 in 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.

6.2.a.5 For any 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.6 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.7 If dampers are to be used, SLC approval is required to ensure compliance with the rules.

6.2.a.8 All the damper connections should be in accordance to Section 2.9. Any discrepancy will result in 2% penalty for each connection.

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

Maximum total weight 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 increment over the tolerance

### 6.3 Increase in Annual Seismic Cost

Increase in Annual Seismic cost will be due to insecure weight-to-structure connections and accelerometer after shaking.

6.3.a **Failed connections (D)**

After each ground motion the judges will inspect the structure for failed connections. A connection has failed if the threaded bar is loose; each failed connection results in a 5% increase.

6.3.b **Accelerometer (F)**

If the accelerometer is about to hit the floor during shaking, then the structure has collapsed. A collapsed structure results in a 100% increase.

### 6.4 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:

$$FAI = (1+X+Y+Z+APS) \times AI$$

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:

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

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

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

$$FASC = (1+D+F) \times ASC$$

where,

ASC: Annual Building Cost
D: Annual Seismic Cost increase from insecure weight-to-structure connection and accelerometer
E: Annual Seismic Cost increase from insecure accelerometer

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

$$FABR = FAI - FABC - FASC = (1+X+Y+Z+APS) \times AI - (1+N+M+L) \times ABC - (1+D+F) \times ASC$$

# 7. Special Awards

## 7.1 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.

## 7.2 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 judges.

## 7.3 Fazlur Khan Award for Architectural Design

As a Structural Engineer Fazlur Khan played a central role behind the “Second Chicago School” of Architecture in the 1960’s and is regarded as the “Father of tubular design for high-rise buildings”. His most famous buildings designs are the John Hancock Center and Willis Tower (formerly Sears Towers). He was born in Bangladesh in 1929. He obtained his bachelor’s degree from the Engineering Faculty at the University of Dhaka. In 1952 he immigrated to the U.S. where he pursued graduate studies at the University of Illinois at Urbana-Champaign, he earned two Master’s degrees (one in Structural Engineering and one in Theoretical and Applied Mechanics) and a PhD in Structural Engineering. In honor of his contribution to Structural Engineering and Architecture Design of high-rise buildings, the team whose building provides a remarkable expression of architecture design and inherently integrates a sound structural design will be awarded the Fazlur Khan Award for Architectural Design. The winner for this award will be determined by the judges.