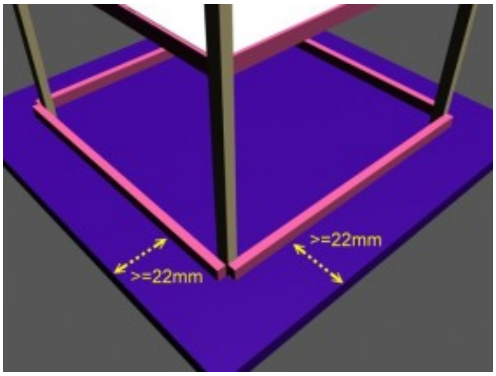
Rules for 8th National Earthquake Competition 2017

1. Configuration of Models

1.1 Base board: The model will be constructed on a provided base board of 270mm × 270mm × 6mm in size. The weight of the base board, M_B, will be weighted and recorded before the construction of a model. 22mm of clearance must be left around the edges of the base board such that the model can be easily fixed onto the Two-Dimensional Earthquake Simulator with screws.



1.2 Number of holes: Holes drilled on the base board are only for fixing columns of a model to the base board. Therefore, the number of holes drilled on a base board is equal to the number of columns designed for the model.

1.3 Number of floors: The building model shall have **Four (4) Stories** in height and so shall consists of **Five (5)** horizontal floors inclusive of the base board, which may be supported at any way desired. A flat roof will be treated as a floor. The base board can be used as the ground (first) floor of the model.

1.4 Clear distance: As shown in **Figures A**, the distance between the top of the girder (beam which connects the columns) of any floor and the bottom of the girder of the floor above must be minimum **15cm** and maximum **20cm** (i.e. the clear distance). The fixings for the steel blocks on floors of a model are not counted as part of the floors.

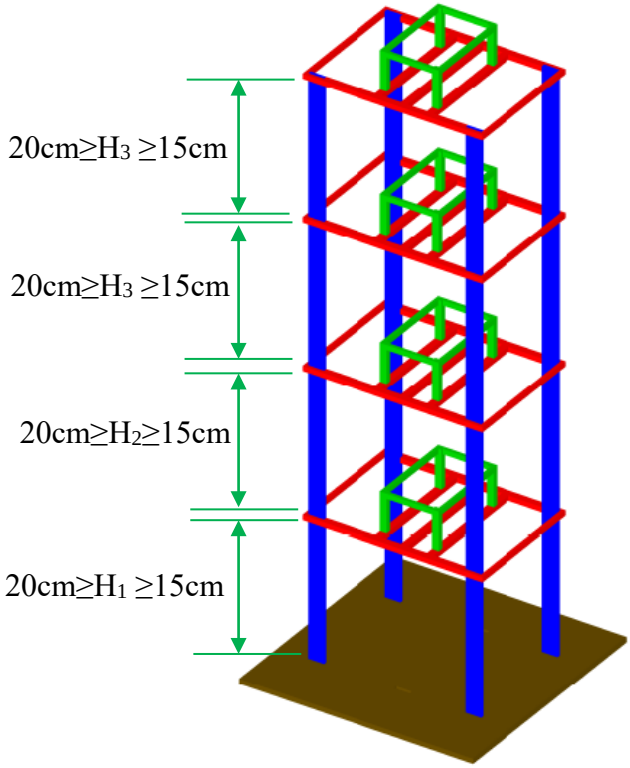


Figure A

1.5 Location of Columns: In order to eliminate the obstruction of fixing steel blocks onto each floor, columns are only allowed to be placed along the perimeter of a model, therefore no columns is allowed to be placed inside a model. **Figure B** shows that all the columns are only placed along the perimeters of models with different shapes of floors.

1.6 Area of floors: Not counting the ground (first) floor, the total area of the rest four floors must be between **1000cm^2** and **1200**cm^2. The minimum and maximum areas allowed for each floor are **200cm^2** and **300cm^2** respectively, except the ground (first) floor. The floor area of each floor is the area surrounded by the outmost columns including the space taken up by columns. **Figure B** below shows some general shapes of floors. The shaded area enclosed by the columns represents the area of the floor. Any structural components that are projected from the exterior side of the outmost columns are not counted as a part of the floor area. For example, beams may be cantilevered from the outmost columns.

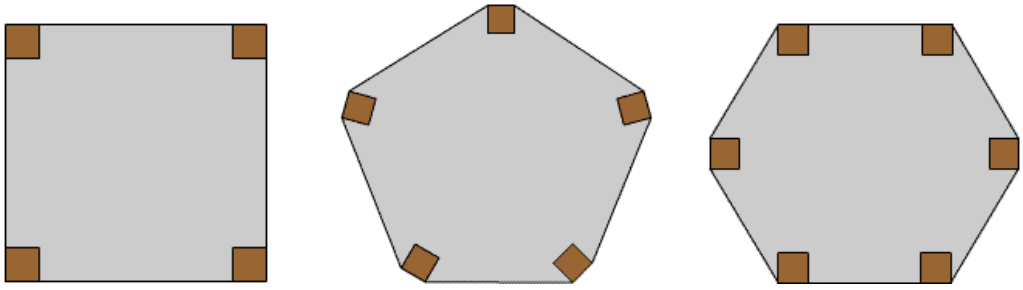


Figure B

2. Materials

The participating teams can only use the provided materials to construct the building models. The specifications and quantities of the materials are listed in the table below.

Materials	Specifications	Quantity
MDF timber strips	Length: 90cm Cross-section dimensions: 6mm x4mm	40
Cotton string	Cotton Twines No. 6	2m
Square baseboard	Dimension: 270mmx270mmx6mm	1

3. Construction of Models

3.1 Exterior Clearance: In a real building, windows are needed in every storey. For each storey of the model, at least half the length of the perimeter (on plan) must be left completely clear of any obstructions due to bracings between two immediate adjacent floors. Refer to **Figures C and D** for calculation details.

Figure C shows a side view of two immediate adjacent floors of a model with straight columns. The green arrow shows the length between the outmost columns (including the width of the columns), and the red arrows show the projection lengths that are taken up by the bracings.

Figure D shows the lower floor plan view of the same model as in **Figure C**. The perimeter, **L**, of the lower floor of the model is calculated by adding up the lengths of all green arrows. The total length occupied by bracings, **x**, is equal to the summation of the projection lengths of all the bracings to the lower floor beams marked by red arrows. The following equation must be satisfied with this rule:

$$\frac{x}{L} \leq \frac{1}{2}$$

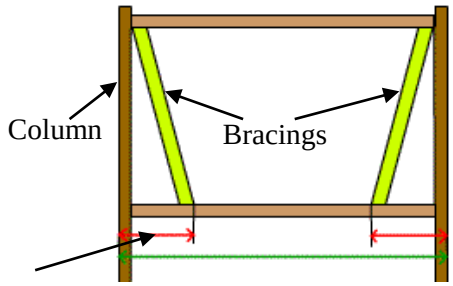


Figure C

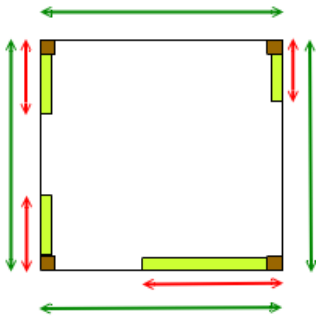


Figure D

Similar to **Figure C**, **Figures E and F** show a side view of projection lengths to the lower floor beam of different types of bracings of a model with inclined columns. The method to calculate x and L is the same as that shown in **Figures C and D**.

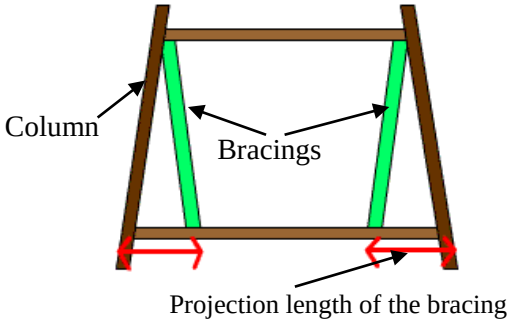


Figure E

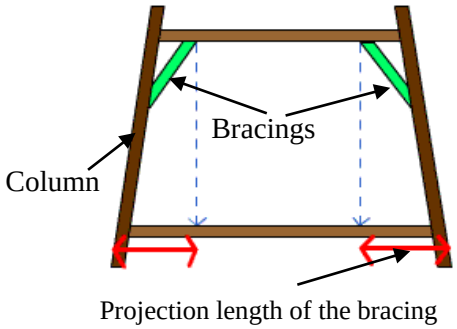


Figure F

3.2 Additional Weights: Additional weights will be applied to the model at each storey level using steel weights to simulate the mass in a real building. Therefore, additional fixings should be constructed for securing the steel weights onto your model. Fixings should be used only for holding the steel weights in place. It cannot connect to the structural frame (Columns, girders and braces) directly. If the fixings are also used as structure supporting components, then they will be counted as part of the floor and hence the clear height of that floor may not be enough.

Every floor of a model must be able to carry 4 numbers of steel weights with **6.0cm × 4.5cm × 3.0cm** in size and **635g** in weight. Therefore, each model will have to carry total 12 numbers of steel weights. **Figure G** shows the steel weights that will be used.

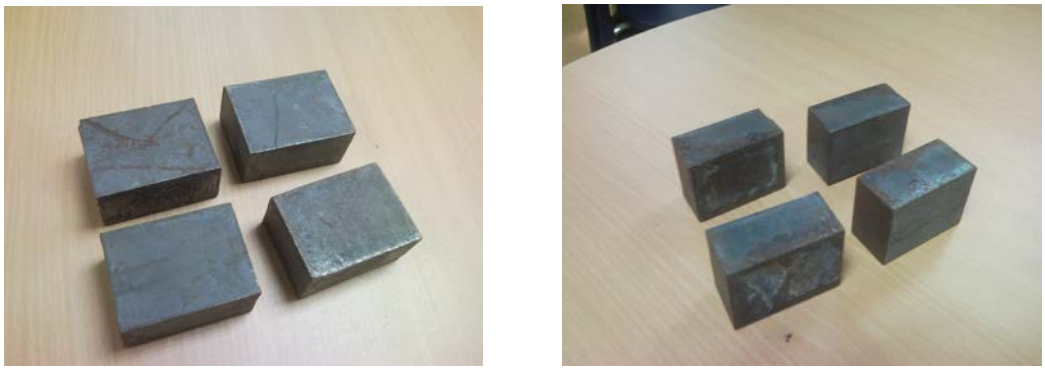


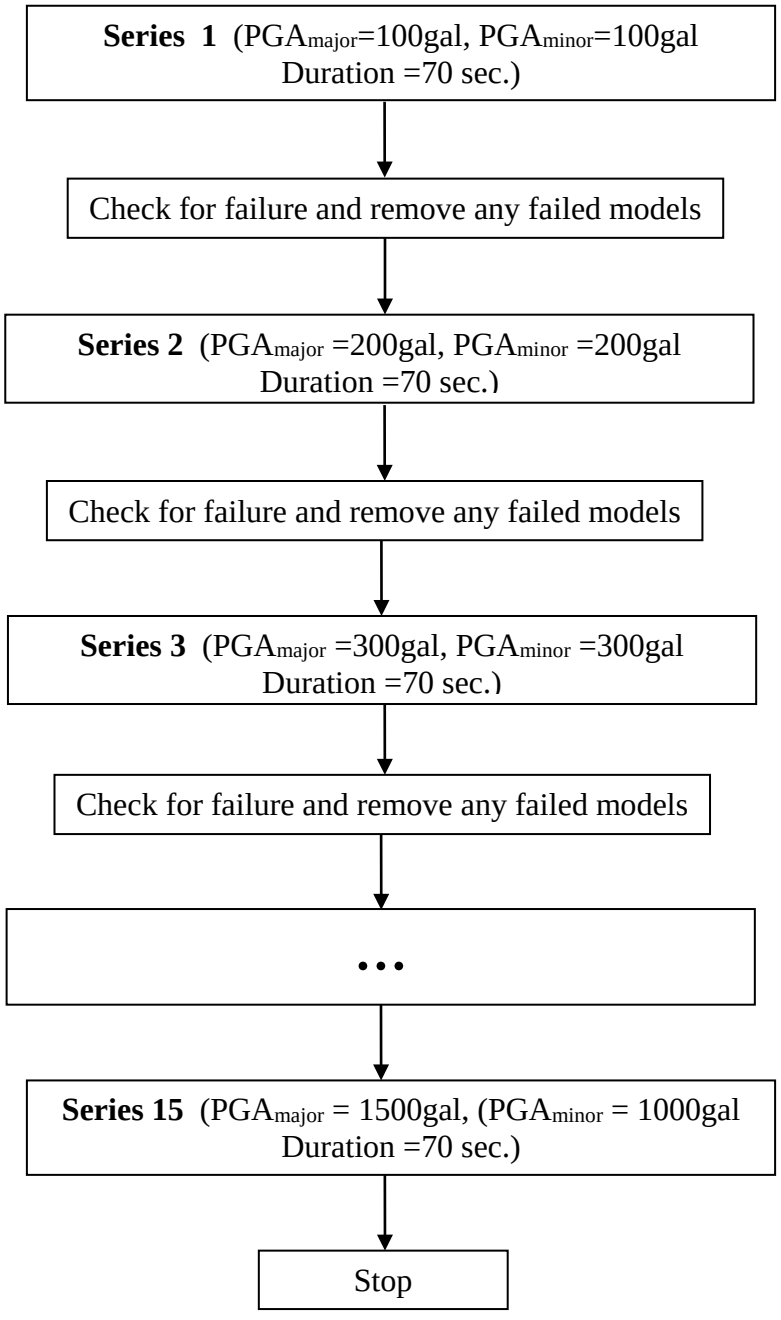
Figure G Additional Steel Weights

3.3 Qualification: Once a model is completed, the total mass of the model (including the base board), M_M will be weighted and recorded. The judge will then check the model, and the additional penalty weight (M_P) will be determined and included for the calculation of efficiency ratio if it does not meet the specified rules.

4. Competition

4.1 Mounting of the Model and Fixing of Steel Weights: The organizer will arrange personnel to mount the model securely onto the Two-Dimensional Earthquake Simulator. Each participating team shall to send to team members to fix the steel weights to the floors of their model.

4.2 Earthquake-Resistant Test: All the models will be tested simultaneously at most 15 rounds of simulated shaking tests along two perpendicular directions. The peak shaking accelerations at each round are 100gal, 200gal, 300gal, 400gal, 500gal, 600gal, 700gal, 800gal, 900gal, 1000gal, 1100gal, 1200gal, 1300gal, 1400gal and 1500gal respectively along major direction and 100gal, 200gal, 300gal, 400gal, 500gal, 600gal, 700gal, 800gal, 900 gal along minor direction for round 1 to round 9 and 1000gal along the minor direction for the rest rounds with frequencies ranging from 1.0Hz to 16Hz and duration of about 70 seconds for each round. The following flow chart shows in detail the earthquake resistant test.



4.3 Failure of Building Model: A model is deemed to have failed under following conditions:

- Complete collapse of the model.
- Collapse of one or more stories.
- The model has deformed excessively (maximum lateral permanent deformation is more than 15% of the gross building height).
- Half or more than half of the columns are detached from the base board.
- Any of steel weights fall off from one of the floors.

4.5 Efficiency Ratio: The score of the competition is based on the efficiency ratio, which is calculated by dividing the maximum intensity the model system survives (**I**) by its mass ($\mathbf{M_M} - \mathbf{M_B} + \mathbf{M_P}$). A higher efficiency ratio means that the model can survive a stronger earthquake using less amount of material, thus, the model system is more efficient in terms of earthquake-resistant. The efficiency ratio is defined as follows:

$$Efficiency \quad Ratio = \frac{I}{M_M - M_B + M_P}$$

where:
I = Maximum intensity that a model system can survive
$\mathbf{M_M}$ = Total mass of the model system (excluding steel weights)
$\mathbf{M_B}$= Mass of the base board
$\mathbf{M_P}$= Penalty weight

4.6 Violation Penalty: Teams will be disqualified if:

❖ Using other materials that are not specified in the rules;