2011 IDEERS
Rules for High School Teams

The List of Rule Revisions

Version No.	Date	Remarks
V1	2011-07-13	None
V2	2011-08-24	1. Rules 4.3, 8, 8.2, 8.4 are revised. 2. Figure 12. is revised.

The content presented below serves as primary rules for this competition. However, if events occur that are not covered or clearly defined by these rules, the organizers reserve the right of final interpretation.

1. The competition

Each team is required to design and construct a building model at the competition venue. The model will be loaded and should be able to stand up to the artificial earthquakes generated on the shaking tables at the National Center for Research on Earthquake Engineering (NCREE).

This is a two-day event. The first day is for making the model. Each team will be given 6.5 hours (including a lunch break) to build the model using the materials and tools provided by the host.

On the second day, models will be tested on a shaking table in NCREE with earthquakes of various intensities imposed. The first earthquake will be small, and then the intensity will be gradually increased, up to a maximum level of 800 gal.

The Efficiency Ratio (ER) is the main criterion in this competition. The mass of the building model, the number of weight blocks it carries and the maximum intensity of earthquake the model can survive will be noted. These values will be used to calculate the model's efficiency ratio. The models will be ranked by their ERs, and those with the highest ER will be the winners.

In order to raise the level of difficulty, and to make it more interesting, the theme of this year's competition will be a "planar asymmetry". Competing teams are encouraged to overcome problems with ingenious thinking and to build economical and earthquake-resistant structural models.

2. Team composition

Each team must have four students from the same university and one advisor (a teacher from the same school). During the model-making process, the advisor is not allowed to work by hand on the model.

3. Materials and tools

Teams are allowed to use only the materials and tools provided by the host. Stationery such as pencils, rulers, erasers, and calculators may be brought in; however, they can only be used to mark the materials when sizing and to do calculations, not for cutting.

3.1 Materials

The materials provided include:

Item	Quantity	Details
1. Wooden base board	1	Made of MDF (Medium Density Fiberboard), about 0.55 cm thick, 34 cm × 24 cm (±0.3 cm)
2. Wooden stick	40	Made of MDF, used for making the model and the description board, 70±0.5 cm long with a cross-sectional dimension of 5.5 × 4 mm (±1 mm)
3. Hot melt glue	20	20 strips of hot melt glue, 30 cm long and 6 mm in diameter
4. Rubber band	16	3 mm wide, 1.5 mm thick, and the perimeter is roughly 240 mm.
5. A4 paper	10	10 sheets of A4 paper
6. String	1	A cotton string 200 cm long
7. Bamboo stick	1	For the making of the team pennant
8. Base board for the description board	1	For the making of the description board

3.2 Tools

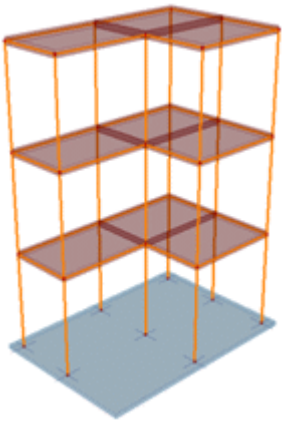
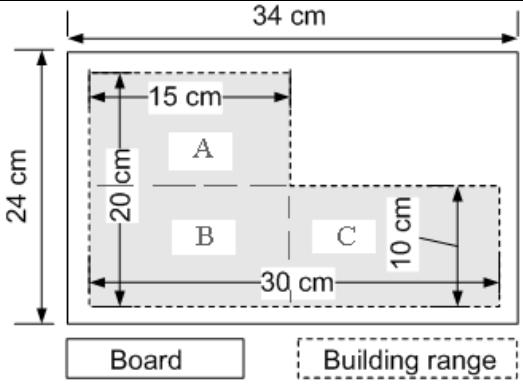
The tools provided include:

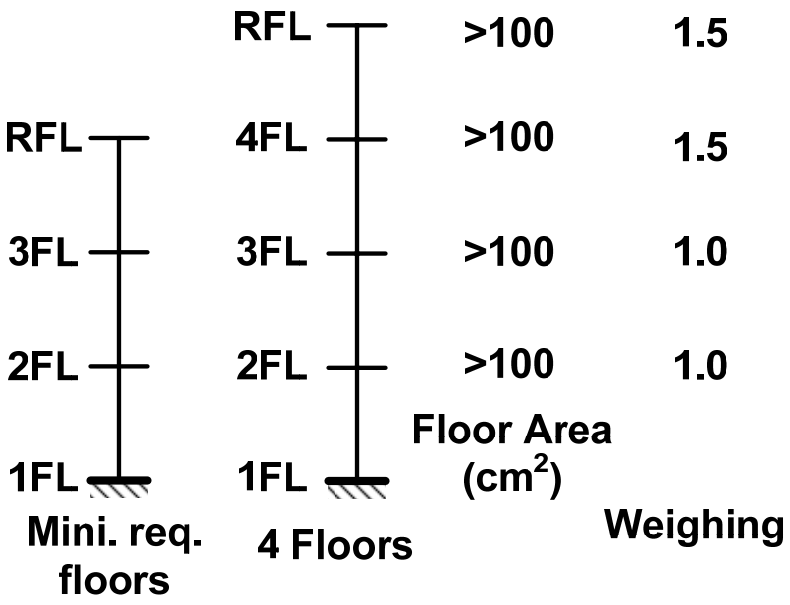
Item	Quantity	Details
1. Scissors	1	General office scissors
2. Wire saw	1	0.9 cm wide and 30 cm long
3. Tape measure	1	Total length is 5.5 m
4. Manual drill	1	With an 8 mm bit
5. Hot melt glue gun	1	General hot melt glue gun
6. Large utility knife	1	The blade is about 1.8 cm wide

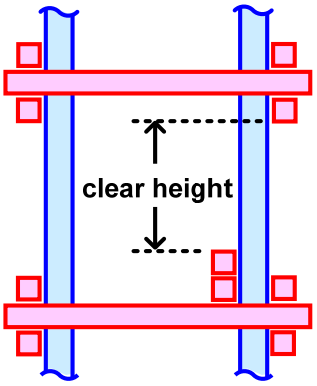
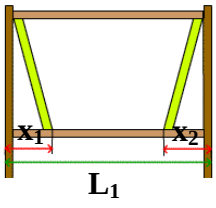
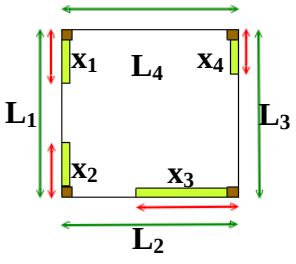
Before building the model, it is the responsibility of each team to make sure that they have received the correct materials and tools. If some materials and tools are missing or damaged, please report to the judges who will handle the matter.

4. Rules for the structure

To courage ingenuity and creativity, models only need to comply with the following requirements:

Item	Details
4.1 Basic structure	All models must comply with the general rules of building construction. They must have the basic structural components of a building, including beams, columns, slabs, walls, and bracings. Cladding or decoration for the purpose of aesthetic appearance of the building is not a requirement. However, models must meet the clearance requirements, and no items should hinder the judge's inspection and calculation of the floor area of the model.  Figure 1. Schematic diagram of the building model.
4.2 Construction area of the model	 Figure 2. Model construction area. Models will be constructed on the base board provided (34×24×0.55 cm). A 2 cm clearance around the edges of the MDF base board must be left so that the model can be fixed onto the shaking table (teams that violate this rule will be disqualified or punished with penalty weights). The allowable construction area is marked in gray in Figure 2; the entire model must lie within the L-shape enclosed by

	the dash lines. The model must not be shifted or rotated.
4.3 Number of wood sticks fixed on the base board	Each team will need to drill on the base board to anchor their model's columns. However, the allowable number of wood sticks to be anchored onto the base board through drilled holes is 16 maximum. Other than the drilled holes, the MDF base board must be kept intact. The bottom of the base board must be kept clean and flat without trespassing of any materials, including wooden sticks, hot melt glue, cotton string, and rubber bands, etc. Teams violating this particular rule will be asked to remove trespassing materials during inspection in order to be qualified for the contest.
4.4 Floors	The floor layout is as shown in Figure 3. The total height of the model cannot exceed 75 cm. The model must contain at least 3 complete floors. Therefore, excluding the first floor (the ground floor), there must be 3 floors available for weight blocks. All (including the roof) but the first floor will be loaded.  Figure 3. Floor layout.
4.5 Floor area	Except for the first floor, the total floor area is defined as the area enclosed by the wooden edge beams (i.e., to their outer boundary). The edge beams are defined as those that are directly connected to columns at both ends, and they have to have a complete cross section. The perimeter columns should run up from the ground floor without mid-floor intermittence to provide a continuous path for transferring vertical loads. If there is an atrium in the model, it must also be bounded by wooden edge beams. The minimum floor area for each floor of the model, above the ground level, is 100 cm^2.

	Furthermore, above the ground level at least two floors must have an area of at least 310 cm^2. The total floor area of the entire model must be between 760 and 1800 cm^2 (excluding the ground floor). The ground floor is not counted in the total floor area, and no weights will be put on it. In order to save time in measuring and calculating the area of every floor, each team must draw a sketch before building the model so that the floor area plan is clearly presented for the judges.
4.6 Clear distance between floors	The clear distance between the top of any floor and the bottom of the floor above must be at least 15 cm. The clear distance between floors is defined as the minimum clear height, measured from the bottom of the lowest edge beam of the upper floor to the top of the highest edge beam of the floor below, as shown in Figure 4.  Figure 4. Definition of a floor's clear height.
4.7 Exterior clearance	In a real building, every level has openings for doors and windows. In this competition, for each level of the model, at least half of its perimeter must be left clear of any materials. Therefore, for every floor, the total breadth of projection of bracings or inclined columns (x_1 and x_2 in Figure 5) must not exceed half of the floor's perimeter. It should be noted that bracings and inclined columns can project upward or downward.  Figure 5  Figure 6

4.7.1 In Figure 5 (side view), the column spacing is L_i (including the column widths), and the projection length of the bracing is x_i (including the width of the bracing).

4.7.2 In Figure 6 (plan view), the sum of the lengths of all four sides, marked by green arrows, gives the total outer perimeter $\sum L_i$. The sum of the lengths of the bracings, marked by red arrows, is $\sum x_i$. The following condition has to be satisfied:

$$\Sigma x_i / \Sigma L_i < 50\%.$$

4.7.3 For adjacent floors in the model, if the floor above is wider than the one below when viewed from the side, such as in Figures 7a and 7b, the projection length of the bracing to the floor below, x_i, should be used, and L_i should be taken as the column spacing on the bottom floor. Meanwhile, if the floor below has a larger width than the one above, as in Figures 8a and 8b, then x_i should be the upward projection length of the bracing to the floor above, while L_i is the column spacing on the top floor.

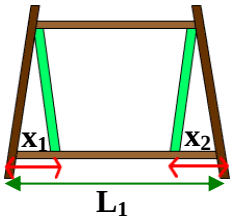


Figure 7a

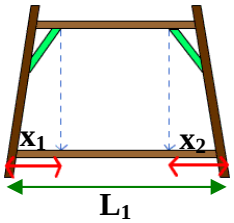


Figure 7b

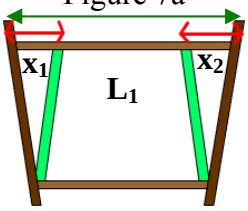


Figure 8a

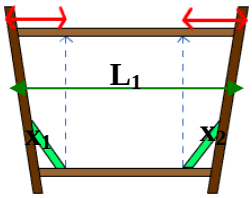


Figure 8b

4.7.4 In this competition, when regarding interior and exterior space, it is a regulation that the space taken by all materials both internal and external to the structure (e.g., wooden sticks, cotton string, paper, *etc*.) must be included in the space calculation.

4.8 Interior clearance	There must not be a confined space on any floor. An opening of at least 5 cm should be left to ensure access.

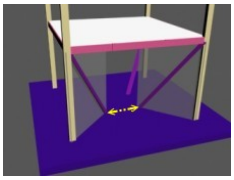


Figure 9.

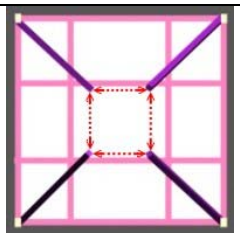


Figure 10.

4.8.1 Materials inside the building, when viewed from vertical projection, need to have an opening for access, as in Figure 9. The dimensions marked by red arrows in Figure 10 have to each be at least 5 cm.

4.8.2 If on the vertical cross-section, some material inside the building is too close to the external wall, it is considered to be bracing for that wall (refer to Figure 11). This is decided based on the distance from the end of the bracing member to the outer boundary of the slab. If this distance is less than 2.5 cm, the member is treated as bracing for that wall.

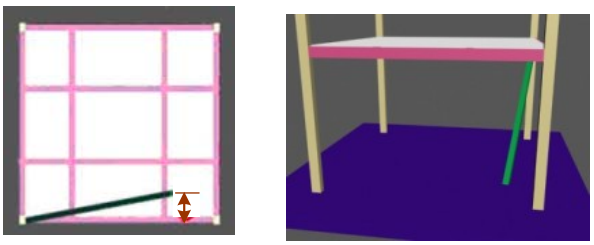


Figure 11. External wall bracing.

5. Rules of the loading

Real building structures are subjected to multiple types of loading. In this competition, steel blocks are used to simulate the floor loading. The rules of the placement of the steel blocks are as follows:

5.1 Each model must carry two steel blocks of weights on each floor except the ground floor. Furthermore, each model shall carry no less than 12 blocks and no more than 29 blocks of weights in total depends on the total floor area of the model.

5.2 At the zones A, B and C of Figure 2, each zone must have two steel blocks at least. However, it is not necessary to place those steel blocks on the same floor at the three zones A, B and C. Furthermore, on the roof floor (RFL), there is placing one steel block at least for each zone A and zone C.

5.3 Each steel block has dimensions of 6.0 × 4.5 × 3.0 cm (±2 mm) with a mass of approximately 635 grams.

5.4 Every square centimeter of the floor must be able to carry a load of 10 grams. The number of blocks that will be placed on each floor is based on the floor area. If the result is a decimal number, it will be rounded up to the next integer.
5.5 Steel blocks may be placed horizontally or vertically on the floor, but they must not be stacked up.
5.6 Steel blocks may be placed on the primary beams or the secondary beams. However, they may not touch columns or bracings. Otherwise, they will be treated as part of the structure and the clearance between floors will be calculated from the highest contact point.
5.7 Steel blocks must be placed inside the floor area, the boundaries of which are defined by the primary edge beams. They must not be outside this boundary.
5.8 After inspection of the model, the number of steel blocks cannot be changed.
5.9 Steel blocks will be placed when the model is fixed to the shaking table. Only hot melt glue can be used to affix steel blocks to the floor. Other materials, such as paper, cotton string, rubber bands, *etc*. are not permitted.

Example:

Floor No.	Floor Area (cm^2) (A)	Calculated Steel Blocks (B)=(A) x 10 / 635	Applied Steel Blocks (C)
4FL	150	2.20	3
3FL	310	4.88	5
2FL	310	4.88	5

6. Rating criterion: Efficiency Ratio (ER)

The main criterion for this competition is the Efficiency Ratio (ER). Models will be ranked according to their ER. The ER of each model is calculated by dividing the product of the maximum earthquake acceleration it survived and the number of steel blocks loaded on the floors of the structure by the mass of the structure above the base board (including any penalty mass). Teams that use less material and resist larger earthquake forces will have a higher ER. A greater number of steel blocks supported also increases the model's ER. The formula to calculate the ER is:

$$ER(Efficiency\ \ Ratio) = \frac{I \bullet \sum W_i}{M_M - M_B + M_p}, \qquad \text{(Equation 1)}$$

where:

I: Maximum intensity that the model survives (gal).

$\sum W_i$ **:** Number of steel blocks on the floors. As shown in Figure 3, for blocks on the 2nd and 3rd floors, each block counts as 1 weight unit; for blocks on the 4th floor and higher, each block counts as 1.5 weight units (where 1st floor is the ground floor).

M_M: Total mass of the model (excluding steel blocks).

M_B: Mass of the base board (weighed first).

M_P: Penalty weight in case of violation of the rules as outlined in Table 1. Please refer to the model check table for more details on penalty weight.

Table 1. Calculation of the penalty weight.

Violations	Penalty weight
1. Field clean up and tools collation	500 g
2. Building arrangement and board boundary clear width (≥ 2 cm)	500 g
3. Model height H ≦ 75 cm	50 g / cm
4. Total floor area (760 cm^2 ≤ A ≤ 1800 cm^2)	5 g / cm^2
5. No. of wood sticks fixed on the base board (≤ 16 sticks)	50 g /stick
6. Clear floor height(≥ 15 cm)	50 g / cm
7. Exterior clearance (Σx_i /ΣL_i < 50%)	10 g / %
8. Interior clearance (≥ 5 cm)	100 g / cm
9. The minimum floor area for each floor of the model, above the ground level, is 100 cm^2. Furthermore, above the ground level at least two floors must have an area of at least 310 cm^2.	5 g / cm^2
10. On the roof floor (RFL), there is placing one steel block at least for each zone A and zone C.	5 g / %

For example, suppose the total mass of a team's model (excluding steel blocks), M_M, is 1200 g, while the base board mass, M_B, weighs 170 g. In addition, they were penalized with a weight, M_P, of 200 g. The team placed 3, 4 and 5 steel blocks on the 2nd, 3rd and 4th floors, respectively. The loaded model survived a 600 gal (I) shaking test. However, it collapsed during the following 700 gal shaking test. Therefore, the efficiency ratio of the team's model is calculated as follows:

$$\frac{\mathbf{I}\times\mathbf{W}}{\mathbf{M_M}-\mathbf{M_B}+\mathbf{M_P}}=\frac{600\times(3\times1+4\times1+5\times1.5)}{1200-170+200}=7.073$$

7. Mounting the model

Prior to the model earthquake resistance testing, each team will be allowed some time to mount their model on the shaking table and to fix steel blocks on the floors:

7.1 Only two team members will be allowed for this task. It is to be completed within 15 minutes. It is the members' responsibility to make sure that their models are glued and screwed firmly in place.
7.2 The model is to be screwed onto the shaking table using a screwdriver and the sufficient number of screws provided to each team.
7.3 Steel blocks are to be glued onto the floors using a hot melt glue gun and the sufficient hot melt glue provided to the team.
7.4 No materials and tools other than those provided may be used.
7.5 This time should be spent only on affixing the model and the steel blocks. It is not allowed to strengthen the structure during this time.
7.6 Team members must be very careful not to touch other models and players nearby while performing this task.
7.7 In order to ensure the safety of the models, after all teams have completed this task, staff will double check and reinforce them where necessary.
7.8 The judges will examine all mounted and loaded models. Should any of the following occur, team(s) involved may be disqualified in severe cases:
    1. Number of steel blocks on each floor is inconsistent with that reported in the check table.
    2. Steel blocks are glued to columns/bracings with hot melt glue.
    3. Steel blocks are placed outside the bounded floor area.

8. Testing procedure

All models will be mounted onto the shaking table at NCREE, which simulates artificial earthquakes. The artificial earthquakes contain a broadband of sweeping excitation frequencies. The intensity of artificial earthquakes is gradually increased from one test run to another. One sample of the input bidirectional displacement time histories and their directions is shown in Figure 12.

It should be noted that all the input bi-directional displacement-time history records are measured from the instrument system of the shaking table at NCREE.

8.1 There will be at most six rounds of shaking table tests, starting at small earthquakes and increasing gradually. The peak ground accelerations will be 250 gal, 400 gal, 500 gal, 600 gal, 700 gal, and 800 gal in sequential order.

8.2 Teams making models that can resist an earthquake of at least 400 gal (equivalent to an intensity 7 earthquake in Taiwan scale) will be presented the Quake-Resistant Certificate.

8.3 Models that pass the test of 600 gal earthquake are qualified for ER ranking.

8.4 The bidirectional time histories of the artificial earthquake are available for download at the IDEER competition website.

8.5 The adopted mounting orientations in this competition are those specified by the laboratory, and can be found in Figure 13.

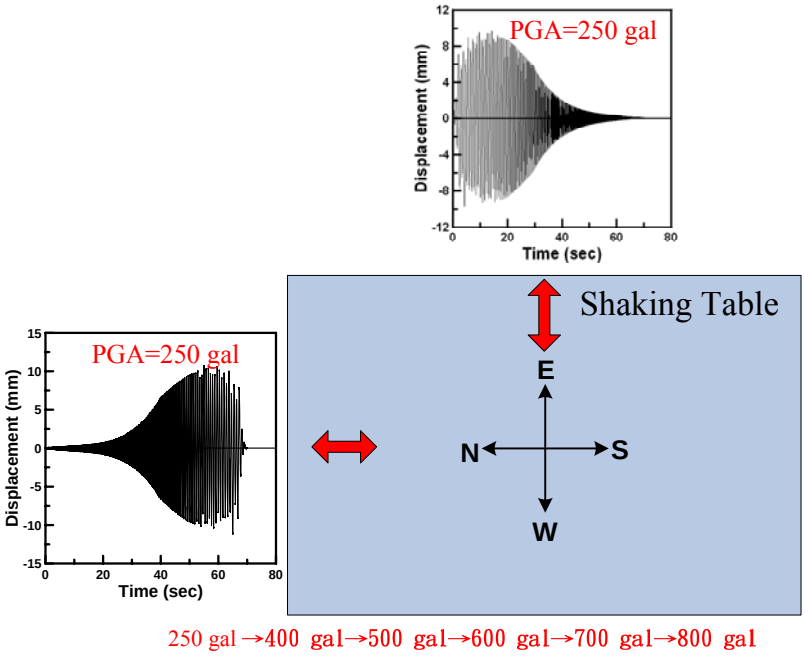


Figure 12. Input displacement-time profiles and directions.

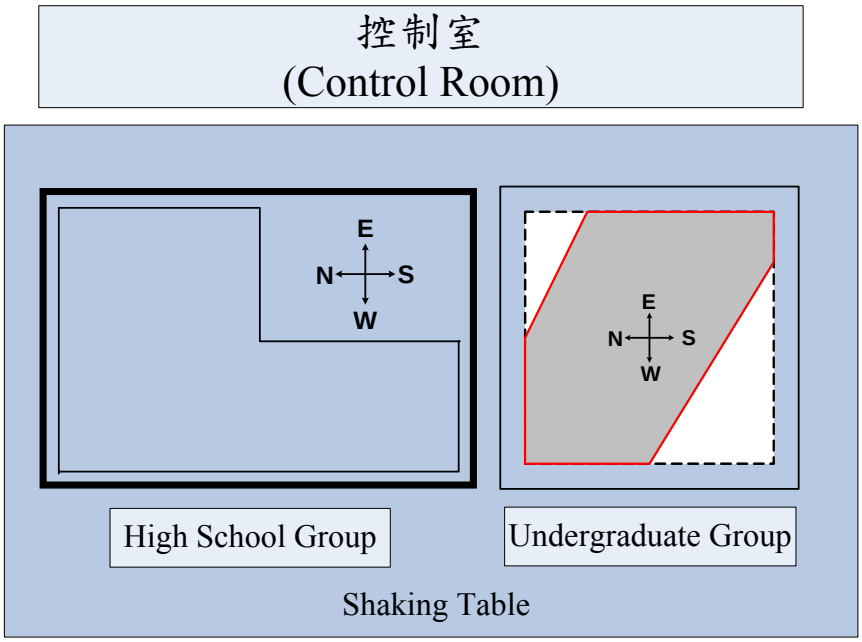


Figure 13. The adopted mounting orientations mentioned in regulation 8.5.

9. Failure criteria

During the shaking-table tests, a model will be judged to have failed for any of the following conditions:

1. Any one of the floors becomes unstable or collapses.
2. Any steel block falls out of the building or moves excessively.
3. Half or more of the columns are detached from the base board.
4. The maximum displacement of tilt projection of the model exceeds 10 cm (inclusive).
5. Any other failure that the judges decide would reasonably cause deaths within a building.

10. Model poster

10.1 Description poster: each team is required to make a poster to describe the model. The size is that of an A4 sheet (29.7 cm long and 21 cm wide). The poster presents the creative design concepts. The name of the university/school should be placed at the top of the poster.

10.2 Description board: each team is required to complete a description board and paste the poster onto the board within the model construction time. The board is made of the thin wooden board and wooden sticks that are provided (refer to Figure 14).

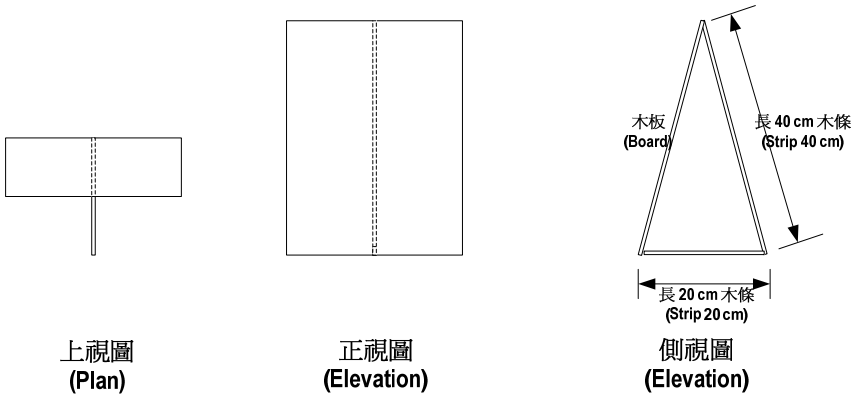


Figure 14. Description poster and board.

11. The making and installation of the team pennant

Each team must design a team pennant for their model. The pennant has to be fixed onto the model within the time limit. It can be drawn in advance or during the competition. While any shape is allowed, its size should be smaller than an A6 sheet (14.4 cm long and 10.5 cm wide, a quarter of an A4 sheet). It is to be installed on the model using the bamboo sticks provided (as optional material) within the construction time of the model.

12. Special considerations

12.1 The rules for this year's competition differ greatly from those of previous years. Therefore, competing teams should read these rules carefully, and ask the judges for further clarification if there are any questions. The main changes include:

1. The length of the wooden stick has changed to 70 cm.
2. The rule that limited the number of drill holes on the base board has changed to one that limits the allowable number of wooden sticks fixed onto the base through drill holes.
3. The definition of the edge beam has changed to beams that are directly connected to columns at both ends. The edge beams are used to calculate the total floor area.

4. The number of steel blocks loaded on each floor is calculated from the actual floor area.
5. On the roof floor (RFL), there is placing one steel block at least for each zone A and zone C.
6. Penalty weights for violations are increased. All teams should examine their model carefully during the design process.

12.2 In order to save time when calculating the area of every floor, each team is required to draw a sketch before building their model so that the floor area plan is clearly presented for the judges.

12.3 In order to reduce the time spent in examining the model, each team must complete their model check table for the judge's reference before the examination takes place.

12.4 Teams must clean the field and put tools in order after finishing their model. Otherwise, a penalty weight of 500 g will be imposed.

Check Table of 2011 IDEERS High School Teams

Team No.		**School Name**	

No. of wood sticks fixed on the base board (≤ 16 sticks)	≤ **16** sticks	Penalty(**50g**/stick)	**Building range and board boundary clear width**	≥ **2** cm	Penalty (**500g**, if <2 cm)
	sticks	g		**cm**	g
Field cleanup &tools collation		Penalty (**500g**)	☐ O.K. ☐ N.G.		g

Height	Model: ≤**75** cm Each floor: ≥**15** cm	Penalty (**50g**/cm)	**Exterior clearance (≥ 50%)**		Penalty (**10g**/(1%))	**Interior clearance (> 5cm)**		Penalty (**100g**/cm)
4F clear height:	cm	g	4F :	%	g	4F :	cm	g
3F clear height:	cm	g	3F :	%	g	3F :	cm	g
2F clear height:	cm	g	2F :	%	g	2F :	cm	g
1F clear height:	cm	g	1F :	%	g	1F :	cm	g
Model:	cm	g						

Floor area (each floor)			Penalty (5g/cm^2)	**Floor area** (total / largest floor)		Penalty (5g/ cm^2)
5F:	cm^2	≥ 100cm^2	g	Total:	≤1800 and ≥760 cm^2	g
4F:	cm^2	≥ 100cm^2	g			
3F:	cm^2	≥ 100cm^2	g	Largest	≥310 cm^2	g
2F:	cm^2	≥ 100cm^2	g	2nd Largest	≥310 cm^2	g

Two whole blocks in each area			Penalty (5g/(1%))	**Number of steel blocks of each floor**		Weighing	W_i
				5FL:		1.5	
Area A	%	≥100%		4FL:		1.5	
Area B	%	≥100%		3FL:		1	
Area C	%	≥100%		2FL:		1	
Both Area A and Area C have one steel block at roof floor level at least.		≥100%		Total:		$\sum W_i$	

Model mass M_M	g	**Board** M_B	g	**Penalty** M_P	g	M_M-M_B+M_P=	g	**Reviewer**	

Unit of area: cm^2. Unit of length/height: cm. Unit of mass: g