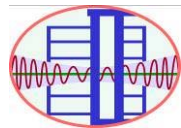
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## The List of Rule Revisions

Version No.	Date	Remarks
V1	2022-05-05	First version

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The content presented below serves as the primary rules of this competition. However, if there are cases not stipulated or clearly defined in the rules, the organizer reserves the right of final interpretation of the cases.

## **1. The Overview of the Competition**

Each team is required to design and construct a building model at the competition venue. The model should be able to resist the earthquakes that generated by the shaking table at National Center for Research on Earthquake Engineering (NCREE). This is a two-day competition. On the first day, each team has 5.5 hours (lunch break included) for constructing the building model. All the materials and tools are provided by the organizer. On the second day, all models will be tested on the shaking table at NCREE. The artificial earthquakes with various intensities will be generated by the shaking table. The peak ground acceleration (PGA) will gradually increase to 800 gal (gal =  $\text{cm/s}^2$ ).

The theme of this year is “making a tower structure with a single load platform.” Single load structures are very common in daily life, such as water tanks, bridge piers, huge T-shaped billboards along highways, telecommunications towers (with telecommunication equipment), high towers with observatory, and incinerator with revolving restaurant, etc. Taking water tank as an example, the more water storage is better for higher water height (also higher water pressure) and its function. To examine the model of this contest, the maximum base shear and the base bending moment are used to represent the *capability* of the model. The cost price for model materials is used to represent the *price*. Our main concern will focus on capability-price ratio (CP value = capability/price). The higher CP value represents higher team score for the contest.

## **2. The Composition of Team Members**

Each team should consist of four students registered in the same high school and one instructor who is a teacher at the same school. Please be notified that instructors are forbidden to do the constructing models with their own hands during the two-day competition.

## **3. Materials and Tools**

Please note that only the materials and tools provided by the organizer can be used in this competition; the service counter will provide some L-shape rulers for proper use in computing and marking. In addition, Participating teams are welcome to use their own stationery such as pencils, rulers, erasers, and calculators for measuring, calculating, positioning and marking functions.

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### 3.1 Materials

The materials provided by the organizer include:

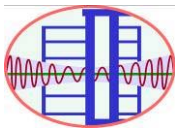
Item	Quantity	Details
1. Wooden base board	1	It is made of medium density fiberboard (MDF). The size of the board is about 0.55 cm thick, 26 cm (L) × 26 cm (W) ( $\pm 0.3$ cm).
2. Wooden stick	30	They are made of MDF and are used for constructing the model. Each stick is $70 \pm 0.5$ cm long with a 5.5 mm × 4 mm ( $\pm 1$ mm) rectangular cross section.
3. Hot-melt glue stick	20	Each stick is about 30 cm long and 6 mm in diameter. These glue sticks cannot be used as the members of the building model.
4. Rubber band	16	Each rubber band is 3 mm wide, 1.5 mm thick, and the perimeter is about 240 mm.
5. A4-size paper	12	12 sheets of A4-size paper
6. String	1	A tinted cotton string with 4 m long
7. Bamboo stick	1	This item is used for making the team flag.

### 3.2 Tools

The tools provided by the organizer include:

Item	Quantity	Details
1. Fixing plate	1	This plate is used for fixing the models onto the shaking table as well as for checking the building area.
2. Scissors	1	A general office scissors
3. Wire saw	1	0.9 cm wide and 30 cm long
4. Tape measure	1	The total length is 5.5 m.
5. Manual drill	1	Its bit is 8 mm.
6. Hot-melt glue gun	1	It is a general hot-melt glue gun
7. Large utility knife	2	The width of the blade is about 1.8 cm.
8. Pencil	1	It is a general office pencil.
9. Pencil sharpener	1	It is for sharpening the pencils.
10. Protractor	1	It is a general office plastic semicircular protractor.
11. Marker pen	1	It is a general office marker pen.
12. Ruler	1	A 30 cm long plastic straight ruler
13. Cotton gloves	2	The participants can wear the cotton gloves to avoid burns when using the hot-melt glue gun.
14. Hammer	1	A small hammer
15. File	1	A small file
16. Glue stick	1	A glue stick
17. Cutting mat	1	A3 size

Every team should examine provided materials before making the building model. Please refer to the table 3.1 and 3.2 for checking provided materials. If you find any lack or broken material,

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please inform the responsible judge immediately. Except for tools provided by the organizer, participating teams are allowed to take their own hand tools (such as curve knives, gardening shears, cutting pads, various sizes of drill bits, etc.) Please be notified that **electric tool is forbidden to take and use.**

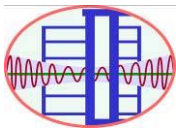


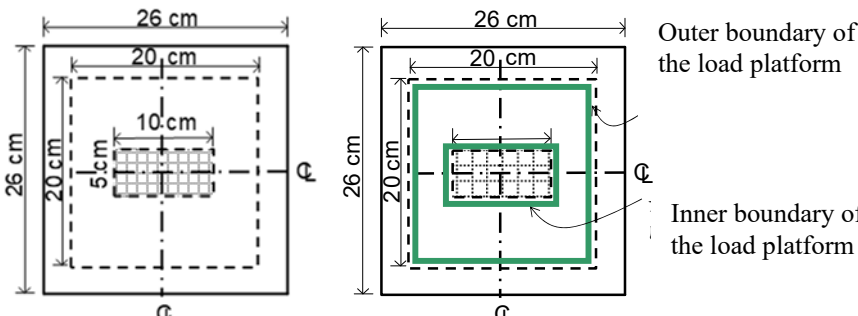
Schematic picture of the tools

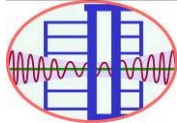
#### **4. The Regulation of the Model Features**

All teams are encouraged to exert their creativity on constructing the model. Nevertheless, the building model has to meet the requirements below:

Item	Description
4.1 Basic Requirement	4.1.1 Each team has 5.5 hours in total for constructing their building model.
	4.1.2 The structural components should be composed of the materials provided by the organizer. For example, the structural components can combine with a single wooden stick, multiple wooden sticks, strings, rubber bands and papers.
	4.1.3 Models must be constructed on the base board (26 cm × 26 cm × 0.55 cm) provided by the organizer. A <b>3 cm clearance</b> around the edges of the base board must be kept in order to fix the model onto the shaking table.
	4.1.4 There is only a load platform for every team. The number of mass blocks is from 12 to 24, and two layers of mass blocks are the limit.
	4.1.5 The vertical projection of the entire model and mass blocks must be located in the center of the 20 cm x 20 cm base board (The allowable site area is

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	<p>shown in Figure 1). Also, the vertical projection of material (hot-melt glue included) and mass block must not project within the center range (10 cm x 5 cm) of base board.</p> <p>4.1.6 The load platform is constructed by wooden sticks (or cotton strings, rubber bands, and paper, etc.). If there are any structural components erected on the load platform, the height of the structural components are not included into the height of the load platform (shown as Fig. 2 and rule 4.3.6).</p> <p>4.1.7 The load platform of the model should be made of wooden sticks. The border also should be marked by wooden sticks that include inner and outer boundary (shown in Figure 1). The range of inner and outer boundary should follow the rule 4.1.5.</p> <p>4.1.8 <b>Seismic isolation design is forbidden.</b></p> <p>4.1.9 Adding claddings/decorations to the models for the purpose of aesthetic appearance is allowed.</p> <div style="text-align: center;">  </div> <p style="text-align: center;">Figure1 The allowable site area of the model.</p>
4.2 Site Area of the Model	<p>4.2.1 It is allowed to drill holes on the base board for fixing columns. There is no restriction on the number of columns fixed on the base board.</p> <p>4.2.2 It is acceptable to carry out enhancing column elements (e.g., enlarged holes, cotton strings running in a ditch, etc.) to fix columns on the base board. However, all holes (enlarged holes, ditches, etc.) should be backfilled with hot-melt glue to avoid intended reduction of the base board</p> <p>4.2.3 The base board should be kept flat and integral in case the board cannot be mounted onto the shake table with troubles.</p> <p>4.2.4 No materials (such as wooden stick, cotton string, rubber band, etc.) can appear on the surface of the back side of the base board.</p>

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<p>4.3</p> <p>Model Height</p>	<p>4.3.1 <math>H_{min} \leq</math> the height of the model that not includes mass blocks, denoted as <math>H_{model} \leq H_{max}</math></p> <p>4.3.2 <math>H_{min} \leq</math> the height of the load platform, denoted as <math>H_{platform} \leq H_{max}</math></p> <p>4.3.3 <math>H_{min} = 50</math> cm, <math>H_{max} = 65</math> cm</p> <p>4.3.4 The model height (including the mass blocks and team flag) should be less than 75 cm.</p> <p>4.3.5 Schematic diagram of the model facade is shown in Figure 2</p> <p>4.3.6 All abovementioned model heights are measured from the top of base board, i.e., the thickness of the base board is not included in the model heights. The height of the load platform is the vertical distance between the top of the base board and the lowest point of the surface that the load platform contacts with the mass blocks (Fig. 2).</p> <div> </div> <p style="text-align: center;">(a) <math>H_{model} = H_{platform}</math>      (b) <math>H_{model} &gt; H_{platform}</math></p> <p style="text-align: center;">Figure 2 Sketch of the elevation of a model</p>
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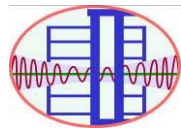
## 5. The Placement of Mass Blocks

In this competition, mass blocks represent the vertical loading of the model. The weight of each mass block is about 635 gram force. The dimension of each mass block is 6.0 cm × 4.5 cm × 3.0 cm (±2 mm). The rules of placing the mass blocks are:

5.1 Changes are not allowed (the number of mass blocks and the planning) after the confirmation of model inspection from the judge.

5.2 Mass blocks should be installed on the load platform.

5.3 Mass blocks are placed on the floor when mounting the model to the shaking table. Only

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hot-melt glue can be used to fix mass blocks to the floors. Other materials (such as paper, cotton string, rubber bands etc.) are not permitted to fix mass blocks.

5.4 Drawing a schematic diagram of mass block layout (as appendix 1) within 20 cm x 20 cm (load platform should be included). It's allowable to draw on other empty A4 size papers for related layout. The schematic diagram of mass block layout should contain plot plan, elevation drawing, and side elevation drawing or 3D perspective drawing. Every team should deliver the schematic diagram of mass block layout (this could be done before the construction day) on the construction day (before 12:00 p.m.).

## 6. The Grading Rules: Capability-Price Ratio

The criterion used for grading the performance of the models is the capability-price ratio (CP). The higher CP value represents higher rank in the contest.

The CP is computed as:

$$CP = \frac{\phi \times Capability}{Price} \quad (1a)$$

where

$$Capability = c_0 \bar{V}_{base} + c_1 \bar{M}_{base} \approx \frac{a_{max} W_{mass} / g}{V_{min}} \left( c_0 + \frac{c_1 H_{platform}}{H_{min}} \right) \quad (1b)$$

$$Price = \frac{W_{model}}{W_0} \quad (1c)$$

Capability : The capability of the model

Price : The cost of model

$\phi$  : Reduction (punished) factor =  $1 - 0.02 n_v$  °

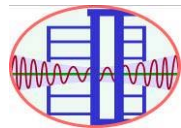
$n_v$  : Participant teams must strictly abide the category-I items listed in the model inspection form (Appendix 2). Any violation of the category-I items disqualifies the team from the competition (i.e.,  $n_v = 50$ ).  $n_v$  is also equal to 50 when other serious violations unanimously identified by judges. In addition,  $n_v$  is equal to the total number of violated category-II items listed in the model inspection form (Appendix 2), which may result from the construction error. Participant teams must submit the model inspection form filled with only the team number and the name of department & school before 12 p.m. on the construction day if the model is constructed on-site.

$\bar{V}_{base}$  : Normalized base shear

$\bar{M}_{base}$  : Normalized base bending moment

$c_0, c_1$  : weight coefficient ,  $c_0 = 1$  ,  $c_1 = 50/65$  °



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$a_{max}$  : Maximum test acceleration of the model (gal)

$g$  : Gravitational acceleration (= 980 gal)

$W_{mass}$  : Total weight of mass blocks (N)

$V_{min}$  : Minimum base shear = 20 cm × 20 cm × 10 g/cm<sup>2</sup> × 400 gal = 16 N ◦

$H_{platform}$  : The vertical distance from top of the base board to the top of load platform (cm)

$H_{min}$  : Minimum height of the model (= 50 cm)

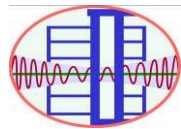
$W_{model}$  : The model weight that excluded the weight of base board and mass blocks; also refers to the total weight for used materials (gw)

$W_0$  : The target value for total weight of the model ( $W_{model}$ ) (= 320 gw)

## **7. Mounting Models onto the Shaking Table**

- 7.1 Only two members of each team are allowed to mount their model onto the shaking table and fix the mass blocks. This task should be completed within 12 minutes. The team members are responsible for the completion of this task.
- 7.2 The organizer will provide each team with two screwdrivers and screws for mounting the model onto the shaking table.
- 7.3 The organizer will provide each team with a hot-melt glue gun and hot-melt glue sticks for fixing the mass blocks on the floors of the model.
- 7.4 The materials and tools not provided by the organizer cannot be used to mount the models onto the shaking table and fix the mass blocks.
- 7.5 During the period of mounting the models onto the shaking table and fixing the mass blocks, it is not allowed to strengthen the structure of the model.
- 7.6 The team members mounting the models onto the shaking table should be careful not to touch other teams' models, which have already been mounted on the table.
- 7.7 The side of the base board marked with a sticker is where the model should be built on. In addition, when mounting the model onto the shaking table, the sticker should be on the northwest corner (shown as Figure 12). If there is any question about the relative positions or directions shown in Figure 13, please ask the staffs/judges for assistance.
- 7.8 The base board is fixed to the shaking table by using a metal plate (Figure 4). Please note the orientation of the metal plate because the layouts of the holes on the four sides of the metal plate are not the same.



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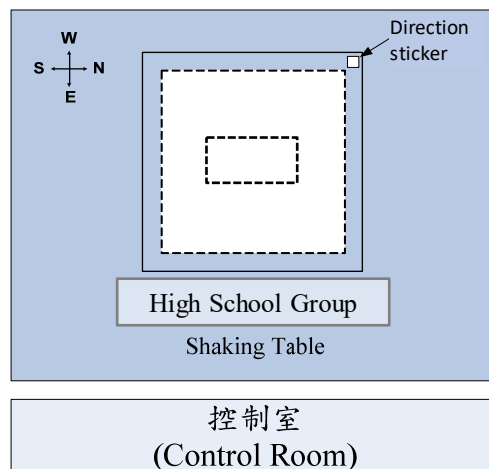


Figure 3. The orientation of the model fixed on the shaking table.

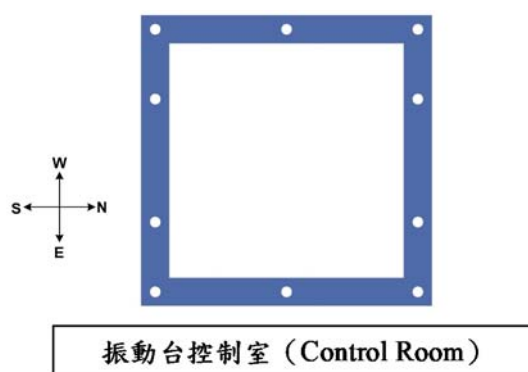
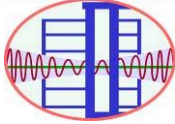


Figure 4. The metal plate for fixing the base board

## **8. Loading Protocols**

All models will be tested simultaneously on the shaking table. The artificial earthquakes generated by the shaking table contain a broadband of sweeping excitation frequencies. The intensity of each artificial earthquake is represented by using the peak ground acceleration (PGA). The PGA increases from one test to another. Figure 5 shows the two components of the displacement time histories of the artificial earthquake with the PGA equal to 250 gal.

- 8.1 There will be at most six tests, in which the PGAs are arranged in the sequence of 250 gal, 400 gal, 500 gal, 600 gal, 700 gal, and 800 gal.
- 8.2 The teams whose models pass the test with the PGA equal to 400 gal will receive the Quake-Resistant Certificate.
- 8.3 Only the models passing the test with the PGA equal to 600 gal are qualified for ranking in this contest.
- 8.4 The bidirectional time histories of the artificial earthquakes are available on the IDEER's website. All teams are encouraged to download these data.

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8.5 The E-W and N-S components of displacement time histories of the artificial earthquake with the PGA equal to 250 gal are shown in Figure 5.

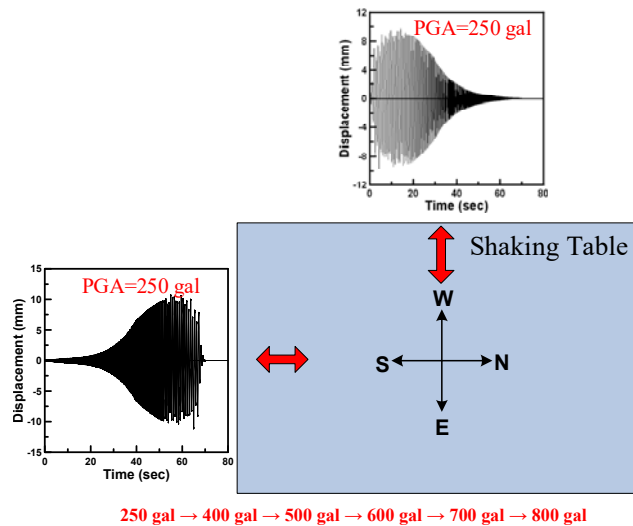


Figure 5. The E-W and N-S components of displacement time histories of the artificial earthquake with the PGA equal to 250 gal.

## **9. The Failure Criteria**

A model will be judged as a failure when the following situations occur. The failed model will be removed from the shaking table before the next test.

9.1 The model is collapsed.

9.2 The load platform is unstable or collapsed.

9.3 Any mass block falls off, significantly dislocates, sways, or rocks.

9.4 The number of columns detached from the base board is larger than or equal to one half of the total number of columns.

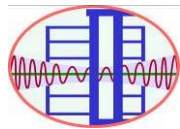
9.5 The residual lateral displacement of the inclined model should be greater than 10 cm after every test.

9.6 The base board is apparently loosened during the test.

9.7 The jury has the consensus that a model fails in the test.

## **10. The Exhibition Object**

Each team must prepare an exhibition object displaying the design concept and creativity of the model. This exhibition object is done before this two-day competition. The object could be either two-dimensional or three-dimensional. The way of exhibition could be in a static and/or

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dynamic style. The space for this exhibition is limited to 35 cm (height) × 25 cm (width) × 25 cm (depth) shown as Figure 6. The Design-Concept Exhibition Award is granted based on the clarity and creativity of displaying the design concept of the model. The affiliation of the team should be presented in the exhibition object. If the exhibition object uses electronic products, the team is responsible for the safe keeping of the electronic products. In addition, the team is responsible for the power supply to the electronic products.

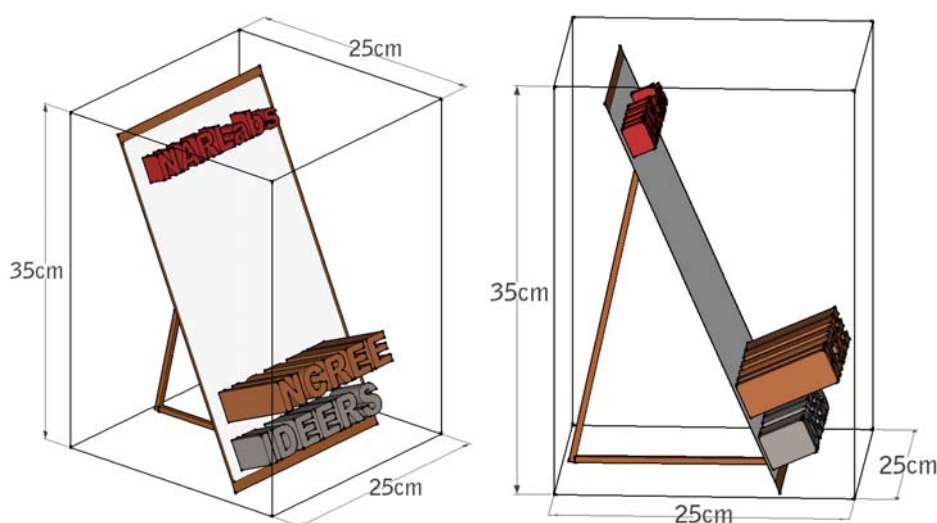


Figure 6. The allowable exhibition space

## **11. The Team Flag**

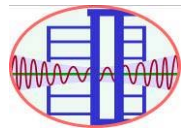
Each team must design a team flag, which is installed on the model during the first day of this contest. This flag may be drawn before or during this contest. All possible shapes of this flag are allowed. Nevertheless, the size of this flag should be no larger than that of a sheet of A6-size paper (14.4 cm L × 10.5 cm W, i.e., a quarter of an A4-size paper). This flag can be installed on the model by using any provided materials, such as the bamboo sticks.

## **12. Model Inspection**

The period of the model inspection begins at the end of the model construction and ends at the start of the shaking table tests. During the two-day contest, jury has the right to re-inspect any models. The team, whose model needs to be re-inspected by the jury, cannot reject this request.

12.1 The procedures of the model inspection are as follows:

- (1) The host calls the team number. (2) The team members weigh the model. (3) The judges inspect the model and then fill in the inspection form. (4) The staffs take a picture of the model and the exhibition object. (5) The team members place the model and the exhibition object on the designated table for displaying. On the second day, all competitors and judges

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vote models and exhibition objects for some special prizes. (6) Each team sent two representative members to mount the model onto the shaking table for the tests.

12.2 The items submitted to the judges for inspection are as follows:

(1) the model, (2) the model inspection form and the layout of mass blocks, (3) the exhibition object to the specific judge desk. All of the abovementioned items are taken to the judges by two members of each team

12.3 During the model inspection period, judges have the right to request the model to be modified or to make penalties to the model if the model violates the contest rules.

### **13. Aesthetic Awards, Structural Design Awards, and Design-Concept Exhibition Awards**

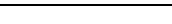
13.1 Aesthetic Awards are granted on the basis of the architectural features, the efficiency of using the site area, and the plan of inner space. The jury chooses at most three models for these awards. The team winning this award will be granted NT\$5000 and a certificate for each team member. The evaluated items and the corresponding percentage of score for these awards are listed below:

Item	Percentage	Description
Model features	100%	<ul style="list-style-type: none"> <li>● aesthetic of the model</li> <li>● feature and creativity</li> </ul>

13.2 Structural Design Awards are granted on the basis of the structural design of models, the concept and creativity of seismic resistance. The jury chooses at most three models for these awards. The team winning this award will be granted NT\$5000 and a certificate for each team member. The evaluated items and the corresponding weights for these awards are:

Item	Percentage	Description
Structural design	65%	<ul style="list-style-type: none"> <li>● The arrangement of structural elements</li> <li>● The rationality of loading path</li> </ul>
The concept and creativity of seismic resistance	35%	<ul style="list-style-type: none"> <li>● The rationality of the concept of seismic resistance</li> <li>● The creativity of the concept of seismic resistance</li> </ul>

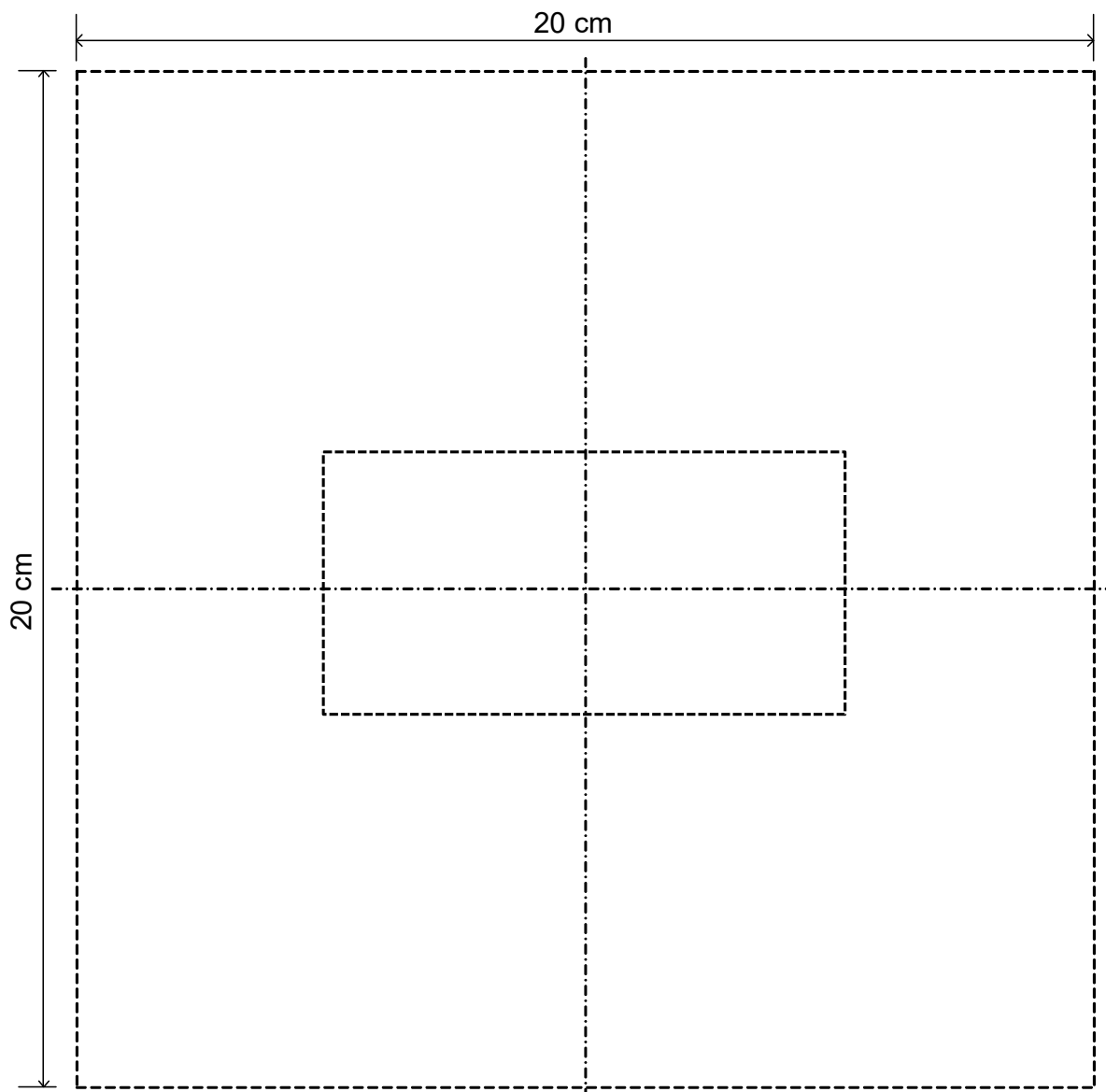
13.3 Design-Concept Exhibition Awards are granted on the basis of the clarity and creativity of displaying the design concept of the model. The jury chooses top three exhibition objects for these awards. The team winning this award will be granted NT\$3000 and a

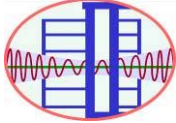
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certificate for each team member. The evaluated items and the corresponding weights for these awards are listed below:

Item	Percentage	Description
Introduction of the design concept	70%	<ul style="list-style-type: none"> <li>The clarity of introducing the design concept</li> </ul>
The creative of showing the exhibition object	30%	<ul style="list-style-type: none"> <li>The vividness of the way showing the design concept</li> <li>The creativity of the way showing the design concept</li> </ul>

**Appendix 1-** Schematic diagram of mass block layout (The content is not actual proportion).

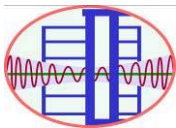


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## Appendix 2- The model inspection form

Team Number		Name of Department & School	
Weight of model and base board (not included mass blocks) ( $W_{gross}$ )		gw	Signature of examiner
Weight of model base board ( $W_b$ )		gw	
$W_{model} = W_{gross} - W_b$		gw	
Number of mass block		block	
Height of load platform( $H_{platform}$ )		cm	

Check list	OK	NG
I-1. Only one load platform for loading mass blocks		
I-2. $12 \leq \text{number of mass blocks} \leq 24$		
I-3. No more than 2 layers of mass blocks		
I-4. The load platform should use wooden sticks to mark the boundary of model (inner and outer boundary are included)		
I-5. No seismic isolation design		
I-6. Every hole on the base board should be filled with hot-glue; the base board should keep flat		
I-7. No material on the back side of the base board		
I-8. Handing out the model inspection form and the drawing of mass block layout before 12 p.m. on the construction day		
I-9. Cleaning working area and organizing tools in order		
I-10. Any other apparent violation that is not construction tolerance error, such as model is obviously over the boundary obviously, the height is apparently against the regulation, etc.		

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II-1. Keep 3 cm clear around the mode site and the base board		
II-2. The vertical projection of the entire model and mass blocks must be in the range of 20 cm x 20 cm base board		
II-3. The vertical projection of material and mass block must not project within the center range (10 cm x 5 cm) of the base board.		
II-4. $50 \text{ cm} \leq$ the height that not include mass blocks $\leq 65 \text{ cm}$		
II-5. $50 \text{ cm} \leq$ the height of the load platform $\leq 65 \text{ cm}$		
II-6. The model height (including the mass blocks and team flag) should be less than 75 cm.		
II-7. Mass blocks must be placed on the load platform.		
II-8. Not finishing installation of all mass blocks, but still meet the requirement of I-2 & I-3 on the check list		
$n_v =$		

\*Part 1 (I-2~I-10) must be strictly followed. The team would be disqualified from the competition (i.e.,  $n_v = 50$ ) if any category-I items are violated.

\*Part 2 (II-1-II-9) is for the possible construction errors. The  $n_v$  value is the total number of violated category-II items.