Revision List

Version No.	Date	Remarks
V1	2019-05-16	None

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. Overview

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 = cm/s^2).

The theme of this year is "making a tower structure with a single load platform." Structures with single concentrated load are very common in daily life, such as water tanks, bridge piers, huge T-shaped billboards along highways, telecommunication towers topped with equipments, high towers with observatories, and chimneys with revolving restaurants, etc. Taking water tanks as an example, an elevated large water tank, which stores a huge amount of water with high hydraulic pressure, is generally preferred. Therefore, the maximum base shear and bending moment that the model resists during the shaking table tests are regarded as the capability of the model. In addition, the total weight of the materials used to construct the model is considered as the price of the model. The score of the model is the capability-price ratio, denoted as *CP*, i.e., $CP = capability/price$. A greater value of *CP* represents a higher score of the model.

2. Team Composition

Each team should consist of four students registered in the same university/college and one instructor who is a teacher at the same school. The instructors are not allowed to construct models using their own hands.

3. Materials and Tools

In addition to the hand tools prepared by participant teams, only the materials and tools provided by the organizer can be used in this competition. Participant teams are allowed to use their own stationery, e.g., pencils, rulers, erasers, and calculators. The service counter will provide some L-shape rulers for computing and marking.

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) (±0.3 cm).
2. Wooden stick	30	They are made of MDF and are used for constructing the model. Each stick is 70 ± 0.5 cm long with a 5.5 mm × 4 mm (±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 cotton string with 4 m long
7. Bamboo stick	1	This material 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 participators 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

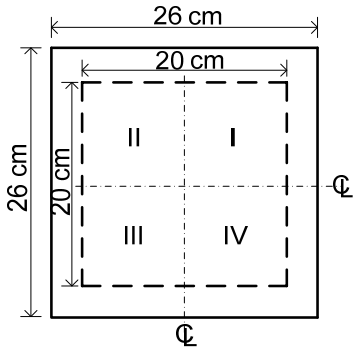
Every team should check the provided materials and tools according to Tables 3.1 and 3.2, respectively, before constructing the building model. If there are broken tools or shortages of materials, please inform the responsible judge immediately. Besides the tools provided by the organizer, participant teams are allowed to take their own hand tools, e.g., gardening shears, chisels, cutting pads, bits with various sizes, etc. Nevertheless, electric tools are forbidden to take and use.

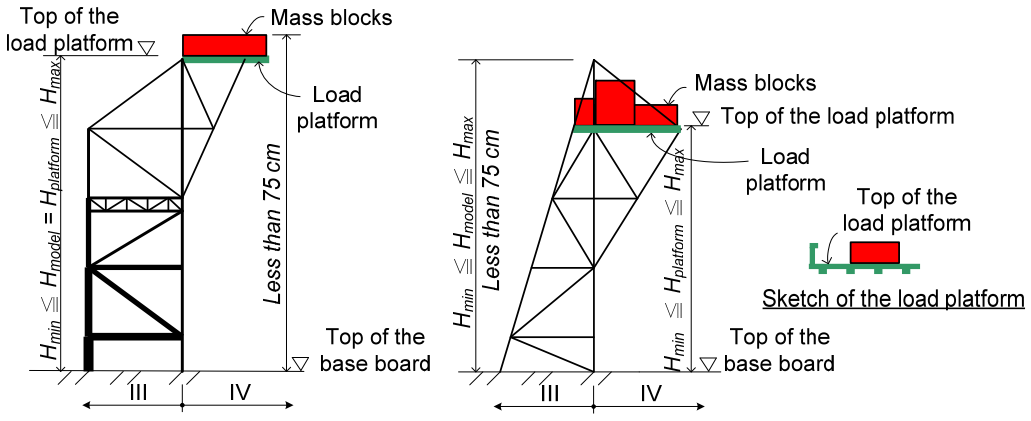
Tools provided by the organizer

4. Requirements for Structures

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

Item	Description
4.1 Basic Require-ments	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 3 cm clearance 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 each model. The number of mass blocks is from 12 to 24, and two layers of mass blocks are the maximum limit. 4.1.5 The vertical projection of the entire model and mass blocks must be located in the 20 cm × 20 cm central area of the base board (i.e., the area enclosed by the dashed lines shown in Fig. 1). Any material (hot-melt glue included) must not contact the fourth-quadrant (IV) base board. In addition, the number of the mass blocks completely, not including partially, located on the fourth-quadrant load platform must be not less

	than 1/2 total number of mass blocks. 4.1.6 The load platform is a horizontal surface, which is constructed by wooden sticks (or cotton strings, rubber bands, and paper, etc.). Load platforms with curved/inclined/stepped surfaces are not allowed. If there are any structural components erected on the horizontal surface (i.e., 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). 4.1.7 The abovementioned fourth-quadrant load platform is the region whose vertical projection is within the 10 cm-by-10 cm fourth-quadrant (IV) base board. 4.1.8 The boundary of load platform must be constructed with wooden sticks (edge beams). Additionally, the boundary of the fourth-quadrant load platform must be marked with wooden sticks. 4.1.9 Seismic isolation design is not allowed. 4.1.10 Adding claddings/decorations to the models for the purpose of aesthetic appearance is allowed.  Figure 1. The allowable site area of the model.
4.2 Base Board	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. 4.2.2 It is allowed to carry out the measures that enhance the fixity of columns to the base board. Nevertheless, all holes on the base board should be backfilled with hot-melt glue to avoid reducing the weight of the base board. 4.2.3 The base board must be kept flat and integral in case the board cannot be mounted onto the shake table. 4.2.4 No materials (e.g., wooden sticks, cotton strings, rubber bands, etc.) are

	on the back side of the base board.
4.3 Model Height	4.3.1 $H_{min} \leqq$ the height of the model that not includes mass blocks, denoted as $H_{model} \leqq H_{max}$ 4.3.2 $H_{min} \leqq$ the height of the load platform, denoted as $H_{platform} \leqq H_{max}$ 4.3.3 H_{min} = 50 cm, H_{max} = 65 cm 4.3.4 The height of the model including the mass blocks and team flag must be not greater than 75 cm. 4.3.5 The elevations of two models are sketched as Fig. 2. 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 top of the load platform, which is the horizontal surface contacting with the bottom of the mass blocks (Fig. 2).  Figure 2. Sketch of the elevation of a model

5. Requirements for Mass Blocks

In this competition, mass blocks represent the vertical loading exerted on the load platform. 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 After the model confirmed by the judges, any changes of the number and the arrangement of the mass blocks are not allowed.

5.2 Mass blocks must be installed on the load platform and not over the boundary of the load platform.

5.3 Mass blocks must not contact with columns or bracings.

5.4 Mass blocks are not installed on the load platform until mounting the model to the shaking table. Only hot-melt glue can be used to fix mass blocks to the load platform. Other materials (e.g., cotton strings, rubber bands and paper etc.) are not permitted to fix mass blocks.

5.5 Every team must provide the drawings showing the layout of the mass blocks and the boundary of the load platform within a 20 cm-by-20 cm region of A4-size paper (Appendix 1). It's allowable to use additional blank A4-size papers for related drawings. The layout drawings of mass blocks must clearly indicate the number, the locations, and the directions of the mass blocks. These drawings may contain plan, front/side elevation, or 3D perspective drawings. The drawings can be done before the construction day. Every team should submit the drawings before 12:00 p.m. on the construction day.

6. Scoring the Models: Capability-Price Ratio

Scoring the models is based on the capability-price ratio, denoted as *CP*. A greater value of *CP* represents a higher rank of the model in the contest.

CP is computed as:

$$CP = \frac{\phi \times Capability}{Price} \tag{1a}$$

where

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

$$Price = \frac{W_{model}}{W_0} \tag{1c}$$

Capability: Capability of the model

Price: Price of the model

ϕ: Reduction (or 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.

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

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

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

a_{max}: Maximum ground acceleration successfully resisted by the model (gal)

g: Gravitational acceleration (= 980 gal)

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

V_{min}: Minimum base shear (= 16 N)

$H_{platform}$: The height of the load platform (cm)

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

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

W_0: The target value for 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 for fixing the mass blocks on the load platform 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 Fig. 3). If there is any question about the relative positions or directions shown in Fig. 3, please ask the staffs/judges for assistance.

7.8 The base board is fixed to the shaking table by using a metal plate (Fig. 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.

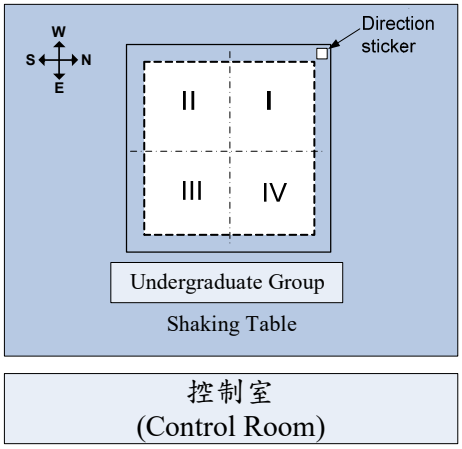


Figure 3. The orientation of the model fixed on the shaking table.

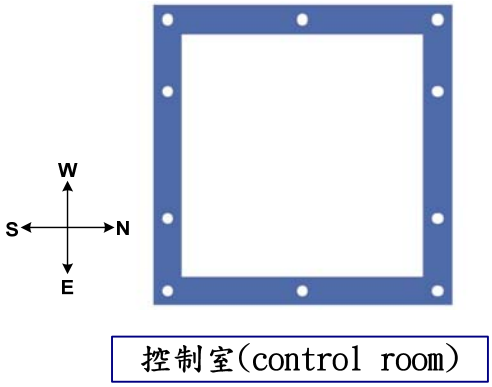


Figure 4. The metal plate for fixing the base board

8. Loading Protocol

All models will be tested simultaneously on the shaking table. The artificial earthquakes generated by the shaking table are broadband excitations, which are bi-directional sinusoidal waves with varied frequencies. The intensity of each artificial earthquake is represented by its peak ground acceleration (PGA).

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, which is equivalent to an intensity-VII earthquake in Taiwan, 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 bi-directional time histories of the artificial earthquakes are available on the IDEER's website. All teams are welcome to download these data.

8.5 Figure 5 shows the two components of the displacement time histories of the artificial earthquake with the PGA equal to 250 gal.

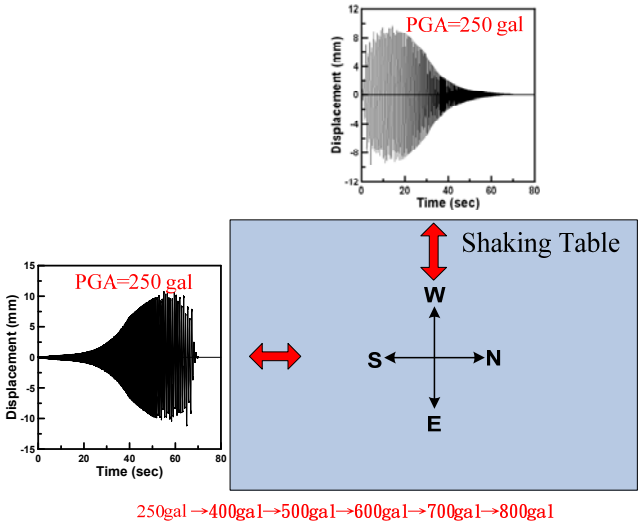


Figure 5. The E-W and N-S components of displacement time histories of the artificial earthquake with the PGA equal to 250 gal.

9. 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 blocks fall off, significantly dislocate, sway, or rock.

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

9.5 The residual displacement of the inclined model is greater than 10 cm. The residual displacement is the maximum lateral displacement of the model after a shaking event.

9.6 The base board is obviously loosened during the test.

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

10. 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 dynamic style. The space for this exhibition is limited to 35 cm (height) × 25 cm (width) × 25 cm (depth) shown as Fig. 6. The design-concept exhibition award is granted based on the clarity and creativity of displaying the design concept of the model through the exhibition object. The affiliation of the team including the department and the university/college must be presented in the exhibition object. If electronic products are employed in the exhibition object, 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.

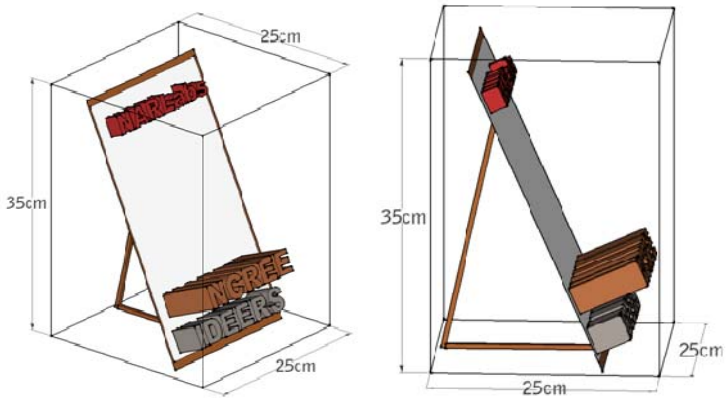


Figure 6. The allowable exhibition space

11. 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 the contest. All possible shapes of this flag are allowed. Nevertheless, the size of this flag must be not larger than that of a sheet of A6-size paper (i.e., 14.4 cm length × 10.5 cm width, or 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 period of the model inspection, jury has the right to change the reduction factor (i.e., ϕ) or require the teams to modify/improve their models if the models violate any competition rules.

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

12.2 The required items for model inspection are (1) the model, (2) the model inspection form and the drawings showing the layout of mass blocks, and (3) the exhibition object. All the required items are taken to the judges by two members of each team.

12.3 During the two-day competition, if jury has disputes over any models, jury has the right to request the models to be re-examined.

13. Awards

The organizer provides three additional awards, i.e., aesthetic award, structural design award, and design-concept exhibition award to the teams whose model or exhibition object outperform the other teams.

13.1 Aesthetic award is granted on the basis of the architectural features. The jury chooses at most three models for this award. The teams winning this award will be granted NT$5000/team and a certificate for each team member. The evaluated items and the corresponding percentage of score for this award are:

Item	Percentage	Description
Model features	100%	● aesthetic of the model ● characteristic and creativity

13.2 Structural design award is granted on the basis of the structural design of models, the concept and creativity of seismic resistance design. The jury chooses at most three models for this award. The teams winning this award will be granted NT$5000/team and a certificate for each team member. The evaluated items and the corresponding percentage of score for this award are:

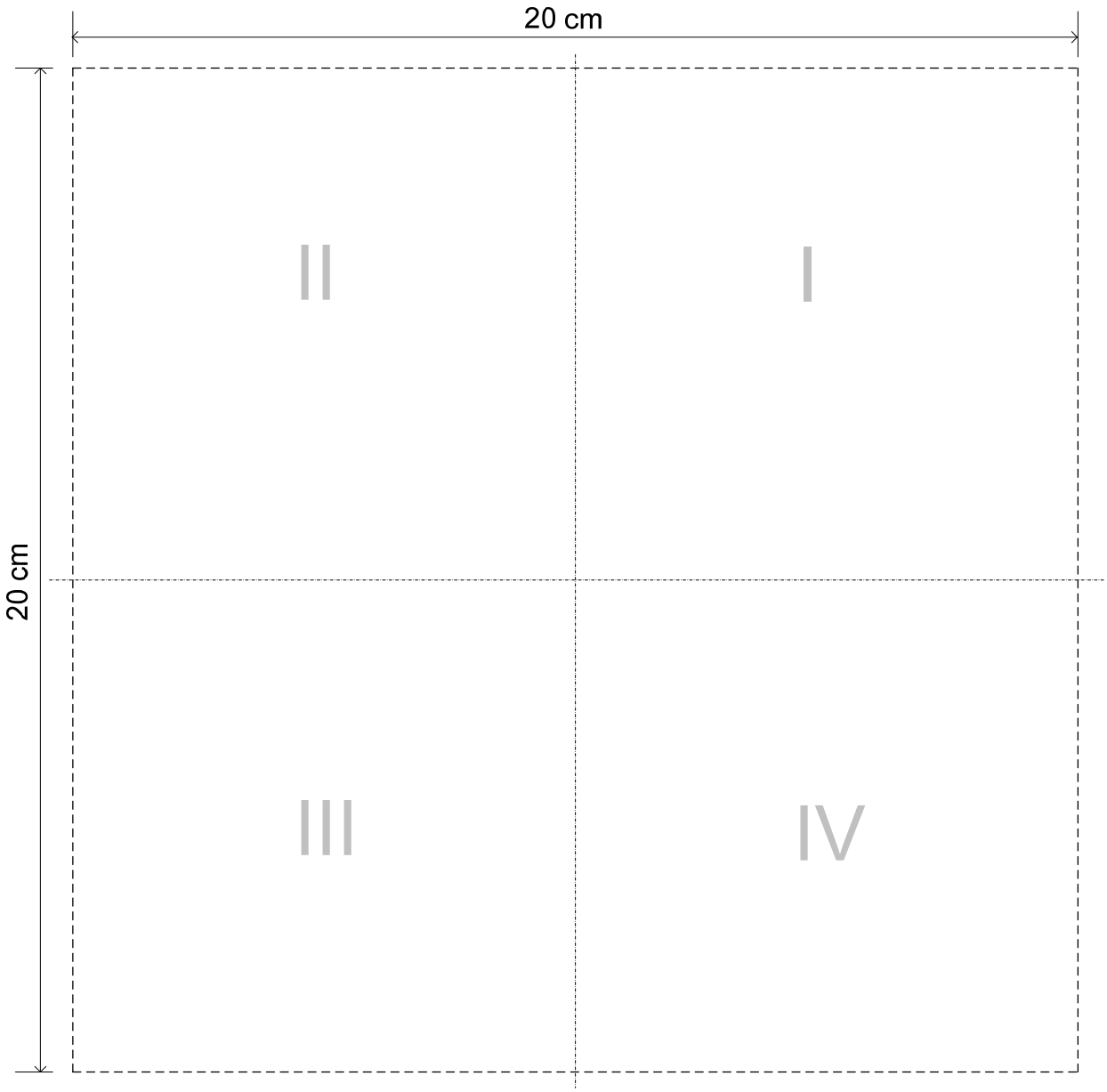
Item	Percentage	Description
Structural design	65%	● The arrangement of structural components ● The rationality of loading path
The concept and creativity of seismic resistance design	35%	● The rationality of the concept of seismic resistance design ● The creativity of the concept of seismic resistance design

13.3 Design-concept exhibition award is granted on the basis of the clarity and creativity of displaying/delivering the design concept of the model. The jury chooses at most three exhibition objects for this award. The teams winning this award will be granted

NT$3000/team and a certificate for each team member. The evaluated items and the corresponding percentage of score for this award are:

Item	Percentage	Description
The contents of introducing the design concept	70%	● The clarity and effectiveness of introducing the design concept and structural characteristics
The creativity of the way of displaying the design concept	30%	● The vividness of the way showing the design concept ● The creativity of the way showing the design concept

Appendix 1. Drawing of the layout of the mass blocks.



Appendix 2. Model inspection form

Team Number		**Department & School**		
Weight of model (including base board, but excluding mass blocks) (W_{gross})			gw	Signature of examiner
Weight of base board (W_b)			gw	
$W_{model} = W_{gross} - W_b$			gw	
Number of mass blocks			block	
Height of load platform ($H_{platform}$)			cm	

Check list	OK	NG
I-1. Only one load platform for placing mass blocks		
I-2. Any material (hot-melt glue included) must not contact the base board of the fourth quadrant		
I-3. Using wooden sticks to make the boundary of the load platform		
I-4. Using wooden sticks to mark the range of the fourth-quadrant load platform		
I-5. 12 ≦ number of mass blocks ≦ 24		
I-6. Number of the mass blocks completely located on the fourth-quadrant load platform must be not less than 1/2 total number of mass blocks.		
I-7. No more than 2 layers of mass blocks		
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. No seismic isolation design		
I-10. No material on the back side of the base board		
I-11. Every hole on the base board must be filled with hot-glue. The base board must keep flat.		
I-12. Cleaning working area and organizing tools in order		
II-1. Keep 3 cm clearance around the edges of the base board		
II-2. The vertical projection of the entire model and mass blocks must be in the 20 cm x 20 cm central region of the base board		
II-3. 50 cm ≦ the model height that not include mass blocks ≦ 65 cm		
II-4. 50 cm ≦ the height of the load platform ≦ 65 cm		
II-5. The model height including the mass blocks and team flag must be not greater than 75cm.		
II-6. Mass blocks must be placed on the load platform, and must be not over the boundary of the load platform		
II-7. Mass blocks must not be attached with any column or bracing.		
II-8. Not finishing installation of all mass blocks, and still meet the requirement		

of I-5 & I-6 of the check list		
n_v =		

*Category I (I-1~I-12) must be strictly followed. The team would be disqualified from the competition (i.e., n_v = 50) if any category-I items are violated.

*Category II (II-1~II-8) is for the possible construction errors. The n_v value is the total number of violated category-II items.