nzsee
NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING

2024

He Tohu Pūpū

Seismic design competition

Rules

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Basileostylus bollonsi (Suter, 1908), collected 6 October 1948, SW seaward slope, Great Island, New Zealand.

Behind the name

He Tohu means *The Award*

Pūpū is the common name for the endangered land snail that dates from the Pliocene era when New Zealand was part of Gondwanaland. The large flax snails *(Placostylus hongii)* survive today in the Hokianga, as well as on the Mokohinau and Poor Knights Islands. Legend tells of the extraordinary sounds produced by the recoiling snail, frightening away enemy warriors and alerting the resident people of approaching danger.

The sculptor Virginia King won the People's Choice Award for her artwork depicting this snail, which was later purchased by Ernst & Young in memory of their employee Lisa Patricia Willems who died during the 2011 Christchurch Earthquake.

Contents

1 Introduction

The New Zealand Society of Earthquake Engineering is holding a seismic design competition for emerging engineers (undergraduates, postgraduates, and early-career practitioners) at the NZSEE 2024 annual technical conference.

The objectives of the competition are:

- To promote the study of earthquake engineering within the NZSEE community.
- To build relationships between NZSEE emerging engineers.
- To promote NZSEE activities among emerging engineers.

2 Problem Statement

Billionaire Meelon Usk has bought the social media network Twutter for $44 billion USD. To celebrate, he has commissioned your team to build Twutter's new HQ, which will need to house the world's fanciest chandelier. It also has to fit his ego, so he has forbid your team from using structural walls as they would block the world's view of the chandelier.

Your team needs to design the building: the architecture, the load resisting structural system, and most importantly, the chandelier.

Detailed constraints are provided in Section 8.

Teams must design and build a small-scale earthquake-resistant building that will be tested on a shake table during the 2024 NZSEE Conference. The model shall be able to resist a scaled earthquake time history from the NGA Database.

3 Awards

It is a team prize of $2,000 shared amongst the team plus complementary membership of NZSEE for a year for each member of the winning team. All teams will receive a certificate of participation.

4 Teams

Each team is required to have four participants and should consist of undergraduates, postgraduates, and/or early-career practitioners (under 30 years old). Due to limits of time and equipment, a maximum of eight teams will be allowed to participate in the competition. Full registration (rather than single day) is required.

5 Presentation

Teams will have an opportunity on Wednesday 10 April 2024 at the breakfast session to present for 3-5 minutes on their model. This is a chance to pitch the architectural and innovative aspects of your design which could win you more points.

6 Workshops and monthly meetings

Workshops and meetings will be held via zoom in in the time leading up to the conference to support participants. Participants will be able to ask questions, solicit advice, and get to know each other. This will be held in March and April 2024.

7 Scoring: Penalties and Points

Scoring for the 2024 differs from previous competitions, with mass penalties for measurable parameters and points for architectural and seismic performance.

7.1 Penalties – It's like golf: Get it as low as possible

Penalties will be assigned to teams by impairing seismic performance through adding weight.

Mass block penalties will be assigned by based on overall rankings for the Penalty Rating:

$$\textit{Penalty Rating} = \textit{Weight Ranking} + \textit{Height Ranking} + \textit{Violation Penalties}$$

For an example, consider six teams scoring as in Table 1:

Table 1: Example penalty scoring and mass blocks added

Ranked Team	#1	#2	#3	#4	#5	#6
Weight Ranking (lowest best)	1	3	2	4	6	5
Height Ranking (tallest best)	2	1	3	5	4	6
Violation Penalties	0	0	1	0	1	2
Total	3	4	6	9	11	13
Mass blocks added	**0**	**1**	**2**	**3**	**4**	**5**

7.1.1 Weight of the Model

The teams will be distributed in a scale from one to six where the heaviest model will score the lowest store (e.g., if we have six teams, the lowest score will be one) and the lightest will score six (i.e., max score). When models have the same weight, models will be assigned to the higher score accordingly.

7.1.2 Height of the model

The teams will be distributed in a scale from one to six where the shortest model will score the lowest store (e.g., if we have six teams, the lowest score will be one) and the tallest will score six. When models have the same height, models will be assigned to the higher score accordingly.

Note that the total height of the building must be between 450mm and 700mm as specified in Section 8.4 below. If the height category rule is broken, teams will be scored with the minimum score depending on the number of teams.

7.1.3 Violation Penalty

Penalty points will be applied after assigning other points. If the model does not meet the criteria, one penalty point will be added, if two criteria's points were not meet, then two penalty points will be added and so on. The judges panel will define penalty points.

7.2 Points – It's like Pokémon: You gotta catch 'em all

The overall score will be based on the architectural design, innovation, and the seismic performance of the shake table.

Points = Architectural Design and Innovation + 2 x Seismic Performance

The architectural design and innovation score will be publicised prior to shake table testing, so the winner of the competition will be known as soon as the testing is concluded. In the case of a tie, the judges will assign a winning team.

7.2.1 Architectural Design and Innovation

A panel of three judges will score the architecture design of models. Scoring from the lowest score depending on the number of teams (poorest design) to six (coolest design). Scores are granted on the basis of the architectural features, the efficiency of using the site area, clarity and creativity of displaying the building. New this year: the more impressive the chandelier, the higher the points. Innovative seismic load resisting systems will score highly.

7.2.2 Seismic Performance on the Shake Table

The models will be subjected to a single ground motion scaled to varying levels of intensity, indexed by the Peak Ground Acceleration (PGA). The teams will be distributed in a scale from one to six where the model that resisted the weakest PGA will score the lowest score depending on the number of teams and the one that resisted the strongest PGA will score six. When models resist the same PGA, models will be assigned to the higher score accordingly. Note that seismic performance is worth twice as much as architectural design and innovation points.

8 Materials and tools

All materials and tools must be provided by the teams themselves.

Teams are welcome to use any tools available to them. The materials of the superstructure are limited to those listed below:

- Wooden dowel (up to 10mm diameter)
- MDF only for horizontal elements
- Balsa wood
- Popsicle/Stirring sticks (or equivalent crafting wooden sticks)
- Hot glue
- String
- Rubber bands

9 Model features

All teams are encouraged to exert their creativity on constructing the model. The building model is also to meet the requirements below:

9.1 Basic structure

- All models must be composed of typical structural components (beams, columns, walls, braces etc.).
- The HQ must have a lobby at ground floor. This must be designed as 1.5 times the typical floor to floor height and be spacious and open. No structural walls are allowed.
- Adding claddings/decorations to the models for the purpose of aesthetic appearance is allowed and encouraged.

9.2 Floor area

- The floor area is defined as the area enclosed by the exterior edge of the floor diaphragm.
- The minimum floor area for each floor is 10,000mm^2. The total floor area, excluding the ground floor, of the model must be between 40,000mm^2 and 160,000mm^2.

9.3 Exterior requirements

- Teams cannot block the view of the chandelier with structural walls.

9.4 Interior requirements

- Partitions and any non-structural elements should not be included in the model. Only internal structural elements should be modelled. Space must be left for mounting mass blocks.

9.5 Number of columns fixed on the base board

- There is no restriction on the number of columns fixed on the base board.
- Enhancing the fixity of columns to the baseplate beyond simple glue is encouraged, however all holes on the base board should be backfilled with hot-melt glue to avoid reducing the weight of the baseboard.
- All of the columns must be fixed on the baseboard.
- The board must be kept flat.

9.6 Model base

- Models must be constructed on a solid timber base board (260 mm × 260 mm × 5.5 mm MDF). A 30 mm clearance around the edges of the base board must be kept in order to fix the model onto the shaking table. **Teams violating this rule will be disqualified or there will be the addition of penalty weights to the models.**
- The allowable site area is the 200 mm × 200 mm square shown as the dotted lines in Figure 2. The projection of the entire model onto the base board must be within 200 mm × 200 mm.
- Teams need to drill through-holes in the model base to accommodate M6 bolts, such that the model can be fixed to the model mounting board on the day of the competition. Bolt holes are to be 220 mm centres apart. Refer Figure 2 for clarity.

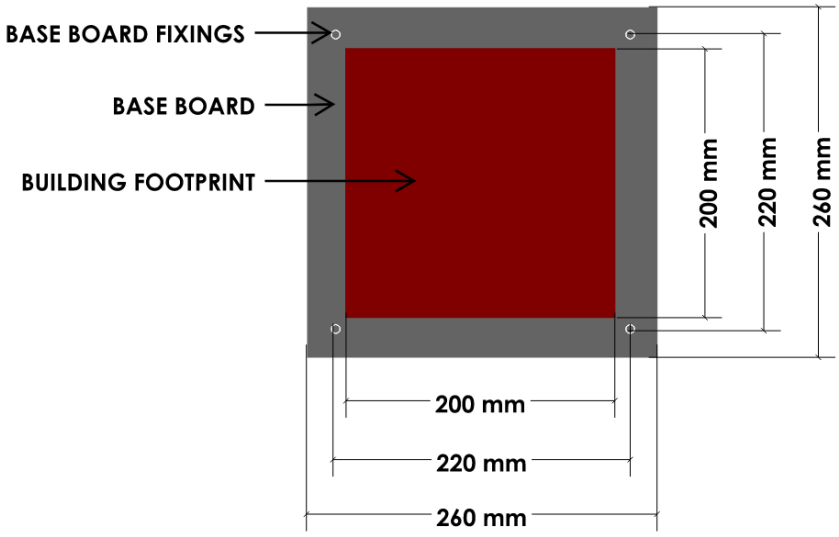


Figure 2: Definition of building footprint and base board

9.7 Building and floor heights

- Figure 3 shows the definition of floor numbers and the height constraints. There must be three suspended floors in the model.

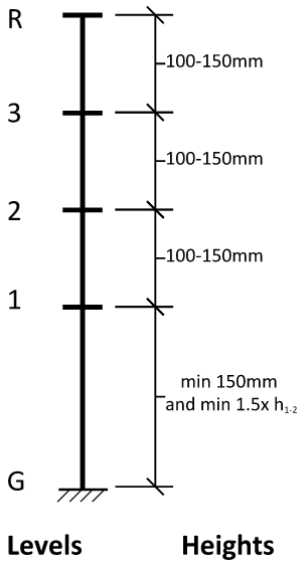


Figure 3: Building floor level and height requirement

- The clear floor height is defined as the distance between the bottom edge of the lowest beam at the floor above, and the top edge of the highest beam or floor diaphragm (whichever is higher) at the level below. This is shown in Figure 4 below.
- The clear floor height between ground and first floor must be at least 150mm, and at least 1.5 times the first to second floor clear height.
- For all other floors, the clear height must be between 100 and 150mm.
- The height of the model, measured from the top of the base board to the top of the RFL, must be not less than 450mm and no larger than 700m.
- The thickness of all floor diaphragms is limited to be greater than or equal to 5mm to allow for anchoring of mass blocks at each level.

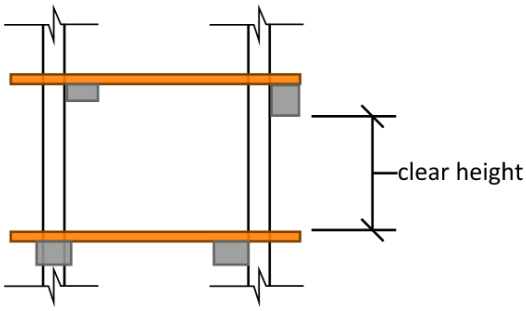


Figure 4: Definition of clear height

10 Requirements for Mass Blocks

In this competition, mass blocks represent the vertical loading exerted on the floors. The weight of each mass block is about 635 g. The dimension of each mass block is 50 mm x 40 mm x 40 mm thick, made of mild steel, with a through-hole drilled vertically in the centre of the 50 mm x 40 mm face. It will be anchored to the floors using a bolt (M8), a nut, and two larger diameter washers.

Each floor will have one block assigned. Further mass blocks will be added based on penalty points. Additional mass blocks must be added to each floor from the roof downwards. Table 2 demonstrates this, following the example teams' penalties assigned in Table 1.

Table 2: Example penalty scoring and mass blocks added

Ranked Team	#1	#2	#3	#4	#5	#6
Mass blocks added	**0**	**1**	**2**	**3**	**4**	**5**
	Number of mass blocks					
Floor 4 (roof)	1	2	2	2	2	3
Floor 3	1	1	2	2	2	2
Floor 2	1	1	1	2	2	2
Floor 1	1	1	1	1	2	2
Ground	0	0	0	0	0	0

Teams must drill **three** through-holes anywhere on each of their model floors, and must ensure that the mass blocks can be physically installed. Mass blocks will be added prior to model shaking. Mass blocks, bolts, nuts, and washers will be supply by the organising team prior to the shake table test.

Teams must let the organising committee know the thickness of their model floors before the conference, so that the correct length M8 bolts for securing the mass blocks can be purchased.

The rules of placing the mass blocks are:

- After the model is confirmed by the judges, any changes of the number and the arrangement of the mass blocks is not allowed.
- Mass blocks must be installed on the load platform and not over the boundary of the load platform.
- Mass blocks must not be in contact with columns or braces. Otherwise, teams may choose where masses are located on the floor plate.
- Mass blocks are not installed on the load platform until after the model has been connected to the shake table.

11 Mounting models onto the shaking table

The competition will be held during lunch time on the second day of the conference.

All teams to submit the finished model by lunchtime of the first day of the conference.

Due to shake table dimensions, a mounting board (see Section 9.1) will be anchored to the shake table allowing anchoring more than one model. Two mounting boards will be provided if more than six teams enter the competition. Teams fix their models to the mounting boards prior to the competition. Mounting boards with anchored models will be anchored to the shake table by the organizing committee. Please, see details below:

- The organizer will provide each team with the required items to fix models to the mounting boards.
- 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.
- After all teams completed the task of mounting their models onto the shaking table and fixing the mass blocks, staff will check whether or not the screws on the four corners of each model are secure. Nevertheless, each team is still completely responsible for the fixing of the model onto the shaking table (rule 7.1). The team shall raise no objection once the model if the base board is apparently loosened during the test.

12 Testing procedure

12.1 Loading protocol

The models will be anchored to the shake table via the MDF model mounting board and subjected to a ground motion scaled to incrementally increasing intensities until structural failure occurs. The intensity measure for the sake of the competition will be PGA.

The shake table will be run using ‘open-loop’ control, meaning the actual response of the shake table and mounting board may vary by some amount from the input motions (i.e., there will be some uncertainty in the actual applied accelerations and displacements). This includes potential for the model mounting board to move in the vertical direction (due to mounting board stiffness).

The organisers may vary the magnitudes of the applied motions as they see fit on the day, depending on how the various structures are performing, competition time constraints, etc.

13 Structural failure criteria

A model will be judged as a failure when the following conditions occur.

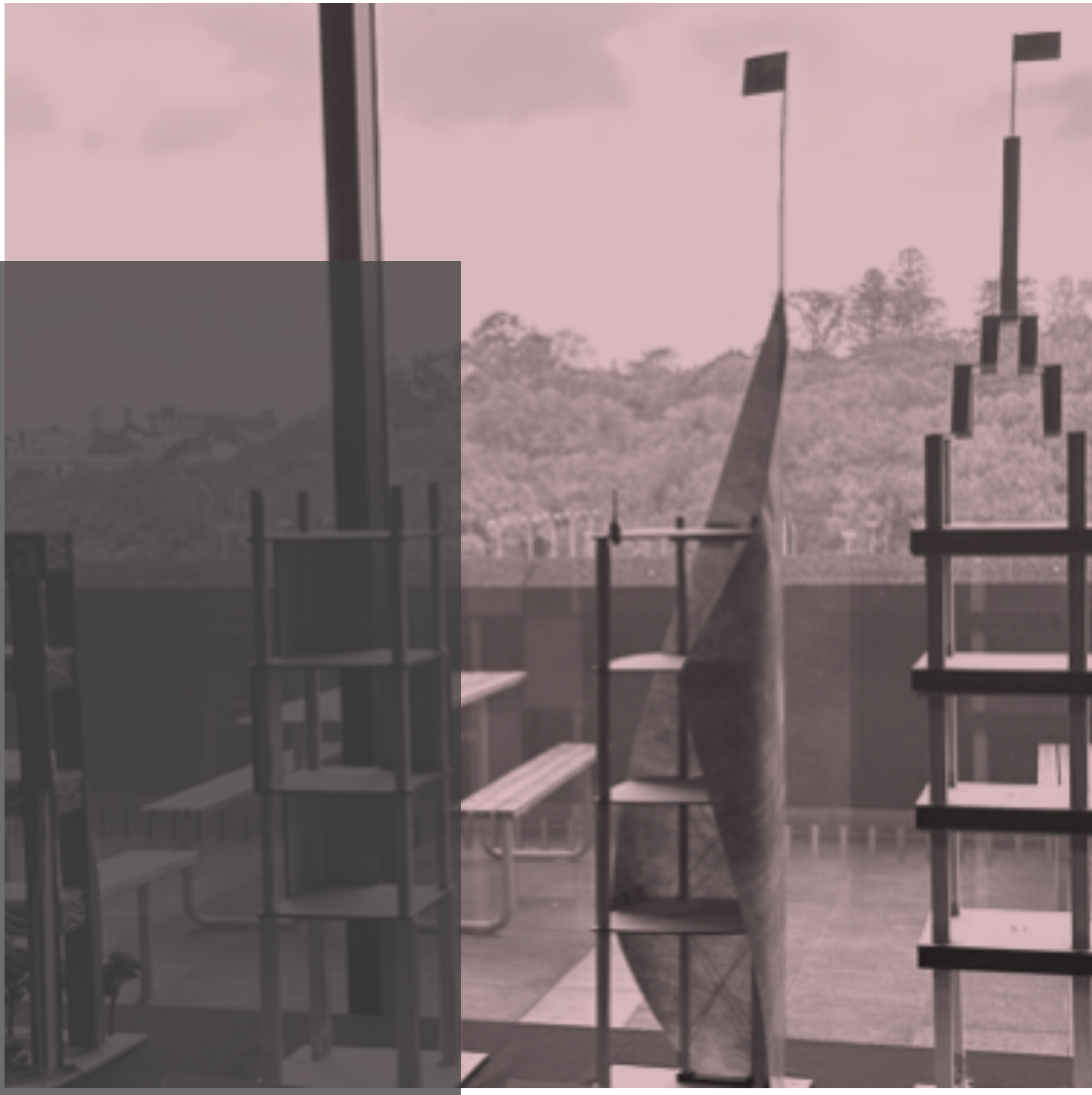
- Any floor is unstable or collapsed.
- The number of columns detached from the base board is larger than or equal to one half of the total number of columns.
- The residual displacement of the inclined model, which is the horizontal distance measured from the original roof position to the final roof position, is greater than or equal to 100mm.
- The base board is apparently loosened during the test.
- The jury has the consensus that a model fails in the test.

The failed model will be removed from the shaking table before the next test.

14 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. The procedures of the model inspection are as follows:

- The host calls the team number.
- The team members weigh the model.
- The judges inspect the model and then fill in the inspection form.
- The staff takes a picture of the model and the exhibition object.
- The team members place the model and the exhibition object on the designated table for displaying.



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He Tohu Pūpū Organisation Committee

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