He Tohu Pūpū Seismic Design Competition

sponsored by

2023

Rules

Last update 12.04.2023

Behind the name

"He Tohu" means "The Award" and 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 and 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. You can read more about this endemic NZ snail here: https://www.gotonewzealand.co.nz/flax-snail/.

Also, Virginia King (a sculptor) 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. See here for this story: https://www.virginiakingsculptor.com/pupu-harakeke

Contents

1 Introduction

1.1 Competition Objectives

The objectives of the Annual Seismic Design Competition (ASDC) held at the NZSEE 2023 conference are:

- To promote the study of earthquake engineering among the NZSEE community.
- To build relationships between NZSEE, undergraduates, postgraduates, and early-career practitioners.
- To promote NZSEE activities among undergraduates, postgraduates, and early-career practitioners.

1.2 Problem Statement

Teams are required to design and build a small-scale earthquake-resistant building that will be tested on a shake table during the 2023 NZSEE Conference. The model shall be able to resist a scaled earthquake time history from the NGA Database.

Client is after a multi storey hotel building. The building will be facing the sea in a diagonal direction, which requires triangle open areas and free bracing axis facing the sea, as sketch below. Detailed constraints are provided in Section 7.

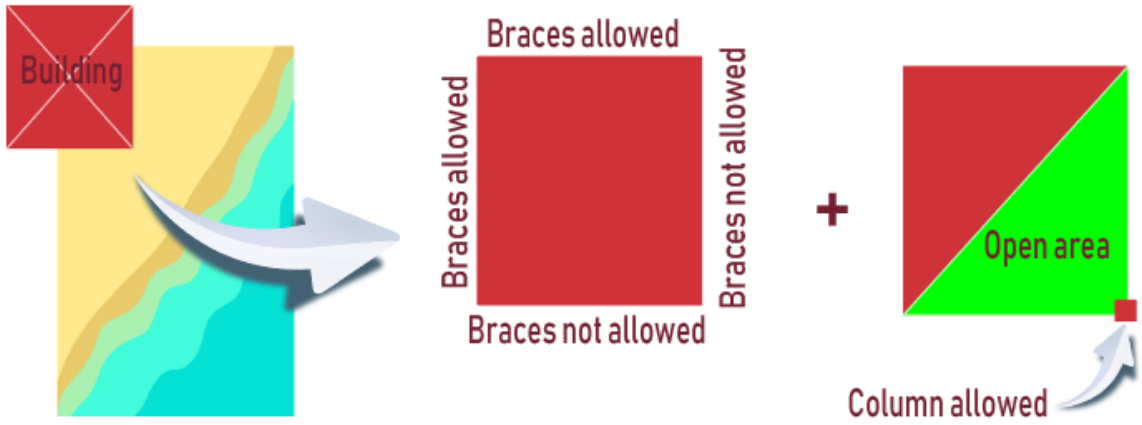

Figure 1 Sketch of hotel location and open areas.

2 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.

3 Workshops and monthly meetings

To support participants in the time leading up to the conference, several workshops and meetings will be held via zoom. In these meeting participants will be able to ask questions, solicit advice, and get to know each other.

Meeting	Topic	Facilitators
March	Rules - Q&A session	Catalina Miranda, Sean Rees, Angela Robinson
April	Rules - Q&A session	Catalina Miranda, Sean Rees, Angela Robinson

4 Scoring

All models are raked by using the efficiency ratio (ER). The value of ER is calculated based on the weight of the model itself (W), height of the model (H), PGA resisted by the model (P), an architectural aesthetic component (A), and penalty points (PP). The winner (first place) will be the team whose model obtains the largest value of ER.

The ER is calculated as follows:

$$ER = W + H + P + A - PP$$

Where ER has a maximum of 24 and all components are defined as follow:

- Weight of the model (W)

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. See Table 1.

- Height of the model (H)

The teams will be distributed in a scale from one to six where the smallest 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 7.4 below. See Table 1. If the height category rule is broken, teams will be scored with the minimum score depending on the number of teams.

- PGA resisted by the model (P)

The models will be subjected to a single ground motion scaled to varying levels of intensity. 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. See Table 1.

- Architectural design (A)

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 model' (hotel building). See Table 1.

Table 1 Min scoring and number of teams

Number of teams	1	2	3	4	5	6
Min score depending on number of teams	6	5	4	3	2	1

- Penalty points (PP)

Penalty points will be applied after assigning W, H, P and A points. For instance, a team scored W = 6, H = 6, P=2 and A=3, but it does not meet the criteria of one of the points listed below, 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.

5 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:

- MDF
- Balsa wood
- Popsicle/Stirring sticks (or equivalent crafting wooden sticks)
- Hot glue
- String
- Rubber bands

6 Model features

All teams are encouraged to exert their creativity on constructing the model. As stated in section 1.2, the building is to be a high-end hotel. The building model is also to meet the requirements below:

6.1 Basic structure

- All models must be composed of typical structural components (beams, columns, walls, braces etc.).

- The hotel 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. This means that no external braces or walls are allowed.
- Adding claddings/decorations to the models for the purpose of aesthetic appearance is allowed and encouraged.

6.2 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 this 200 mm × 200 mm square.
- 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.

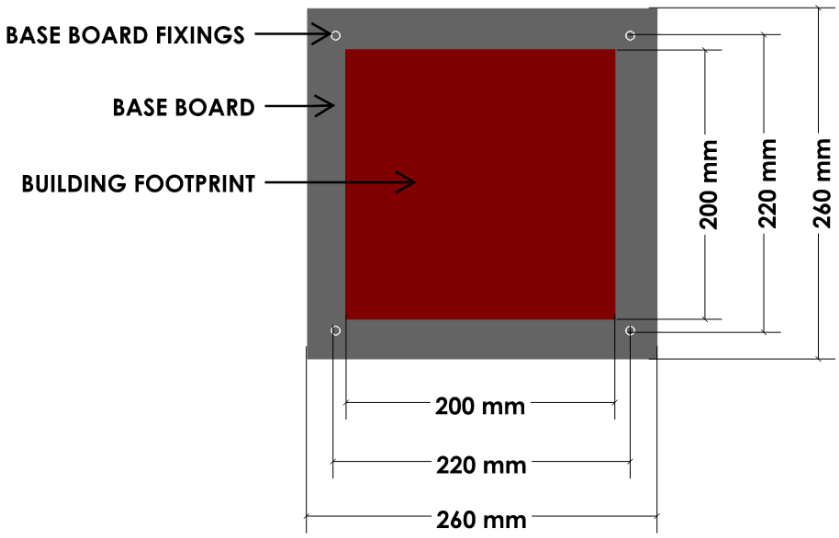

Figure 2: Definition of building footprint and base board

6.3 Number of columns fixed on the base board

- There is no restriction on the number of columns fixed on the base board.
- Walls and braces are allowed on adjacent sides not facing the sea. Sides with bracing cannot exceed 50% over the length of the side.
- 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.

6.4 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.

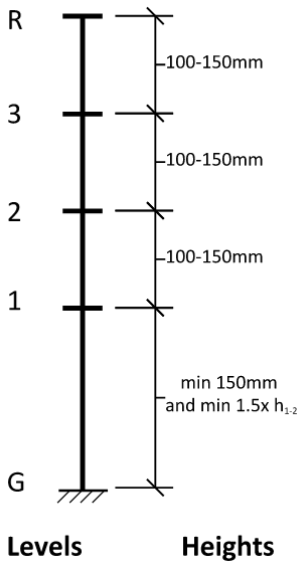

Figure 3: Building floor level and height requirement

- 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.

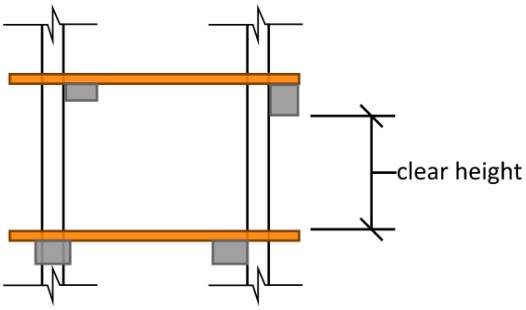

Figure 4: Definition of clear height

6.5 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.

6.6 Exterior requirements

- Based on flow and space consideration, the model building must have full windows on adjacent sides facing the sea. These windows don't have to be framed out but must be achieved such that there is no structure in the window space.

6.7 Interior requirements

- Partitions and any non-structural elements should not be included in the model. Only internal structural elements should be modelled.

7 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. This will require each team to drill a through-hole in each of their model floors to ensure that the mass blocks can be physically installed prior to model shaking. Mass blocks, bolts, nuts, and washers will be supply by the organising team prior the competition.

Teams must let the organising committee know the thickness of their model floors by or before Wednesday 12th April, so that the correct length M8 bolts for securing the mass blocks can be purchased prior to the competition.

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.

8 Mounting models onto the shaking table

The competition will be held on the 20th of April during lunch time.

All teams to submit the finished model by lunchtime of the 19th of April at the Sir Owen G Glenn Building, University of Auckland.

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.

9 Testing procedure

9.1 Shake table & model mounting board

The shake table is 650 x 650 mm. The model mounting board is a 1220 mm x 1220 mm x 25 mm thick MDF board.

9.2 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.

Please find attached to this document the IDEERS ground motions, which will be used for testing the models during the competition.

Note that:

- We will only be applying the N-S component of the IDEERS records (i.e., the E-W components in the IDEERS motions can be ignored).
- 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.

10 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.

11 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.

12 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.