NEW ZEALAND SOCIETY FOR EARTHQUAKE ENGINEERING

He Tohu Pūpū

Seismic Design Competition

2016

RULES AND REGULATIONS

Kieran Haymes
Natalie Morrison
Anastasios Giouvanidis
Guillaume Roux

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 presents He Tohu Pūpū, the annual Seismic Design Competition for emerging engineers (undergraduates, postgraduates, and early-career practitioners) to be held at the NZSEE 2025 annual technical conference.

The objectives of the competition are:

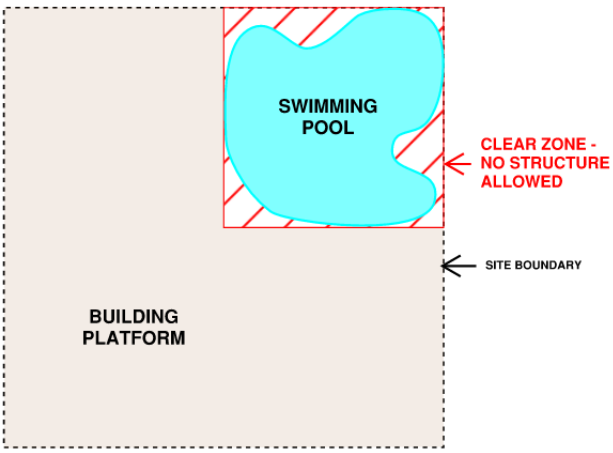
- To promote the study of earthquake engineering within the NZSEE community.
- To build relationships between NZSEE emerging engineers.
- To promote NZSEE activities and seismic design principles among emerging engineers.

2 Problem Statement

Ronald Trumpet, billionaire real estate mogul, is expanding his empire with the new Trumpet Tower hotel in Auckland. He's going to make a big splash by using one-quarter of the ground floor area for a large swimming pool. Trumpet, known for his Olympic diving ability, has requested that this area be double-height for a tall diving tower. As a result, no structural members can be accommodated on the ground of the North East corner of the site, as shown in the ground level plan sketch below. The first floor above the ground must not intrude into allocated area above the pool. The location of the swimming pool is locked in by Mr. Trumpet and nobody wants to get on his bad side by moving it elsewhere on the site.

Trumpet, known for his Olympic diving ability, has requested that this area be double-height for a tall diving tower. The first floor above the ground must not intrude into allocated area above the pool. No structural walls are permitted at the ground level to prevent obstruction of views when he leaps from the board.

The building is to be four storeys, with efficient use of site area, maximised height with minimal weight.



Your team needs to design and create a model of the building, considering both the architectural form, and the load resisting structural system for the ultimate seismic performance. Detailed constraints are provided in the following sections of these regulations. **Please read the regulations carefully, and in their entirety.**

Teams must design and build a small-scale earthquake-resistant building that will be tested on a shake table during the 2025 NZSEE Conference. The model shall be able to resist a series of earthquake excitations of increasing intensities.

As the shake table is unidirectional, the models will only be tested for loading in one orientation. However, please note that the orientation of each teams' model on the shake table will be at the discretion of the SDC Organising Committee staff. Models will typically be placed in their least favourable orthogonal orientation, where asymmetric.

3 Awards

It is a team prize will 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. The sponsorship of this prize will be finalised and teams will be notified before the competition.

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 six 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 9 April 2025 at the breakfast session to present for 3-5 minutes on their model, prior to the shake-table testing. This is your chance to briefly summarise your design process, and showcase the innovative aspects of your model to the judging panel. There is no expectation for teams to produce accompanying presentation slides.

6 Workshops and monthly meetings

Workshops and meetings will be held via Zoom in in the lead up to the conference to support participants. Participants will be able to ask questions of the organising committee, solicit advice, and get to know each other. This will be held in March and April 2025.

7 Scoring: Penalties and Points

As a baseline, each model will have one mass block added per floor during testing. However, prior to the shake-table testing, the models will be ranked against one another in both weight and height, to determine the number of *additional* mass blocks to be added to each structure. Additional mass blocks may also be added for any infringements to the provided design constraints.

The final score of each model (and competition winner) is then dependent on both the seismic performance during testing, and the points awarded by the judging panel for innovation and architectural design.

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

Mass blocks will be assigned based on overall rankings for the Penalty Rating:

Penalty Rating = Weight Ranking + Height Ranking + Violation Penalties

Where the lightest structure will get the best weight ranking, and the tallest structure will get the best height ranking.

7.1.1 Weight of the Model

The teams will be ranked on the weight of their models without any mass blocks added, where the lightest model will score the lowest score (i.e. one) and the heaviest will score the maximum (i.e., if we have six teams, six). 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 ranked on the height of their models, measured to the FFL of the uppermost structural floor diaphragm, where the mass block(s) are mounted. The tallest model will score the lowest score (i.e. one) and the shortest will score the maximum (i.e., if we have six teams, 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 9.6 below. If the height category rule is broken, teams will be scored with the maximum score depending on the number of teams.

7.1.3 Violation Penalty

Penalty points will be applied if necessary, where any model infringes upon the criteria provided in the regulations. If the model breaches one design criteria, one penalty point will be added; if two criteria are breached, then two penalty points will be added, and so on. Application of penalty points will be at the final discretion of the judging panel. The judging panel will also have the right to disqualify any models deemed grossly in breach of the competition parameters.

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 (lightest 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 Penalty Rating:	3	4	6	9	11	13
Additional Mass Blocks:	**0**	**1**	**2**	**3**	**4**	**5**

In this example, Team #1 had the lightest and second tallest structure, so overall earned the lowest Penalty Rating (and therefore no additional mass blocks).

Note also that additional mass blocks must be applied one per floor, starting at the top level. In this example, Team #6, who earned 5 additional mass blocks, would need to put two extra mass blocks on their top level and one extra on each of their other levels.

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 model on the shake table.

$$Points = Architectural\ Design\ and\ Innovation + 2 \times Seismic\ Performance$$

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 architectural and design philosophy of the models. Scores will be awarded from one (poorest design) to six (coolest design). Scores are granted on the basis of architectural features, efficient use of the site area, and ingenuity in the structural form. The judges will also take into consideration how well teams communicate their design features (and seismic design thinking) in their presentation. 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 unidirectional ground motion scaled to varying levels of intensity, indexed by the spectral acceleration at a period of 0.5 seconds. The model that resists the weakest intensity record will score the lowest (one point), and so on through to the model that resists the strongest motion which will score six. When models fail during the same record, models will be assigned a tied 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

Non-structural and architectural elements may be made of materials outside of those listed above, however the judging panel must be satisfied that any alternative materials used are not unfairly enhancing the seismic performance of the model.

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 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 – hence **no structural walls are permitted on the ground floor**.
- The Hotel has specified that the Northeast quarter of the ground area of the site is to be reserved for a swimming pool, and therefore no structure can land within this area. The building footprint may extend over this clear zone, but no connections to the base plate are permitted.
- 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 edges of the floor diaphragm.
- The minimum floor area for each floor is 10,000mm2. The total floor area, excluding the ground floor, of the model must be between 40,000mm2 and 160,000mm2.

9.3 Interior requirements

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

9.4 Number of columns fixed on the base board

- There is no restriction on the number of columns fixed on the baseboard.
- Enhancing the fixity of columns to the baseplate beyond simple glue is encouraged, however all holes on the baseboard should be backfilled with hot-melt glue to avoid reducing the weight of the baseboard. **(Note that column base connection failure has been a very common failure mechanism in previous years!)**
- The baseboard must be kept flat.

9.5 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 – please do not add any non-structural decorations outside the "building footprint" zone shown in Figure 2 below. **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. Additionally, no columns or other structural elements may connect to the baseboard within the 100 mm x 100 mm clear zone shown in Figure 2 below.
- 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.

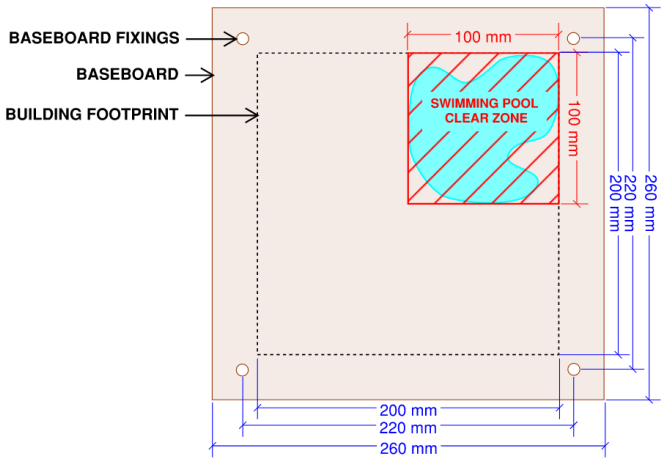


Figure 2: Definition of building footprint and base board

9.6 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.

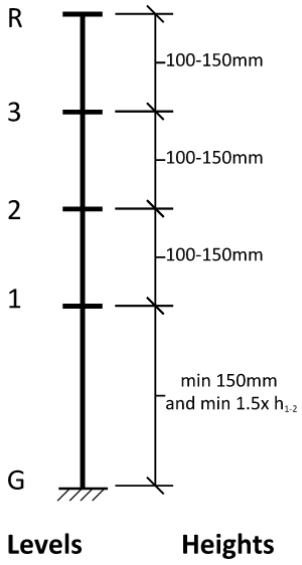


Figure 3: Building floor level and height requirement

- 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.

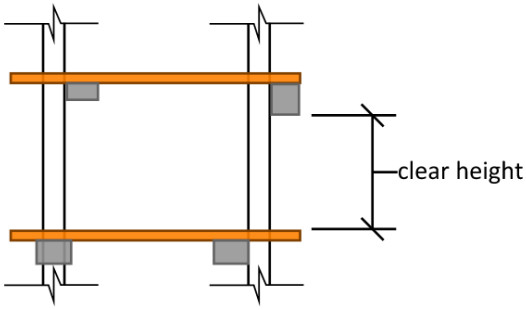


Figure 4: Definition of clear height

10 Requirements for Mass Blocks

In this competition, mass blocks represent the typical 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.

As a baseline, each floor will have one mass block assigned to it. Further mass blocks will then 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**
	Total 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 through which to attach the mass blocks, 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 supplied 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 sourced.

11 Mounting models onto the shaking table

All teams must present their finished model for display and judging by lunchtime of the first day of the conference. The models will then be weighed, measured, and inspected for infringements of the design criteria.

The presentations will be held during the breakfast session on the second day of the conference. After the presentations, the judging panel will finalise the penalty scores awarded to each team. Prior to the testing portion of the competition, which will be held during lunchtime on the second day of the conference, the teams will have the opportunity to install their model on the shake table and attach the required mass blocks.

Please note that the shake table is unidirectional, hence the models will only be tested via loading in one direction. However, the orientation of each team's model on the shake table will be at the discretion of the SDC Organising Committee staff. Models will typically be placed in their least favourable orthogonal orientation, where asymmetric.

Due to shake table dimensions, a mounting board (see Section 9.5) will be anchored to the shake table allowing anchoring more than one model. 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 organizers will provide each team with the required items to fix models to the mounting boards, and confirm the orientation at which they are required to install their model.
- During the period of mounting the models onto the shaking table and fixing the mass blocks, it is not permitted to strengthen the structure of the model.
- Mass blocks must be installed on floor plate and not over the boundary of the diaphragm. 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.
- After all teams completed the task of mounting their models onto the shaking table and fixing the mass blocks, staff will check whether the base board 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. The team shall raise no objection if the base board fixings loosen during the test, which shall count as failure of the structure.
- After the model is confirmed by the judges, any changes of the number and the arrangement of the mass blocks is not allowed.

12 Testing procedure

12.1 Loading protocol

The models will be anchored to the shake table via the MDF mounting board and subjected to ground motions of increasing intensities until structural failure occurs. Teams will be provided with two ground motions for each intensity level prior to the competition. One of the two will be used in the competition.

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).

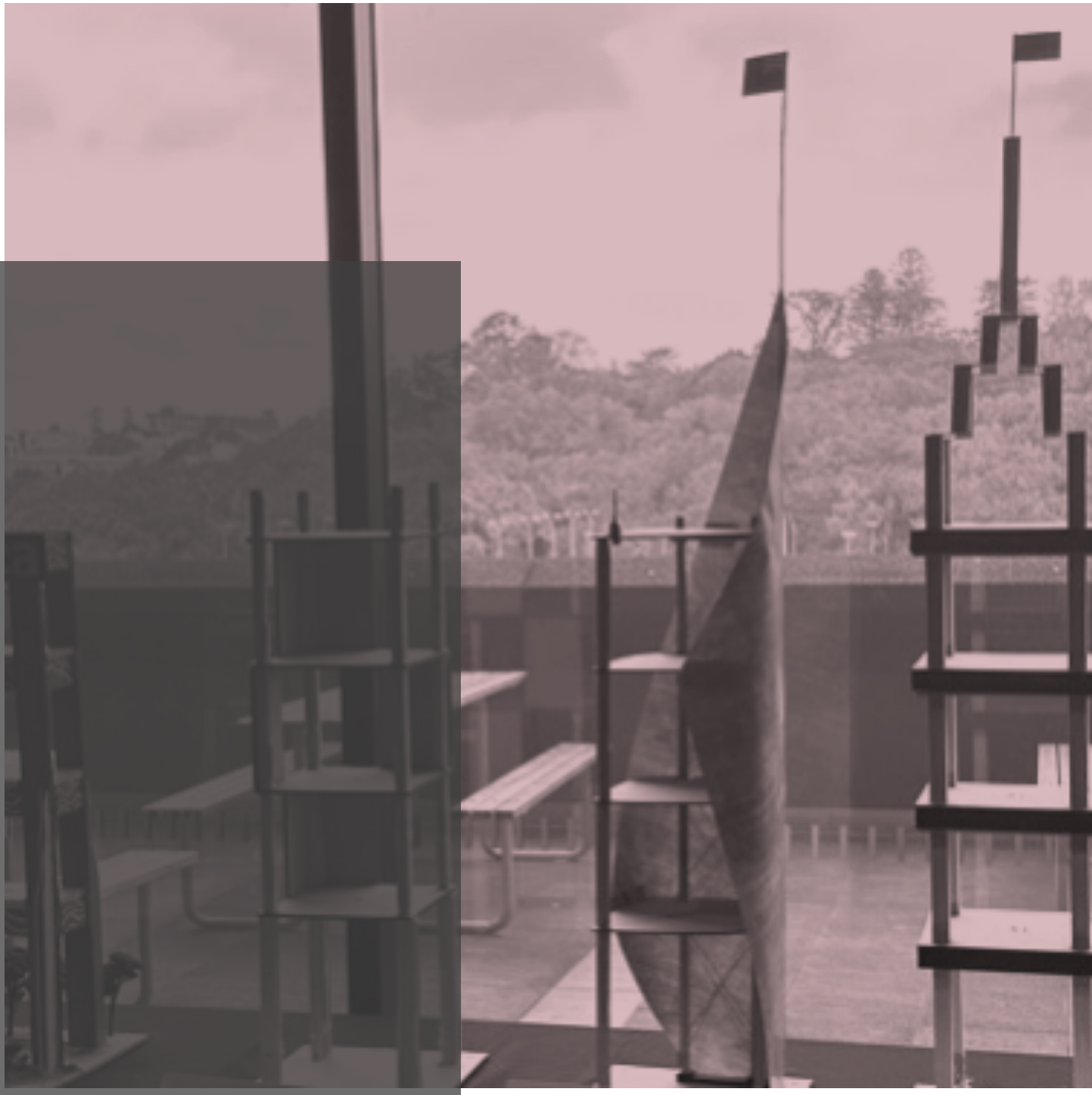
The organising committee staff may vary the magnitudes of the applied motions as they see fit on the day, depending on how the various structures are performing, competition time constraints, etc.

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 fixings have significantly loosened during the test.
- Failure of non-structural elements which the judging panel deems would, in a real-scale building, constitute a life-safety hazard.
- The judging panel has the consensus that a model fails in the test.

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



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Annual Technical Conference 2025