

SEISMIC PROBLEM STATEMENT

INTRODUCTION

Do you ever wonder, how safe is your residential building or office building during an earthquake? The Indian subcontinent has a background marked by devastating earthquakes. The reason for the intensity and high frequency of earthquakes is the Indian plate driving into Asia at a rate of approximately 47 mm/year. North-east India is the most elevated risk zone that endures earthquake.

Earthquake resistant structures are designed to withstand earthquakes. While structure can not completely resist earthquakes, the objective of earthquake resistant structures is to perform better during earthquakes.

This year AAKAAR brings you a challenge where you get to design efficient and sustainable earthquake resistant structure. It is a great opportunity for students to come up with an innovative solution for the crisis that our era is facing. The objective of our competition is to promote the study of earthquake engineering among students.

TASK

Design and build a two-storey structure that can withstand maximum earthquake acceleration and shows minimum inter-storey drift. The building should incorporate advanced earthquake resistant techniques using limited credits (Refer Earthquake Resisting Mechanism for credit allotment).

DIMENSIONS

Building in general:

- The participants need to bring a two-storey building to be tested against earthquake loading.
- The building's each floor area must lie inside the square of 150mm*150mm. (Penalty: Participants will be disqualified if this criterion is not satisfied)
- The clear height of the building must be 450mm with an allowance of +/- 10mm.
- The total vertical distance of the top of the structure from the base plate must be less than 500 mm (as shown in figure).
- The building must essentially contain ground floor + one floor of horizontal levels.
- All levels must have a floor and roof made of popsicle sticks itself resting on the beams.
- Boundary of 50mm height should be made on the first floor of the building (as shown in figure).
- A maximum of four columns must be present on all four corners to connect two floors (i.e. a total of 8 columns can be used).
- Penalty Criteria for above-mentioned rules: Penalty of 5 points (refer Scoring section) will be added for each dimension lying within 5 mm beyond the allowance limit. Further extension in dimension values will lead to direct disqualification.
- The dead load of the building must be less than 1.5 kg. (Penalty: Participants will be disqualified if this criterion is not satisfied)

Structural Elements Specification:

Column

- A maximum of four columns are essential on the corners of two connected floors.
- The maximum cross-sectional dimension of column must not be greater than 12mm*10mm make sure that not more than four Popsicle sticks should be overlapped longitudinally (only for the thickness of column member).

Beam

- Each floor surface should rest on beams. Beams would be further connected to columns.
- The cross-sectional dimensions of a beam must be 150mm*12mm*10mm (L*B*D) with an allowance of +/-2mm on each side.
- Make sure that not more than four Popsicle sticks should be overlapped longitudinally to make a beam member (only for the depth of beam member).

Roof and Floor Specification:

- All levels must have a floor made of popsicle sticks itself resting on the beams.
- Floor dimension must be less than 150mm*150mm (L*B) and should have thickness of maximum 2 popsicle sticks.

Base Plate Specifications:

- The structure must be attached to Base Plate after incorporating the earthquake resisting mechanism.
- The Base Plate must be made with wooden slab.
- Thickness of Base Plate must lie between 6mm to 8mm.
- The base area of Base Plate must be 350mm*350mm with an allowance of +/- 5mm.
- Centre of base place should coincide with Centre of building (when viewed from top view).
- The building can be connected to Base Plate by screws (bolt and nut).
- A maximum of 4 screws are allowed to attach building structure. Screws should not be used anywhere else.

Note: The Base Plate will be directly fixed on the testing setup so any discrepancies in Base Plate dimensions will directly lead to disqualification.

Boundary Specification:

- Boundary should start from beam of 1st floor and should have height of 50mm.
- Boundary should be present on all 4 faces of the building and should cover entire width of face as shown in figure.
- Boundary should be of 1 popsicle stick thickness (i.e. 2mm).

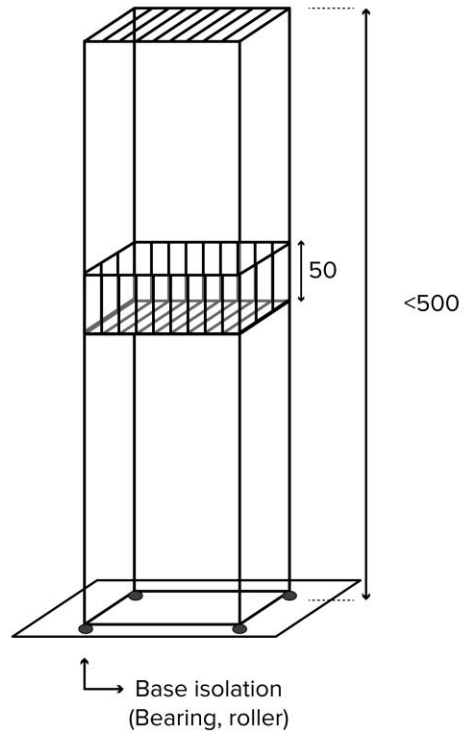
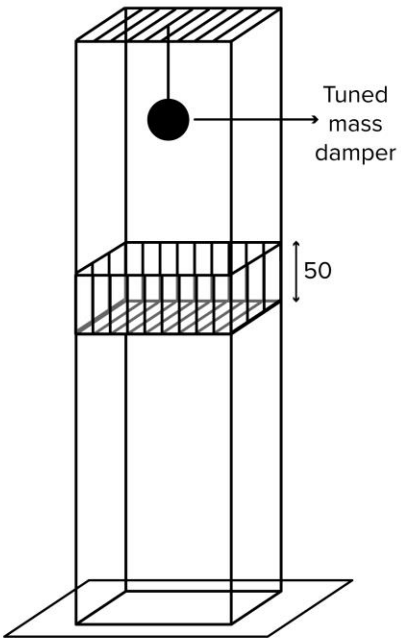
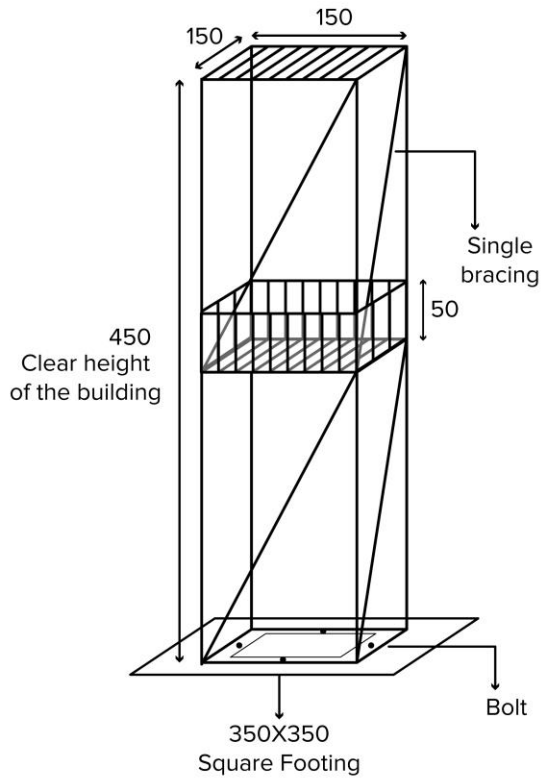
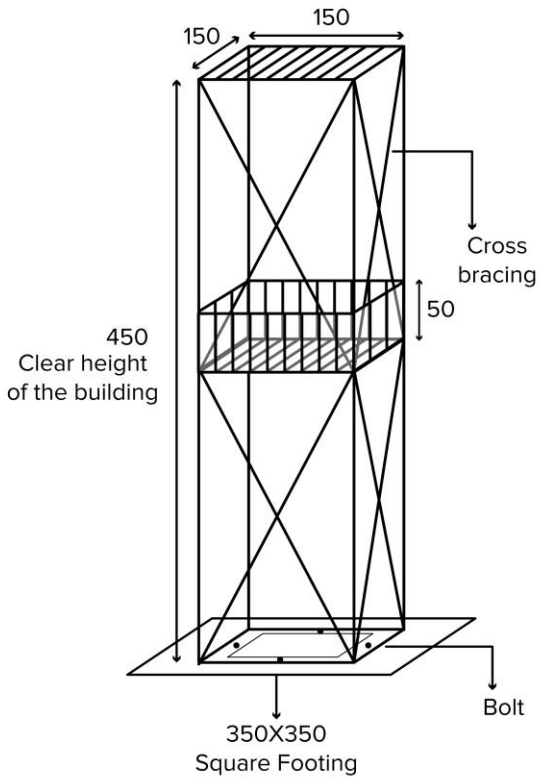
Earthquake Resisting Mechanism:

- Participants are free to use cross bracing technique, Base Isolation technique, Tuned mass damper or any other innovative earthquake load resisting mechanism.
- It will be very crucial for participants to fix the mechanism and then go for construction of building.
- Mechanism should lie within the area of building (i.e. 150mm*150mm)
- A total of 100 credits is given to Participants for designing earthquake resisting mechanism.
- Use of more than 100 credits will lead to disqualification.

Cross Bracing (on 1 face of a floor)	15 credits
Single Bracing (on 1 face of a floor)	10 credits
Any other type of Bracing (on 1 face of a floor)	15 credits
Base Isolation (as a whole)	40 credits
Tuned Mass damper	40 credits
Any other technique	40 credits

- **Bracing-**

- Above credits are given for bracing of a single face of a floor, for subsequent faces credits will get added. (example- if participant wish to provide cross bracing in 5 faces credits counted will be $15*5=75$).
- Popsicle Sticks should not be longitudinally overlapped for bracing (i.e. thickness should be of 1 popsicle stick only).
- As per Architecture requirement, any type of **bracing should not be done in at least 1 face** of upper floor of building (1st floor of building).
- Combination of any mechanisms can be used.
- Violation of any criteria of earthquake resistant Mechanism can lead to direct disqualification.
- **Please go through the testing and judging criteria carefully before deciding on the mechanism.**



*All units in mm

MATERIAL CONSTRAINTS

- Popsicle sticks (maximum length 120 mm, width 12 mm and thickness 2 mm) and Fevicol MR White glue must be used to construct the structure. The Popsicle sticks can be cut or trimmed to any shape or size.
- Adhesive must only be used to join Popsicle sticks together. Adhesives can't be connected on the free surface of a part made of Popsicle sticks to enhance strength.
- Wooden plank can only be used to make the Base Plate of the structure. And 4 screws can be used to attach the superstructure with Base Plate.
- Any other material **can only be used** to incorporate earthquake resistant technique except for bracing (bracing should be made up of popsicle stick).

TESTING CRITERIA

- The structure will be weighed first and all the dimension will be noted down.
- A deadweight of 500 gm will be added on the first floor and the top of building before testing.
- The footing of the structure will be then fixed to a shake table and external dynamic load will be imparted in form of ground motion in the direction of more flexible side of structure. This will be decided by organizing team.
- Two accelerometer will be connected to base of building (not base plate) and top of the structure and at the center of beam.
- A simple harmonic motion will be sweep between frequency of 8Hz and 15Hz and peak acceleration of 2G will be given for time duration of 60 seconds as ground motion to the footing of structure.
- With the help of accelerometer, drift will be recorded which will be further used to calculate maximum drift.

PENALTY

- Penalty Criteria for all above-mentioned rules: Penalty of 5 points will be added for each dimension lying 5 mm beyond the allowance limit.
- Further extension in dimension values, i.e., beyond 5 mm of allowance values will lead to direct disqualification.

JUDGING CRITERIA

- The maximum drift (D) of your Structure.
- The highest maximum drift (D_{max}) among all participants.
- The lowest maximum drift (D_{min}) among all participants.
- Credits used for earthquake resisting mechanism (U)
- Dead weight of the structure (W kg).
- Penalty (P)

MARKING SCHEME

D is the maximum value to the inter-storey drift recorded.

$$\text{Total Score: } S = \frac{(S1+S2)}{W} * \left(1 - \frac{P}{100}\right)$$

$$S1 = \frac{D_{\max} - D}{D_{\max} - D_{\min}} * 70$$

$$S2 = \frac{100 - U}{3}$$

Where P is the total point of penalty incurred by the team and W is the deadweight of building.

Higher the value of the score, higher are your chances of winning!

In case of a tied final score, the team with the lower value of D will receive the higher rank. In the unlikely event, the teams are still tied, the team with lower value of U will receive the higher rank. In the unlikely event, the teams are still tied, the team with lower value of W will receive the higher rank.

RULES

- This competition is a bring from home competition.
- Certificates will be awarded to every participant.
- Student should form teams comprising of minimum 2 members and maximum of 4 members. Students from different colleges can also form single team.
- Once the structure is measured, teams will not be not permitted to change their structure.
- In case that any of these requirements are not met, point deductions (as mentioned) or disqualification might be forced at the sole discretion of the organizers.
- Structure will not be tested if Earthquake resistant mechanism is not used by team.
- No certificate will be provided to disqualified teams.
- Team Aakaar's decision will be last and authoritative on all.
- The organizers hold all rights to change any or all of the above rules as they deem fit.

CONTACT DETAILS

For any queries regarding this competition Email us in Email Id given below. We will try our best to revert back as soon as possible. Please avoid contacting AAKAAR team members directly without following the first step. Queries already mentioned in comments won't be entertained again.

Email Id: aakaar.competitions@gmail.com

(Subject: Query regarding Seismic competition: Team Leader Name_AAKAAR ID)

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