ISUCCES 2017

Challenge in seismic design of structures

Rules for building a small-scale model

http://isucces.sgfos.org/

isucces@sgfos.com

Faculty of Civil Engineering Osijek
Vladimira Preloga 3, Osijek, Croatia

Osijek, 01. March 2017

TABLEOF CONTENTS

1 Introduction 2

2 Model 3

2.1. Material and geometry 3

2.2 Loading 4

2.3 Energy dissipating devices 5

3 Instrumentation 5

4 Scoring 5

4.1 General 5

4.2 Aesthetics and structural design 6

4.3. Obeying the rules 6

4.2 Mass to height ratio 6

4.3 Withstanding earthquake signals 6

5 Final remarks 8

6 FAQ 8

1 INTRODUCTION

Your team has been invited to submit a design for a multi-story building and to verify the seismic load resistance of the building. A small-scale model must be constructed from balsa wood. Models are going to be tested using Quanser's Shake Table II installed at the Faculty of Civil Engineering Osijek.

Figure 1 ISUCCES workshop

The challenge will be held during ISUCCES 2017 days, starting with 9 July till 15 July when the models are going to be tested using Quanser's Shake Table II installed at the Faculty of Civil Engineering Osijek

Challenge objectives:

- ✓ to stimulate international collaboration,
- ✓ to deepen engineering skills and knowledge,
- ✓ to show importance of seismic design of structures,
- ✓ to raise awareness on the importance of teamwork,
- ✓ to provide multicultural interaction.

Although desirable, no knowledge about earthquake engineering is needed to be successful in building the model. Models are going to be built using simple hand tools and soft balsa wood that is easy to cut and shape.

Questions and concerns regarding the design of the model should be directed to the ISUCCES organizing committee via e-mail:isucces@sgfos.com.

N.B. These rules are subjected to change by the organizer. Any changes made will clearly be informed to all participants before the challenge.

2 MODEL

2.1. MATERIAL AND GEOMETRY

Here you can find the rules and limitations (restrictions) for your model. The model must comply with the following dimensions:

✓ Maximum floor plan dimension:	22 x 22 cm
✓ Minimum floor plan dimension:	16 x 16 cm
✓ Maximum building height:	90 cm
✓ Minimum building height:	60 cm
✓ Ground floor height:	15 cm
✓ Characteristic floor height (except ground floor)	12 cm

Model height is measured from the top of the models base plate (i.e. foundation) to its uppermost member. A square plywood plate will be used to attach the model to the shake table. Also, one square plywood plate will be used to attach instrument for measuring acceleration (accelerograph) on the models roof. Roof plate will be attached to the center of the roof to ensure even weight distribution and will be aligned with the base plate.

Models shall be made from balsa wood and the members cross sectional dimensions are:

Rectangular column:	8 mm x 8 mm
Beam:	5 mm x 8 mm
Diagonal (bracing):	5 mm x 5 mm
Shear wall:	5 mm x 20 mm

The model can be connected directly to the base plate while base isolation is also permitted. Columns can be attached to the ends of a shear wall. Connections of members will be made using hot glue.

Figure 2 Process of model building

Floor level diaphragms (slabs) are not required. Weights, that are to be attached by ISUCECES organizing team, will simulate dead and inertia mass of floor diaphragms, walls, furniture and live load.

It is forbidden to cover a whole member, or the most of part of the member with glue. By doing so, one is making a more flexible member → different mechanical characteristics.

N.B. The balsa wood slats come in length of 100 cm. All the balsa wood, plywood plates and tool needed for making the model will be provided by the ISUCCES organizing team during the ISUCCES days. The model is not supposed to be made at home university.

2.2 LOADING

Dead loads and inertia masses will be installed through threaded steel bars with nuts, washers (Fig.3.a) and dumbbell plates (weights) (Fig.3.b). Clear length of threaded bar with nuts and washers at its very ends is 250 mm. Threaded bar diameter is14 mm. Washers have outside diameter equal to 46 mm. These bars will be firmly attached to the frame in the direction perpendicular to shaking.

(a) Bolts, washers and nuts

(b) Dumbbell plates (weights)

Figure 3 Objects for mass simulation

Floor mass: 435 g

Roof mass: 1000 g(plywood plate with extra load and instrument for measuring acceleration)

Threaded bars with nuts, washers and weights will be placed on the top floor, and then on every second floor.Nuts and washers will be tightened by hand to secure weights for testing. This can cause the balsa frame to deflect inwards, if not properly braced. Figure below shows recommended locations for extra beams to prevent deflection of balsa frame due to clamping action of weight attachment (note that Fig.4 shows only a part of the model!)

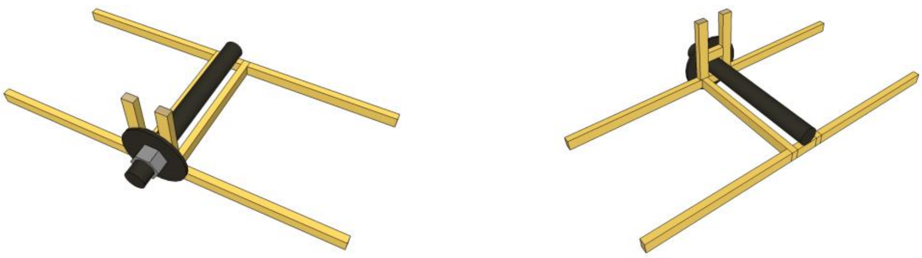

Figure 4 Recomended strenghtening near the mass

There are four types of signals that can be commanded to the shake table:

a) Chirp – sine wave that increases frequency from 1 Hz to 5 Hz in 30 seconds. User can change amplitude.
b) El Centro 1940 –Table tracks position trajectory to replicate the recorded accelerations of the El Centro earthquake.
c) Northridge 1994 – Table tracks position trajectory to replicate the recorded accelerations of the Northridge earthquake.
d) Banja Luka1969 – Table tracks position trajectory to replicate the recorded accelerations of the Banja Luka earthquake.

Note that the maximum amplitude for every signal will be around 2,2 g, which is different from the original signal. If your team needs the signal file for your calculations feel free to contact us and we will send it to you.

Maximum displacement of shaking table:	± 7,00 cm
Frequency domain:	0,25 – 5,00 Hz
Peak velocity that the shaking table can produce:	66,5 cm/s
Peak acceleration that the shaking table can produce:	2,5 g

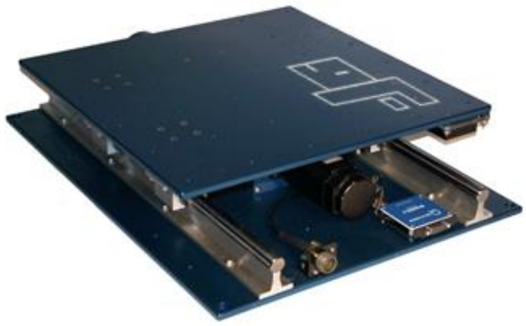

Figure 5 Falcultys shake table

The ISUCCES organizing team will determine the direction of shaking on the model!

2.3 ENERGY DISSIPATING DEVICES (DAMPERS)

Structural damping devices, such as viscous dampers, are allowed and desirable in the design. Any material is allowed to manufacture a damper; however, the dampers should be homemade!

The material for the energy dissipation devices will not be provided by the ISUCCES organizing team.

3 INSTRUMENTATION

Horizontal displacement will be measure in the direction of shaking using accelerographs mounted on the roof of the structure and on the shake table.

4 SCORING

4.1 GENERAL

This section describes the method used to score the models. Maximum points that each team can win is 100. Points are added based on the following criteria:

- ✓ aesthetics and structural design
- ✓ obeying rules
- ✓ minimum mass to height ratio
- ✓ withstanding earthquake signals
- ✓ originality in design, and concept

The team with maximum points collected wins.

Table 1 Points by criteria

Criteria	Points
Aesthetics and structural design	10
Obeying the rules	20
Mass to height ratio	40
Withstanding earthquake signals	30

Before the testing, each model will be evaluated by the ISUCCES organizing team and by one member from each participating team. The most points will be given to the team with more innovative and creative solution and with a model that is neatly assembled. A unique architectural form and quality workmanship is highly desired! Based on the points collected from evaluation, each team will win points as described in Tab.1.

4.2 AESTHETICS AND STRUCTURAL DESIGN

Judges will individually rate each model for the Aesthetic appeal and structural design. Every judge will give a score 1-10 to the models. Then, points given by judges will be summarized and divided by the number of judges. Hence, the equation:

$$AS = \frac{\sum scored\ given\ by\ judges}{\sum judges} \quad (1)$$

4.3. OBEYING THE RULES

Serious rule disobeying can lead to disqualification. In case of smaller deviations from the rules, judges will deduct some part of the maximum points.

4.2 MASS TO HEIGHT RATIO

Each model will be weighed upon completion. The total mass of the bare model with energy dissipating devices installed will be divided by the total height of the model. The total mass does not include threaded bars, nuts and washers, base and roof plates, nor an instrument for measuring acceleration. The smallest mass to height ratio will receive the most point (40). Other models will lose points by the magnitude from which they differ from the best model, by following equation:

$$HT = 40 \cdot \frac{height\ to\ mass\ ratio\ of\ referred\ model}{minimum\ height\ to\ mass\ ratio} \quad (2)$$

4.3 WITHSTANDING EARTHQUAKE SIGNALS

The team will score 3 points for each successful step that model endures. Successful step is considered after the earthquake signal stops, and the model hasn't collapsed or lost its "normal behavior". Braking of a certain member isn't considered a collapse or loss of normal behavior. "Losing normal behavior" is considered when the model acts in the way that any building wouldn't. For example: Due to rubber band glued to the base, the model will not fall out of its dampers even though it "jumps around" . Therefore, model regains its initial position after the signal stops. One can understand that the notion of "jumping around" building isn't normal and so it is considered to be a failed step. See the table below:

Table 2 Points per step

Level	Mass applied by each level	Step (signal)	Points
1.	1kg	Chirp	3
		Northridge	3
		El Centro	3
		Banja Luka	3
2.	2kg	Northridge	3
		El Centro	3
		Banja Luka	3
3.	3kg	Northridge	3
		El Centro	3
		Banja Luka	3
If a model endures the last signal, it gains maximum number of points. From there, model will be subjected to different signals, amplitudes, and masses until it is broken.			

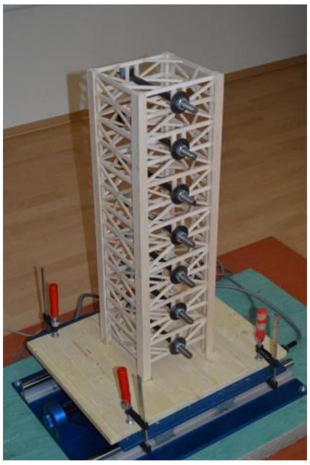

Figure 6 Testing the model

5 FINAL REMARKS

Each team will give a short (max. five-minute) oral presentation of the model before the testing. The presentation will be open to public.

Home university names can be placed at the top of the structure, on a banner or paper (non-structural element). The size of this banner shall not exceed a length of 10 cm and a height of 5 cm.

If financial assistance is provided by external sponsors, their names and/or logos may appear on the structure or on any clothing worn by the team. However, the sponsors should be named below the university name.

6 FAQ

Q: *It is understood that the Isolation should be homemade, but are we free to choose the kind of Isolation System (for example sliding or rubber)? Should we prepare the isolation during the competition, so we should have to bring the materials we need, or we can create it at home and bring it ready to the competition? Are we free to choose the materials?*

A: You can choose any material. Isolation has to be homemade and not purchased from market in one piece. They have to be simple so you can make them with simple tools and techniques. Isolation can be made at home and brought to conference, but you have to make one isolator at conference as a proof that you are able to make it.

Q: *Is the isolation considered to the total height of the building?*

A: No.

Q: *What form should our design be submitted in? e.g. A (.dwg) drawing?*

A: Which you prefer the most (.DWG, .JPEG) but we recommend .PDF

Rules can be subjected to change during the Conference, in case of change, participants will be informed.

BEST OF LUCK!

Your ISUCCES team