Twenty-First Annual Undergraduate
Seismic Design Competition (SDC)

OFFICIAL RULES

Organized and Run by:

EERI Student Leadership Council (SLC)

Competition Website:

https://slc.eeri.org/2024-sdc/

Table of Contents

1. INTRODUCTION

1.1 Competition Objectives

The objectives of the 21st Annual Undergraduate Seismic Design Competition sponsored by EERI are:

- To promote the study of earthquake engineering among undergraduate students.
- To build professional relationships between EERI student members and EERI professional members.
- To provide civil engineering and architecture undergraduate students with an opportunity to work on a hands-on project designing and constructing a cost-effective frame building to resist seismic loading, and to promote collaborations between undergraduate students in different majors.
- To promote EERI activities among undergraduate students as well as the general public, and to encourage international participation in these activities.

1.2 Team Eligibility Requirements

The following eligibility requirements will be strictly enforced:

- Teams must be affiliated with a registered EERI student chapter in good standing. To start a student chapter, please reference the following website: https://www.eeri.org/get-involved/student-chapters/how-to-start-an-eeri-student-chapter
- Exceptions for first year teams creating a new EERI Chapter will be made on a case-by-case basis by the SLC Co-Presidents and EERI staff.
- Teams shall be composed of undergraduate students only. A team shall have at least two registered participants and may have as many undergraduate student participants as they wish.
- Each undergraduate student registered for a team must be a student member of the national EERI organization and a member of the EERI student chapter for the school being represented. Exceptions to this will be made on a case-by-case basis by the SLC Co-Presidents. Decisions by the Co-Presidents are final and may not be appealed.

- Each competing university shall enter only one undergraduate student team and one structure at the competition.

- Each team must complete all registration requirements.

- Any team member who has earned their undergraduate degree between the submission of the design proposal and the start of competition shall be permitted to participate in the competition, provided that their name appears on the design proposal. Team members meeting eligibility requirements can be added to the team roster after the design proposal has been submitted.

- Each team shall identify a team captain who will act as the team liaison for correspondence with the Seismic Design Competition Chairs (SDC Chairs, hereafter).

1.3 Problem Statement

Seattle, Washington is located between Puget Sound and Lake Washington, and is the most populous city in the Pacific Northwest. A popular tourist destination, Seattle is close to Olympic National Park and Mount Rainier National Park. The tallest mountain in the Cascade Range, Mount Rainier, dominates the skyline south of Seattle at over 14,000 ft. The Seattle basin is prone to frequent minor earthquakes which originate from nearby local faults and is located approximately 175 miles away from the Cascadia fault. The port of Seattle-Tacoma is the 4th busiest port in the United States for container traffic; a large magnitude earthquake would not only be a regional economic disaster, but it would also be felt internationally as well.

Your company has been tasked with responding to a request for proposal (RFP) to design a new building in Seattle. The client envisions an iconic and distinctive structure that stands out in the Seattle skyline. To achieve this, the client's request involves a unique approach: the building's footprint is intended to commence with a narrow area at the base, with the area widening at specific levels above the ground (refer to Section 8.2.c and 8.3). To bring this concept to life, the client is seeking the expertise of the architects within your firm to design both the internal area distribution and the exterior aesthetics.

Fortunately, the client has acquired a leveled piece of land in downtown Seattle for this development that is not situated on a slope. Due to the high density of the downtown corridor, additional considerations will need to be taken during construction that need to be addressed within the RFP.

Additionally, the client desires the structural engineers to conceptualize and create an innovative system capable of supporting this level of irregularity. Furthermore, the client has expressed the requirement for adaptability in the mass distribution of the upper floors, in response to the anticipated dynamic changes in floor usage. Considering this, the client, after assembling a team, has proposed a strategy involving the deliberate adjustment of the center of mass for specific floors to achieve calculated distances that align with the client's needs. The distances are presented in Section 8.3.

The client wishes for their building to become a part of the Seattle 2030 District, an interdisciplinary collaboration between the public, private, and nonprofit sectors. This collaborative effort aims to establish a pioneering high-performance building district in downtown Seattle. The primary objectives of this initiative are to mitigate the environmental impacts of building construction and operations, achieve a 50% reduction in building energy consumption, and a 50% reduction in building water consumption.

This collaboration with the City of Seattle is focused on transforming challenges posed by climate change into innovative solutions through the thoughtful design of the built environment. Consequently, the client is making a request for engineers and architects to incorporate ideas within their architectural designs that would enable their building to meet the criteria for acceptance into the 2030 District. Notably, the city plans to reward buildings that meet these stringent standards with various benefits and incentives.

Geotechnically, Seattle is a mix of both hilly and flat areas with a wide range of soils. Alluvium deposits, artificial fill areas, and water tables that fluctuate seasonally are encountered regularly on construction sites. Subsurface investigation information from an adjacent site, including boring logs and geophysical measurements, have been provided as part of the RFP to assist your company in providing preliminary foundation design recommendations.

A scaled balsa wood model of the proposed building design will be constructed and tested to verify the performance of the seismic load-resisting system. The model will be subjected to two ground motions and must not collapse during either of the ground motions; these ground motions will be representative of the Design Earthquake (DE) and Risk-Targeted Maximum Considered Earthquake (MCE_R) as defined in the ASCE/SEI 7-22 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* [1]. The roof drift and roof acceleration will be used to estimate monetary losses due to damage. The monetary losses will account for demolition, reconstruction, and downtime if a collapse occurs.

A cost-benefit analysis will be carried out to determine the most cost-effective building. This will be done by balancing the revenue with the initial building cost and seismic cost.

- The *Annual Revenue* (Section 4.3) will be a function of the rentable floor area. Bonuses in revenue will be given to those teams with the best design proposal, architecture, presentation, poster, and damping bonuses, if present. These bonuses account for the positive effect that quality architecture and effective communication skills can have on increasing the value of the floor area to be sold or rented.

- The *Annual Building Cost* (Section 4.4) will be a function of the weight of the building model. Penalties that increase the initial cost will be applied to those models that do not meet all structural model requirements.

- The *Annual Seismic Cost* (Section 4.5) will be based on the building's seismic performance. A bonus will be given to the teams with the best performance predictions. This bonus will reduce the seismic cost of the building. This accounts for the fact that a detailed structural analysis can improve structural design and lead to desired seismic performance.

The winner of the competition will be the team with the highest *Final Annual Building Income* (Section 4.6) whose building is not deemed collapsed after both ground motions. Teams whose buildings are deemed collapsed will be ranked in a lower category than teams whose buildings are not deemed collapsed.

1.4 Important Deadlines and Deliverables

The following are the deadlines for the SDC deliverables. Cutoff will be at 11:59 PM Pacific Time.

Table 1 Important deadlines and deliverables.

Submittal	**Deadline**
Interest Survey	Friday, October 13, 2023*
Proposal Submission	Friday, December 15, 2023
Proposal Acceptance	Tuesday, January 5, 2024
Damping Proposal Submission	Friday, January 26, 2024
Damping Proposal Acceptance	Monday, February 5, 2024
Final Registration	TBD
Floor Area Calculations & Performance Predictions	TBD

*If a team has not submitted the interest survey but would like to participate in the competition, please contact sdc@eeri.org.

Teams will be invited to participate by January 5, 2024.

The number of teams invited to participate in the competition will be determined by the Student Leadership Council (SLC). The Design Proposal (Section 7.1) will be used to evaluate which teams will be invited to the competition. Invitations will be announced by email to the team captain and advisor by the date listed on the competition website. Historically, most teams have earned an invitation to participate in the SDC by submitting a competitive Design Proposal, and meeting eligibility requirements. However, a growing interest in the SDC has led to an increasing number of applicants. The SLC continues to encourage all eligible teams to submit Design Proposals but retains the ability to restrict the number of invited teams based on time limitations and space availability at the conference venue. Therefore, the SLC recommends paying particular attention to the Design Proposal.

All deadlines, instructions, and forms will be posted on the competition website (listed on the cover page). Teams must be affiliated with a registered EERI student chapter in good standing. To start a student chapter, please refer to the following website: https://www.eeri.org/get-involved/student-chapters/how-to-start-an-eeri-student-chapter. Exceptions for first year teams creating a new EERI chapter will be made on a case-by-case basis by the SLC Co-Presidents and EERI staff. Any team failing to meet the aforementioned eligibility requirements or complete the registration requirements by the deadlines shall not be eligible to compete in the competition.

1.5 Units

The competition will employ United States customary units exclusively for measurements and specifications. Specifically, these include inches (in.) for length and pounds (lb.) for weight and loads. For reference, 1 in. = 25.4 mm and 1 lb. = 4.44822 N.

1.6 Summary of Notable Rule Changes for this Year

This year's competition brings several notable rule changes. Special attention should be given to the ***Design Guide***, which serves as a vital supplement to the Official Rules. Key modifications in comparison to previous editions of the SDC include:

- **Annual Revenue per Floor (Section 4.3):** There has been a change in the annual revenue per floor, which is now based on building zones defined along the height of the structure.

- **Deadloads and Floor Plan Alterations (Sections 9.4, 9.5, and *Design Guide*)**: Significant changes have been made to deadloads, including their locations on the floor plan. Teams must closely adhere to the updated specifications outlined in these sections and the ***Design Guide***.

- **Building Geometry Adjustments (Section 8.2) and Building Zones (Section 8.3):** Building geometry has undergone significant changes, with floor plan dimensions increasing in proportion to height. Additionally, floors are now categorized into distinct building zones along the height.

- **Additional Violation Criteria (Section 4.7):** New criteria for rule violations have been introduced. Participants must familiarize themselves with these additional guidelines to ensure compliance.

- **Ground Motion Selection (Section 9.2):** Teams are required to conduct a ground motion selection as part of their design proposal. Detailed instructions can be found in the *Proposal Requirements* and *Ground Motion Selection Guide* documents.

- **Release of Ground Motions (Section 9.1):** The first ground motion, characterized by lower intensity, will be available on the competition website before Shake Day. However, the specifics of the second ground motion will only be disclosed on Shake Day itself. Teams are expected to utilize their selected ground motions for the proposal as an upper bound for the anticipated demands imposed by the second ground motion.

1.7 Contact Information

Questions about the competition rules, team eligibility, and registration should be directed to: sdc@eeri.org

2. EERI'S CODE OF CONDUCT

EERI's Code of Conduct applies to all members participating in EERI activities, including SDC team members, advisors, and observers involved in the SDC. Portions of the Code of Conduct are included below. **Code of Conduct violations are strictly prohibited and may result in disqualification, non-invitation of individuals or teams to future SDC events, or possible stripping of any titles won. Any disciplinary actions stemming from violations of the Code of Conduct are at the discretion of EERI.**

EERI is committed to fostering the exchange of ideas by providing a safe, productive, and welcoming environment at all EERI activities and on all EERI platforms, including use of the EERI mailing lists or member directory. We value the participation of every member of the community and want all participants to have an enjoyable and fulfilling experience.

All EERI members, event attendees, guests, staff, volunteers, vendors, and partners are expected to be considerate and collaborative, communicating openly with respect for others, and critiquing ideas rather than individuals. Behavior that is acceptable to one person may not be acceptable to another, so use discretion to be sure that respect is communicated.

By accepting an invitation to participate in an EERI event (by email or online registration), engaging in an EERI activity, or using and/or interacting with an EERI platform, participants agree to abide by the EERI Code of Conduct.

2.1 Expected Behavior

All participants are expected to maintain the following behaviors during all EERI activities and on all EERI digital platforms, including unofficial and/or social activities at EERI events:

- Treat all participants, attendees, and EERI staff with respect and consideration at all times.
- Be collaborative, recognizing the value of a diversity of experiences, views, and opinions.
- Communicate openly with respect for others, critiquing ideas rather than individuals. • Be mindful of your surroundings and of your fellow participants. Alert EERI staff if you notice a dangerous situation or someone in distress.
- Abide by the rules and regulations of any digital or virtual platform, physical venue, or any other location associated with an EERI activity or event.

2.2 Unacceptable Behavior

Unacceptable behavior includes but is not limited to:

- Harassment, intimidation, or discrimination in any form.
- Offensive comments, either verbally or through any other communication channel, related to gender, gender identity, sexual orientation, disability, physical appearance, medical condition, body size, race, marital status, religion, national origin, or any other protected characteristic.
- Threats (implied or real) of physical, professional, or financial harm.
- Intentional, uninvited physical contact of any form.
- Behavior that is in violation of EERI expectations for professional conduct and the established ethics policies of one's home institution.
- Harassing, threatening, or offensive images, actions, gestures, or other behavior that are visible or audible to participants or presenters.

2.3 Consequences

Anyone requested to stop unacceptable behavior is expected to comply immediately. EERI may take actions deemed necessary and appropriate, including but not limited to:

- Immediate removal from the event, session, or platform without warning.
- Suspension or termination of membership in EERI, denial to participate in future EERI activities or events, or other action(s) may be taken at EERI’s sole discretion, depending on the severity of the unacceptable behavior. EERI reserves the right to report the circumstances to the appropriate authorities, including but not limited to the police and/or the involved party’s home institution(s).

Reports or evidence of past allegations or institutional proceedings resulting in a finding of professional misconduct, or any current formal complaints related to professional conduct, even if the matter is still pending, may be grounds for:

- Ineligibility or removal from EERI leadership positions.
- Ineligibility or rescindment of an EERI honor, award, or recognition.

The entire EERI Code of Conduct can be found at:

https://www.eeri.org/about-eeri/bylaws/code-of-conduct.

All participants (teams, advisors, and observers) are required to uphold and abide by this code (before, during and after the competition), including any future updates to the code or the annual meeting code that are active at the time of the competition.

All SDC team members, advisors, observers, and SLC leaders are encouraged to report any potential code of conduct violations or unacceptable behavior to EERI. Visit the EERI Code of Conduct website for reporting instructions prior to the competition or use the event-specific reporting form/mechanism shared in advance of the competition during the event.

3. PARTICIPANT ROLE EXPECTATIONS

EERI aims to ensure a safe, fair, and educational competition experience for all participants by clearly defining roles for all participants.

Teams that don’t abide by these role expectations or act in the spirit of these expectations may be subject to disciplinary action and found in violation of the competition rules or code of conduct. Disciplinary action may include disqualification of the team(s) or advisor(s) from participating in the 2024 SDC or future competitions, including stripping of any awards or titles.

3.1 Role Expectations for Undergraduate Team Members

The 2024 SDC is a strictly undergraduate competition, requiring all work contributing to it to be completed solely by registered EERI undergraduate students from the participating College or University. This includes the following:

- The entirety of the contents of the Design Proposal and Damping Device Proposal (if applicable), outlined in Section 4 and Section 7 of the 2024 Official Rules, must be completed by undergraduate students at the participating school.

- The design concept, including the building structural and architectural configuration, must be the work of the undergraduate team members.

- All construction must be completed by undergraduate students at the participating school; this includes the final building model that will be tested on the shake table and any preliminary models constructed prior to the competition (if applicable).

- All numerical and analytical modeling, and calculations related to the 2024 SDC must be completed by undergraduate students. This includes but is not limited to computer modeling of the balsa wood structure, modal analysis, time history analysis and the performance predictions and floor area calculations outlined in Section 4 and Section 8 of the 2024 Official Rules.

- All architectural renderings must be completed by undergraduate students at the participating school.

- Poster and Presentations which will be presented by undergraduate students and graded at the 2024 SDC, must contain contents only contributed by the undergraduate students at the participating school.

3.2 Role Expectations for Advisors

The competition is a student-led effort and teams should only receive limited appropriate feedback and guidance from any advisors. Advisors include, but are not limited to, Faculty Advisors, Industry Professionals, Graduate Student Advisors, Professors/Lecturers, university staff, Alumni, and Team Sponsors.

Advisors may only play a limited role in the 2024 Undergraduate SDC by providing feedback and training for the participating undergraduate students on any problems or questions they may have throughout the process of applying, modeling, constructing, preparing deliverables, and ultimately participating in the SDC. All feedback and guidance should be provided in ways that promote team member learning by guiding them through a constructive line of inquiry, rather than directly proposing solutions or suggestions.

Advisors are not permitted to:

- contribute to any contents of the team proposals, posters, or presentations.
- work on construction of the structure in any capacity; however, the faculty advisor is permitted to oversee the construction for safety concerns but shall not contribute to the physical construction itself.
- contribute to any modeling and calculations required for the 2024 SDC. Advisors may provide feedback that helps the students troubleshoot modeling challenges or errors but may not edit the analytical model directly.
- contribute to any architectural renderings.

Fundraising and travel/shipping logistics may be led or supported by undergraduate team members, Advisors, or other university representatives, as determined appropriate by the host university and EERI Student Chapter Faculty Advisor.

4. SCORING

To test the seismic performance of the proposed design solution, a scaled balsa wood model that is representative of a real building design must be constructed and tested. The model will be subjected to two specific ground motions: **GM#1**, representative of the Design Earthquake (DE), and **GM#2**, representative of the Risk-Targeted Maximum Considered Earthquake (MCE_R) as defined in the ASCE/SEI 7-22 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. In this edition of the SDC, only the GM#1 record will be available before Shake Day.

To ensure life safety, the client requires a design that does not collapse for either **GM#1** or **GM#2**. In addition, the response of the model in terms of roof drift and roof acceleration will be measured for both ground motions. Peak relative roof drift will be used to estimate the monetary loss from structural damage, while peak roof accelerations will be used to estimate the monetary loss due to damaged equipment contained inside the building. If a building is deemed collapsed (as defined in Section 9.10), the monetary losses will account for demolition, reconstruction, and downtime. Finally, the *Annual Seismic Cost* will be the sum of the economic loss estimated for each of the earthquakes divided by their respective return periods.

This section describes the method used to score the performance of the buildings in the seismic competition. Scoring is based on three primary components:

1. Annual Revenue,
2. Annual Building Cost, and
3. Annual Seismic Cost.

The overall measure of structural performance is the *Final Annual Building Income*, which is calculated as the *Annual Revenue* minus the *Annual Building Cost* minus the *Annual Seismic Cost*. In the event of a tie for an award in any category, the *Analysis Prediction Score* (Section 4.2.a) will be used as the tiebreaker.

4.1 Design Proposal, Presentation, Poster, Damping Device and Architecture

The design proposal portion is detailed in Section 7.1. Bonuses in revenue will be given to teams that rank highest in the design proposal, presentation, poster, or architecture scores. These bonuses account for the positive effect of having effective communication skills or architectural appeal that could increase the value of the floor to be sold or rented. An additional bonus can be earned for incorporating a damping device (Section 7.2).

Failure to complete any of the requirements in Sections 4.1.a and 4.1.b will result in an increase in the factor V (Section 4.4). Specific penalties are quantified in each section.

4.1.a Presentation

Each team is required to give an oral presentation of no longer than ten minutes to a panel of judges at the scheduled time for the team. Judges will have up to five minutes to ask questions following the presentation, which can only be answered by the presenters. The presentations will be open to the public.

Teams must follow the instructions and guidelines for the presentation that will be provided in the Presentation Requirements document on the competition website. Failure to follow the Presentation Requirements will lead to ineligibility to receive the presentation annual revenue bonus.

Any team that does not present at the scheduled time will have 100 added to V (Section 4.4).

Teams must submit their presentation files by email before the week of the competition (check the official website for the exact deadline). Any team that does not email their final presentation by the deadline will have 10 added to V (Section 4.4).

4.1.b Poster

Teams are required to display a poster providing an overview of the project. Teams must submit their poster by email *before* the week of the competition (check the official website for exact deadline). Individual teams are responsible for providing the physical poster for display.

Teams must follow the instructions and guidelines for the poster that will be provided in the Poster Requirements document on the competition website. Failure to follow the Poster Requirements will lead to ineligibility to receive the poster annual revenue bonus.

Any team that does not email their poster by the deadline will have 10 added to V (Section 4.4).

Any team that does not have a poster in the display area meeting all requirements in this section by the time listed in the schedule will receive up to 50 added to V (Section 4.4).

4.1.c Architecture

The architecture will be judged based on the aesthetic appeal of the architectural renderings, functionality of the design, consideration of the structural model, and accessibility throughout the building. Renderings on the poster and design of the tower will be used in the architecture score. Refer to the competition website for the score rubric that will be used. Failure to follow the score rubric will lead to ineligibility to receive the architecture annual revenue bonus.

Because not all teams have access to laser cutting, quality of member fabrication will not be considered in the architectural judging.

4.1.d Damping Device Bonus

An *Annual Revenue* bonus will be given to teams that incorporate creative and unique damping devices (Section 7.) into their structure. The damping bonus will be contingent on an accepted damping proposal (Section 7.1) and the proper implementation of the damping device (Section 7.2). The annual revenue bonus quantity will be based on the quality of the proposal, research, and design of the damping device. Damping proposals that are not accepted will not be eligible for the damping bonus. In addition, to receive the damping device bonus, the damping device must deviate from any similar device a previous team from the same school has used in the past four years.

4.1.e Bonus Scoring

The increase in *Annual Revenue* will be determined by the team's rank in the design proposal, oral presentation, poster, and architecture. Only the top 9 teams in each category will receive this benefit. See Table 2 for the percentage increase per rank.

Table 2 *Annual Revenue* bonus.

Rank	Proposal	Presentation	Poster	Architecture
1st	15%	15%	15%	15%
2nd	12%	12%	12%	12%
3rd	10%	10%	10%	10%
4th	8%	8%	8%	8%
5th	6%	6%	6%	6%
6th	4%	4%	4%	4%
7th	3%	3%	3%	3%
8th	2%	2%	2%	2%
9th	1%	1%	1%	1%
≥10th	0%	0%	0%	0%

4.2 Performance Predictions and Floor Area Calculations

A bonus will be given to the teams with the best performance predictions. This bonus will reduce the seismic cost of the building. This accounts for the fact that a detailed structural analysis can improve structural design leading to better seismic performance.

Teams are required to predict the peak roof drift and the peak roof absolute acceleration of the structure under **GM#1** shaking in both the North-South and East-West directions. This means making a total of four predictions: N-S drift, N-S acceleration, E-W drift, and E-W acceleration. Note that only one pair of drift and acceleration values will be utilized based on the specific ground motion direction chosen by the SLC on Shake Day (as outlined in Section 9.6).

These performance predictions must be submitted before the deadline specified on the competition website. Instructions for submission will be provided on the competition website as well. If predictions are not submitted on time, the SDC chairs will assume zero values for all predictions.

4.2.a Performance Predictions Requirements

The *Annual Seismic Cost* will be reduced based on the team's rank in the performance predictions for **GM#1**. Each team must report two values: the peak relative roof displacement in inches (referred to as $Disp_{1,Predicted}$) and the peak absolute roof acceleration (denoted as $Accl_{1,Predicted}$) expressed as a fraction of the standard gravity acceleration g:

$$Disp_{1,Predicted} = \left|\Delta_{1,Roof\ Predicted}\ [\text{in}] - \Delta_{1,Base\ Predicted}\ [\text{in}]\right| \quad (1)$$

$$Accl_{1,Predicted} = \left|Accl_{1,Roof\ Predicted}\ [g]\right| \quad (2)$$

The *Analysis Prediction Score* (APS) is used to evaluate the accuracy of the predicted performance (taken to two significant figures). The APS is defined as the sum of the displacement prediction score, APS_{disp}, and the acceleration prediction score, APS_{accl} is for the peak roof absolute acceleration.

$$APS_{disp} = \frac{\left|\frac{Disp_{1,Predicted}}{Structural\ Model\ Height} - XPeak_1\right|}{XPeak_1} \quad (3)$$

$$APS_{accl} = \frac{\left|Accl_{1,Predicted} - APeak_1\right|}{APeak_1} \quad (4)$$

$$APS = APS_{disp} + APS_{accl} \quad (5)$$

See Section 4.5 for how $XPeak_1$, and $APeak_1$ are determined.

Each team will be ranked based on the accuracy of the predictions. Any team that does not submit a prediction by the deadline will receive an APS equal to 100%. Any team with an APS value greater than 100% will receive an APS value of 100%. The top four teams with the lowest APS, and with an APS value under 100%, are awarded an *Analysis Prediction Score Bonus* (*APS Bonus*). If less than four teams have APS values under 100%, then the *APS Bonus* will only be applied to those teams (i.e., some bonus percentages may not be given). See Table 3 for the percentage increase per rank.

Table 3 *Analysis Prediction Score* bonus.

Rank	APS Bonus
1^{st}	8%
2^{nd}	6%
3^{rd}	4%
4^{th}	2%
$\geq 5^{th}$	0%

4.2.b Floor Area Calculations

Along with performance predictions, teams are required to submit their rentable floor areas (Section 8.2). Submitted floor areas will be verified by the SDC Chairs. Any team that does not submit their rentable floor areas by the deadline will receive the minimum value (Section 8.2.b) for those floors.

4.3 Annual Revenue

The *Annual Revenue* will be based on the total rentable floor area (Section 8.2.d):

- $225 per year per square inch for zone 1 (Section 8.3)
- $325 per year per square inch for zone 2
- $500 per year per square inch for zone 3

The *Annual Revenue* is equal to the sum of each rentable floor area multiplied by its respective revenue per square inch factor.

4.4 Annual Building Cost

The *Annual Building Cost* will be obtained as a function of the *Construction Cost* (C_c), *Additional Construction Cost* (C_a), *Land Cost*, and *Design Life*. No discount rate is considered in these annual cost calculations.

$$C_c = \left(2{,}000{,}000 \left[\frac{\$}{\text{lbf}^2}\right]\right) \times (W_s\ [\text{lbf}])^2 + 6{,}000{,}000\ [\$] \tag{6}$$

$$C_a = (150{,}000\ [\$]) \times V \tag{7}$$

$$Land\ Cost = \left(35{,}000\ \left[\frac{\$}{\text{in}^2}\right]\right) \times \left(A_f[\text{in}^2]\right) \tag{8}$$

$$Design\ Life = 100\ [\text{years}] \tag{9}$$

$$Annual\ Building\ Cost = \frac{C_c[\$] + C_a[\$] + Land\ Cost\ [\$]}{Design\ Life\ [\text{years}]} \tag{10}$$

Any violations will result in an increase in V and will contribute to the *Additional Construction Cost*, C_a. The structural model weight, W_s, is defined in Section 8.13. The building footprint, A_f, is defined as the maximum floor plan area projected onto the base plate in square inches.

4.5 Annual Seismic Cost

The $Annual\ Seismic\ Cost$ will be based on the building's seismic performance, the $Equipment\ Cost$, the $Return\ Period_n$ of a given ground motion **GM#*n***, the structural damage XD_n (Section 9.9.a), the equipment damage AD_n (Section 9.9.b), and $Construction\ Cost$ (Section 4.4).

$$Equiment\ Cost = 15{,}000{,}000\ [\$] \tag{11}$$

$$Return\ Period_1 = 50\ [\text{years}] \tag{12}$$

$$Return\ Period_2 = 300\ [\text{years}] \tag{13}$$

The structural damage as a percentage of the construction cost, XD_n [%], and equipment damage as a percentage of the equipment cost, AD_n [%], for a given ground motion **GM#*n***, are calculated using a cumulative distribution function (Section 9.9) and are defined as follows:

$$XD_n = \text{CDF}(\mu_X\ [\%], \sigma_X[\%], XPeak_n\ [\%]) \tag{14}$$

$$AD_n = \text{CDF}(\mu_A\ [g], \sigma_A[g], APeak_n\ [g]) \tag{15}$$

The mean and standard deviation peak roof drift and mean and standard deviation peak roof acceleration are defined as follows:

$$\mu_X = 1.5\ [\%] \tag{16}$$

$$\sigma_X = 0.5\ [\%] \tag{17}$$

$$\mu_A = 1.75\ [g] \tag{18}$$

$$\sigma_A = 0.7\ [g] \tag{19}$$

The measured peak roof drift, $XPeak_n$ [%], and measured peak roof acceleration, $APeak_n$ $[g]$ for a given ground motion **GM#*n***, are calculated using the absolute roof displacement, absolute base displacement, absolute roof acceleration (Section 9.8), and *Structural Model Height* (Section 8.2.a) and are defined as follows:

$$XPeak_n = \frac{\left|\Delta_{Roof\ n}\ [\text{in}] - \Delta_{Base\ n}\ [\text{in}]\right|}{Structural\ Model\ Height\ [\text{in}]} \tag{20}$$

$$APeak_n = |Accl_n\ [g]| \tag{21}$$

If the structural model is not deemed collapsed (Section 9.10.c) after ground motion **GM#*n*** and all previous ground motions, the *Economic Loss* for the given ground motion, **GM#*n***, will be equal to:

$$Economic\ Loss_n = XD_n\ [\%] \times Construction\ Cost\ [\$] + AD_n\ [\%] \times Equiment\ Cost\ [\$] \tag{22}$$

The accelerometer must be left in place for **GM#2**. However, the data from the accelerometer will not be used for computing XD_n and AD_n for **GM#2**. If the structural model does not collapse after **GM#2**, both XD_n and AD_n will be equal to 50%.

If the structural model is deemed collapsed (Section 9.10.c) after ground motion **GM#*n***, the *Economic Loss* for the given ground motion, **GM#*n***, and subsequent ground motions will be equal to:

$$Economic\ Loss_n = Equipment\ Cost\ [\$] + 2 \times Construction\ Cost\ [\$] + 3 \times Annual\ Revenue\ [\$] \tag{23}$$

The Annual Economic Loss, AEL, for a given ground motion, **GM#*n***, is equal to:

$$AEL_n = \frac{Economic\ Loss_n}{Return\ Period_n} \tag{24}$$

A penalty, D_n, for unsecured floor dead loads will be applied after each ground motion, **GM#*n*** (Section 9.10.a).

The Annual Seismic Cost is equal to:

$$Annual\ Seismic\ Cost = AEL_1(1 + D_1) + AEL_2(1 + D_2) \tag{25}$$

4.6 Final Annual Building Income

The team with the largest Final Annual Building Income ($FABI$) will be the winning team. $FABI$ is equal to the Final Annual Revenue (FAR) minus the Final Annual Building Cost ($FABC$) and Final Annual Seismic Cost ($FASC$).

Final Annual Revenue (FAR) is equal to:

$$FAR = (1 + Proposal\ Bonus + Presentation\ Bonus + Poster\ Bonus + Architecture\ Bonus + Damping\ Device\ Bonus) \times (Annual\ Revenue) \quad (26)$$

Final Annual Building Cost ($FABC$) is equal to:

$$FABC = Annual\ Building\ Cost \quad (27)$$

Final Annual Seismic Cost ($FASC$) is equal to:

$$FASC = (1 - APS\ Bonus) \times Annual\ Seismic\ Cost \quad (28)$$

The Final Annual Building Income ($FABI$) is equal to:

$$FABI = FAR - FABC - FASC \quad (29)$$

4.7 Additional Criteria for Factor V

The SLC reserves the right to assess the addition of a penalty of 30 added to V with the aim of improving rule compliance within the context of the competition. In line with the code of conduct, in the event of disrespectful behavior towards SLC members or other competition participants, including but not limited to participation in disrespectful arguments and disputes or failure to abide by the SLC instructions throughout the competition, penalty might be added. This penalty seeks to uphold respect, discipline, and smooth coordination within the competition's environment.

Additionally, considering the importance of maintaining a clean and organized workspace all participants, teams might be penalized if they neglect to promptly clean up their designated areas for tower construction or setup, especially if they have already received a warning to clean their space. Vacuums or cleaning equipment may not be readily accessible at the venue, and thus teams must be responsible for keeping their space organized and clean.

Furthermore, teams are urged to avoid materials such as Styrofoam beads for packaging due to their challenging cleanup and potential environmental impact. Failure to comply with these guidelines may result in penalties of up to 30 added to V. This directive is in line with the sustainability goals outlined in the Seattle 2030 vision underlining the competition's commitment to eco-conscious practices and encouraging responsible choices in material usage.

These penalties collectively serve to uphold the principles of order, responsibility, and environmental consciousness within the competition, ultimately fostering a more harmonious and sustainable event.

5. SUMMARY OF DISQUALIFICATION RULES

5.1 Code of Conduct and Plagiarism (Section 2)

Code of Conduct violations are strictly prohibited and may result in disqualification, non-invitation of individuals or teams to future SDC events, or possible stripping of any titles won. Any disciplinary actions stemming from violations of the Code of Conduct are at the discretion of EERI.

Plagiarism is strictly prohibited throughout the competition. Taken from OSSJA [2], examples of plagiarism include:

- Taking credit for any work created by another person.
- Copying any work belonging to another person without indicating that the information is copied and properly citing the source of the work.
- If not directly copied, using another person's presentation of ideas without putting it in your own words or form and not giving proper citation.
- Creating false citations that do not correspond to the information you have used.

So-called common knowledge does not need to be cited; for more information, see What is Common Knowledge? | Academic Integrity at MIT [3].

Reports of plagiarism will be investigated as a potential violation of the Code of Conduct and may lead to disqualification.

5.2 Violation of Role Expectations (Section 3)

Teams that do not abide by, or act in the spirit of, the role expectations defined in Section 3 may be subject to disciplinary action and found in violation of the competition rules or code of conduct. Disciplinary action may include disqualification of the team(s) or advisor(s) from participating in the 2024 SDC or future competitions, including stripping of any awards or titles.

5.3 Structural Model Materials (Section 8.1)

All frame members and wall members shall be made of balsa wood.

5.4 Building Zones (Section 8.3)

The structural model of the building is divided into distinct building zones, each characterized by specific features and floor areas. Violating these requirements will result in the structural model not being tested on the shake table and the structure deemed as collapsed for all ground motions.

5.5 Floor Isolation (Section 8.2.e)

Floor isolation of any kind is strictly prohibited. This includes isolating floor dead loads and the roof plate.

5.6 Damping Devices (Section 7.2)

Any use of a damping device that is not pre-approved or in a pre-approved location will result in disqualification.

5.7 Building Finish

The finish on all frame and wall members must be bare wood. Paint or other coatings will not be allowed on any portion of the model.

5.8 Appealing after Signing Scoring Sheet(s) (Section 10)

If a team captain tries to make an appeal for penalties assessed on the scoring sheet(s) already signed, the team captain will be warned. If after the team captain is warned and they attempt to continue appealing for penalties assessed on the scoring sheet(s) already signed, the team will be disqualified.

5.9 Judging and Appealing (Section 12)

Under no circumstances may anyone, other than the **team captain,** approach an SDC Chair regarding penalties or scoring. This includes but is not limited to other teammates, alumni, professors, and especially other SLC members. If this becomes an issue, the team captain will be warned, and in extreme cases, the SDC Chairs reserve the right to disqualify the team.

6. COMPETITION AWARDS

6.1 Competition Winner and Ranking

The team that designs the building with the highest Final Annual Building Income ($FABI$) that is not deemed collapsed in any of the two ground motions will be the winner of the competition.

Teams whose buildings collapse will be ranked in a lower category than teams whose buildings do not collapse. Within each category, teams will be ranked based on the Final Annual Building Income, $FABI$.

The teams ranked overall 2nd and 3rd will also be awarded.

6.2 Honorable Mentions

Two honorable mentions will be awarded to a team that exemplifies strong performances in individual aspects of the competition:

- An Honorable Mention for Best Architecture will be awarded to the team ranked 1st in architecture.

- An Honorable Mention for Best Seismic Performance will be awarded to the team with the lowest Final Annual Seismic Cost, $FASC$.

6.3 Best Communication Skills Award

An award will be given to the team that best exemplifies professional communications throughout all facets of the competition. The communications score will be primarily considered for this award, but the SLC reserves the right to consider other variables as needed to determine the winner.

$$\begin{aligned} Communications\ score &= 1.5(Presentation\ Score) + (Poster\ Score) \\ &+ (Proposal\ Score) \end{aligned} \tag{30}$$

The SLC reserves the right to assess a penalty of a 5% reduction in the communications score to any team which demonstrates unprofessional written or oral communications to the SLC members at any time leading up to or during the competition.

6.4 Charles Richter Award for the Spirit of the Competition

The most well-known earthquake magnitude scale is the Richter scale which was developed in 1935 by Charles Richter of the California Institute of Technology. In honor of his contribution to earthquake engineering, the team which best exemplifies the spirit of the competition will be awarded the Charles Richter Award for the Spirit of Competition. The winner for this award will be determined by the participating teams.

6.5 Egor Popov Award for Structural Innovation

Egor Popov was a Professor at the University of California, Berkeley for almost 55 years before he passed away in 2001. Popov was born in Russia and escaped to Manchuria in 1917 during the Russian Revolution. After spending his youth in China, he immigrated to the U.S. and studied at UC Berkeley, Cal Tech, MIT, and Stanford. Popov conducted research that led to many advances in seismic design of steel frame connections and systems, including eccentric bracing. In honor of his contribution to structural and earthquake engineering, the team which makes the best use of technology and/or structural design to resist seismic loading will be awarded the Egor Popov Award for Structural Innovation. The winner of this award will be determined by the SLC members.

6.6 Most Improved Team

Learning from the design process is an important aspect of the SDC. This award will be given to the team that has shown the most improvement from last year's SDC. The scores will be normalized from the 2023 SDC results, and the team with the largest improvement will receive this award. Participation in the 20th annual SDC is required to be eligible for this award.

6.7 Rookie of the SDC

Competing in the SDC for the first time can be an entire challenge of its own. This award will be given to a new team with the highest $FABI$. A new team will be defined as a team that has not participated in any stage of the SDC within the past four years.

7. DESIGN PROPOSALS AND DAMPING DEVICE APPROVAL PROCESS

7.1 Design Proposals

Your team is required to submit a proposal for evaluation by the SDC Chairs. Invitation to participate in the competition will be determined by the proposal score. If a team fails to submit their proposal by the deadline, they will not be invited to participate in the competition. The number of accepted teams will be based on time limitations and space availability at the conference venue. A bonus score multiplier will be awarded to the nine best proposals (Section 4.1.e). Teams must follow the instructions and guidelines for the proposal that are provided in the *Proposal Requirements* document on the competition website.

7.2 Damping Device Approval Process

All proposed damping devices shall be subject to the approval process. A separate PDF document shall be submitted to sdc@eeri.org. The requirements of the damper proposal can be found on the competition website. This year, the accepted damping proposals will be eligible to be awarded a bonus up to 9% (Section 4.1.d). The date of the submission of the damping device proposal is shown in Table 1. The proposed damping device must be described in detail, explaining the materials used and the device's placement(s) within the structural model. Figures are highly recommended to aid in describing the damping device.

The SDC Chairs will evaluate the proposal based on the rubric that can be found in the *Damper Proposal Requirements* document. Approved damping devices are required to be used in the submitted structural model at the competition and will be checked by the SDC Chairs prior to the competition.

The criteria used by the judges to approve a damping system are as follows:

- If the damping system is removed, the balsa wood structure, with all dead load weights attached, should be stable and firmly fixed to the base plate.
- The primary purpose of the pre-approved damping devices is to dissipate energy.
- Base or floor isolation of any kind is prohibited.
- The proposal meets all the guidelines that are provided in the Damping Device Proposal Requirements on the competition website.

General notes:

- Damping devices may be attached to the base plate.
- All damping devices should dissipate energy at each location used in the structural model.
- Any material is allowed to be used in a damping device.
- The damping device must be designed by the team and cannot come pre-made or in a kit.
- 3D printing objects for the damping device is acceptable as long as the object is designed by the team and not pre-made.

If a damping device is approved, the damping device shall not deviate from the proposed design approved through this process in the final structural model. If a team wishes to change their damping device in any way (e.g., installation location, connection to structure, material, etc.) after the results of the damper proposal, they must submit a revised damper proposal; however, they will lose any bonus given to them in this category. Moreover, the device may only be located at the approved locations. Furthermore, the damping device must not interfere with dead load installation locations.

Teams must submit only one damping device proposal by the final deadline. If the device is not approved, and it is after the final deadline, teams are not allowed to use the disapproved device on their model.

All damping devices will be checked during pre-judging of structures. Damping devices that have not been approved by the SDC Chairs or deviate from the approved damping device proposal (e.g., installation location, connection to structure, material, etc.) will have to be removed, and the team will lose the corresponding bonus. If a team is unable to remove an unapproved damping device, the structure will be considered collapsed for all ground motions.

8. STRUCTURAL MODEL

This section describes the rules and limitations to be followed for the structural model. Most violations will result in penalties added to V (Section 4.4). Some violations may result in disqualification. Penalties will be given in accordance with the official rules and at the discretion of the judges. The SLC reserves the right to cap violations as needed in accordance with the spirit of the competition.

Structural models shall be constructed of only balsa wood (Section 8.1), frame members (Section 8.4) and balsa wood wall members (Section 8.5) that are attached to a structural model base plate (Section 8.8) with a structural model roof plate attached on top of the structural model (Section 8.9). Pre-approved damping devices may be made of any material (Section 8.10). All connections requirements are provided in Section 8.6. Floor labels (Section 8.12) and the school's name at the top of the building (Section 8.12) may be constructed out of paper.

Any architectural features (i.e., features not intended for structural purposes) on the model must be made of balsa wood (Section 8.1) and meet all the requirements for a frame member (Section 8.4) or wall member (Section 8.5) including all connection requirements (Section 8.6).

8.1 Structural Model Materials

Any violation of this section will result in the structural model not being tested on the shake table and the team being disqualified.

All frame members and wall members shall be made of balsa wood.

8.2 Structural Floor Plan

8.2.a Floor and Roof Requirements

Each violation of this section will result in 5 added to V.

The total number of floors in the structural model, denoted as F, must fall within the specified range of minimum and maximum floors. A floor is defined in detail in Section 8.2.b.

- Maximum number of floors: $F \leq 19$
- Minimum number of floors: $F \geq 15$

A floor, f, as defined in Section 8.2.b, is required to be within ¼ in. tolerance at specific elevations measured from the top of the base plate to the top of the perimeter beams at the floor level.

For instance, the lobby area at $f = 1$ must be precisely at zero inches elevation. For floors ranging from $f = 2$ to the top floor ($f = F$), elevations must adhere to the guidelines outlined in Table 4.

A roof is required above the topmost floor ($f = F$) at the height indicated in Table 4. While the roof does not contribute to the floor count or rentable area, it must adhere to the specifications detailed for a typical floor in Section 8.2.b. Additionally, the roof must have identical floor plan dimensions to the floor directly beneath it (i.e., floor F) as specified in Section 8.2.c. Furthermore, the structural model's roof plate (as described in Section 8.9) must be affixed to the roof structure.

The requirements in this section will be checked with a measuring device along the side of the structural model. All floor height measurements will be measured from the top of the base plate**.**

8.2.b Floor Definition

Each floor in violation of the requirements in this section will result in 5 added to V.

To be considered a floor, the following requirements must be met:

- A continuous set of perimeter beams shall clearly define the floor where the top of the perimeter beams defines the floor. Walls and non-horizontal frame members may interrupt the continuous set of perimeter beams as long as two horizontal members acting as perimeter beams are at the same elevation and connected to the interrupting member(s). Interior floor beams shall be flush with the top of the perimeter beams. The plane defined by the top of the perimeter beams, the floor, shall be flat and level.

- Using a black permanent marker, a dot should be centrally placed on the top of each perimeter beam, so judges know which beams define the floor area for a given floor.

- The lobby floor is defined by straight black permanent marker lines drawn on the base plate between frame or wall members attached to the base plate. A beam at the second-floor level shall be directly parallel to any straight black line drawn on the base plate.

- The continuous set of perimeter beams will be checked visually. Rentable floor area will be checked with a ruler or other measuring device. The floor will be checked for levelness by using a level. If the bubble on the level is completely outside of the level lines, the floor is not considered level. The structural model will be placed on a level floor or table when performing this check.

Table 4 Floor and roof elevations.

Floor, $\boldsymbol{f}$	Elevation [in] corresponding to buildings of varying heights, denoted by the number of floors, $\boldsymbol{F}$.				
	$\boldsymbol{F = 15}$	$\boldsymbol{F = 16}$	$\boldsymbol{F = 17}$	$\boldsymbol{F = 18}$	$\boldsymbol{F = 19}$
1st	0	0	0	0	0
2nd	6	6	6	6	6
3rd	9	9	9	9	9
4th	12	12	12	12	12
5th	15	15	15	15	15
6th	18	18	18	18	18
7th	21	21	21	21	21
8th	24	24	24	24	24
9th	27	27	27	27	27
10th	30	30	30	30	30
11th	36	33	33	33	33
12th	39	39	36	36	36
13th	42	42	42	39	39
14th	45	45	45	45	42
15th	48	48	48	48	48
16th		51	51	51	51
17th			54	54	54
18th				57	57
19th					60
Roof	51	54	57	60	63

Note: colors and thick borders indicate building zones, as defined in Section 8.3.

8.2.c Maximum Floor Plan Dimensions

Each floor in violation of the requirements in this section will result in 5 added to V.

The maximum floor plan dimensions (inches) are defined in Figure 1 for different building zones along the height of the structural model. These zones are defined in Section 8.3. All floors of the model must fit within the specified floor plan dimensions. No members may be placed within the hatched areas of these figures.

To check this requirement, a template with a cutout of the maximum floor plan dimensions will be passed over the structural model. Said template will have a tolerance of 1/16 of an inch in each dimension. The template shall remain parallel to the top surface of the structural model base plate as it passes over the structural model. The template cannot be rotated as it is passed over the structure. The floor(s) where the template cannot freely pass over will be in violation of this section. Teams will not be allowed to bend or force the template over any floors.

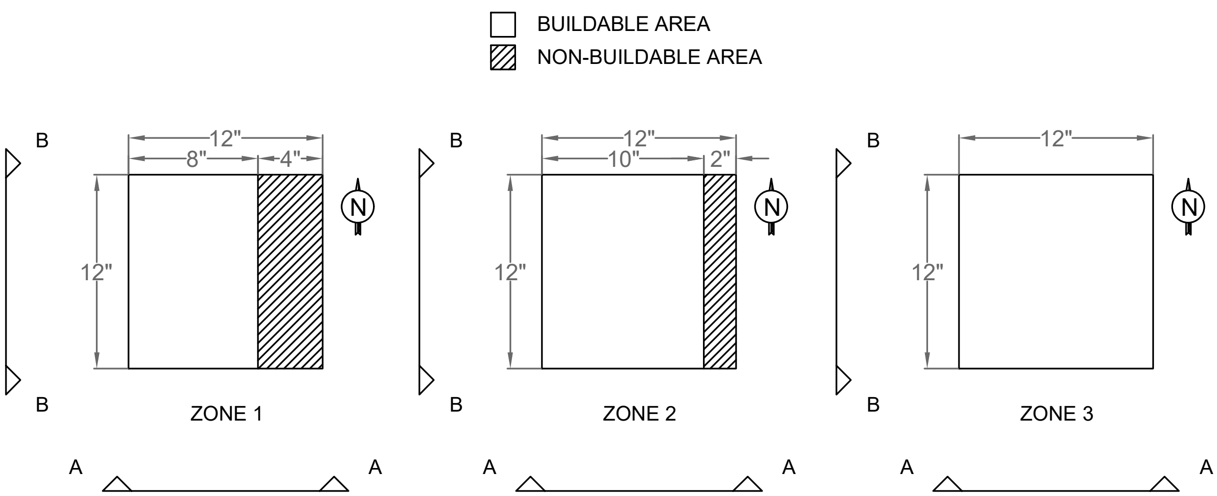

Figure 1 Buildable floor areas for a typical floor in different building zones.

8.2.d *Rentable Floor Area*

Any floor area that violates the requirements in this section shall not count towards rentable floor area.

A floor shall have at least 80 in^2 of rentable area.

Rentable floor area may only be within the continuous perimeter beams of the floor (Section 8.2.b).

At floor level, the distance between any two structural members (perimeter beams, interior beams, or vertical wall members) is required to be between

0.5 inches and 2.5 inches, measured perpendicular to the members and parallel to the floor plane.

Each rentable floor area is calculated using the total plan area defined by the perimeter beams, meeting Section 8.2.b and this section's requirements. Individual structural members penetrating the rentable floor area (frame members and wall members) are not subtracted from the rentable floor area.

Maximum rentable total floor area for different building heights is specified in Table 5.

The total rentable floor area will be calculated by summing the individual rentable floor areas from the bottom up. If the maximum rentable total floor area is reached, the remaining rentable floor areas above will not count.

The minimum height clearance for rentable floor area is 2.25 in.

Occupants on the rentable floor must be able to access any area of the rentable floor through at least one access point or doorway originating from the interior of the structure. The exterior of the building may not be used as an access point. Additionally, occupants on the lobby floor, or $f = 1$, should be able to access the exterior of the building through at least two access points or doorways. A sufficient access point is defined as a clear opening with the following minimum dimensions:

- Width: 1 in.
- Height: 2.25 in.

Table 5 Maximum total rentable area.

Number of floors, ***F***	15	16	17	18	19
Maximum rentable total floor area [in^2]	1872	1968	2064	2160	2256

8.2.e Floor Isolation

Any violation of this section will result in the structural model not being tested on the shake table and the team disqualified.

Floor isolation of any kind is strictly prohibited. This includes isolating floor dead loads and the roof plate.

8.3 Building Zones

Violating these requirements will result in the structural model not being tested on the shake table and the structure deemed as collapsed for all ground motions.

The structural model of the building is divided into distinct building zones, each characterized by specific features and floor areas. Building zones are illustrated for the cases of $F = 19$ and $F = 15$ in Figure 2. These zones are designed to accommodate rentable spaces while adhering to a unique structural floor plan.

- *Building Zone 3* comprises the uppermost 6 floors of the structure. It stands out as the largest among the building zones, offering a spacious and expansive floor area. The lowermost floor of this zone features a double-height space, providing an opportunity for architectural creativity and innovation.

- Located just below Zone 3, *Building Zone 2* encompasses the subsequent 6 floors. While smaller in area compared to Zone 3, these floors still offer a substantial rentable space.

- *Building Zone 1* consists of the remaining lower floors of the structure. These floors have the smallest rentable area among the building zones. Additionally, Zone 1 includes a lobby at the first floor that boasts a double-height ceiling, creating a grand and welcoming entrance for visitors.

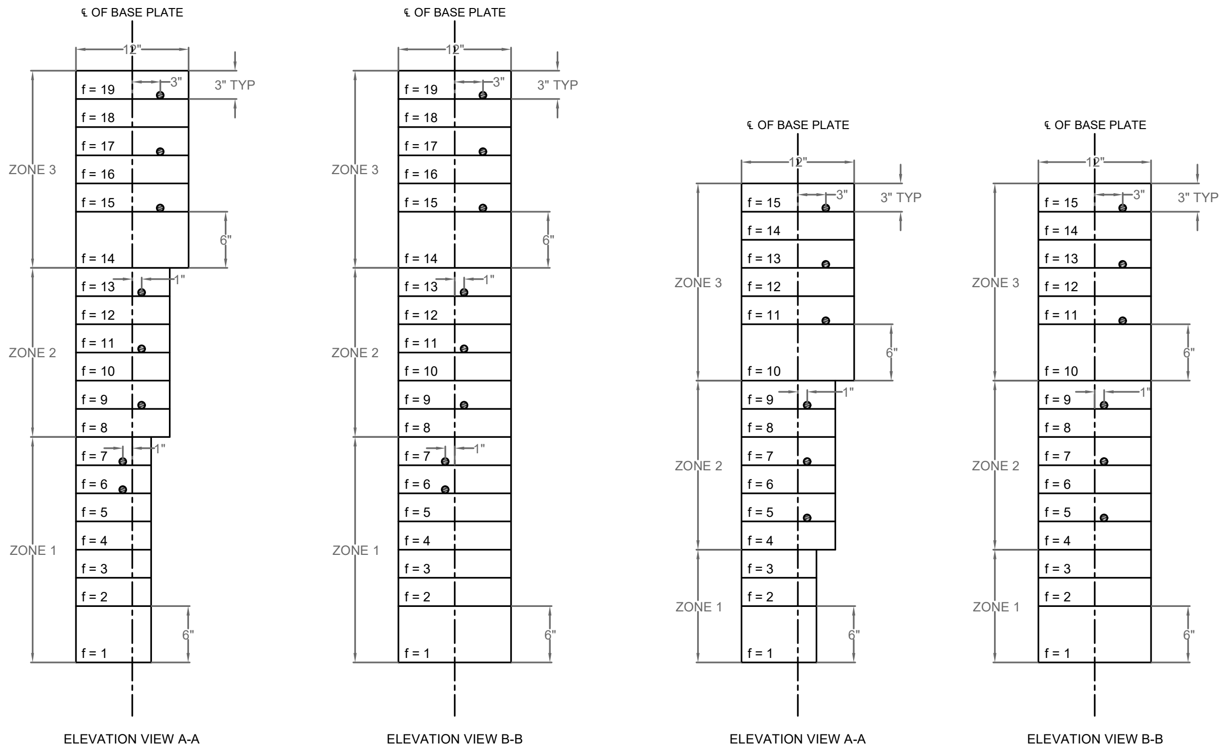

Figure 2 Illustration of building zones in the structural model for $\boldsymbol{F = 19}$ and $\boldsymbol{F = 15}$. Refer to Figure 1 for notation used in elevation views. Black-filled circles represent the location of dead loads for shake-table testing.

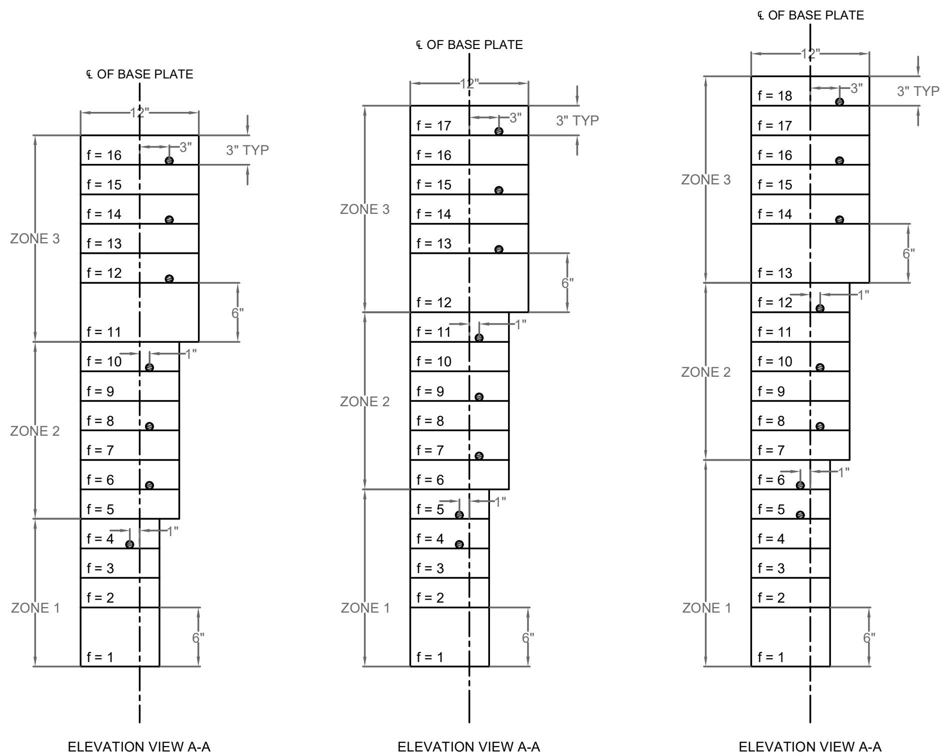

Figure 3 Illustration of building zones in the structural model for $\boldsymbol{F = 16}$, $\boldsymbol{F = 17}$, and $\boldsymbol{F = 18}$. Refer to Figure 1 for notation used in elevation views. Black-filled circles represent the location of dead loads for shake-table testing.

8.4 Frame Members

8.4.a Frame Member Dimensions

Each member found to be in violation will be assessed a penalty of 2 added to V for every 0.100 in. increment in unit length found to be in violation. Dimensions between increments will be rounded up. A tolerance of 0.01 in. shall apply.

Each individual frame member in its final state attached to the model shall fit in a 0.200 in. by 0.200 in. by 15.000 in. box.

Each individual frame member shall have no individual dimension smaller than 0.09 in.

Any two adjacent vertical frame members must have a clear space of at least 0.25 in. between them. This requirement does not apply to horizontal or inclined frame members.

Individual frame members will not be removed from the model to check the requirements for this section. Instead, a caliper or other measuring device will be used to check the requirements for this section. Judges must be able to visually observe the extent of all members for measuring. Judges reserve the right to use destructive inspection methods after completion of shaking to assess penalties in this section.

8.4.b Frame Member Requirements

Each violation of this section will result in 3 added to V.

Any frame member to frame member connections not easily visible to the naked eye shall be marked with a black arrow pointing to the connection.

8.5 Wall Members

8.5.a Wall Member Dimensions

Each member found to be in violation will be assessed a penalty of 3 V for every 0.100 in. increment in unit length found to be in violation. Dimensions between increments will be rounded up. A tolerance of 0.01 in. shall apply.

Each individual wall member in its final state attached to the model shall fit in a 0.100 in. by 3.000 in. by 11.000 in. box.

A wall member must span vertically (measured perpendicular to the base plate) at least 2.75 in. When measured along the base plate, one of its dimensions (referred to as the wall width) should also be a minimum of 1.0 in. Consequently, walls with a triangular shape do not meet these requirements.

Individual wall members will not be removed from the model to check the requirements for this section. Instead, a caliper or other measuring device will be used to check the requirements for this section. Judges must be able to visually observe the extent of all members for measuring. Judges reserve the right to use destructive inspection methods after completion of shaking and assess penalties in this section.

8.5.b Wall Member Requirements

Each violation of this section will result in 3 added to V.

A wall shall be oriented so that the direction of the grain of wood is normal to the top surface of the structural model base plate.

Wall members shall have a continuous load path to the base plate to transfer forces to the ground level.

8.6 Structural Connections

8.6.a Connection Requirements

Each violation of this section will result in 3 added to V.

Only glue shall be used between the contact surfaces of individual members. There are no restrictions on the type of glue.

Glue shall only be present at the faying surfaces of individual members unless deemed excess glue. The faying surface is defined as the surface or portion of a surface of a member in direct contact with the surface or portion of a surface of another member. Excess glue must be confined to 0.5 in. in any direction of the edge of any faying surface.

Any members in contact must have glue between the faying surfaces of the two members. It is the discretion of the SDC Chairs to assess V for unglued connections if that connection (regardless of if the two adjoining members are close but are not touching) is reasonably expected to be joined. For example, floor beam elements can be reasonably expected to be connected to perimeter beams and are typically not cantilevered within a footprint of perimeter beams. This requirement is applicable for connections between any types of members (frame, wall, or gusset).

All frame members and wall members in contact with the base plate must be glued to the base plate.

All frame members and wall members in contact with the roof plate must be glued to the roof plate.

8.6.b Frame Member to Frame Member Connections

Each violation of this section will result in 3 added to V.

A faying surface shall not exceed 1 in. in any direction from the centroid of the faying surface. For each inch that a faying surface exceeds the 1 in. maximum from the centroid (e.g., 2 in. faying surface), an additional 3 will be added to V. Each surface in contact with another surface will be considered a faying surface.

8.6.c Gusset Plates

Each violation of this section will result in 3 added to V.

Gusset plates are permitted but shall not be in contact with any wall members. A gusset plate shall be in contact with and glued to at least two frame members in contact. Individual gusset plates shall not be in contact with one another. Each gusset plate shall fit in a 0.100 in. by 1 in. by 1 in. box.

Individual gusset plates will not be removed from the model to check the requirements for this section. Instead, a caliper will be used to check the requirements for this section.

8.6.d Wall Member to Wall Member Connections

Each violation of this section will result in 3 added to V.

There is no restriction on the length of faying surface in wall member to wall member connections.

All wall members in their final glued state must have a thickness less than or equal to 0.1 in.

8.7 Floor Dead Load Connections

Floor dead loads will be added to the structural model prior to shake testing in the form of threaded rods (Section 9.4 and 9.5). The floor dead load will require sufficient support for gravity loading and lateral seismic loading.

8.7.a Floor Dead Load Connection Design Requirements

Each violation of this section will result in 5 added to V.

All members used in floor dead load connections must conform to frame or wall member requirements (Sections 8.4 to 8.6).

Floor dead load connections are required in both North-South and East-West directions and to be placed according to Figure 2 and the drawings found in the ***Design Guide***.

The floor dead load connection shall be designed so that the bottom of the threaded rod is resting on top of the perimeter floor beams at the following floors:

- For $F = 15$, on floors f = 5, 7, 9, 11, 13, and 15.
- For $F = 16$, on floors f = 4, 6, 8, 10, 12, 14, and 16.
- For $F = 17$, on floors f = 4, 5, 7, 9, 11, 13, 15, and 17.
- For $F = 18$, on floors f = 5, 6, 8, 10, 12, 14, 16, and 18.
- For $F = 19$, on floors f = 6, 7, 9, 11, 13, 15, 17, and 19.

Refer to Section 8.3 for details on the floor numbering scheme, including definitions of f and F.

The dead weights should be able to be installed and nuts be tightened to ensure a snug fit without breaking any of the connections, frame members, or wall members in the structural model.

Floor dead loads will be secured to the structure using nuts and washers.

8.7.b Floor Dead Load Connection Recommendations

A time limit will be implemented for teams installing floor dead loads (Section 9.5.a). Ensure the connections are not too intricate that they require an excessive amount of time to install.

The connection should be strong enough for the team to tighten the nuts enough to engage adequate friction between the innermost washer and the exterior face of the building to ensure the floor dead load is secure (see Section 9.5.a)

It is *strongly* recommended that each team purchase a sample weight to try out and ensure proper attachment. Penalties will be assessed for dead weights that are not secured to the structural model after each ground motion testing and may result in judges deeming the building collapsed (Sections 9.10.b and 9.10.c).

8.8 Structural Model Base Plate

8.8.a Structural Model Base Plate Plan Dimensions

Any dimensional violation in this section greater than 0.25 in. may result in the judges not allowing the structural model to be tested on the shake table and, therefore, the model will be assumed collapsed for both ground motions.

An 18.00 in. by 18.00 in. square continuous wooden (Plywood or MDF) base plate will be used to attach the model to the shake table. Teams are responsible for providing a wood base plate.

For the 2024 SDC, the structural model should have increasing floor area with increasing height, occurring only on one side of the building and not symmetrically (Figure 2). To ensure uniformity and proper alignment, teams are required to install the structural model on the base plate such that the center of the top floor aligns with the centroid of the base plate. The outer perimeter of the structure at any level should not be closer than 1.25 in from the outside edge of the structural model base plate to allow securing the structural model to the shake table (Section 9.6).

All measurements will be checked with a tape measure or other measuring device.

8.8.b *Structural Model Base Plate Thickness Dimensions*

Any dimensional violation in this section resulting in the base plate thickness falling outside of the indicated range may result in the judges not allowing the structural model to be tested on the shake table and assuming the model is collapsed for both ground motions.

The wood base plate shall be between 0.25 in. to 0.50 in. thick.

All measurements will be checked with a caliper.

8.8.c *Structural Model Base Plate Requirements*

The model will not be tested if the base plate does not meet the requirements in Sections 9.10.a and 9.10.b. In this case, the model would be considered collapsed for both ground motions.

Notching the base plate is allowed but only at locations where a frame member or wall member is in contact with the base plate. The notched area must be filled in completely with the frame member, wall member, or glue. Glue may not be present 1/4 in. from the edge of any member breaking the plane of the top of the base plate visible from the top of the base plate. Each violation of the requirements for notching the base plate will result in 5 added to V.

Excessive notching is not permitted. The judges will add 100 to V in cases where excessive notching is found.

On the top of the base plate, a letter 'N' or the word 'North' shall be written with black permanent marker within 1 in. from the North edge and within 6 in. of the East edge of the base plate. The 'N' sign needs to conform with the direction specified in Figure 1.

The bottom of the base plate must be flat and smooth. If the judges deem the structural model cannot be firmly affixed to the shake table, the accelerometer will not be attached to the structural model and maximum damage will be assumed for the first ground motion. If the structural model cannot be physically attached to the shake table, the structural model will not be tested, and the structural model will be assumed collapsed for both ground motions. Failure of the base plate (i.e., delamination, crushing or fracture) that causes the structure to become unstable, to rock back and forth unattached from the base, or to fall off the shake table is considered a collapse of the structure.

A hole, no larger than 1/4 in. diameter, may be drilled no further than 2 inches from each corner to secure the structural model for shipping. That means a total of four holes may be drilled in the base plate for securing the model to ship.

A second identical wood base plate shall be provided by the team for judges to weigh in lieu of weighing the base plate attached to the structural model. The second identical base plate shall have the name of the school written in black permanent marker. Identical notching is not necessary in the second base plate. If the judges deem the second base plate is not identical or the team fails to provide a second identical plate, the judges will assign the base plate a tare weight of 0.0 lbs. Therefore, the weight of the base plate will be included in the Structural Model Weight W_s (Section 8.13) used for scoring purposes.

8.9 Structural Model Roof Plate

The structural model roof plate will be where the accelerometer is attached for shaking. Care must be taken when designing the roof beams to allow for two C-clamps to clamp the accelerometer to two diagonally opposing corners of the structural model roof plate. The structural model roof plate shall be level and centered on the roof so that the centroid of the roof plate coincides vertically with the centroid of the base plate. If the judges deem the roof plate is not level or centered, the accelerometer will not be attached to the model. If the accelerometer cannot be attached to the model for any reason, the team will receive an APS equal to 100% (Section 4.2).

8.9.a Structural Model Roof Plate Plan Dimensions

Any dimensional violation in this section greater than 0.25 in. may result in the judges not allowing the accelerometer to be attached to the structural model during shaking.

A 6.00 in by 6.00 in square continuous wood roof plate is needed to attach the accelerometer to the building. The roof must contain the entire square roof plate on its surface. No part of the roof plate is allowed to not land on the roof surface.

All plan measurements will be checked with a tape measure or other measuring device.

8.9.b Structural Model Roof Plate Thickness Dimensions

Any dimensional violation resulting in the roof plate thickness falling outside of the indicated range will result in 20 added to V and may also result in the judges not allowing the accelerometer to be attached to the structural model during shaking.

The roof plate thickness shall be between 0.3 in. and 0.4 in. Therefore, teams are recommended to use 3/8 in. plywood or MDF plates and independently verify that the measured thickness falls within the indicated range.

All thickness measurements will be checked with a caliper.

8.9.c Structural Model Roof Plate Requirements

Due to safety concerns, the roof accelerometer will not be attached if the roof plate does not meet the requirements in Sections 8.9.a and 8.9.b.

Notching the roof plate is allowed, but only at locations where a frame member or wall member are in contact with the roof plate. The notched area must be filled in completely with the frame member, wall member, or glue. Glue may not be present 1/4 in. from any edge of a member breaking the plane of the bottom of the roof plate visible from the bottom of the roof plate. Each violation of the requirements for notching the roof plate will result in 5 added to V.

The top of the roof plate must be flat and smooth. If the judges deem the accelerometer is not firmly affixed to the structural model using two C-clamps (scaled drawings of the C-clamps will be provided in the ***Design Guide***), the accelerometer will not be attached to the structural model.

A second identical wood roof plate shall be provided by the team for judges to weigh in lieu of weighing the roof plate attached to the structural model. The second identical roof plate shall have the name of the school written in black permanent marker. Identical notching is not necessary in the second roof plate. If the judges deem the second roof plate is not identical or the team fails to provide a second identical plate, the judges will assign the roof plate a tare weight of 0.0 lbs. Therefore, the weight of the roof plate will be included in the Structural Model Weight W_S (Section 8.13) used for scoring purposes.

8.10 Innovative Damping Devices

All damping devices must be approved in the Damping Device Approval Process (Section 7.2). Any use of a damping device that is not pre-approved or in a pre-approved location will result in disqualification. The implementation of such a device needs to allow for the placement of weights as discussed in Section 8.6.

8.11 Building Finish

Any violation of this section will result in the structural model not being tested on the shake table and the team being disqualified.

The finish on all frame and wall members must be bare wood. Paint or other coatings will **not** be allowed on any portion of the model. Burned surfaces from laser cutting are permitted.

8.12 Building Display Requirements

Failure to meet all requirements in this section by the designated time listed in the schedule will result in 5 added to V. (Section 4.4). Incorrect floor numbering, if dead load connections are correctly placed, will also result in 5 added to V. Incorrect numbering causing load misplacement will result in the building not being tested at the shake table and deemed as collapsed for all ground motions.

The school's name shall be displayed at the top of the building facing all four cardinal directions (North, East, South, and West), on paper (a non-structural element). The dimensions of each paper are restricted to 6 in. by 1.5 in.

Each floor must be legibly labeled for judges to see. You can add a sticker of floor label with minimum dimensions of 0.5 in by 0.5 in. The floor at the base of the building is not required to be labeled. The floor above the lobby shall be labeled

'2', and so on. The label may be written on the balsa wood structure with a pen or marker, or small pieces of paper may be attached with the floor labels written on the pieces of paper. The label must not be designed to assist in the structural performance or interfere with the installation of the dead weights.

8.13 Structural Model Weight

For scoring purposes, the Structural Model Weight, W_s, is equal to the weight of the structural model including damping devices but **does not** include the weight of the floor dead loads, roof dead load, base plate, or roof plate.

Due to the capacity limits on the shake table, the structural model shall not be approved for shake table testing and will be deemed collapsed for all ground motions if the weight of the structural model, damping devices, base plate and roof plate exceed 5.0 lb.

9. STRONG GROUND MOTION TESTING

The building will be subjected to two ground motions of increasing intensity. The structural response to both ground motions will contribute to the annual seismic cost.

9.1 Scaled Ground Motions

Structures will be subjected to two scaled and modified ground motions named Ground Motion 1 (**GM#1**) and Ground Motion 2 (**GM#2**). Both the ground motions will be based on the hazard level and soil condition at the building site in Seattle. These two ground motions will be selected and released to the participants as follows:

9.1.a Ground Motion 1 (GM#1)

GM#1 will be selected to approximately represent the Design Earthquake (DE) hazard level at the building site. This is verified by plotting the response spectrum for the chosen ground motion and comparing (approximately) with the DE spectrum given by ASCE 7-22 [1]. **GM#1** will be released on the competition website listed on the cover page.

9.1.b Ground Motion 2 (GM#2)

GM#2 will be selected to approximately represent the Risk-Targeted Maximum Considered Earthquake (MCE_R) hazard level as defined in ASCE 7-22 [1]. Recall that the MCE_R response spectral coordinates can be directly obtained by scaling up the DE response spectrum by a factor of 3/2. Note that **GM#2** will not be released until the day of the competition.

9.2 Target Response Spectra

A few **important** notes about the selection of ground motions are:

- The DE and MCE_R response spectra and other hazard parameters can be found using the 'ASCE 7 Hazard Tool' (https://asce7hazardtool.online/). To obtain the response spectra, assume that the structural model complies with the requirements of Risk Category II. When selecting **GM#1** and **GM#2**, the SDC Chairs will assume **Site Class D**, irrespective of the soil properties identified in the geotechnical evaluation.

- Teams can refer to the PEER NGA-West2 strong ground motion database (https://ngawest2.berkeley.edu/) to pick suitable ground motions that can represent **GM#2** (Section 9.1.b) to consider qualitative similarity of the response spectrum with the MCE_R spectrum. Such motions can be used to assess/design the building teams are proposing, should they want to. Teams may or may not scale the motions (in time or acceleration) to match the intensity of the MCE_R. *A ground-motion selection guide* will be available on the competition website describing the use of the PEER NGA-West2 database.

- **GM#1** will be released in its scaled form, exactly as it will be used on the shake table. **GM#2** will be chosen by the SDC to align with the criteria in Section 9.1 and adhere to shake table limitations: Peak Ground Acceleration, $PGA \leq 2.5g$; Peak Ground Velocity, $PGV \leq 33$ [in/s]; and Peak Ground Displacement, $PGD = 3$ [in].

- Note that the response spectra for DE and MCE_R prescribed in ASCE 7-2 are derived using probabilistic analyses and hence its similarity with the response spectrum of a specific ground motion is only going to be reasonable and qualitative rather than exact (both on the spectral amplitude and the time scale).

9.3 Shake Table

Structures will be tested on the University Consortium for Instructional Shake Tables (UCIST) unidirectional earthquake shake table, with plan dimensions of 18.0 in. by 18.0 in. The specific direction in which the building will be shaken will be determined on Shake Day, as outlined in Section 9.6.

9.4 Dead Load Specifications

9.4.a Floor Dead Loads

A floor dead load shall be installed at the locations specified in Section 8.7 and illustrated in Figure 2 and Figure 3 following the instructions in Section 9.5.a. The representation of the floor dead loads can be found in the ***Design Guide***. The dead load located nearest the top of the structure will add up to 2.76 lbs, whereas the dead loads for the rest of the floors will add up to 2.36 lb /floor.

9.4.b Roof Dead Loads

The roof dead load will be represented by the accelerometer and two C-clamps. The two C-clamps will be used to secure the accelerometer to the structural model roof plate. Each C-clamp has a jaw opening of 1 in. and a throat opening of 1 in. The total weight of the roof dead load is equal to 0.85 lb.

9.5 Dead Load Installation

9.5.a Floor Dead Loads

Each floor dead load shall be securely attached to the structural model at the floors indicated in Section 8.7 in the direction perpendicular to shaking. A floor dead load is defined as secured if it is restricted from movement in any translational direction after installation (including the vertical direction). Movement of the floor dead loads can be restricted with frame or wall members and/or using friction from tightening the nut at each end of the threaded rod (keep in mind nuts can become loose during shaking). Each team is responsible for installing and securing the floor dead loads. See Section 8.7.a for penalties associated with unsecured floor dead loads.

If a floor dead load connection is not available at a floor required to have a floor dead load connection, the judge may have the team install a floor dead load on the required floor and try to secure the floor dead load using the nuts and washers. If the floor dead load is physically unable to be installed while centered in plane with the center of the base plate, or if the judges deem the floor dead load connections are intentionally not available at a required floor or direction, the model will not be allowed to be tested and will be assumed collapsed for both ground motions.

Each floor dead load shall be installed by inserting the ½ in. threaded rod through structural model at the dead load connection locations (Section 8.7). From the building to the end of the threaded rod, the order of the washers, nuts, and plates for each end of the threaded rod are as follows: 1 washer, 1 nut, required number of plates (per *Design Guide*), 1 washer, and 1 nut. The nut immediately following the washer touching the building on each side of the rod are recommended to be tightened by hand to ensure the floor dead loads are restricted from movement in any translational direction.

Each team will have 10 minutes to install and tighten the dead loads. If the allocated time has passed and the team has not finished installing the floor dead loads, a penalty of 20 will be added to V. Teams may recruit other non-team members (excluding SDC Chairs) to assist in installing floor dead loads.

A SDC Chair shall be present while the team is installing the floor dead loads to ensure proper installation of the floor dead loads. Another SDC Chair shall check the floor dead loads before the structural model is attached to the shake table (Section 9.6). If the SDC Chair finds any weights free to move in any translational direction, the SDC Chair shall notify the team captain prior to shaking. After the 10 minutes, the team will not be able to make any changes to the structural model or dead loads, shaking shall commence, and unsecured floor dead loads will be penalized after each ground motion as described in Section 9.10.a.

9.5.b *Roof Dead Loads*

The roof dead load shall be attached to the structural model roof plate with two C-clamps at opposing corners (scaled drawings of the C-clamps will be provided in the *Design Guide*). It is the responsibility of the SDC Chair(s) to secure the roof dead load to the structural model roof plate before installing the structural model to the shake table (Section 9.6). The time required to attach the roof accelerometer will not be included in the time each team has for installing the dead loads. If the roof dead load is not level before **GM#1**, then the roof dead load will be removed from the structural model for **GM#1**. The roof dead load is considered not level if the bubble of the level is completely outside of the lines. See Section 9.10.a for penalties associated with an unsecured or not level roof dead load.

9.6 Attachment of Structural Model to the Shake Table

SDC Chairs will determine the direction of shaking by flipping a coin prior to the beginning of shaking. The coin flip will determine if shaking is in the North-South direction or East-West direction and apply to all structures for the duration of the competition.

Each team will attach the structural models to the shake table with at least 6 C-clamps at the corners and center along the two sides of the structural model base plate parallel with the direction of shaking. Two 18 in. long aluminum angles (1 in. legs and 1/8 in. wall thickness) will span on top of the structural model base plate perpendicular to the direction of shaking on each side of the building. The two aluminum angles will be secured with the 4 corner clamps. Two 12 in. long aluminum angles (1 in. legs and 1/8 in. wall thickness) will span on top of the structural model base plate parallel to the direction of shaking on each side of the building. The two aluminum angles will be secured with a center clamp. If the base plate is warped, the corners of the base plate will be clamped so there are no gaps at the corners between the shake table base, the aluminum angle, and the base plate. A SDC Chair will check each clamp after installation. All necessary clamps and aluminum angles will be provided on Shake Day.

9.7 Instrumentation

Two accelerometers will be used in the competition: one accelerometer will be attached to the shake table, and the other accelerometer will be part of the roof dead load (Section 9.4).

9.8 Data Processing

The raw acceleration data obtained from the two accelerometers, at the base and at the roof, will be processed using a suitable Butterworth filter to remove low-frequency noise. The processed acceleration data will be used to determine the roof and base displacement time history.

9.9 Damage Calculations

9.9.a Structural Damage Calculations

Structural damage to the building will be calculated using a function of the measured peak roof drift, $XPeak_n$ This function is a cumulative normal probability density function with peak roof drift mean and standard deviation listed in Section 4.5. The structural damage as a percentage of the construction cost (XD_n) is a function of $XPeak_n$ and is plotted in Figure 4.

Tip: The cumulative distribution function can be computed using many commercially available software packages (e.g., the NORMDIST function in Microsoft Excel, with the 'cumulative' field set to TRUE).

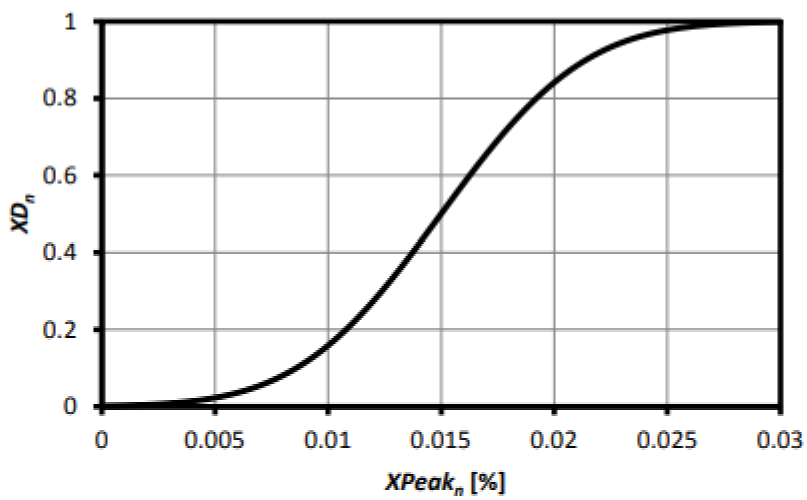

Figure 4 Function relating peak roof drift, $\boldsymbol{XPeak_n}$ and structural damage as a percentage of construction cost ($\boldsymbol{XD_n}$).

9.9.b Equipment Damage Calculations

The building is assumed to house equipment that is sensitive to acceleration. Damage to this equipment will be a function of the measured roof acceleration, $APeak_n$. This function is a cumulative normal probability density function with peak roof acceleration mean and standard deviation listed in Section 4.5. The equipment damage as a percentage of the equipment cost (AD_n) is a function of $APeak_n$ and is plotted in Figure 5.

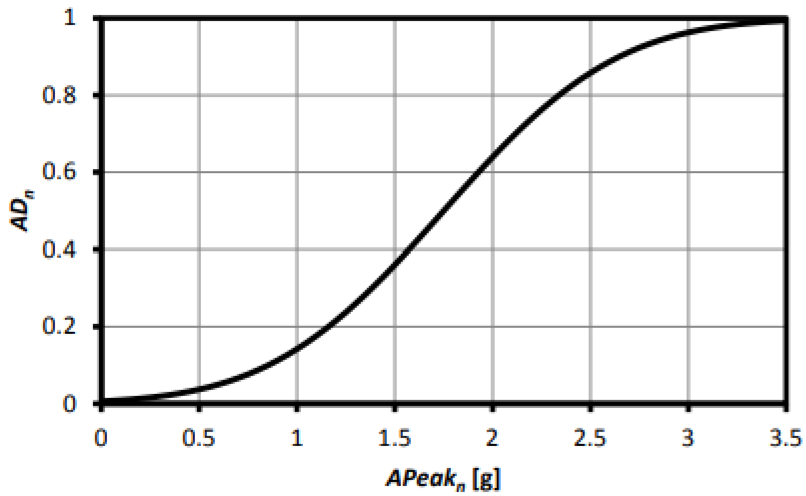

Figure 5 Function relating peak roof drift, $\boldsymbol{APeak_n}$ and structural damage as a percentage of construction cost ($\boldsymbol{AD_n}$).

9.10 Penalties and Determining Collapse

9.10.a Unsecured Floor Dead Load Penalties

After each ground motion, an SDC Chair will inspect the building for any unsecured floor dead loads (Section 9.5.a). 5% will be added to D_n for each unsecured floor dead load. If a penalty D_n is applied, it will only affect the monetary structural and equipment damage for the ground motion immediately following the inspection. If a structural model is deemed collapsed by a SDC Chair (Section 9.10.c), a penalty D_n will not be applied for the ground motion(s) in which the structural model is deemed collapsed.

For example, if all of the floor dead loads remain secured after Ground Motion 1, the penalty D_1 for Ground Motion 1 will be equal to 0%. If two of the floor dead loads are found to be unsecured after Ground Motion 2, the penalty D_2 for Ground Motion 2 will be equal to 10%.

A floor dead load is considered unsecured:

- If any end of the floor dead load has moved more than ½ in. in any translational direction from its original pre-shaking location measured at the exterior face of the building
- If any end of the floor dead load can be moved more than ½ in. in any translational direction measured at the exterior face of the building. This includes the vertical direction. The amount of force applied by the SDC Chair to the floor dead loads will be enough to check for movement and is at the discretion of that SDC Chair.
- If one floor dead load is in contact with another floor dead load, both are considered unsecured.

9.10.b Unsecured or Not Level Roof Dead Load

Before each ground motion, an SDC Chair will inspect the roof dead load. If an SDC Chair deems the roof dead load is not secured to the structural model or not level, the roof dead load will be removed from the structural model and the score will assume maximum structural and equipment damage for any of the ground motions where the roof dead load is not attached to the structural model. An unstable roof plate is not grounds to declare a structural model collapsed.

9.10.c Defining Collapse of a Structural Model

An SDC Chair deems a structural model has collapsed if any of the following happens:

- 50% or more of the floors are not level.
- 50% or more of the frame members or walls attached to the base plate are separated from the base plate or the structural model.
- 50% or more of the floor dead loads are considered unsecured (Section 6.9.a).
- 50% or more of the vertical and diagonal members (combined) connecting any two floors are disconnected.
- The structural model base plate has delaminated to the point where the structural model is rocking on the shake table.

The floor levels will be checked with a level. If the whole bubble is outside of the lines on the level, the floor is considered not level.

The frame members and/or walls attached to the base plate will be visually inspected to see if separation has occurred between the member and the base plate and/or the rest of the structural model.

If any of the conditions for collapse are met prior to **GM#1**, the structural model will still be shaken but deemed collapsed for both ground motions regardless of the outcome after shaking has completed.

If collapse occurs during **GM#1**, collapse will be assumed to happen for **GM#2** for scoring purposes.

10. SCORE SHEETS

All score sheets can be reviewed and signed by the team captain immediately after judging has been completed. Only team captains shall discuss penalties and score sheets with the SDC Chairs (Section 12).

At the team meeting, the SDC Chairs will indicate a time when team captains can begin to come by the judging table to review the judging sheets. The indicated time may change depending on the time required to review all the models.

The SDC Chairs will specify a cut-off time for appeals when the final competition schedule is released (check the website for updates). After this time, the judges can refuse to review any score sheets and hear any appeals. The score sheets will be signed by two SDC Chairs and the penalties assessed can no longer be appealed.

10.1 Judging Sheet Review

The judging sheet review process will occur as follows:

- The judging sheet will be explained by an SDC Chair to the team captain and only the team captain.
- The SDC Chair will show the violation(s), if any, on the model.
- If applicable, penalties will be marked with a red permanent marker or stickers on each structural model for quick visual identification.
- An SDC Chair will show the team captain the rule/violation and penalty assessed in the official rules (or clarifications) if needed.
- If no penalties were found, the team captain may sign the judging sheet or let two SDC Chairs sign the scoring sheet.
- If a penalty is assessed, a team captain may do one of the following:
    - Sign the scoring sheets and forfeit the opportunity to appeal the penalty(s).
    - Review the penalties with his or her team members to prepare for an appeal. The SDC Chair will continue reviewing other team’s scoring sheets and the team captain will need to wait for the next available SDC Chair for the appeal.
    - Appeal the penalties.

The appeal process is explained in Section 12.1.

Once the scoring sheets have been signed either by the team captain or two SDC Chairs, a team captain may not make any appeals for the penalties assessed on the scoring sheets already signed. If a team captain tries to make an appeal for penalties assessed on the scoring sheet(s) already signed, the team captain will be warned. If after the team captain is warned and they 2023 Undergraduate Seismic Design Competition – Rules 50 attempt to continue appealing for penalties assessed on the scoring sheet(s) already signed**, the team will be disqualified.**

10.2 Verification of Electronic Score Sheet Entry

Either during or at the end of shaking day, teams will receive a "shaking day score sheet" via email or hard copy. This score sheet will be a version of the final score sheet: it will contain information including but not limited to building weight, total violations (V), and shake table performance; it will not contain any information about other scores or bonuses received.

It is the duty of the team captain to review the information on this sheet for typographical errors. Any such errors, especially those affecting the calculation of scores, must be reported to the SDC Chairs, either in person or by email, before 9:00 PM competition local time on the evening before the awards ceremony. The SDC Chairs will review the hard-copy score sheets and will rectify any errors that are reported in this way. If a team captain has not reported any errors by the deadline, it is assumed that they have reviewed their score sheet and accept all information as typographically accurate.

Please note that this is **not** an opportunity to initiate any appeals or to dispute the scores in any other way. This is only an opportunity to verify that the information entered electronically is typographically consistent with the information recorded on hard copy (which has already been signed by the team captain or two SDC Chairs, as explained above)

11. RULE CLARIFICATION

All rule clarification requests and answers will be posted on the competition website. The posted question and answer will also include the name of the school submitting the question. To submit a rule clarification, the team captain must fill out and submit an online submission form, which can be found on the competition website. Questions or clarifications about the rules sent via email will not be answered. Be sure to read the rules, guide, and any other current year clarifications thoroughly before submitting a question.

12. JUDGING AND APPEALS

The SDC Chairs have complete authority over the interpretation of the rules and oversight of the competition and are responsible for scoring and decisions. All decisions made by the SDC Chairs are final. If any questions arise during the competition, the team captain should ask one of the SDC Chairs, not other SLC members.

Only a team captain may discuss decisions or appeals with SDC Chairs. SDC Chairs will refuse to discuss a decision or appeal to anyone other than the team captain. A team captain may only make an appeal regarding his or her team. Under no circumstances may anyone, other than the team captain, approach a SDC Chair regarding penalties or scoring. This includes but is not limited to other teammates, alumni, professors, and especially other SLC members. If this becomes an issue, the team captain will be warned. If the behavior continues after the team captain is warned, the team will be disqualified.

The SDC Chairs strive to be fair and consistent with all teams regarding the official rules. During the judging process, the judges are trained and supervised to evaluate all of the structural models for the same requirement(s) so there is consistency in judging. Please be considerate and respectful to the SDC Chairs when making an appeal.

12.1 Appeals Process

A team captain can make an appeal about a penalty or decision before signing a score sheet. An appeal begins the very instant the team captain questions the penalty(s) to a Seismic Design Competition Chair(s). Only one appeal per team can be made for all penalties assessed. The team captain must explain using the official rules and clarifications why the penalty or decision should be changed. An SDC Chair will hear the team captain's appeal and may consult other SDC Chairs before making a final decision. After a final decision has been made by the SDC Chair(s), the team captain cannot appeal the penalty any further. If the team captain refuses to sign the score sheet, two SDC Chairs will sign the score sheet instead and the score sheet will be considered signed by the team captain.

In the interest of time, no appeals are allowed once shaking of the structures has begun. The team captain may ask for an explanation on why their structure was determined as collapsed, but the buildings must be tested and moved along.

12.2 Rule Modifications

In very rare cases, unexpected circumstances may arise that threaten the spirit of the competition. In these cases, the SDC Chair(s) reserve the right to modify the rules, if such a modification would preserve the quality of the competition.

13. REFERENCES

[1] ASCE 7, Minimum Design Loads and Associated Criteria for Buildings and Other Structures, ASCE/SEI 7-22, Reston, Virginia: American Society of Civil Engineers, 2022.

[2] OSSJA, "Code of Academic Conduct," 28 April 2023. [Online]. Available: https://sja.ucdavis.edu/cac.html.

[3] MIT, "What is Common Knowledge?," n.d.. [Online]. Available: https://integrity.mit.edu/handbook/citing-your-sources/what-common-knowledge.