Mastering Movement™ Academy

Mastering Unpredictable Movement – Earthquake-Ready Stairs

AIA Continuing Education Provider

Mastering Movement Academy

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Learning Objectives

UPON COMPLETING THIS COURSE, YOU SHOULD BE ABLE TO:

- List factors that have led to imbalances in design and building codes that are affecting national, state, and local policies.
- Discuss how typical stair systems can contribute to structural failure during seismic activity compromising occupant safety.
- Communicate the importance of stair safety for occupant and first responder egress and ingress during and after seismic events.
- Explain the concepts and benefits behind new technology designed to create movement within stair systems.
- Specify modular (prefab) and standard earthquake-ready stairs to protect buildings from seismic movement and increase occupant and first responder safety during seismic events.

Course Overview

During seismic events, occupant safety becomes the highest priority. But designing for resiliency means we must also create structures that can protect building contents, limit structural damage, and reduce recovery time.

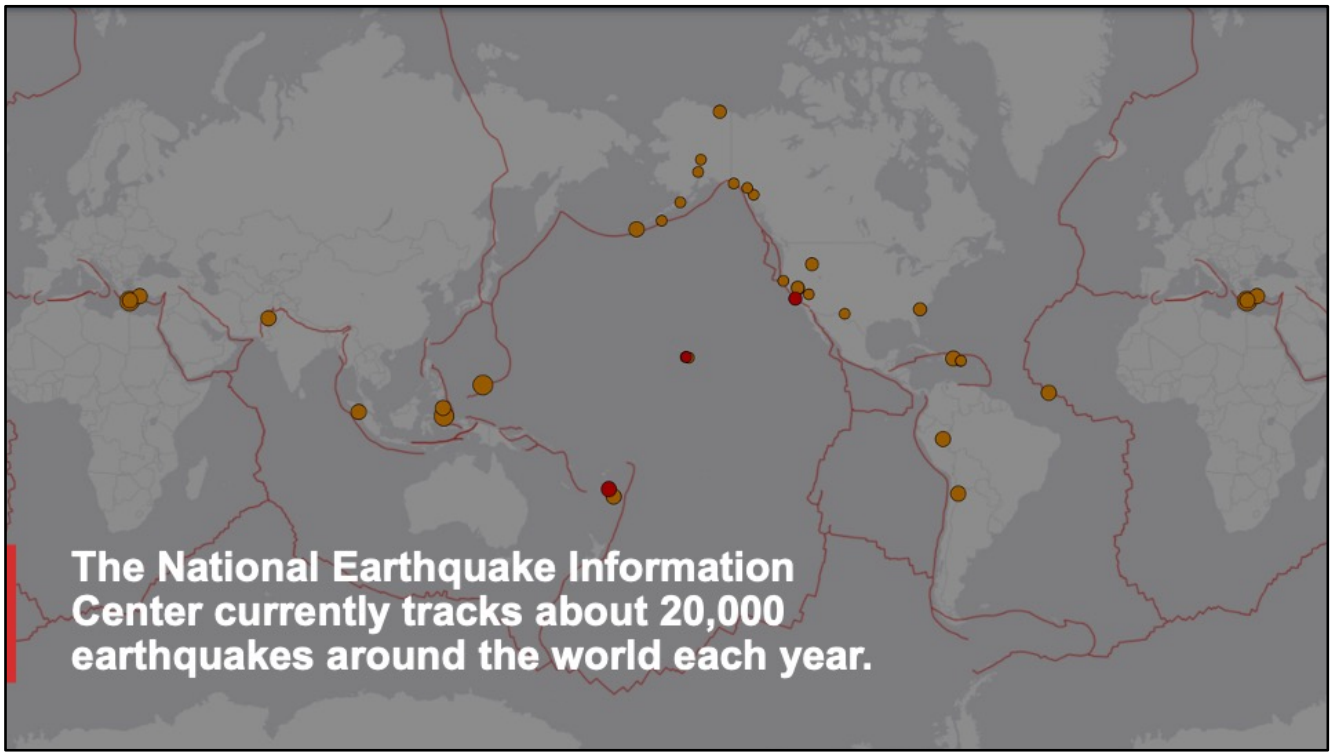
Course Overview

This course will explore new stair system technologies developed to accommodate seismic movement. We will delve into the importance of interstory drift and how a flexible stair design can eliminate system failure and the occupant and structural risks that occur as a result.

This includes:

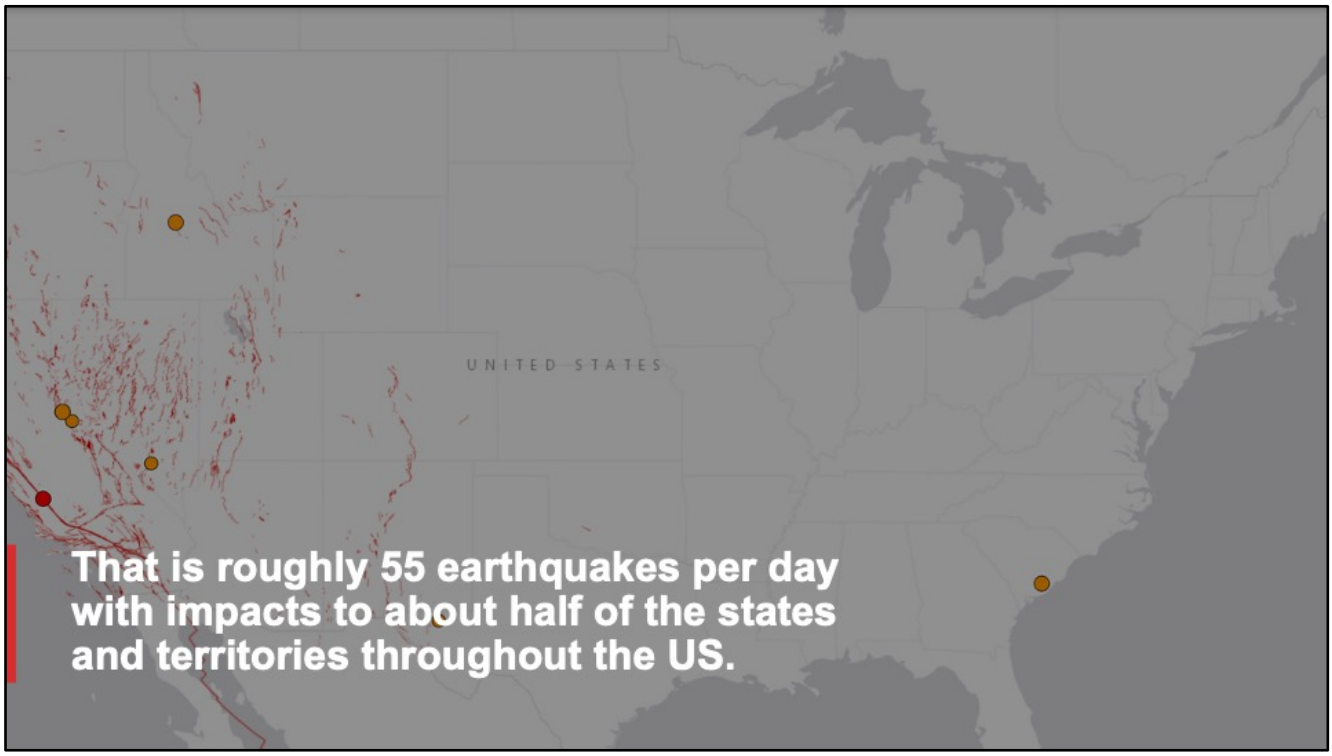
- How typical, fixed stair systems can pose threats to structural integrity and occupant safety during seismic events.
- The critical importance of stair safety during and after seismic activit.y
- How new technologies in stair connection systems provide movement to reduce impact transfer and system failure during seismic events.
- Strategies for discussing and specifying new stair system technologies and benefits.

- Rigid structure attracts force and returns force.
- Life safety of operational stairs
- New tech allows the stair to move with the building.
- Incorporating new technology into your project



Graphic taken from https://www.usgs.gov/natural-hazards/earthquake-hazards/earthquakes

https://www.usgs.gov/faqs/why-are-we-having-so-many-earthquakes-has-naturally-occurring-earthquake-activity-been?qt-news_science_products=0#qt-news_science_products



Graphic taken from https://www.usgs.gov/natural-hazards/earthquake-hazards/earthquakes

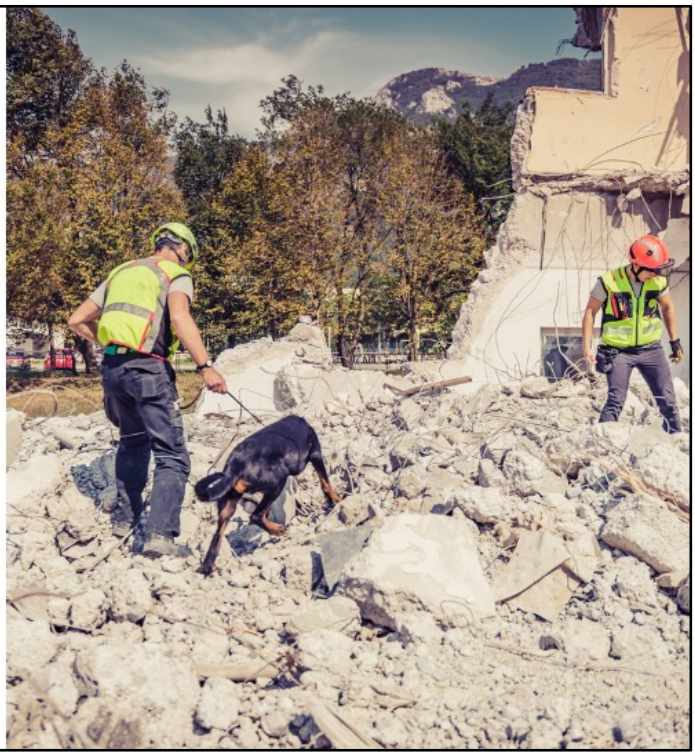
The bulk of this movement is not dangerous or necessarily even noticeable. With that said, the big earthquakes are memorable because of how devastating they are. New stair tech will help protect occupants from the big one.

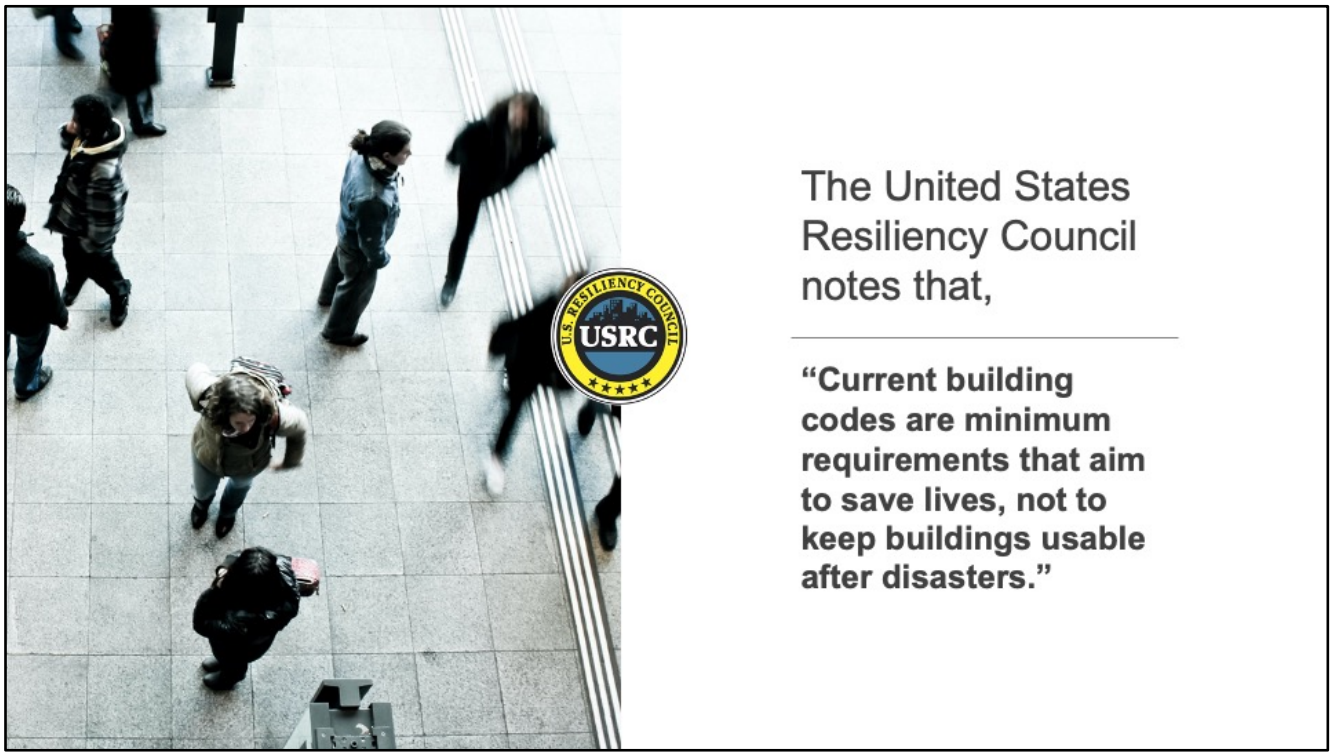
In the wake of an earthquake, damage can range from minor to catastrophic.

It has been estimated that approximately 10,000 people die from the impacts of earthquakes per year.
Source: https://www.nationalgeographic.com/environment/article/earthquakes

Yet earthquakes alone are not a direct threat to people.

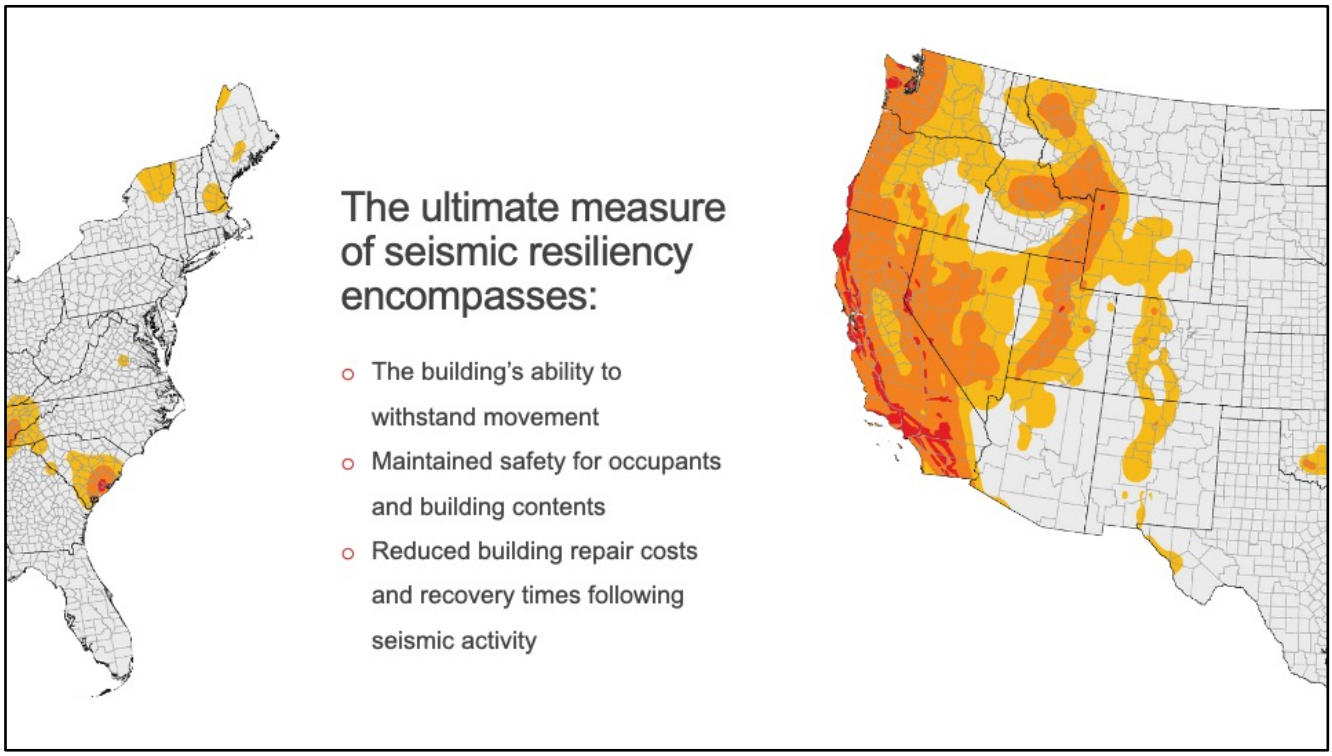
Building failure during seismic activity is.





As members of the built community, occupant safety is paramount. But we also have an obligation to protect the buildings and contents of those structures from catastrophe to ensure they can regain operation as quickly as possible.

Source: https://www.usrc.org/
USRC logo
Photo by Timon Studler on Unsplash



The Annualized Earthquake Losses (AEL), calculated by FEMA, average $6.1 billion per year in the United States. Designing and engineering buildings that not only save lives but protect the building itself is critical to overcoming the crippling impacts of property loss and damage.

Resource: FEMA
https://www.fema.gov/sites/default/files/2020-10/fema_seismic-building-code-provisions-new-buildings-create-safer-communities_fact-sheet.pdf

Graphic: Fema.gov

Stairs are often overlooked when designing for seismic resilience…

…and can pose significant threats to the building structure and occupant safety.

On a typical project, primary route egress stair systems become a deferred submittal item that is not included in the overall structural building design and instead developed later. Often, stair systems are simply purchased from a local steel fabricator.

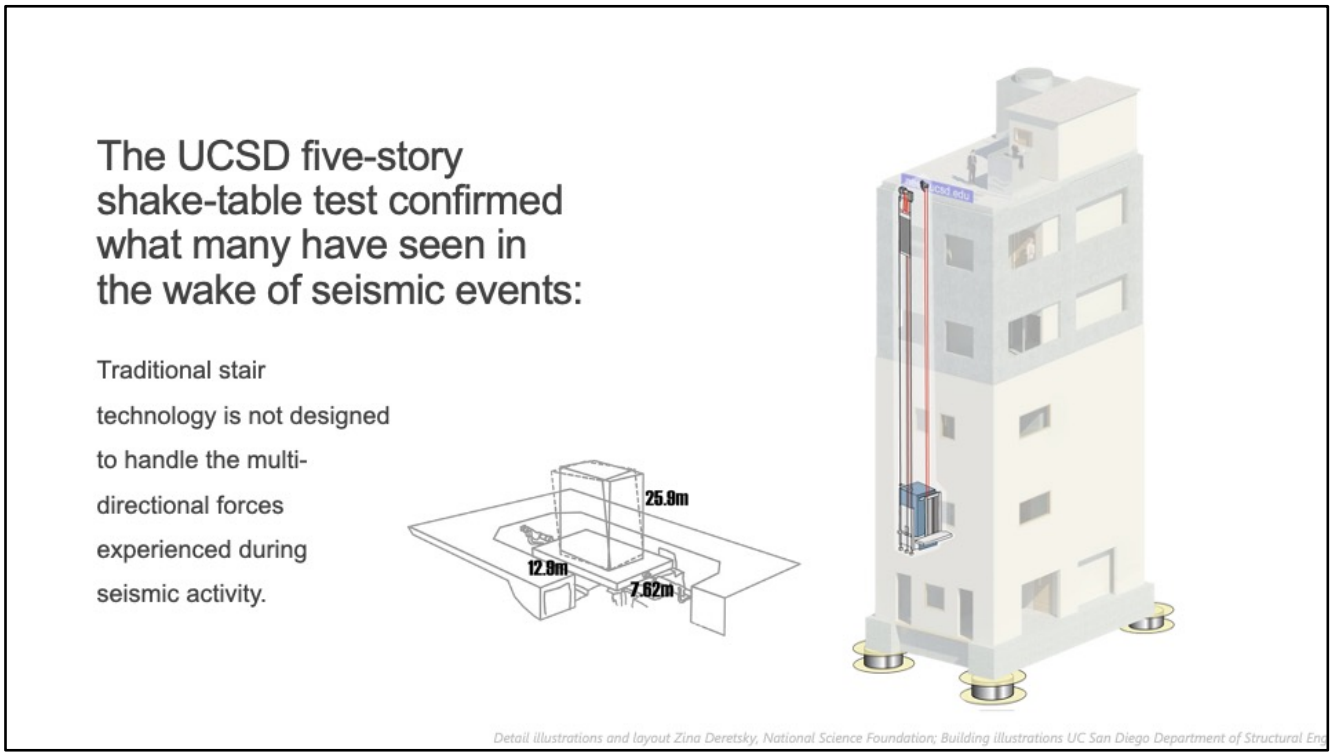
Source: https://www.c-sgroup.com/-/media/files/literature/ejc/additional-resources/022_paper_black.ashx?la=en&hash=0FC859B3CDB6E2799636FA283A91546136D7154D

Historically, data and studies on the seismic behavior of stair systems have been limited and building standards for stairs have remained largely unchanged.

As building standards for seismic activity continue to change, so should the technology for critical components such as stair systems that provide lifesaving passageways.

Photo by Hello I'm Nik on Unsplash

@The UCSD five-story shake-table test provided data was established to understand how a typical stair system interacts with the building structure as well as surrounding non-structural components. It also provided an unprecedented standard on testing and evaluating the function and performance of stair systems during and after seismic activity.



During the test, current ASTM materials were used and the stair system was installed to meet interstory drift demands up to 2.5%.

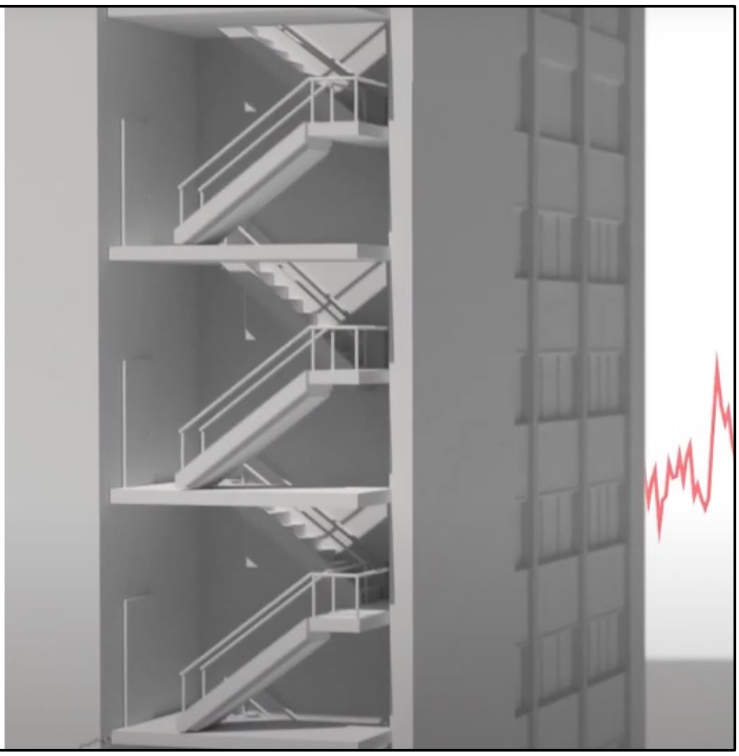
Although the test building was designed to withstand an interstory drift demand of **2.5%,**

stair systems began failing at an interstory drift as low as **0.74%** & **1.41%**

Detail illustrations and layout Zina Deretsky, National Science Foundation; Building illustrations UC San Diego Department of Structural Eng

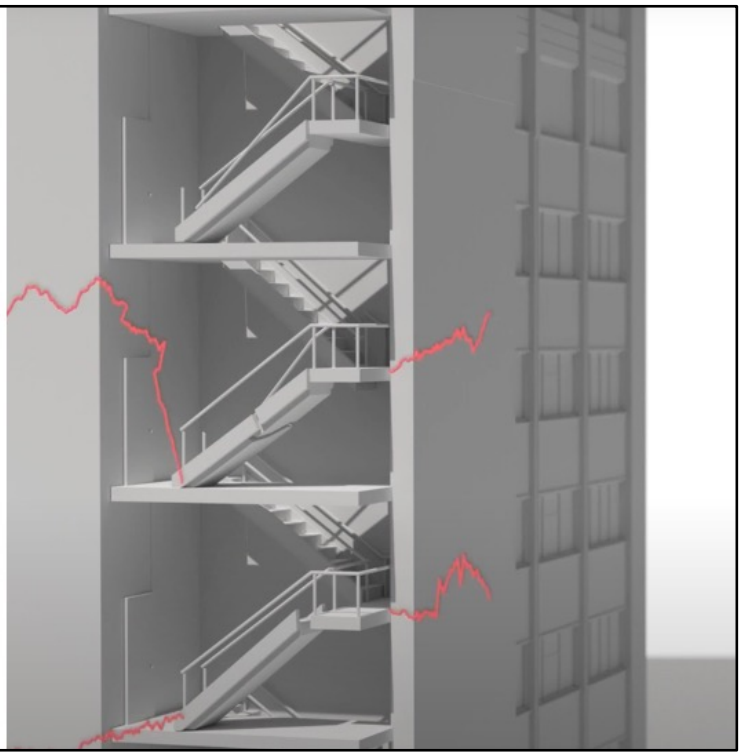
Ultimately the design was built to meet the current building safety and seismic codes, but it was unable to withstand damage – a reality that is often seen in real-world settings.

During seismic activity, the traditional stair system acts as a fixed element causing damage to the building and resulting in potential breakage and system failure.



Seismic design requirements for nonstructural components mandates systems that are required for life-safety purposes after an earthquake, including egress stairways, to be classified as designated seismic systems and be assigned a component importance factor.

Despite these recommendations, traditional stair systems rely on a rigid design. During seismic activity this can create a pathway that transfers force back into the building.

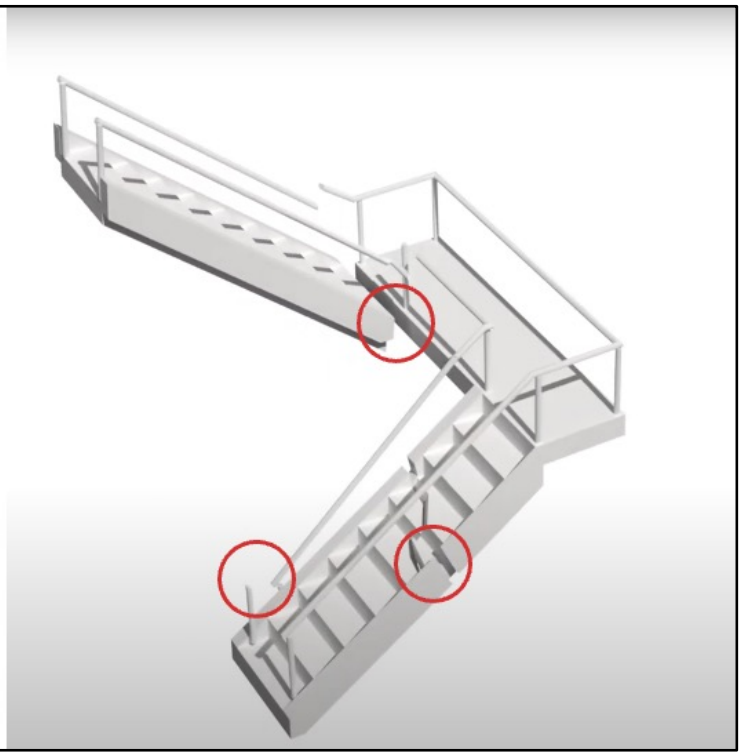


Rigid. They attract force and return said force to the building causing significant damage to the structure and stairs themselves.

The seismic performance of stair systems is highly dependent on the deformability of the stair to landing connection.

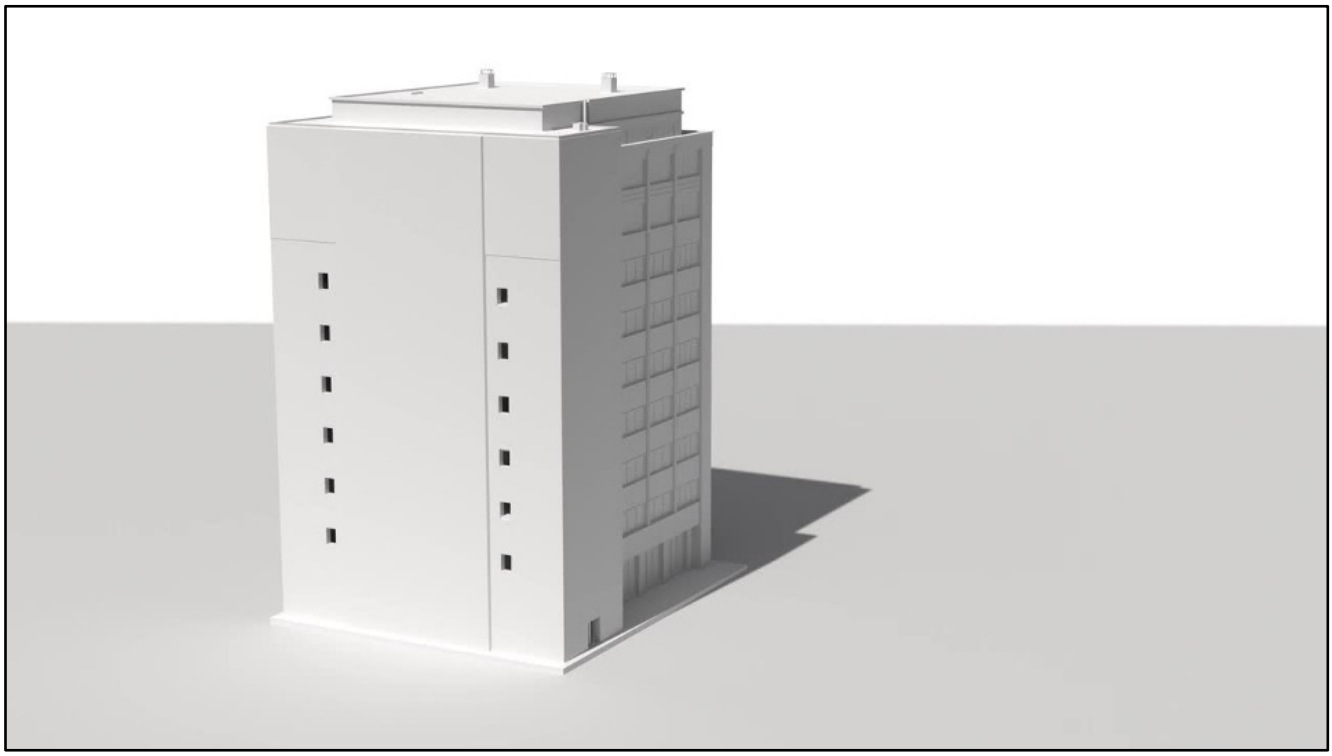
Stair damage during a seismic event often includes:

- Stair detachment from landings
- Cracks and damage to the stairs
- Handrail fractures and failure



Hard fastening and reenforced attachment systems of stairwells are designed to prohibit movement but ultimately become a breaking point during a seismic event. Ne

Source: https://www.c-sgroup.com/-/media/files/literature/ejc/additional-resources/5-dynamic-characteristics-and-seismic-behavior-of-prefabricated-stairs.ashx?la=en&hash=243C4108C90DFBA287FEECB3B864D44B53FF9C29



Video showing stair damage

When stair connections fail building occupants cannot exit and first responders cannot enter.

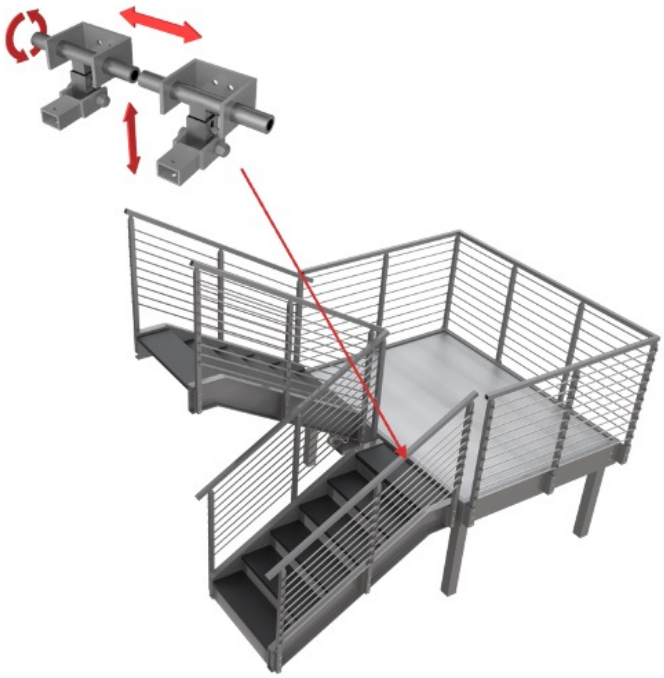
It can quickly become a life-or-death situation.

Photo by Jorge Salvador on Unsplash

But new technologies are becoming available,


Longstanding feedback from structural engineers is that stair systems are a "pain point."
In response, the concept of earthquake-ready stairs was developed.

The innovative stair technology provides stability when at rest, and flexibility when building movement is encountered.

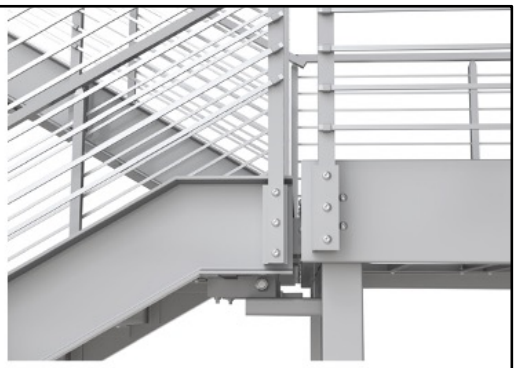


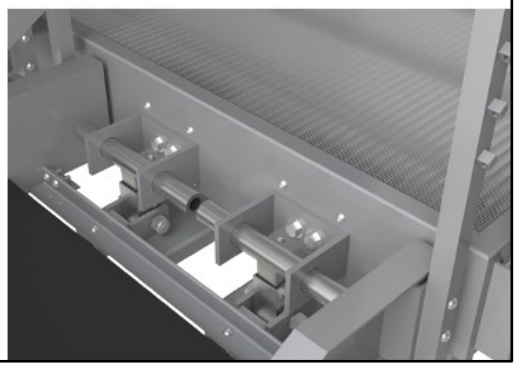
Earthquake-ready stairs provide supportive flexibility during movement at full-range.

Future-ready design to meet today's codes and tomorrow's standards.

Earthquake-ready stairs can be configured to accommodate an interstory drift up to 4%, surpassing the current industry-accepted standard of 2.5%.

This flexibility in the structural design provides unmatched seismic resiliency.



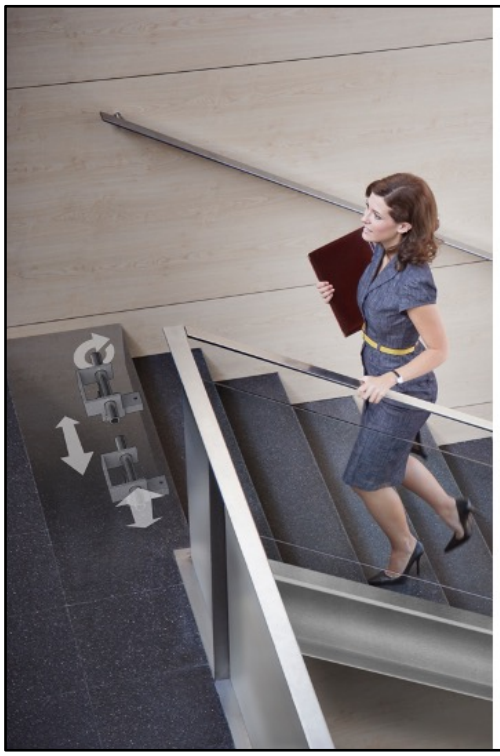


The unique design protects stair system connections, load paths, and reduces force transfer to the surrounding structure.

Earthquake-ready stair technology has been fully tested using the previously proven UCSD shake-table testing format.

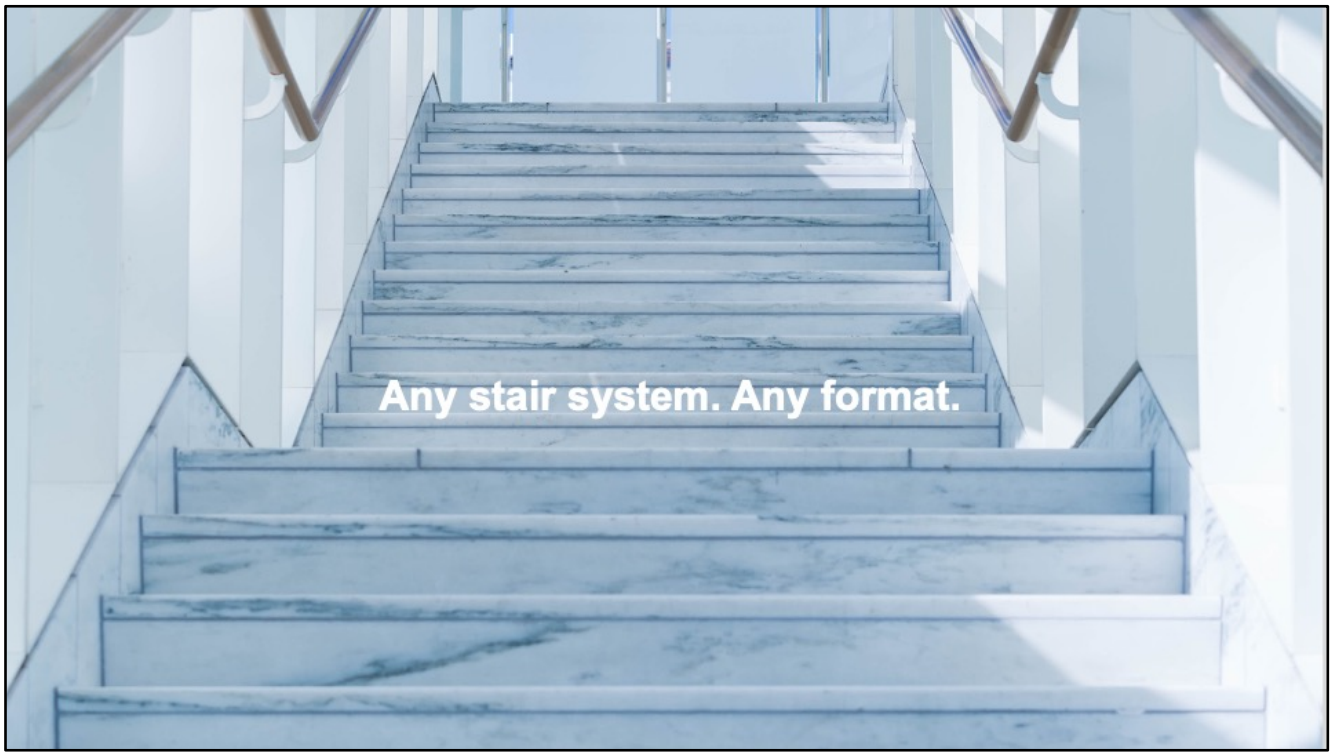
Testing protocol included:

- Full-scale shake-table testing
- 12 different stair systems and mass configurations tested
- Comprehensive solution to tie building components together while allowing independent movement



Earthquake-ready stair system benefits include:

- Safeguarded structural integrity of the building and stair systems
- Maintained paths of egress and ingress during seismic events
- Increased occupant and first responder safety
- Peace of mind and advanced safety for occupants, owners, architects, and engineers



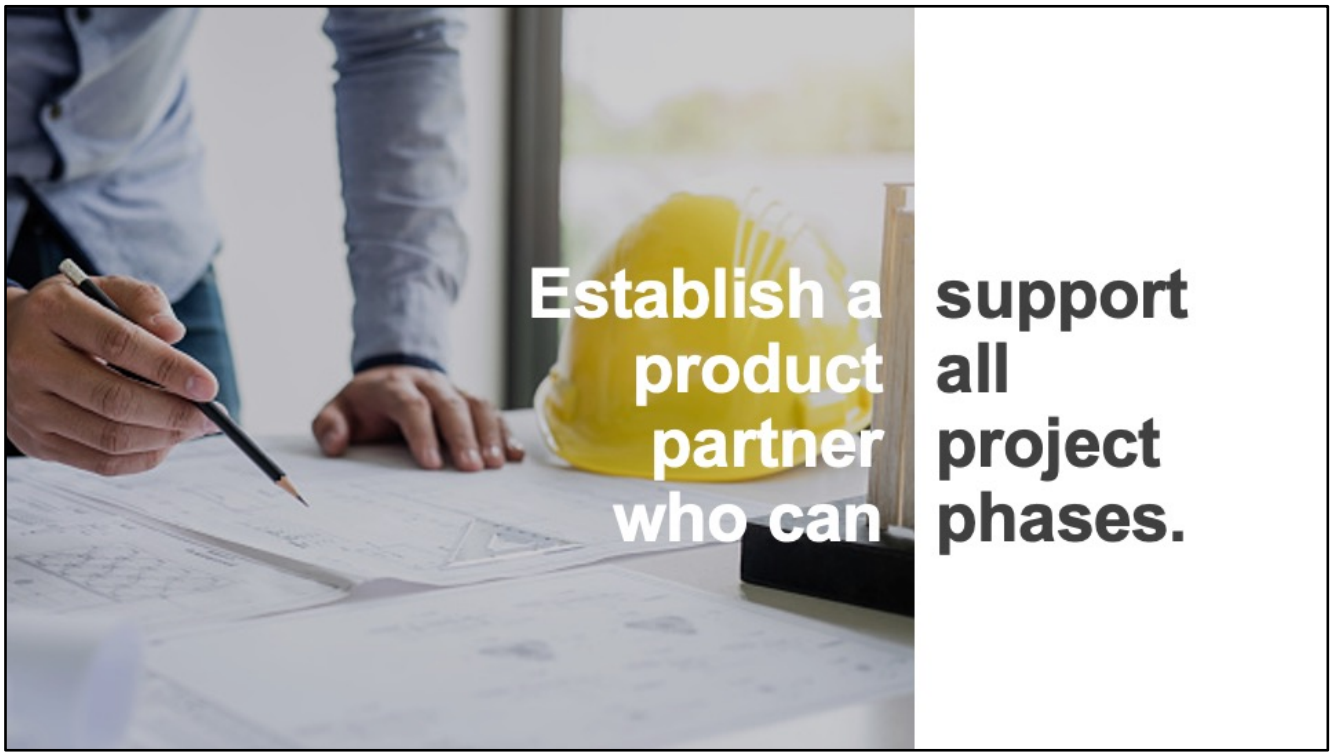
The innovative earthquake-ready stair technology is designed for compatibility with any Division 05 – metal stair system and any format and to be integrated to meet the specific structural design and seismic requirements of your building. Stairs are no longer an afterthought.

Integration: Setting the Standard for Safety

Earthquake-ready stairs can be integrated into countless applications where seismic activity is a risk. This includes:

- Multistory projects in seismic areas
- Egress stairs and entrances where safety is paramount
- High-rise projects susceptible to interstory drift from wind loads
- Office buildings and multifamily dwellings where increased occupant traffic is present
- Education and healthcare facilities where advanced building resiliency standards are required

Designating specific stairways as "safe stairs" using earthquake-ready technologies can create safe egress and ingress to work with emergency evacuation plans and help to stay within a project budget.

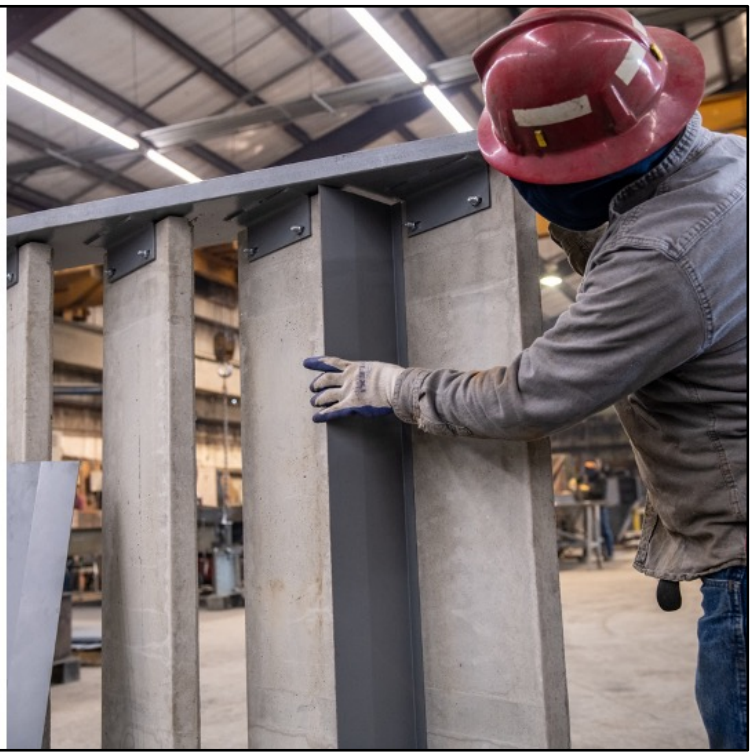


Integration of new technology should not be a pain point. Specify a manufacturer who can work from product selection to installation and maintenance to ensure all stakeholders are working collaboratively to realize complete system benefits.

Specifying and Product Selection

Collaboration between the architect, structural engineer, and manufacturer can ensure the stair system is designed to meet the project requirements including:

- Financial feasibility
- Code compliance
- Integration
- Scheduling feasibility



Early integration can help to ensure system cohesion and insure proper manufacturing and installation.

Maintenance

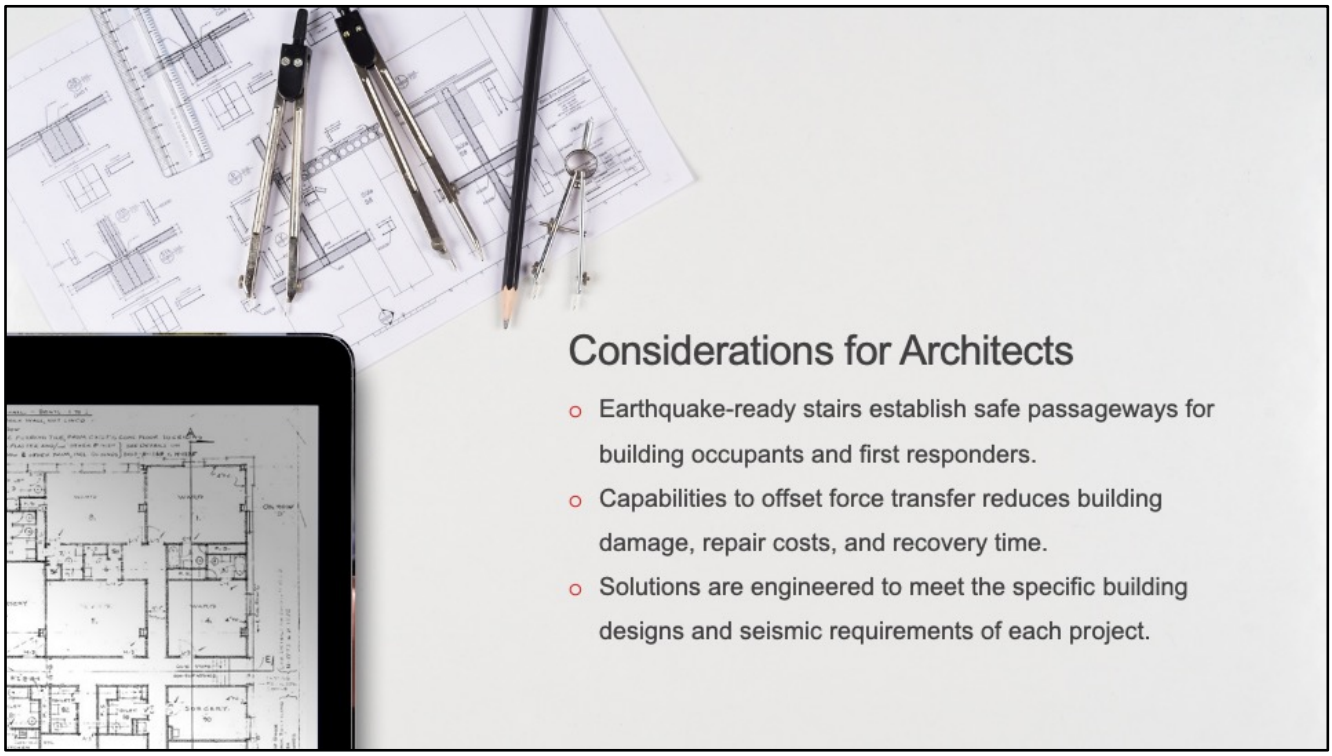
Long-term safety requires the knowledge and skills of engaged facility owners and managers.

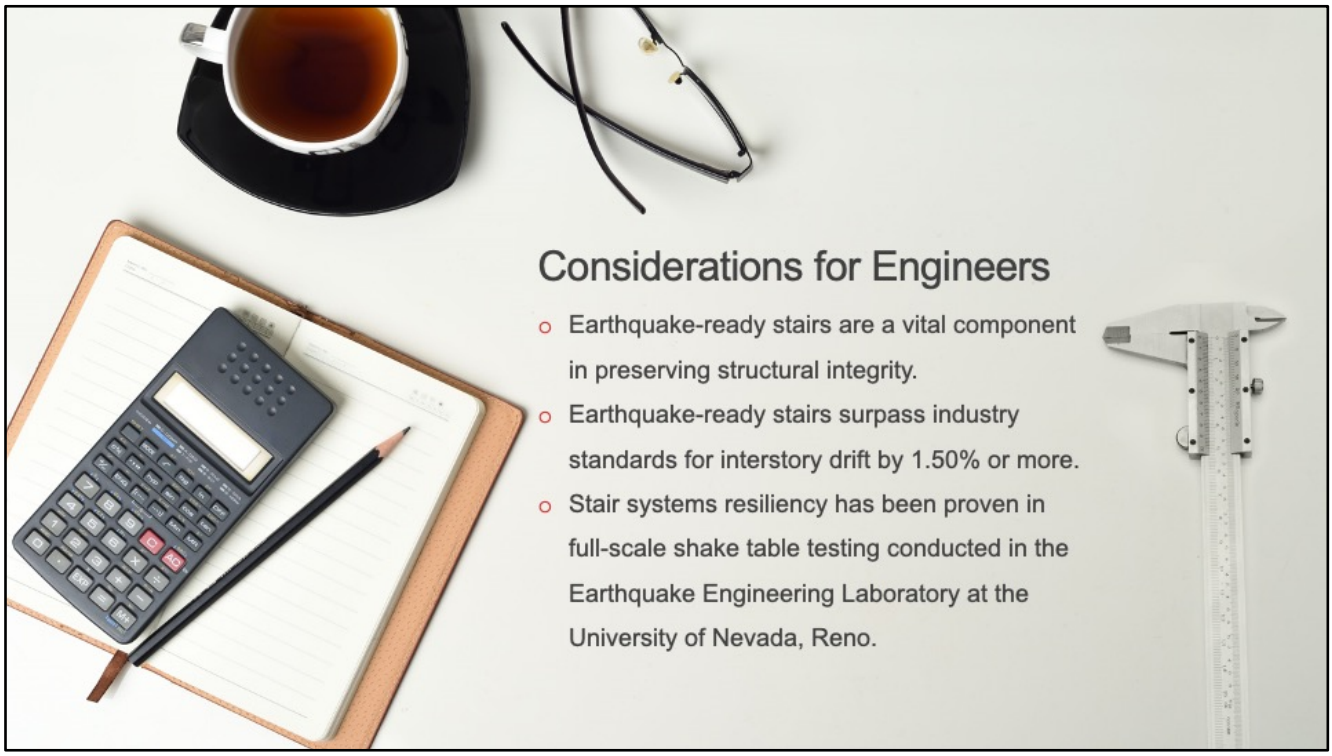
- Ensure facilities teams are provided with closeout information
- Establish safety plans to ensure proper use during catastrophic events
- Post-event inspections are recommended after seismic activity

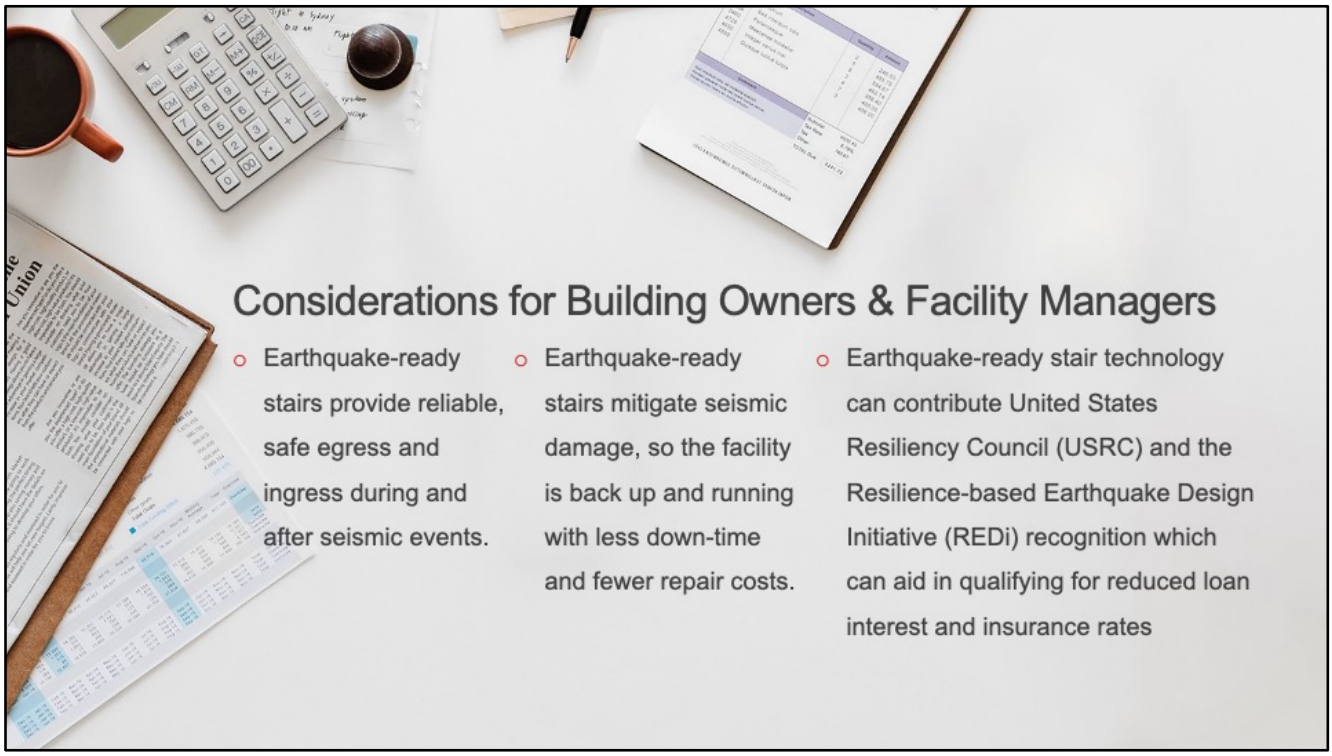
Integration of earthquake-ready stairs can contribute to U.S. Resiliency Council and resilience-based Earthquake Design Initiative (REDi) recognition.

Source: https://www.usrc.org/usrc-rating-system/

Source: https://www.arup.com/perspectives/publications/research/section/redi-rating-system

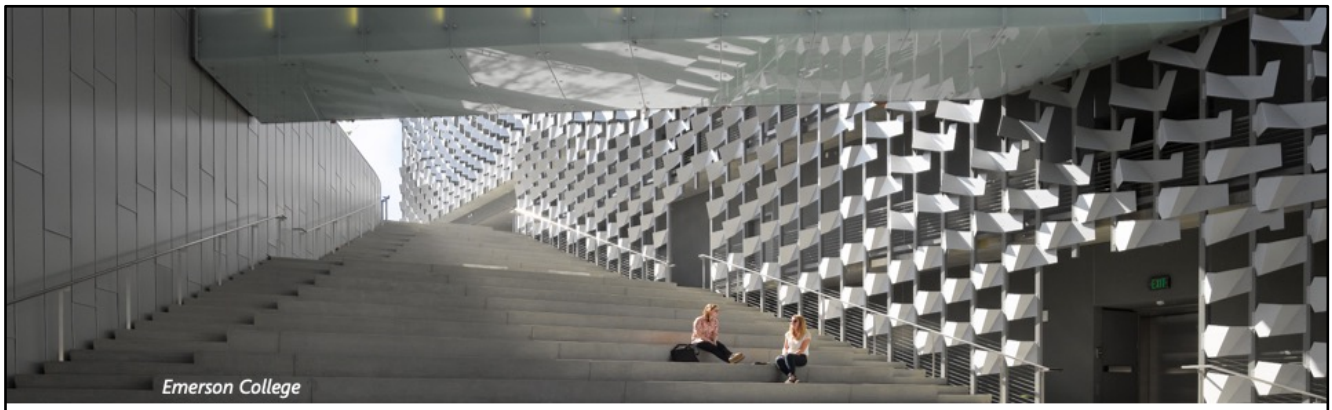

Considerations for Architects
Earthquake-ready stairs establish safe passageways for building occupants and first responders.
Capabilities to offset force transfer reduces building damage, repair costs, and recovery time.
Solutions are engineered to meet the specific building designs and seismic requirements of each project.


Considerations for Engineers
Earthquake-ready stairs are a vital component in preserving structural integrity.
Earthquake-ready stairs surpass industry standards for interstory drift by 1.50% or more.
Stair systems resiliency has been proven in full-scale shake table testing conducted in the Earthquake Engineering Laboratory at the University of Nevada, Reno.


Considerations for Building Owners & Facility Managers
Earthquake-ready stairs provide reliable, safe egress and ingress during and after seismic events.
Earthquake-ready stairs mitigate seismic damage, so the facility is back up and running with less down-time and fewer repair costs.
Earthquake-ready stair technology can contribute United States Resiliency Council (USRC) and the Resilience-based Earthquake Design Initiative (REDi) recognition which can aid in qualifying for reduced loan interest and insurance rates

In conclusion, earthquake-ready stair technology can be integrated and engineered to meet your specific building design and seismic requirements regardless of stair type or accessory options.

- Earthquake-ready stairs feature an innovative, flexible design to accommodate multidirectional movement that occurs during seismic events.
- This design prevents movement force from transferring back into the building.
- Earthquake-ready stairs solve a critical issue for providing safe egress and ingress for building occupants and first responders during and after seismic activity.
- Earthquake-ready stairs can be configured to accommodate an interstory drift up to 4%, surpassing the current industry-accepted standard of 2.5%.



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