Non-Structural Earthquake Seismic Bracing (Q-Brace) Safety Program

Berkeley UNIVERSITY OF CALIFORNIA EH&S OFFICE OF ENVIRONMENT, HEALTH AND SAFETY

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Purpose

Overview

The **Non-Structural Earthquake Seismic Bracing Safety Program** provides guidance on the seismic safety requirements for furnishings and equipment in buildings across the University of California, Berkeley.

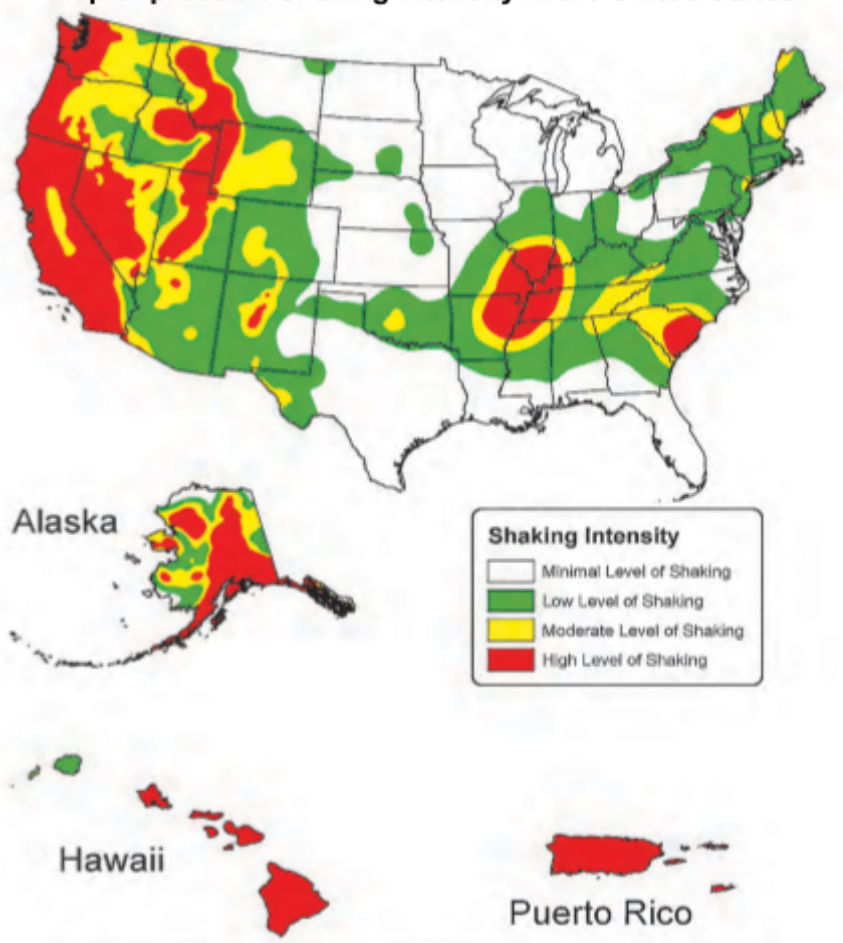
Mitigating Risk of Non-Structural Damage During Earthquakes

Most injuries that occur during earthquakes are caused by the movement of the building's contents, not by the movement of the building itself. In the United States, these non-structural failures have accounted for the majority of earthquake damage in recent years. Raising awareness of potential nonstructural risks, the costly consequences of nonstructural failures, and the opportunities that exist to limit future losses is critical. When an earthquake moves or shakes unrestrained objects, they can slide, swing, overturn, or strike people or other objects. File cabinets, freestanding bookshelves, office equipment, and items stored on shelves or racks can all cause serious injuries by their movement during an earthquake. The primary purpose of this guide is to explain the sources of non-structural earthquake damage and to describe methods for reducing the potential risks in simple terms.

Regional Applicability

UC Berkeley is situated near the Hayward Fault Zone. This means there is a risk of earthquakes impacting the campus. The Office of Environment, Health and Safety (EH&S) has put together the following resource to raise awareness about associated risks and to help secure and prevent building equipment and other non-structural materials from falling over and causing injury or blocking emergency egress from buildings. This resource provides guidance and instructions on how to identify non-structural hazards and how to implement earthquake protection measures. The supplies and materials necessary for the recommended restraint practices are available in most hardware and building supply stores.

Map of probable shaking intensity in the United States.



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ESTIMATING SEISMIC RISK

When considering what the risks of shaking intensity can be at a given site, the **Shaking Intensity Map** can be used

to estimate regional seismicity across geographic locations in the United States. The map shows the areas that are likely to experience minimal, low, moderate, or high levels of ground shaking during future probable maximum considered earthquake events. Most of California can experience high levels of shaking. Estimating the level of shaking intensity for a given location and assigning seismic risk ratings to non-structural items in terms of **life safety**, **property loss**, and **functional loss** can help reduce potential risks. For evaluation, surveying, and assessment tools that can help estimate shaking intensity and seismic risk, see **section D of FEMA E-74**.

Limitations

Please note that the Non-Structural Earthquake Seismic Bracing Safety Program is a voluntary precautionary safety measure and is not required by code. It is intended to reduce damage and disruption of non-structural items that could become hazardous during seismic activity. Non-structural components in buildings across campus, such as desks, benches, and cubicle partitions, are not, in themselves, designed to withstand seismic forces. The intention of the following bracing or anchorage recommendations is to minimize damage, disruption, and injury during earthquake events by preventing excess movement of non-structural components.

Acknowledgments

The information and guidance in this document was compiled by an EH&S Safety Engineering Specialist and is largely informed by **FEMA E-74 : "Reducing the Risks of Nonstructural Earthquake Damage – A Practical Guide"**. Information on "typical" non-structural components of labs was provided by Department of Architecture Professor Mary Comerio and her research team in 2002. Typical seismic restraint details were developed by Rutherford & Chekene, Consulting Engineers, Oakland, CA.

Understanding Non-Structural Components

Understanding the scope and nature of non-structural components in buildings, their behavior during earthquakes, and the potential consequences of associated damage is necessary to effectuate strategies for seismic risk reduction.

Definitions

Buildings contain both "structural" and "non-structural" components. The distinctions between the two types of building components are described below.

Structural Components: The structural components of a building are distinct in that they can resist wind, gravity, earthquakes, and other types of loads. Some examples of elements that meet this description are:

- **Vertical supports** such as columns, posts, pillars, and pilasters;
- **Horizontal supports** such as trusses, girders, beams, joists, and purlins;
- **Load-bearing walls** that provide vertical support or lateral resistance;
- **Diagonal elements** such as braces, floor and roof slabs, sheathing or decking; and
- **Foundation systems** such as slabs on grade, mats, spread footings, or piles.

Note: The structural system of a building is presented on construction drawings or plans. A civil or structural engineer is generally responsible for analyzing and designing the structural system of buildings.

Non-Structural Components: The non-structural components of a building include all building parts and contents except for those previously described as structural.

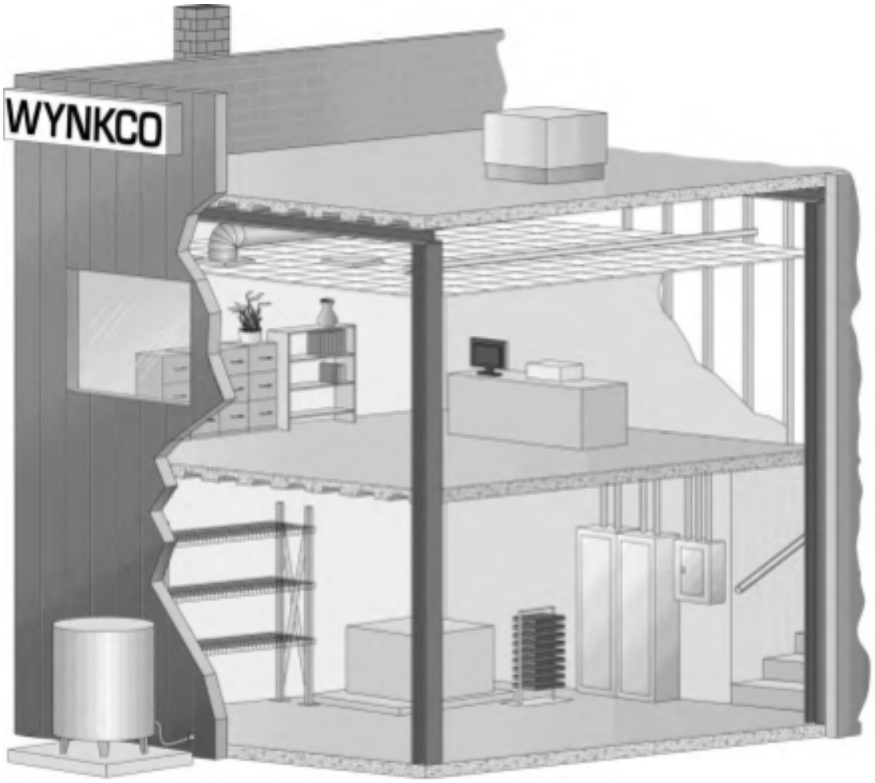
Non-structural components can be specified by architects, interior designers, electrical engineers, mechanical engineers, and plumbers before or during construction. Non-structural components can also be installed after the construction of a building has been completed. Non-structural components can be divided into three broad categories:

- **Architectural Components** such as partitions, ceilings, storefronts, glazing, cladding, veneers, chimney, fences, and architectural ornamentation;
- **Mechanical, Electrical, and Plumbing (MEP) Components** such as pumps, chillers, fans, air handling units, motor control centers, distribution panels, transformers, and distribution systems including piping, ductwork, and conduit; and
- **Furniture, Fixtures & Equipment (FF&E), and Contents** such as shelving and bookcases, industrial storage racks, retail merchandise, books, medical records, computers, electronics, and desktop equipment, wall and ceiling mounted TVs and monitors, file cabinets, kitchen, machine shop or other specialty equipment, industrial chemicals or hazardous materials, museum artifacts, and collectibles.

Note: As new technologies and products emerge, the list of non-structural components can evolve or include new contents not described above.

Visualizing Structural and Non-Structural Building Components

To the right is a three-dimensional view of a portion of a building.
This figure shows both structural and nonstructural components.



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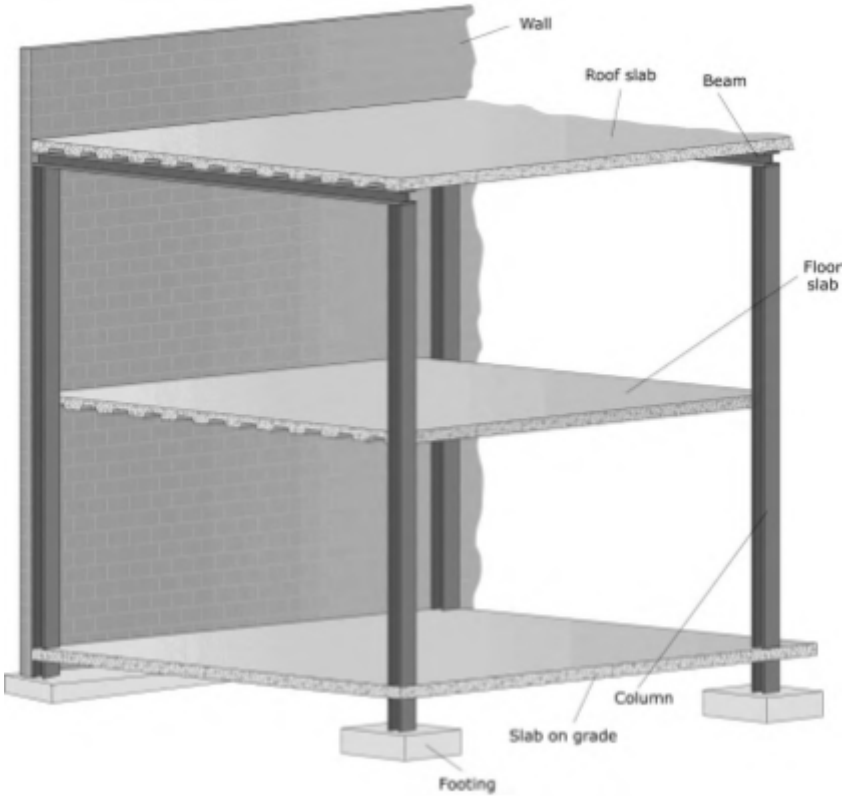
Below is a three-dimensional view of a portion of a building showing structural components only. Where equipment is anchored, it must be bolted to structural elements, such as studs in walls, or secured to concrete with approved anchors.



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Non-Structural Risk Reduction Measures

There are many potential consequences of earthquake damage to non-structural components. Reducing or mitigating the risk of non-structural hazards requires protective measures that involve the installation of seismic bracing and anchorage.

Types of Risks

Many types of non-structural components can be damaged in earthquakes, but the items that are most vulnerable and most likely to result in injuries, significant property losses, and interruption will be described here in terms of the risk posed to (1) **life safety**, (2) **property**, and (3) **functionality**.

Risk to Life Safety

The first type of risk is that people could be injured or killed by damaged or falling nonstructural components.

- **Life Safety (LS) Consideration:** Could anyone be hurt by this component in an earthquake?

Risk of Property Loss

Contents belonging to the building occupants, such as movable partitions, furniture, and office or medical equipment, represent a significant additional value at risk.

- **Property Loss (PL) Consideration:** Could a large property loss result?

Risk of Functional Loss

In addition to life safety and property loss considerations, there is the additional possibility that non-structural damage will make it difficult or impossible to carry out the functions that were normally accomplished in a facility. Thus, functional loss refers to potential post-earthquake operational downtime or reduced productivity.

- **Functional Loss (FL) Consideration:** Could the loss of this component cause an outage or interruption?

Common Sense Risk Reduction Measures

Bracing, latching, or other common sense restraint measures can go a long way toward reducing non-structural risks. Seismic anchoring of furnishings and equipment is required where it may prevent blocking of exit passages, and where items may topple and crush personnel in case of an earthquake. Identifying high or moderate risks of non-structural components in buildings and taking preventive restraint measures can help reduce the time spent on relocating or rearranging furniture and equipment. The following questions can help inform the development of inspection checklists or facility surveys to identify and reduce associated risks:

Load and Occupancy Based Protection

- Which areas of the building have a higher occupant load and hence a potentially higher life safety risk?
- Are there heavy, unstable items currently located near a desk or bed, which could be moved?

Emergency Egress Protection

- Are the exits and exit pathways clear, or are there items that could block doors, corridors, or stairways if they were to fall?

Injury and Damage Prevention

- What is the probability that someone will be injured by falling objects?
- If something slides or falls, in what direction is it likely to move?
- Is a suspended item currently hanging where it may impact a window, wall, or another item?

Safe Storage Protection

- Can items no longer serving a useful function be removed?
- Are all hazardous materials stored properly?
- Which items can be relocated to prevent possible injury and do not need to be anchored, in order to prevent damage or loss?

Note: Reducing non-structural hazards requires a combination of common sense measures and additional protective measures that involve the installation of seismic anchorage and bracing.

Seismic Protection of Non-Structural Components

There are many measures that can be implemented to reduce potential non-structural earthquake damage. Furnishings and equipment in buildings must be secured in accordance with the guidance in the document, the applicable provisions of the California Building Code, and the applicable provisions of the **University of California Seismic Safety Policy and Seismic Program Guidelines**. The following paragraphs outline several seismic protection techniques for common non-structural components in the workplace.

Protection of Functionality

Continued functionality of restrained components following an earthquake is dependent on both the basic restraint and the susceptibility of the component to shocks transmitted through the restraint, or– in the case of smaller bench top equipment– the susceptibility of the component to overturning.

Note: Functionality may also be dependent on the status of utility services such as water, electrical, or gas, which are beyond the scope of this resource document.

Protection of Contents

Shelving, racks, refrigerator/freezers, incubators, etc. must be securely restrained or latched. In addition, the contents inside uprights must be protected from falling from their storage location in the event of an earthquake. Loose items stored on bookshelves, shelves of storage racks or cabinets, and store display racks are all vulnerable during earthquakes. This includes retail merchandise, pharmaceutical and medical supplies, laboratory supplies, stored inventory as well as shelved items found in every home, school, or office. This is a requirement of ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010).

Bracing and Anchorage of Non-Structural Components for Life Safety

The details shown here are intended to prevent excessive movement of various components during seismic activity or strong earthquake motion. Restraints are used as a protective measure to prevent the occurrence of serious injury for occupants (Life Safety); and to significantly reduce the incidence of functional damage to the component (Functional Loss).

Anchoring Heavy Table and Bench Top Equipment

Many types of office and laboratory equipment items rest on desktops, workbenches or countertops. Heavy contents such as computers, monitors, microwaves, or scientific equipment on top of counters, tables, desks, or work benches could become falling hazards during an earthquake. Any of the aforementioned items could cause injury if they fall and hit someone. In addition, damage to fallen items can add to property loss and downtime. Thus, heavy equipment that is 3 feet in height or taller (above the bench top) AND possess a height to depth ratio equal to or greater than 1.5 shall be securely anchored when mounted on a table or bench top.

DESKTOP COMPUTERS AND ACCESSORIES

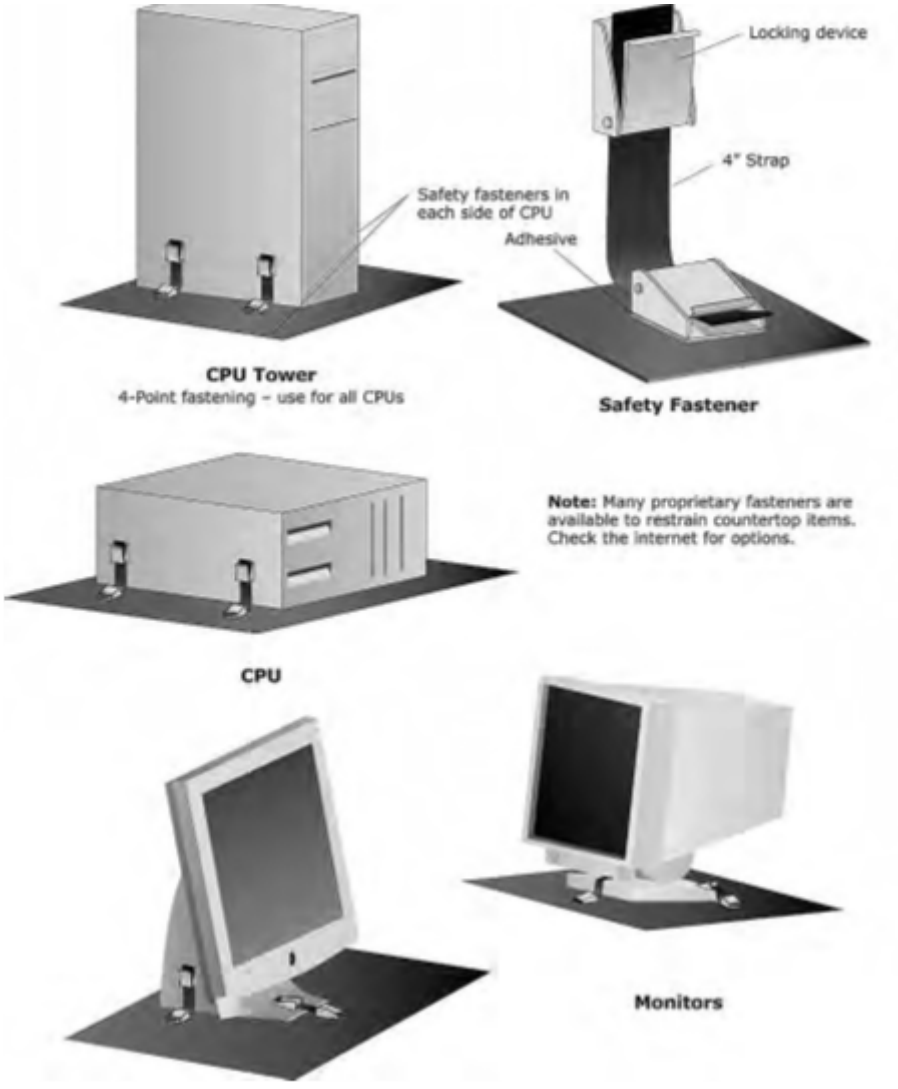
Computer equipment includes CPUs, monitors, scanners, printers, projectors, and other peripherals or electronic equipment. They are found nearly everywhere, most of them resting on desks and tables without restraint. Furniture should be load-bearing and stable, and the surface should remain clean for adhesive restraining purposes.

Typical Causes of Damage

Desktop items may slide, tip, collide with other items or fall. If one item falls, the cords and cables may pull other items down resulting in additional damage. Equipment may suffer internal damage and be rendered inoperable.

Seismic Mitigation Considerations

Desktop equipment should be anchored or tethered to reduce earthquake damage and loss of equipment functionality. The supporting desk, table or cart should also be anchored or tethered if movement could cause additional damage. In addition, cables and cords should be installed with sufficient slack to allow for some movement. Computer bracing can be installed by department staff.



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- Many proprietary safety fasteners are currently available to use to restrain desktop items. Appropriate straps and fastening devices are available in hardware stores, building supply stores, and laboratory supply stores. Several manufacturers or suppliers are listed in the details. Follow specific manufacturer's directions.

Heavy Electronic Equipment

TELEVISIONS AND WALL-MOUNTED EQUIPMENT

Wall and ceiling-mounted televisions, monitors, and projectors are found in many places across the University, including classrooms, conference rooms, and lobbies. Seismic loads for wall-mounted television and video monitors are determined using ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, (ASCE, 2010) Chapter 13. The principal objective is to prevent the components from falling.

Typical Causes of Damage

Wall or ceiling-mounted items can become dislodged and fall from the supporting bracket, the bracket could pull out from the wall or ceiling, or the bracket can break and the television or monitor may be damaged or broken. These items are heavy, may shake, bounce, impact adjacent items, or fall and could cause serious bodily injury if they fall on someone.

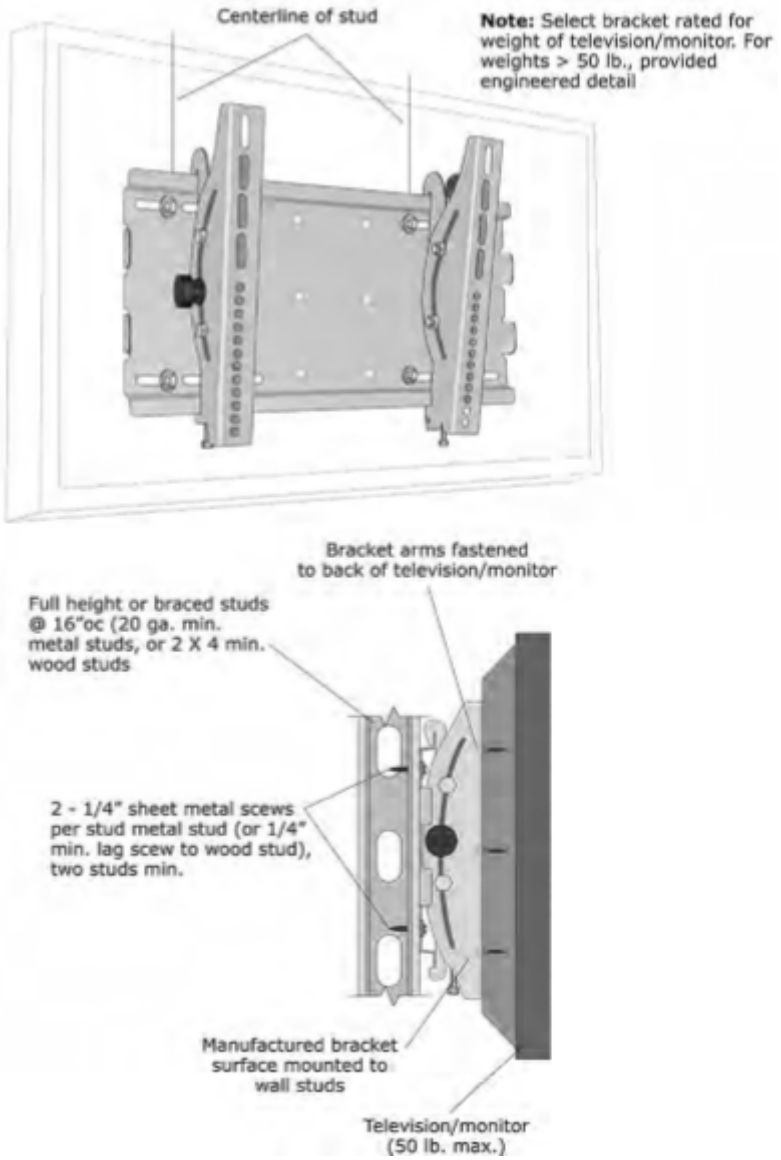
Seismic Mitigation Consideration

Proprietary mounting brackets are available to support overhead or wall-mounted televisions, monitors, and screens of all sizes. These come as rigid mount, tilt mount, or motorized mount. Some mounting products indicate they are seismic-rated for safer installations.

Brackets will not provide seismic protection unless properly installed; follow the manufacturer's installation instructions. It is critical that the lag bolts, screws, or expansion bolts used be installed directly into structural elements such as studs, concrete or masonry wall, or ceiling joists that have adequate capacity to support the additional loading.

- Do not anchor to gypsum board, plaster or a suspended ceiling grid. If the bracket can be adjusted into different positions, make sure it cannot swing and hit a window or light; providing a safety cable or tether to restrict the range of motion may reduce the risk of impact with other objects and the risk of falling.
- Do not locate overhead items directly over a bed, couch, bench, or desk in a classroom where people are likely to be.

Wall-mounted bracket for television or monitor weighing less than 50 lb



For televisions or monitors resting on table tops or furniture, heavy-duty safety fasteners or tethers should be used to prevent the television from falling and the furniture should be anchored to the floor or wall.

Electrical Danger Considerations

Only qualified personnel familiar with proper voltage equipment are to perform work described in the following set of instructions. Workers must understand the hazards involved in working with or near electrical circuits. Perform work only after reading and understanding all of the installation instructions in this manual and the manufacturer's literature. Handle equipment carefully and install, operate, and maintain it correctly in order for it to function properly. Neglecting fundamental installation and maintenance requirements may lead to personal injury, as well as damage to electrical equipment or other property.

- Turn off all power-supplying equipment before working on or inside equipment.
- Always use a properly rated voltage sensing device to confirm that the power is off.
- Beware of potential hazards. Wear Personal Protective Equipment as required by NFPA- 70E, Standard for Electrical Safety in the Workplace (2009), and take adequate safety precautions.
- Replace all devices, doors, and covers before turning on the power to the equipment.
- All activities must be performed by qualified personnel in accordance with local codes.
- Heavy equipment should be stabilized with straps and other tie-downs to reduce the possibility of tipping.
- Spreader bars must be evaluated by the appropriate design professional prior to lifting.
- When lifting, do not pass ropes or cables through lift holes. Use slings with safety hooks or shackles
- Damaged vent housings can constrict proper air flow and expose the interior of electrical voltage compartments to weather
- Do not make any modifications to the equipment or operate the system with interlocks and safety barriers removed. Contact the manufacturer's representative for additional instructions if the equipment does not function as described in this manual.
- Complete seismic installation and proper inspection of work prior to enabling the circuit breakers.
- Restore all seismic restraints removed for maintenance to their original installation configuration and torque all bolts and anchors to their proper values
- Remove all tools, lifting assembly, and miscellaneous items left on the equipment prior to enabling the circuit breaker
- Use out-of-service tags and padlocks when working on equipment. Leave tags in place until the work is completed and the equipment is ready to be put back into service

The following precautions should be taken for circuit breakers:

- The circuit breaker must be removed from its compartment and isolated from the voltage.
- Control voltage must be in the open (O) position.
- The circuit breaker must be in the open (O) position.
- All circuit breaker springs must be discharged.

Note: These electrical danger warnings and guidelines were originally developed for FEMA 413; refer to FEMA 412, 413, and 414 for additional warnings regarding the installation of bracing or anchorage details for Mechanical, Electrical, and Plumbing (MEP) equipment, ducts, and piping.

The instructions provided in this manual and by the manufacturer are written with the assumption that the customer has taken the above measures before performing any maintenance or testing. For additional electrical danger and seismic mitigation considerations, see **sections 6.4.7 - 6.4.7.3** and **sections 6.4.8 - 6.4.8.3 of FEMA E-74**. For information about electrical hazards, electrical safety procedures, equipment design, development and installation for all electrical work, at UC Berkeley, please refer to the **Electrical Safety Program**.

Refrigerator Components

LATCHING DOOR(S) AND DRAWER(S)

There are a variety of ways to correctly latch refrigerator doors and drawers. Positive latches or door locks made for seismic application can be found in hardware or home improvement stores. Other specialty latches—for refrigerator doors, for example—are available through other suppliers.

Positive door latches are necessary to protect the contents of each refrigerator. For further protection, racks or trays separating incompatible contents should be used.

SHELVING

Typical shelving is provided with perimeter lips approximately 1.5 inches high. For sensitive contents, or for contents with heights greater than 3 inches, lips of one-half the height of the contents should be installed. For further protection, racks or trays separating individual contents should be installed on shelves.

Anchoring Uprights (Shelving and Storage)

Uprights are defined as any tall and heavy storage racks, bookcases, file cabinets, and other unstable equipment over 4 feet in height, as well as file cabinets or unstable furniture over 3 feet in height. Uprights are assumed to have the capability to move in ANY direction if not blocked by other substantial fixed structures or objects. For example, shelving, bookcases, and file cabinets frequently overturn during earthquakes if they are unanchored or poorly anchored. These items are particularly hazardous if they are located adjacent to a desk or located where they can jam doors or block corridors and exits.

Exit Door and Egress Consideration: Measure 12-foot distance from door handle when door is closed. To avoid unnecessary risk,

- Uprights within egress corridors shall be anchored.
- Uprights within a room shall be anchored if located adjacent to an exit door AND have the potential to move and impede access to the exit door.
- If a room has only one exit door, then any upright from the door to the midpoint of the room shall be anchored.
- If a room has multiple exit doors and only one egress aisle, then uprights within 12 feet from each exit door shall be anchored.

FILE CABINETS

Sheet metal file cabinets are often tall, narrow, and heavily loaded. During an earthquake, these cabinets frequently overturn. File cabinets should be positioned against walls for greatest stability. One or more can be fastened to the same wall (into the studs).

Typical Causes of Damage

Unanchored file cabinets can slide, tip, or overturn. Drawers may slide open increasing the chance that the cabinet will overturn; contents may fall and get scrambled. Overturned cabinets may block doors and exit corridors.

Seismic Mitigation Considerations

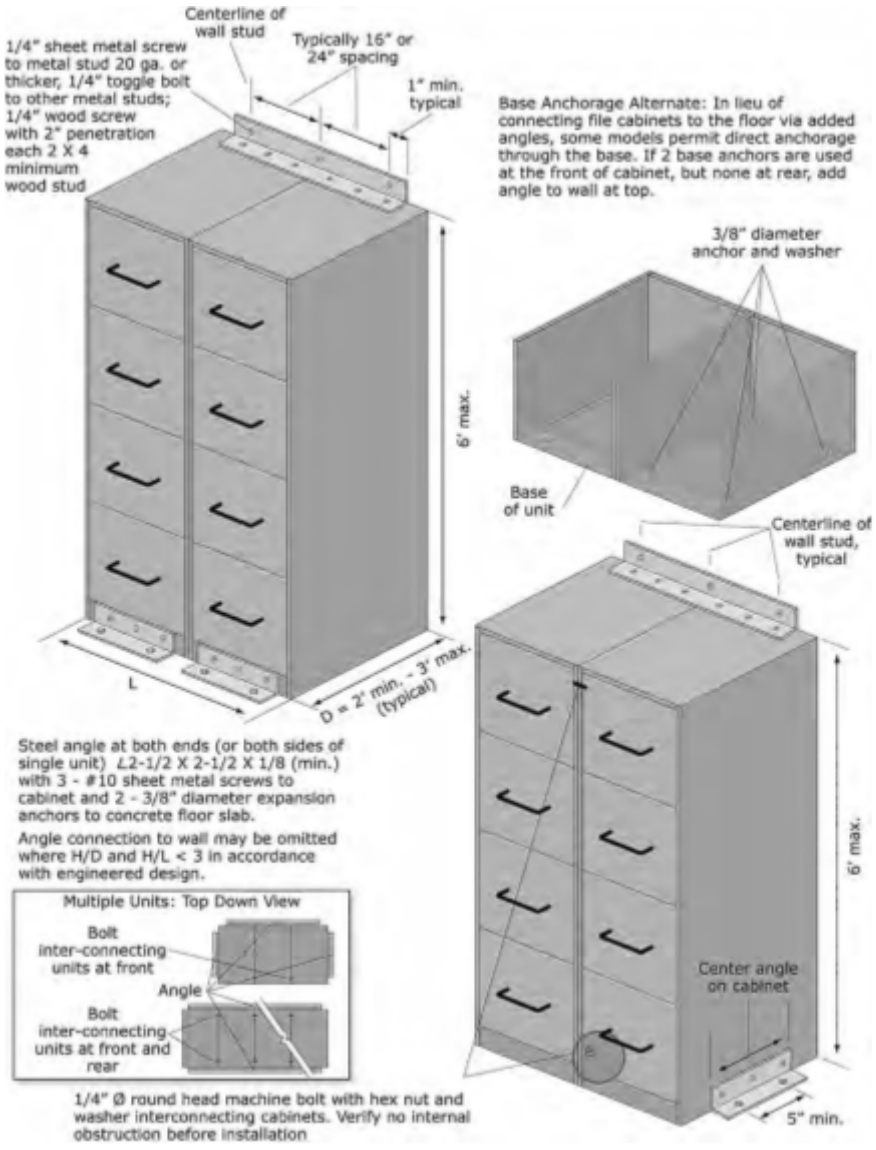
ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), requires that permanent floor supported cabinets or shelving over 6 ft tall be treated as architectural components. This requirement does not apply to wall mounted items with both base and wall anchorage.

- Do not locate cabinets where their failure would block a door or exit corridor; note some school districts do not allow file cabinets within 6 feet of a doorway. Do not locate where they could fall and break a window or glass partition.
- File cabinets should be anchored to the floor or wall. Where cabinets or shelving are anchored to a partition, check that the partition, bracing and attachment to the structure above are adequate for the imposed loading.
- Provide strong drawer latches to prevent the drawers from sliding open. Fluids and files don't mix; do not place flower vases or other breakable fluid containers on top of file cabinets.

Wall-mounted File Cabinets

There are many acceptable ways to reliably protect file cabinets from earthquake damage.

The following wall-mounted file cabinet illustration details measures that can protect loaded cabinets up to 6 ft tall in severe ground shaking at the highest locations within a building; engineering may be required for floor-supported items taller than 6 feet. Alternate less robust details may be developed for less severe loading conditions.



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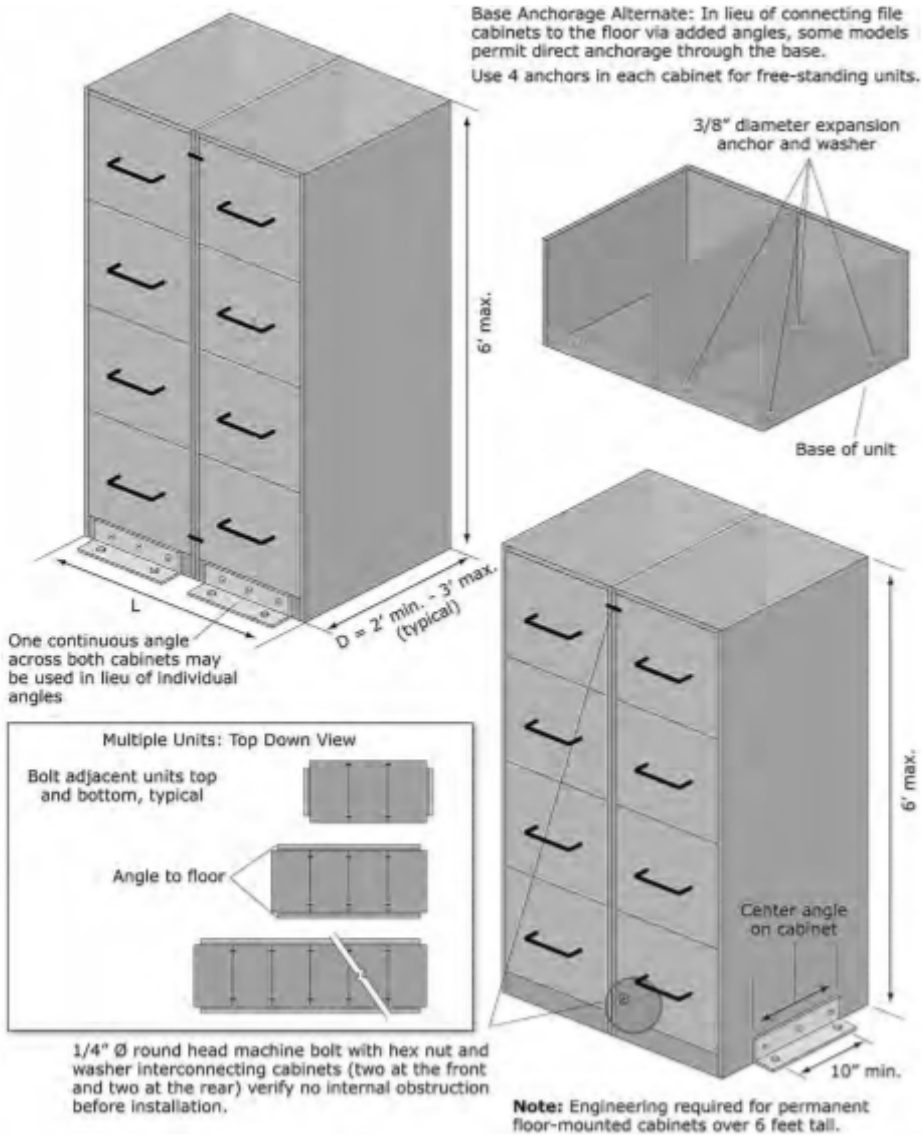

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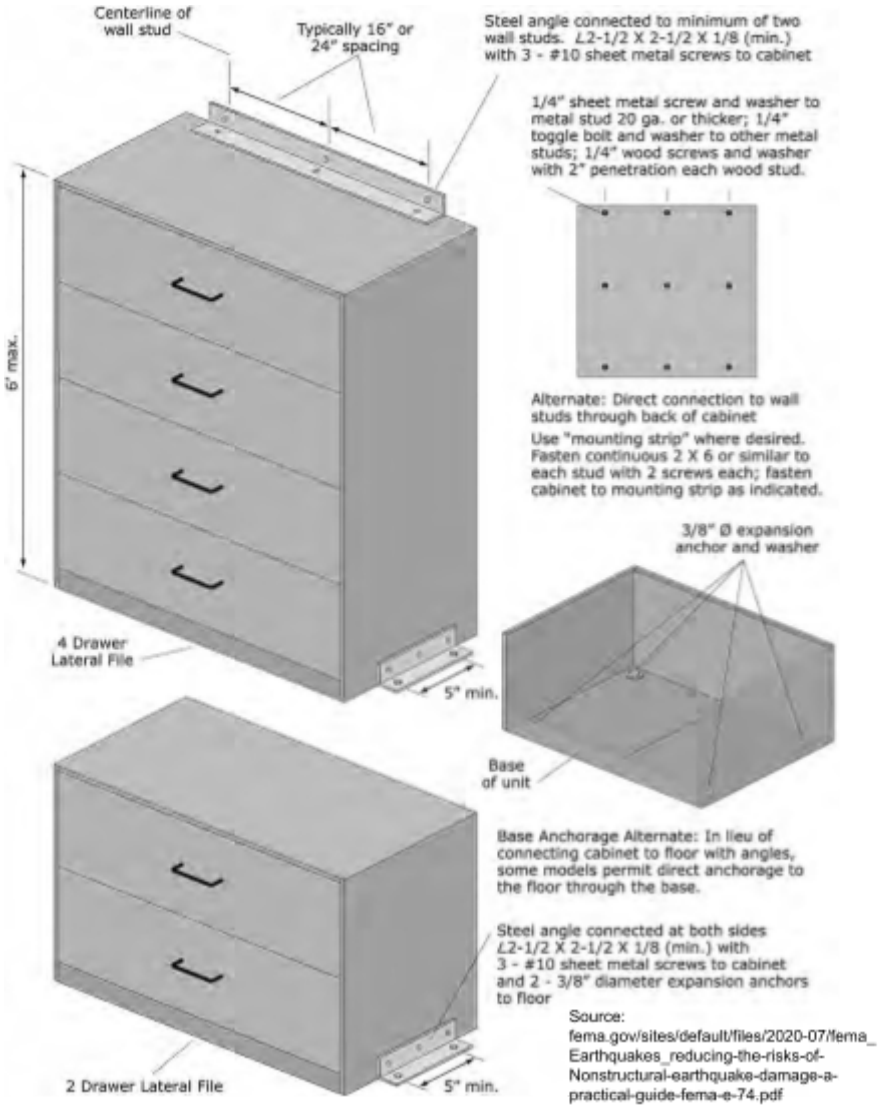
Base-Anchored File Cabinets

File cabinets or shelving not positioned against a wall should be anchored to the floor to increase their stability.

Wall-Mounted and Base-Anchored File Cabinets

Where shelving units are located against a structural wall, anchor the top of the units to the structure.

Where shelving units are not positioned against a wall, anchor the shelving units to the floor.



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BOOKCASES AND SHELVING

Tall wood or metal shelving units frequently tip or overturn in earthquakes unless they are properly anchored.

Typical Causes of Damage

Tall, narrow shelving may tip, overturn, slide or collapse and the contents may spill. Overturned shelving may injure occupants and block doors or exits. Books, files, and medical records may fall and get scrambled or damaged.

Seismic Mitigation Considerations

Permanent floor-supported shelving or storage cabinets over 6-ft tall must be designed as architectural components per ASCE 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010). Bracing and anchorage for these units should be designed considering the weight of the unit and weight of shelved contents.

Bookcases and shelving should be anchored to an adjacent stud wall or concrete or masonry wall.

- Any connections to stud walls must engage the structural studs; do not rely on gypsum or plaster to support shelving.
- Stud walls and partitions and unreinforced or lightly reinforced heavy partitions may not have the adequate lateral capacity to support multiple shelving units; engineering may be required.
- The bracing or anchorage of walls and partitions to the structure above must also be checked for adequacy considering the seismic loads imposed by all anchored items.

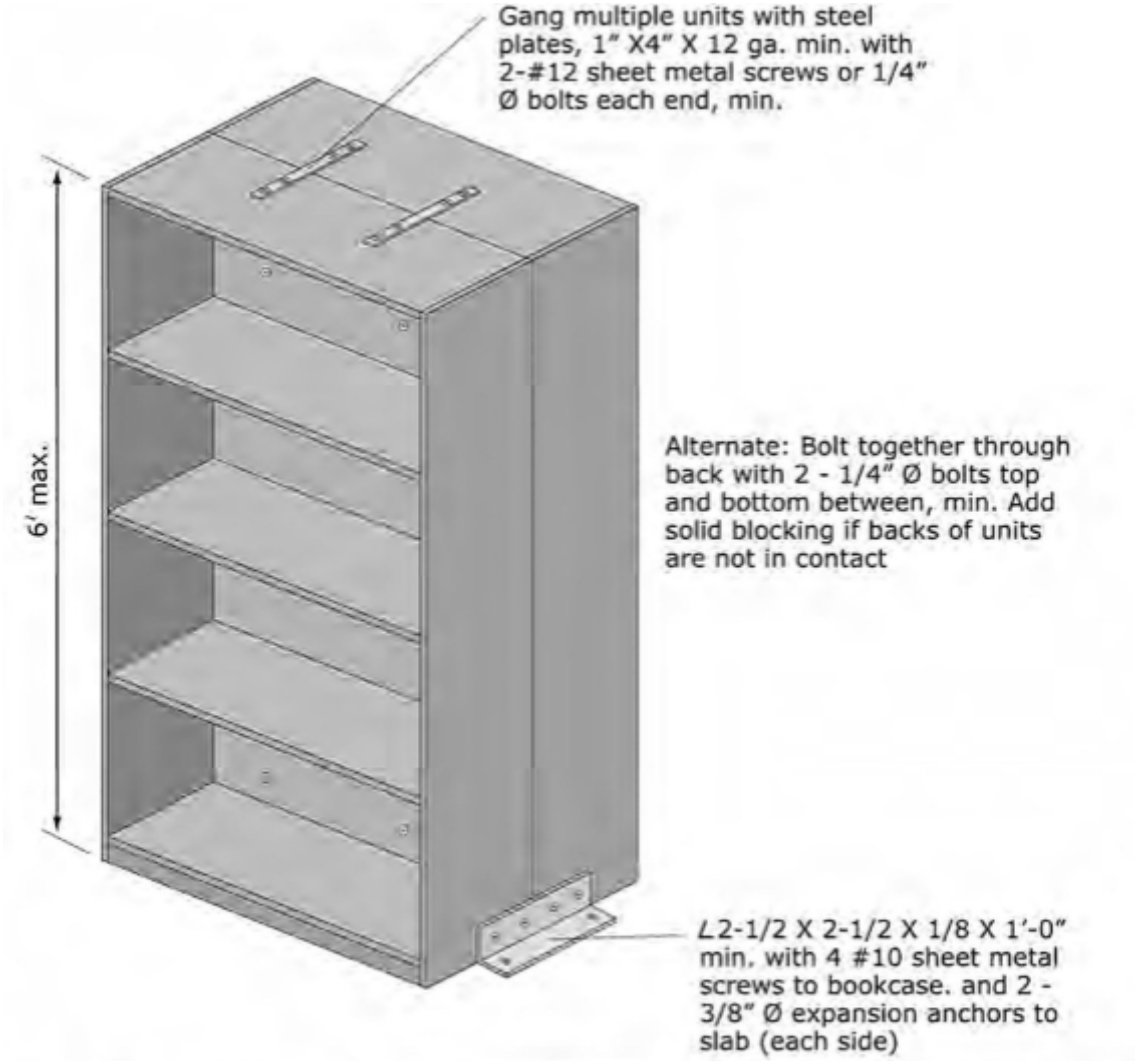
Bookcase or cabinet anchorage can be located either outside or inside the unit as long as the attachment properly engages the “structural” studs. Where aesthetics are a concern, it may be preferable to locate the screws or clip angles on the inside of the unit. In a commercial setting where maintenance personnel or movers may need to verify the anchorage or relocate the unit periodically, it may be preferable to provide exterior anchorage that is readily visible.

Anchorage of Freestanding Bookcases

Adjacent freestanding file cabinets should be anchored together and to the floor. Gang multiple units together to create a more stable arrangement.

Anchor the shelving units to the floor. Where shelving units are located against a structural wall, anchor the top of the units to the structure.

Tie freestanding back-to-back units together to create a larger base. A one-way transverse grid or two-way grid may be installed, either at the top of the units or above the ceiling surface, to tie many units together. This grid should also be anchored to structural walls at the perimeter of the grid or to the structural slab or framing above.



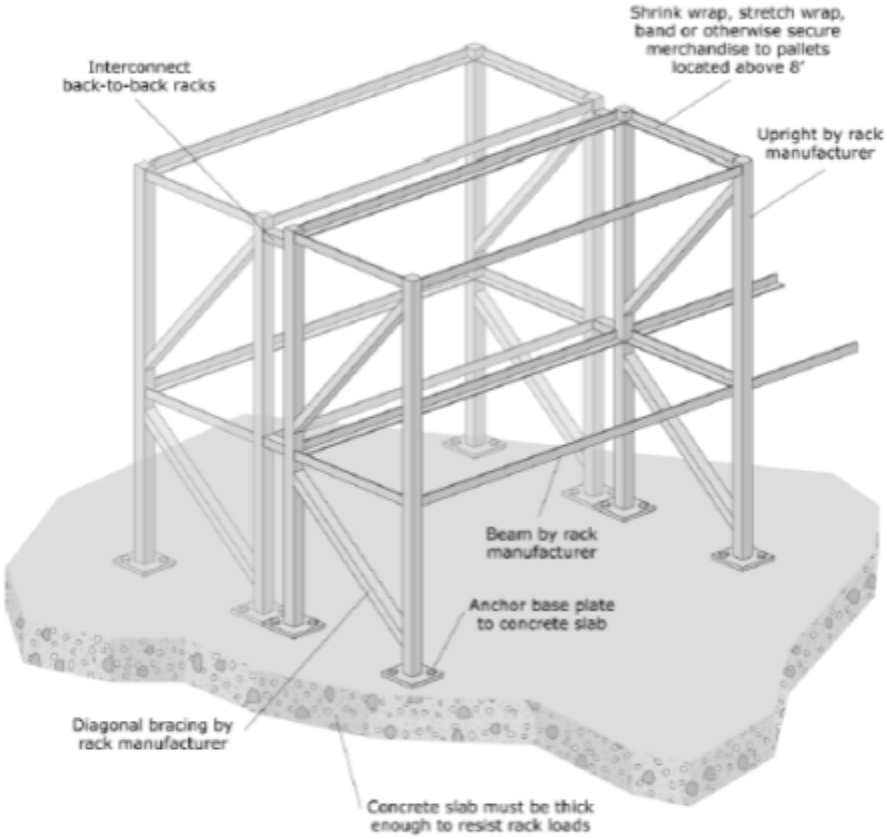
Note: Engineering required for all permanent floor-supported cabinets or shelving over 6 feet tall. Details shown are adequate for typical shelving 6 feet or less in height.

Source: fema.gov/sites/default/files/2020-07/fema_earthquakes_reducing-the-risks-of-nonstructural-earthquake-damage-a-practical-guide-fema-e-74.pdf

Note: Large library collections may contain rare or valuable items that need to be preserved; such library shelving should be engineered to prevent costly downtime and damage to the collection.

For new library installations, it is important to procure heavy duty shelving that has cross bracing or solid sides and backing that will prevent longitudinal collapse. In addition, for units that will receive additional overhead bracing, the unit should be strong enough to receive the attached ties and bracing.

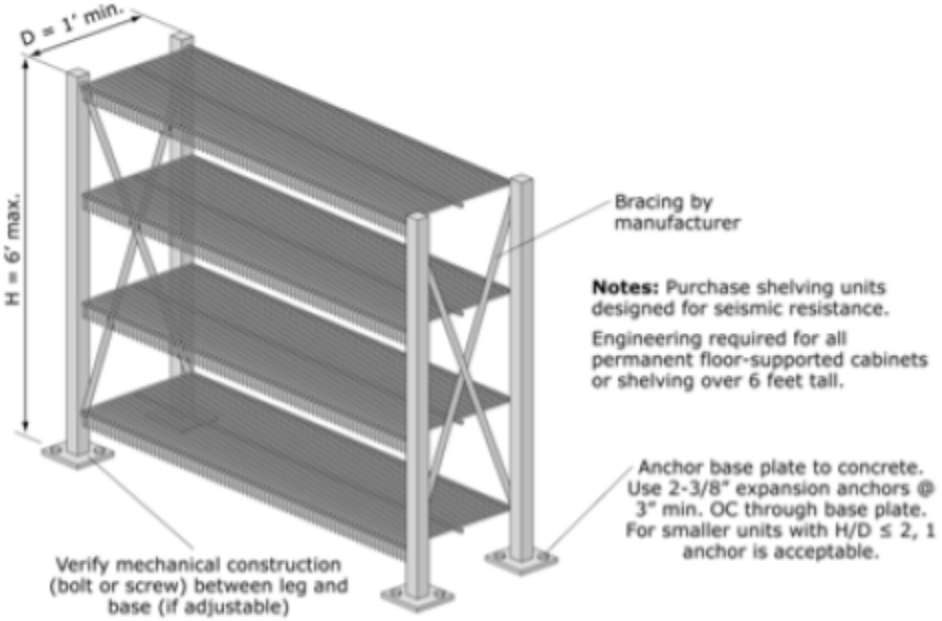
Heavy-Duty Shelving or Industrial Storage Rack



Note: Purchase storage racks designed for seismic resistance. Storage racks may be classified as either nonstructural elements or nonbuilding structures depending upon their size and support conditions. Check the applicable code to see which provisions apply.

Light-Duty Shelving

Light duty steel shelving or weak wood shelving units may require strengthening. Steel shelving may require additional cross bracing. Wood shelving units could be strengthened with the addition of corner brackets or hardware to tie the top, back and sides more securely together.



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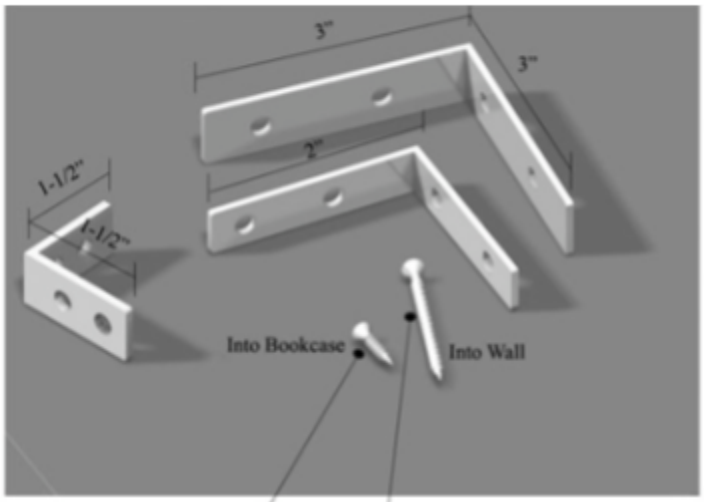
Hardware Considerations

What is appropriate for wood studs and wood floors differs from what is appropriate for concrete floors or metal stud walls.

Choose carefully, see the following illustrations and details for additional guidance.

Wall Anchor

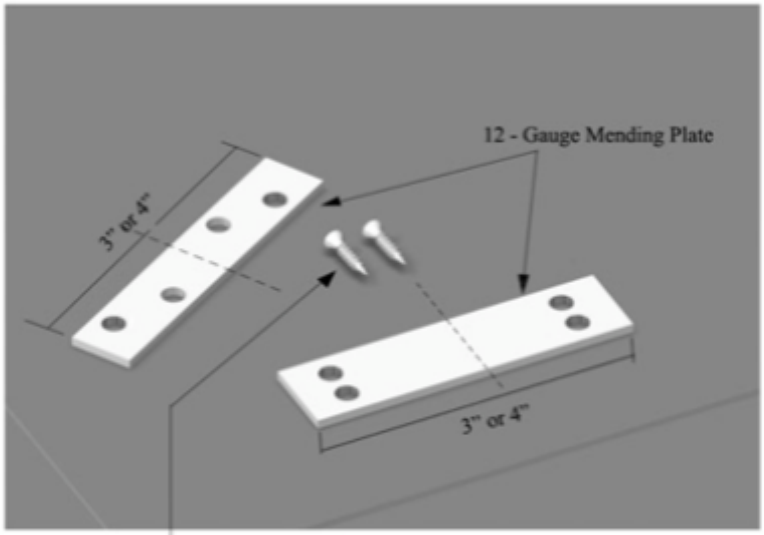


3/4"Long #12 Screw
or 1/4" Dia Bolt
with 2" Dia Washer and Bolt.

#12 Wood Screws (for Wood Studs):
2-1/4" long min.
#12 Sheet Metal Screws (for Metal Studs):
1-1/4" long min.

All screws must be embedded in studs.
- Wood screws go into wood studs.
- Sheet metal screws go into metal studs

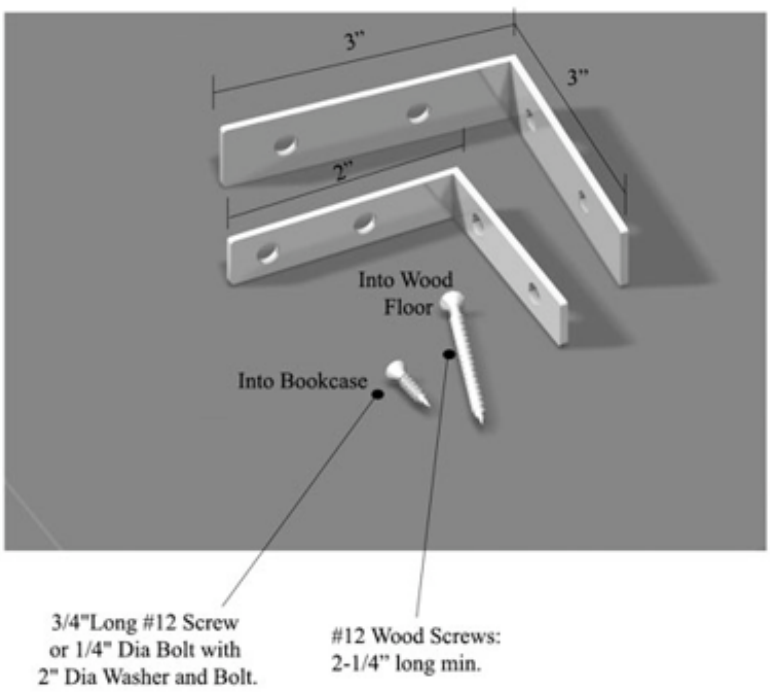
Ganging Mending Plates



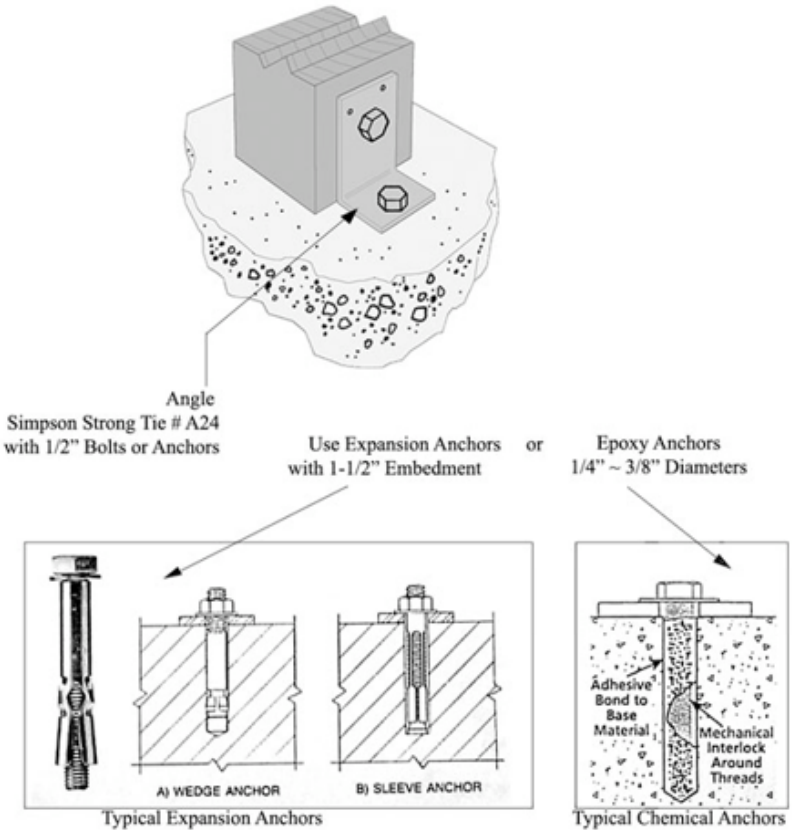
3/4"Long #12 Screw or 1/4" Dia Bolt with 2" Dia Washer and Bolt.

Wood screws go into wood shelves or cabinets
Sheet metal screws go into metal shelves or cabinets

Wood Floor Anchor



Concrete Floor Anchor



Precautionary Considerations

Toggle bolts mounted into gypsum board or plaster are not acceptable.

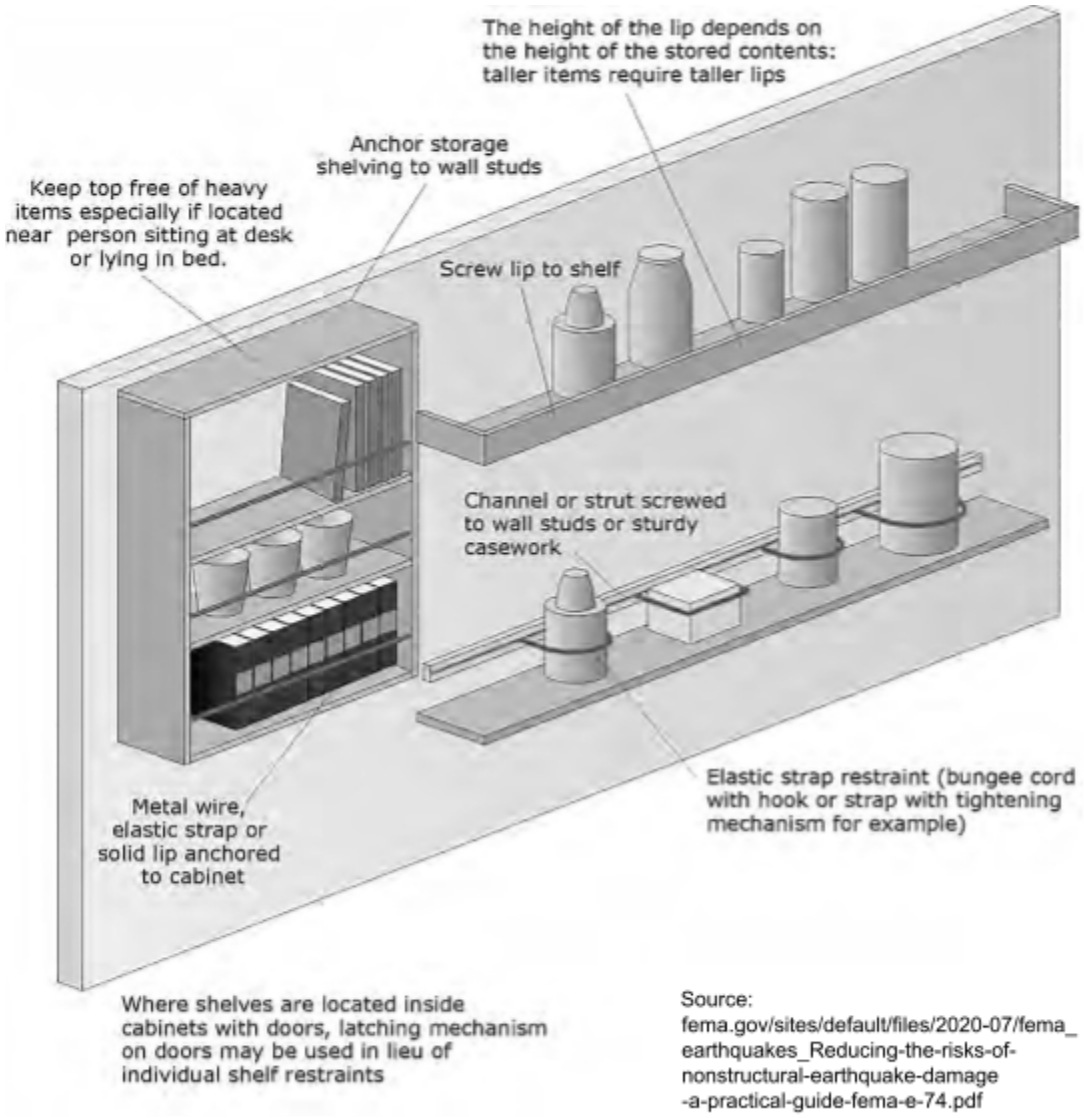
Nails are never allowed for any anchorage.

Dust generated when drilling into concrete may set off fire alarms if smoke detectors are located nearby.

Use best management practices to control the dust; please request approval from the Campus Fire Marshal if you cannot control the dust.

Bracing Shelf-Mounted Items

Loose items stored on bookshelves, shelves of storage racks or cabinets, and store display racks are all vulnerable during earthquakes. This includes retail merchandise, pharmaceutical and medical supplies, laboratory supplies, stored inventory as well as other common shelved items.



Seismic Mitigation Considerations

Unless each item is packed tightly or individually restrained, loose material will slide around during an earthquake. Thoughtful organization of shelved items can reduce the potential for damage.

- Place larger and heavier items on lower shelves and lighter and smaller items on upper shelves
- Provide edge restraints with wood, clear plastic or wire as shown
- Provide individual restraints for especially toxic or costly items
- Purchase storage racks or shelving units with shelving that slopes 3-4 degrees towards the back; or attach a thin wedge to each shelf sloping towards the back as this prevents many items from falling to the floor
- Provide positive latches to prevent cabinet doors or drawers from opening; baby proof latches are one example.

Shelves containing heavy hardbound books or artifacts should have shelf restraints to prevent the objects from becoming potentially deadly airborne missiles. Shelves containing chemicals or biological materials should have restraining lips to prevent containers from tumbling off and becoming potentially hazardous mixtures. It is very important to make the lips tall enough to keep the containers on the shelf: taller containers require higher lips. The minimum lip height is 2 inches.

HAZARDOUS MATERIALS STORAGE

Unsecured or improperly stored hazardous materials may lead to hazardous spills and health concerns during earthquakes. Hazardous materials may include cleaning supplies, laboratory or production chemicals, medical sharps, and biohazard containers.

Note: Hazardous Materials should be stored in specified **Hazardous Chemicals Storage Cabinets**.

Typical Causes of Damage

- Loose containers may slide, tip, overturn, or fall.
- Glassware may break; hazardous contents may slosh or spill and create noxious fumes and toxic mixtures.
- Spilled flammable liquids may cause a fire and destroy a home or business that otherwise may have survived an earthquake without damage.
- Unknown spills may cause building closure until a HAZMAT team can investigate.

Seismic Mitigation Considerations

The National Fire Protection Association (NFPA), the International Building Code, and the International Fire Code (IFC) contain many requirements pertaining to the classification, labeling, handling, monitoring, shipping, containment, and **storage of hazardous materials**.

Hazardous materials storage cabinets and lockers are available with secure door closures and internal containment in case materials spill inside the cabinet. In addition, bracing and anchoring of shelves or cabinets used for the storage of hazardous materials are useful seismic mitigation measures.

- Where shelving or cabinets are anchored to a partition wall, check that the partition, bracing and attachments to the structure above are adequate for the imposed loads.
- Provide edge restraints for containers of flammable or hazardous substances even if they are in closed cabinets.
- Secure large containers of production chemicals or cleaning supplies; these may be secured using tether cables or chains.
- Store small or breakable items in original packaging or in “egg crate” type boxes; not loose on shelves or in drawers.
- Ensure that all toxic items are in the correct containers and properly labeled.

Project Planning and Responsibility

Bracing Oversized or Unique Non-Structural Components

Bracing of larger, heavier, or unique equipment might require custom planning, design, and construction. Custom restraints for these types of non-structural components are beyond the scope of this resource document.

Custom Bracing on Campus

While some custom bracing for non-structural components can be performed by Facilities Services or departmental shops, the design of custom restraint systems for oversized or unique equipment shall be performed by a qualified structural engineer with the support of Capital Strategies. Part of the University's Administrative Division, **Capital Strategies** manages the design and construction of campus buildings to serve the campus community.

INITIATING A CUSTOM PROJECT

Heavy or unique non-structural components that exceed 400 pounds and have a center of gravity of 4-ft or taller shall be seismically restrained. In order to ensure the installation meets code and campus requirements, departments seeking to install and restrain this kind of equipment should **initiate a project with Capital Strategies**. This allows for a Project Manager (PM) to facilitate the hiring of a Contractor and Structural Engineer (SE) to design the restraint system. Subsequently, SEs from Capital Strategies review and approve custom restraint system plans. The process also requires specific permits, inspections, and the involvement of the campus Building Department.