It is necessary to identify nonstructural hazards at the school site to reduce the possibility of injury in the event of an earthquake. Nonstructural hazards can occur in every part of a building and all of its contents with the exception of structure. In other words, nonstructural elements are everything but the columns, beams, floors, load-bearing walls, and foundations. Common nonstructural items include ceilings, lights, windows, office equipment, computers, files, and anything stored on shelves or hung on walls. In an earthquake, nonstructural elements may become unhooked, displaced, thrown about, and tipped over; this can cause injury and loss of life, extensive damage, and interruption of operations. Ever since the Field Act of 1933, public school buildings in California have been constructed to meet stringent seismic design codes; however, attention was not given to nonstructural hazards until relatively recently. Title 24 of the California Code of Regulations now prescribes some nonstructural seismic safety elements for new construction in public schools, but many nonstructural hazards are still not covered. A checklist gives the nonstructural hazards known to be dangerous or problematic in earthquakes. Illustrations contain the specifications necessary to correct the particular nonstructural hazard. (Author/KDP)
IDENTIFICATION AND REDUCTION
OF
NONSTRUCTURAL EARTHQUAKE
HAZARDS
IN
CALIFORNIA SCHOOLS

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If length or width is less than two-thirds the height, the unit may overturn in an earthquake.

Combined width
Connections no more than 4' apart

Height

Bay Area Regional Earthquake Preparedness Project
A Project of the Governor’s Office of Emergency Services

Bolt back-to-back through frame at corners with 1/4" bolts and oversize washers.
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IDENTIFICATION AND REDUCTION OF NONSTRUCTURAL EARTHQUAKE HAZARDS IN CALIFORNIA SCHOOLS

developed by Bay Area Regional Earthquake Preparedness Project

and

Office of the State Architect Structural Safety Section

February, 1990
The publication of this document was supported by funding through a cooperative agreement between the Federal Emergency Management Agency and the California Office of Emergency Services. The recommendations included in this document are intended to improve hazard mitigation. The contents do not necessarily reflect the views and policies of the Federal Emergency Management Agency, the Governor's Office of Emergency Services, or the Office of the State Architect. The contents do not guarantee the safety of any individual, structure, or facility in an earthquake. Neither the United States nor the State of California assumes liability for any injury, death, or property damage that occurs in connection with an earthquake.
NONSTRUCTURAL EARTHQUAKE HAZARDS

INTRODUCTION

This publication is intended to help identify nonstructural hazards at the school site and to show how those hazards can be reduced. Nonstructural hazards can occur in every part of a building and all of its contents with the exception of the structure. In other words, nonstructural elements are everything but the columns, beams, floors, load-bearing walls, and foundations. Common nonstructural items include ceilings, lights, windows, office equipment, computers, files, air conditioners, electrical equipment, furnishings, and anything stored on shelves or hung on walls. In an earthquake, nonstructural elements may become unhooked, dislodged, thrown about, and tipped over; this can cause injury and loss of life, extensive damage, and interruption of operations.

Ever since the Field Act of 1933, public school buildings in California have been constructed to stringent seismic design codes; however, attention was not given to nonstructural hazards until relatively recently. Title 24 of the California Code of Regulations now prescribes some nonstructural seismic safety elements for new construction in public schools, but many nonstructural hazards are still not covered. Both public and private schools can make use of this publication to determine the extent of nonstructural hazards in their facilities.

The checklist on pages 2 through 4 contains the nonstructural hazards known to be dangerous or problematic in earthquakes. School administrators and engineers may carry the checklist with them as they survey a school site. After the survey is complete, any checked NO boxes represent hazards in need of correction.

In parentheses after each hazard listed there is either a brief solution or a numbered reference. The numbers refer to solutions on pages 5 through 18 that illustrate how to restrain or anchor nonstructural elements and thereby reduce their hazardousness. The illustrations contain the specifications necessary in order to correct the particular nonstructural hazard.

For some items the fix is fairly complicated, and (A/E) indicates that an architect or engineer should be consulted. (LS) after an item draws attention to the fact that it is a life safety hazard and should be a high priority for correction. Items in italics are generally already taken care of if they were part of recent state-approved construction in public schools.

This publication was developed jointly by staff at the Bay Area Regional Earthquake Preparedness Project (BAREPP), and the Structural Safety Section of the Office of the State Architect. An earlier BAREPP publication by Robert Reitherman, Reducing the Risks of Nonstructural Earthquake Damage: A Practical Guide, was adapted to address specifically those nonstructural hazards most common in California schools.

Any questions about the use of this document should be directed to Dennis Bellet, Code/Research Engineer, at the Office of the State Architect in Sacramento, (916) 445-8730.
CHECKLIST

Use this checklist to complete a nonstructural hazards survey at a school site. Once the survey is completed, any checks in the NO boxes indicate items that are in need of correction.

YES/NO

EQUIPMENT AND FURNISHINGS

☐ □ Are desktop computers secured? (solution EF1a or b)
☐ □ Are the tops of tall (4- or 5-drawer) file cabinets secured to the wall? (solution EF2) (LS)
☐ □ Do file cabinet drawers have latches? (provide latches)
☐ □ Are large and heavy office machines restrained and located where they will not slide a few inches, fall off counters or block exits? (solution EF3a or b)
☐ □ Are wall-mounted objects over 5 lbs. connected to structural framing? (solution EF4)
☐ □ Are tall cabinets, bookshelves, coat closets attached to the wall or attached to each other? (solution EF5) (LS)
☐ □ Are desks or tables located such that they will not slide and block exits? (move them)
☐ □ Are tall storage racks cross-braced in both directions or, for racks significantly taller than wide, are there large anchor bolts connected to the concrete slab? (solution EF6) (LS)
☐ □ Are heavy or sharp wall decorations securely mounted, with closed eye-hooks, for example? (solution EF4)

☐ □ Are valuable, fragile art objects or trophies protected against tipping over, breaking glass or sliding off shelves or pedestals? (solution EF7)
☐ □ Are refrigerators or ranges restrained by built-in kitchen cabinetry or attachments to floor or wall? (solution EF2) (LS)
☐ □ Is floor-supported freestanding shop equipment secured against overturning or sliding? (solution EF8) (LS)
☐ □ Are fire extinguishers securely mounted? (solution EF9)
☐ □ Are potted plants or heavy items on top of file cabinets or other high locations restrained? (solution EF10)
☐ □ Are display cases or aquariums protected against overturning or sliding off tables? (solution EF1)
☐ □ Are weight room equipment and racks anchored and weights properly stored? (provide secured racks)
☐ □ Is freestanding equipment on wheels locked against rolling? (lock wheels)

HAZARDOUS MATERIALS

☐ □ Are compressed gas cylinders secured top and bottom with a safety chain? (solution HM1)
☐ □ Are laboratory chemicals on shelves restrained? (solution HM2) (LS)

(A/E) indicates an architect or engineer should be consulted. (L/S) indicates a life safety hazard.

Items in italics are generally already taken care of in public schools if they were part of recent, state-approved construction.
YES/NO

☐ Are gas tank legs anchored to a concrete footing or slab? (solution HM3) (A/E) (LS)

☐ Are containers of hazardous materials stored on braced storage racks or tall stacks? (provide secured storage) (LS)

☐ Do gas pipes have flexible connections? (provide flexible connections) (A/E)

OVERHEAD ELEMENTS

☐ Does the suspended ceiling have diagonal bracing wires? (solution OE1) (A/E) (LS)

☐ Are the fluorescent light fixtures merely resting on the hung ceiling grid, without another support? (solution EE1) (A/E) (LS)

☐ Do pendant mounted light fixtures or chandeliers have safety cables? (solution OE4) (LS)

☐ Will hanging light fixtures swing freely, not hitting each other if allowed to swing 45 degrees minimum? (fix or remove fixtures) (LS)

☐ Are decorative ceiling panels or latticework securely attached? (solution OE1)

☐ Will spotlights remain securely attached if shaken? (secure them)

☐ Are sound system speakers in elevated locations anchored to structure? (secure speakers)

☐ Are suspended space heaters, especially gasfired, braced and/or have flexible gas connections? (solution OE2) (A/E)

☐ Do hanging plants, mobiles, or displays have closed eye-hooks, and can they swing freely 45 degrees? (secure objects in safe locations, see solution EF4)

☐ Could chandeliers swing freely, not hitting each other, or windows, roof trusses, or walls? (immobilize or move chandeliers)

☐ Are air distribution grills or diffusers securely mounted? (provide anchorage)

☐ Do large metal air distribution ducts, especially those suspended a few feet, have diagonal bracing? (solution OE3) (A/E)

☐ Have heavy objects been removed from the tops of shelves? For 5 & 6 year olds, overhead objects are only 3 feet off the floor. (remove the objects) (LS)

ELECTRICAL EQUIPMENT

☐ Are fluorescent light bulbs and lenses fastened securely? (solution EE1)

☐ Are emergency battery-powered lights fastened securely on shelves? (secure batteries)

☐ Is essential communications equipment secured? (secure it)

MECHANICAL EQUIPMENT

☐ Are the water heaters restrained? (solution ME1)

☐ Is the furnace or boiler restrained? (solution EF8) (A/E)

☐ Are there masonry incinerator chimneys on the school site that have not been reinforced? (remove them) (A/E) (LS)

(A/E) indicates an architect or engineer should be consulted. (LS) indicates a life safety hazard.

Items in italics are generally already taken care of in public schools if they were part of recent, state-approved construction.
Use this checklist to complete a nonstructural hazards survey at a school site. Once the survey is completed, any checks in the NO boxes indicate items that are in need of correction.

YES/NO

☐ ☐ Are large diameter pipes braced or do pipes that cross expansion joints have accommodation for movement? (solution ME2) (A/E)

☐ ☐ Are fans, chillers, pumps, or other heating-ventilating-air conditioning equipment--typically found in mechanical rooms--restrained or mounted correctly? (solution ME3a or b) (A/E)

☐ ☐ Do the fire sprinkler risers have a v-brace to the wall, and do the large diameter sprinkler pipes have diagonal braces to the structure above? (solution ME2) (A/E)

PARTITIONS

☐ ☐ Are freestanding, movable, partial-height partitions--especially if supporting bookshelves--adequately braced? (solution PA1)

☐ ☐ Have all unreinforced masonry partitions, usually brick or hollow tile walls in pre-1933 buildings, been removed? (remove them) (LS)

☐ ☐ Are light-weight drywall partitions that extend as high as the hung ceiling braced or supported by the structure above, particularly if these partitions are used as lateral support for tall shelving or cabinets? (solution PA3) (A/E)

☐ ☐ Are the clear panels in partitions made of plastic or safety glass? (replace with shatter-proof material or apply shatter-resistant film)

WINDOWS

☐ ☐ Are the large panes made of safety glass, and is it known if the mounting of the panes was designed by an architect/engineer to accommodate expected seismic distortion of the surrounding structure? (apply shatter-resistant film)

☐ ☐ Are transoms (glass panes over doors) of safety glass? (apply shatter-resistant film)

EXTERIORS

☐ ☐ Are decorations or appendages adequately attached? (solution E1) (A/E)

☐ ☐ Are statuary or decorative objects anchored? (solution E1) (A/E)

☐ ☐ Are tall backboards or fences supported by pressure-treated wood posts or galvanized metal posts? (provide anchorage to ground)

☐ ☐ Are fences made of concrete, concrete block, stone or brick, adequately reinforced to resist earthquakes? (reinforce or remove) (A/E)

☐ ☐ If large trees are leaning or in poor health are they supported? (support or remove trees)

☐ ☐ Is signage adequately secured, especially if heavy? (solution E1)

(A/E) indicates an architect or engineer should be consulted. (LS) indicates a life safety hazard.

Items in italics are generally already taken care of in public schools if they were part of recent, state-approved construction.
Threaded washer or nut glued to the underside of the equipment.

Equipment is placed on countertop over holes and bolts are threaded through countertop into base of equipment.

---

EF1(a) - FIXED ATTACHMENT OF EQUIPMENT TO COUNTERTOP

EF1(b) - REMOVABLE ATTACHMENT OF EQUIPMENT TO COUNTERTOP

2" x 2" pads of heavy duty hook and loop material.
Top connections to tie units together to form more stable shape.

Two (2) 1/4" diameter bolts or #14 wood screws per unit.

2" (min) into stud or structural member.

Use continuous angle with lag bolts or expansion anchors to floor.

Do not use toggle bolts.

**EF2 - CABINETS ATTACHED AT TOP, BOTTOM AND SIDES TO STRUCTURE**

"Bicycle" or "Bungee" elastic cord

**EF3(a) - TIE DOWN ATTACHMENT OF RADIO EQUIPMENT**
Glued-on threaded mounting also possible
- Rubber "doorknob" bumpers

**EF3(b) - DETACHABLE LEASH ATTACHMENT OF RADIO EQUIPMENT TO WALL**

Hook connected to wall stud. Close hook with pliers after hanging object.

**EF4 - ATTACHMENT OF SHELVES AND PICTURE FRAMES TO WALLS**
If length or width is less than two-thirds the height, the unit may overturn in an earthquake.

Bolt back-to-back through frame at corners with 1/4" bolts and oversize washers.

**EF5 - BACK-TO-BACK ATTACHMENT OF BOOKCASES TO PREVENT OVERTURNING**

**EF6 - BRACING OF LIBRARY SHELVING (STACKS)**
Bent wire supporting arms can be fashioned to hold onto small sculpture.

"Bean bag" containing sand or shot to lower the center of gravity.

Monofilament fishing line guy lines

Supporting pedestal and cabinet must also be anchored

Glass case close fitting at top or sides

EF7 - BRACING OF FRAGILE DISPLAYS

For objects under 1000 lbs.

For heavier equipment, seek an architect's or engineer's advice.

Minimum 1/2" wide x 3" embedment expansion anchors at each corner. Torque test to 30 foot-pounds.

EF8 - BOLTING OF SHOP EQUIPMENT TO FLOOR
**EF9 - ATTACHMENT OF FIRE EXTINGUISHER TO WALL**

- Good location for flashlight
- Quick-release strap
- Cabinet bolted to structure of wall
- Latch on door (Must not be lockable, or else glazing must be easily broken for access)

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**EF10 - GUARDRAILS TO CONTAIN FALLING OBJECTS**

- Potted plant or other heavy, high object
- Guard rail alternative
- Large patches (4 x 5 sq. in.) of Velcro glued with appropriate adhesive, to bottom of object and top of cabinet.

See separate chart for tall file cabinets
Safety Restraints for Bottled High Pressure Gases

Elastic bicycle strap restraint
Spring and wire restraint
Attach shelves and cabinets to wall securely
Place heaviest or more hazardous objects low and in enclosed cabinet with latching door

1/4" diameter screw eye

Chain restraint
Gas cylinder
Attach securely to structure above.

New bracing bolt or weld to frame.

Duct attachment point.
For exposed fluorescent light bulbs or fixture lenses subject to falling, secure in place with 2 wires that wrap beneath the lens or bulb and attach securely to the fixture.

Light fixture

12 gauge wires at each corner or at least diagonally opposite corners
ME1 - SEISMIC BRACE SYSTEM FOR HOTWATER HEATERS

1. Attach securely to structure

ME2 - SEISMIC BRACING OF PIPING

- 5/16" strap
- 5/16" x 3" lag bolt with washer into structure
- 1/2" EMT conduit with flat ends
- 16 gauge strap
- Flexible gas or electrical connection
- Anchor to floor

- Angle brace
- Pipe clamp
- Pipe

Attach securely to structure
Sufficient gaps to allow springs to isolate motor vibration under normal use.

Neoprene "bumper" pads

2 steel "Z" or other typical snubbers on each of the four sides to prevent upward or lateral earthquake motion.

Anchor bolts

Spring mount

ME3(a) - SEISMIC SNUBBERS AND SPRING MOUNT FOR MECHANICAL EQUIPMENT

Generator
Motor
Steel "chassis"

Anchor bolt
Concrete slab

ME3(b) - ANCHOR BOLT AND CHASSIS SYTEM FOR MECHANICAL EQUIPMENT
**PA1 - INTERLOCKING ARRANGEMENT FOR SEISMIC STABILITY**

- 5/16" diameter lag bolt attached to ceiling structure
- Angle brace 1 1/2" x 1 1/2" x 1/8" at 6' on center
- Bolt to floor or desks
- Zig-zag layout more stable

**PA2 - SEISMIC BRACING OF NON-STRUCTURAL PARTITIONS AND ROOM DIVIDERS**

- 5/16" diameter lag bolt attached to ceiling structure
- Angle brace 1 1/2" x 1 1/2" x 1/8" at 6' on center
- 5/16" diameter bolt
- 5/16" diameter bolt or three (3) #12 sheet metal or wood screws
- Partial height partition
Heavy marquee, sign, canopy

Rustproofing essential

Top strut rather than chain can prevent "seismic bouncing"

Cantilever back-up capability

Connections directly to structure

E1 - BRACING OF CANTILEVERED MARQUEE OR SIGN