Chapter 14: Maintaining the Building

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Maintaining the Building

14.1 Introduction

To maintain maximum building performance, a coastal building's structural system and envelope (i.e., exterior wall covering, doors, windows, and roof covering) must not be allowed to deteriorate. If the building is significantly degraded by corrosion, wood decay, termite attack, or weathering, its vulnerability to damage from natural hazards is increased. Figure 14-1 shows a decayed pile that appears from the outside to be in acceptable condition. Under the loads imposed by a natural hazard event, this pile could fail.

Figure 14-1
Pile that appears acceptable from the outside but that is decayed in the center.

The key to reduced long-term maintenance is the initial selection of appropriate materials and proper construction. **Maintenance and repair demands will be directly influenced by decisions made during building design and construction.** If less durable materials are installed, the frequency and costs of required maintenance and repair will be increased. Design and detailing of various building systems (e.g., exposed structural, window or roof system) also significantly influence maintenance and repair demands.

COST CONSIDERATION

Maintenance and repair costs are directly related to design decisions, materials selection, and construction methods.

To help ensure that a coastal building is properly maintained, this manual recommends that buildings be inspected annually (see Table 14.1) by persons knowledgeable of the systems and materials they are inspecting. The following building components should be inspected annually: building envelope, including wall sheathings, doors, windows, shutters, and roof coverings; foundation and structural frame; and exterior-mounted mechanical and electrical equipment. Items requiring maintenance, repair, or replacement should be documented and the required work scheduled.

Other items that should be inspected include cavities through which air can freely circulate (e.g., above soffits) and, depending on structural system characteristics and access, the structural system. For example, painted, light-gauge, cold-formed steel framing is vulnerable to corrosion, and the untreated cores of treated timber framing are vulnerable to decay and termite attack. Depending on visual findings, it may be prudent to determine the condition of concealed items through non-destructive or destructive tests (e.g., test cuts).

Table 14.1 Maintenance Inspection Checklist

Inspection Item	Condition			Repair/ Replace	
	GOOD	FAIR	POOR	YES	NO
Foundation: *Wood pile* – decay, termite infestation, severe splits, connection to framing					
Sill plates – deterioration, splits, lack of attachment to foundation					
Masonry – deteriorated mortar joints, cracked block, step cracks indicating foundation settlement					
Concrete – spalling, exposed reinforcing steel, ≥ $^1/_4$-in vertical cracks or horizontal cracks with lateral shift in the concrete across the crack					
Exterior walls: *Siding* – deterioration, withdrawal of nails, discoloration, buckling, nails missing studs, caulking					
Trim – deterioration, discoloration, separation at joints					
Porches/columns: Condition of top and bottom connections to framing, deterioration at base of wood columns					
Floors: *Joists or beams* – decay, termite infestation, corrosion at tiedown connectors, splits, excessive holes or notching, excessive sagging					
Sheathing – deterioration, "squeaky" floor, excessive sagging, nails missing joists					
Windows/doors: *Glazing* – cracked panes, condensation between panes of insulated glass, nicks in glass surface, sealant cracked/dried out					
Trim – deterioration, discoloration, separation at joints, caulking dried out or separated					
Roof: *Asphalt shingles* – granule loss, shingles curled, nails withdrawing from sheathing					
Wood shakes – splits, nails withdrawing, discoloration, deterioration, moss growth					
Metal – corrosion, discoloration					
Flashings – corrosion, joints separated, nails withdrawing					
Attic: *Framing* – condition of truss plates, sagging or bowed rafters or truss chords, deterioration of roof sheathing, evidence of water leaks, adequate ventilation					

14.2 Effects of Coastal Environment

14.2.1 Corrosion

The corrosive effect of salt-laden wind-driven moisture in coastal areas cannot be overstated. Salt-laden, moist air can corrode exposed metal surfaces and can penetrate any opening in the building. The need to protect metal surfaces through effective design and maintenance is very important in the long-term life of the individual building components and the life of the entire building. Corrosion of structural elements is particularly damaging to the ability of the building to withstand the forces from a natural hazard event.

14.2.2 Termites

The likelihood of termite infestation in coastal buildings can be reduced by maintenance that makes the building site drier and otherwise less hospitable to termites:

- Store firewood and other wood items, including wood mulch, on the ground, away from the building.
- Keep gutters and downspouts in good repair and positioned to direct water away from the building.
- Keep water pipes, water fixtures, and drainpipes in good repair.
- Avoid dampness in crawlspaces by providing adequate ventilation or installing impervious ground cover membranes.
- Avoid frequent plant watering adjacent to the house, and keep plants trimmed away from the walls.

14.2.3 Moi sture

There are many sources of exterior moisture in the coastal environment. Wherever this moisture is retained, wood decay, mildew, or other forms of deterioration can progress. For example, Figure 14-2 shows decay at the base of a wood post where moisture was retained, and Figure 14-3 shows decay behind a connection plate for a beam. Interior moisture must also be considered. Significant interior sources of water vapor, such as kitchens, baths, and clothes dryers, should be vented to the outside in such a way that condensation does not occur on interior or exterior surfaces.

Figure 14-2
Wood decay at the base of a post supported by concrete.

Figure 14-3
Wood decay behind a metal beam connector.

Decay of wood framing in crawlspaces is very likely in low-lying coastal areas. Moisture migration into the floor system can be reduced if the floor of the crawlspace is covered with a vapor barrier of at least 6 mil polyethylene. Also, in accordance with the local building code, wood framing in this space must be pressure-treated or naturally decay-resistant. In addition, the building code will prescribe ventilation requirements.

14.2.4 Weathering

The combined effects of sun and water on many building materials, particularly wood, cause weathering effects, which include the following:

- fading of finishes
- accelerated checking and splitting of wood
- gradual loss of thickness of wood (see Section 14.3.1)

In combination, the effects of weathering reduce the life of building materials unless they are naturally resistant to weathering or are protected from it, either naturally or by maintenance.

14.3 Building Elements That Require Frequent Maintenance

14.3.1 Siding

Solar ultraviolet (UV) degradation occurs at a rate of about 1/16 inch over 10 years on exposed wood. This is not significant for dimension lumber, but it is significant for plywood with 1/8-inch veneers. If the exterior plywood is the shearwall sheathing, this loss will be significant over time. Maintenance suggestions for siding materials include the following:

- Protect plywood from UV degradation with pigmented finishes rather than clear finishes. Pigmented finishes also are especially recommended for exposed shearwall sheathing.
- Wood siding must be protected with a protective sealant—usually a semi-transparent stain or paint.
- Keep siding surfaces and exterior equipment free of salt and mildew. Wash salt from siding surfaces and outdoor air-conditioning condensers not washed by rain, taking care to direct the water stream downward. As required, wash mildew from siding using commercially available products or the homemade solution of bleach and detergent described in *Finishes for Exterior Wood: Section, Application and Maintenance* (Williams et al. 1996).

- Caulk seams, joints, and building material discontinuities with a caulking compound intended for severe exterior exposures. Renew this caulking every 5 years at a minimum or when staining or painting the siding and trim. Caulking applied at large wood members should be renewed about 1 year later after the wood has shrunk away from the caulked joint.
- Re-nail siding when nails withdraw (pop out). Re-nail at a new location so the new nail does not go into the old nail hole.

14.3.2 Roofs

Roof coverings are typically the building envelope material most susceptible to deterioration. Also, depending on roof system design, minor punctures or tears in the roof covering can allow water infiltration, which can lead to serious damage to the roof system and other building components. Maintenance suggestions for roof materials include the following:

- Check the general condition of the roof covering. Granule loss from asphalt shingles is always a sign of some deterioration, although some loss is to be expected from new shingles. Dab roofing cement under the tabs of the first layer of shingles, including the base course, to help ensure that this layer stays down in high winds. Dab roofing cement under any shingle tabs that have lifted up from the existing tack strip. Check the nails that attach the shingles to the roof for corrosion or pullout. Check metal flashings and replace or repair them as necessary.
- Clean dirt, moss, leaves, vegetative matter, and mildew from wood shakes, and re-coat them with a clear wood preservative.
- Clean corroded surfaces of ferrous metal roofs, and apply an appropriate paint or sealer. Check the attachment of the roof surface to the deck. Screws and nails can work loose and may require tightening. Some roofing systems are attached to the underlayment with clips that can corrode – these clips should be inspected, and any corroded clips replaced. Even structural steel roof support members can become corroded as illustrated in Figure 14-4.
- Remove debris from the roof, and ensure that drains, scuppers, gutters, and downspouts are not clogged.
- Periodically re-coat single-ply asphaltic membranes where appropriate. Check mineral-surfaced cap sheets for granule coverage and re-coat if coverage is insufficient, provided there is sufficient service life remaining with the membrane.

- Remove old asphalt shingles before recovering. Installing an additional layer of shingles requires longer nails. In addition, it is more difficult to install the new layer flat enough, and with enough nails, that uplift will not occur, even in relatively low wind speeds. As a result, the new layer will be susceptible to wind uplift and damage.

Figure 14-4
Typhoon Paka (1997), Guam. Corrosion observed in the bottom flange of a structural steel roof support member. Photograph by Tom Smith.

14.3.3 Glazing

Glazing includes windows, doors, skylights, and shutters. Glazing is particularly vulnerable to damage in coastal areas because high winds create airborne debris that can strike the glazing. Very small objects such as sand grains, small stones, or roof gravel or granules can strike the glazing many times without ever actually breaking the glass. But these repeated impacts will weaken the glass until some object strikes it and causes a failure. The references listed in Section 14.7 include several articles that address this subject. Maintenance suggestions for glazing include the following:

- Check glazing for excessive scratches and chips and replace as needed.
- Check glazing gaskets/sealants for deterioration. Repair or replace as needed. Broken seals in insulated glass are not uncommon in coastal areas.
- Check wood frames for decay and termite attack, and check metal frames for corrosion. Frames should be periodically repainted (where appropriate), and damaged wood should be replaced. Maintaining the putty in older wood windows will minimize sash decay.
- Check for signs of water damage (e.g., water stains, rust streaks from joints). Check sealants for substrate bond and general condition. Repair or replace as needed.

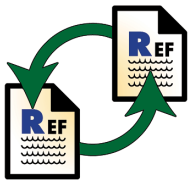
- Check shutters for general integrity and attachment. Periodically repaint where appropriate. Replace or strengthen the attachment of the shutter system to the building as appropriate.
- Check locks and latches frequently for corrosion and proper operation. Lock mechanisms are vulnerable to attack by salt-laden air. Applying a lubricant or rust inhibitor will improve the operation of these mechanisms over the short term.

14.3.4 Outdoor Mechanical/Electrical Equipment

Most outdoor mechanical and electrical equipment includes metal parts, which will corrode in the coastal environment. The life expectancy will improve if the salt is washed off the outside of the equipment frequently. This will occur naturally if the equipment is fully exposed to rainwater; however, partially protected equipment is subject to greater corrosion because of the lack of this natural rinsing action.

Using alternative materials that do not include metal parts would also help reduce the problems caused by corrosion. However, building owners should expect some of the following types of problems simply because of the environment:

- Electrical contacts will malfunction and either short out or cause intermittent operation.
- Housings for electrical equipment, HVAC condensers, ductwork, and other components will deteriorate more rapidly in the coastal environment.
- Metal fasteners and clips used to secure equipment will deteriorate more rapidly in the coastal environment.



CROSS-REFERENCE

Installation of horizontal 2x members with the cup (concave surface) down will minimize water retention and wood deterioration (see Section 13.5.1).

14.3.5 Decks/Exterior Wood

The approach to the maintenance of exterior wood 2x members is different from that for thicker members. The formation of small checks and splits in 2x wood members from cyclical wetting and drying can be reduced by the use of water-repellent finishes. The formation of larger checks and splits in thicker wood members is caused more by long-term drying and shrinking and will not be as significantly reduced by the use of water-repellent finishes.

Cyclical wetting and drying, such as from dew or precipitation, causes the exterior of a wood member to swell and shrink more quickly than the interior. This causes stress in the surface, which leads to the formation of checks and splits. This shrink-swell cycling is worst on south and west exposures. Checks and splits, especially on horizontal surfaces, provide paths for water to reach the interior of a wood member and remain, where they eventually cause decay.

Maintaining a water-repellent finish, such as a pigmented paint, semi-transparent stain, or clear finish, on the wood surface can reduce the formation of checks and splits. These finishes are not completely water- or vapor- repellent, but they significantly slow cyclical wetting and drying. Of the available finishes, pigmented paints and semi-transparent stains have the longest lifetime; clear finishes must be reapplied frequently to remain effective. Matte clear finishes are available that are almost unnoticeable on bare wood. These finishes are therefore attractive for decking and other "natural" wood, but they must be renewed frequently, when water no longer beads on the finished surface.

Moisture-retaining debris tends to collect between deck boards and in the gaps in connections. Periodic cleaning of this debris from between wood members, especially at end grains, will allow drying to proceed and will inhibit decay.

The best way to maintain larger timbers is to keep water away from joints, end grain surfaces, checks, and splits. Much can be learned by standing under the house during a rain with the prevailing wind blowing to see where the water goes. Measures, such as those described in Section 13.2.7, can then be taken or renewed to minimize the effect of this water on the larger timbers.

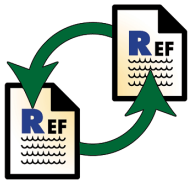
14.3.6 Metal Connectors

Most sheet-metal connectors, such as tiedown straps, joist hangers, and truss plates, used in structural applications in the building should be specified to last the lifetime of the building without the need for maintenance. However, the use of corrosion-prone connectors is a common problem in existing coastal houses.

If galvanized connectors remain gray, the original strength is generally unaffected by corrosion. When most of the surface of the connector turns rust red, the sacrificial galvanizing has been consumed and the corrosion rate of the unprotected steel can be expected to accelerate by up to a factor of 50 times.

The thin steel used in sheet-metal connectors has little reserve strength to offset rapid corrosion. During routine inspections, any sheet-metal connectors found to have turned rust red or to show severe, localized rusting sufficient to compromise their structural capacity should be replaced immediately. Be advised, however, that the replacement of sheet metal connectors is usually difficult for a number of reasons: the connection may be under load, the nails or bolts used to secure connectors are usually hard to remove, and the location of a connector often makes removal awkward.

As indicated in Chapter 13, corrosion rates can be reduced if exposure to salt-laden air is minimized or reduced. Covering exposed connectors with a sheathing material reduces their exposure and therefore increases their life expectancy.



CROSS-REFERENCE

The selection of metal connectors for use within the building envelope and in exposed locations is addressed in Chapter 12 of this manual.

WARNING

Using corrosion-prone sheet metal connectors will increase maintenance requirements and potentially compromise structural integrity.

14.4 Maintenance Techniques Required for Natural Hazards

The maintenance practices described above for minimizing corrosion, wood decay, termite infestation, and UV degradation will improve the resistance of a coastal building to flood, wind, and seismic damage by maintaining the strength of the structural elements. The additional measures described in the following sections will further maintain the building's resistance to natural hazards.

14.4.1 Flooding

When designing for the lateral force capacity of an unbraced or braced pile foundation, the designer should have allowed for a certain amount of scour. Scour in excess of the amount allowed for will reduce the embedment of the piles and cause them to be overstressed in bending during the maximum design flood, wind, or earthquake. As allowed by local regulations and practicality, the grade level should be maintained at the original design elevation.

Scour and long-term beach erosion may affect pile maintenance requirements. If tidal wetting was not anticipated in the original design, the piles may have received the level of preservative treatment required only for ground contact and not the much higher marine treatment level that provides borer resistance. If the pile foundation is wetted by high tides or runup, borer infestation is possible. Wrapping treatments that minimize borer infestation are available for the portions of the piles above grade that are subject to wetting.

14.4.2 Seismic and Wind

Many seismic tiedowns at shearwall vertical chords use a vertical threaded rod as the tension member. Each end of the threaded rod engages the tiedown hardware or a structural member. Over time, cross-grain shrinkage in the horizontal wood members between the threaded rod connections will loosen the threaded rod, allowing more rocking movement and possible damage to the structure. Whenever there is an opportunity to access the tiedowns, the nuts on the rods should be tightened firmly. New proprietary tiedown systems are available that do this automatically.

Owners often want to remodel their buildings, and the remodeling plans often include making new openings in exterior or interior walls for doors or windows. Designers must be careful not to make openings in bearing walls or shearwalls without restoring the lost structural capacity. It is relatively easy to recognize a bearing wall in the field and to use a header or other means to accommodate an opening. It is much more difficult to identify a shearwall in the field without access to the original construction drawings. A shearwall will have structural panel sheathing on one or both sides. Exterior, interior, bearing, and non-bearing walls can all be shearwalls. Removing a portion of a shearwall not

only takes away shear capacity, but also can disrupt the overturning force load path. The designer of the building should be consulted for the placement of any openings of significant size in structural-panel-sheathed walls.

Shearwall sill plates bearing directly on continuous footings or concrete slabs-on-grade, if used in coastal construction, are particularly susceptible to decay if moist conditions are present. Figure 14-5 shows a deteriorated sill plate. Even if the decay of the preservative-treated sill plate is retarded, the attached untreated plywood can easily decay. As a result, the shear wall will lose strength. Conditions that promote this sill and plywood decay include an outside soil grade above the sill, stucco without a weep screed at the sill plate, and sources of excessive interior water vapor. Correcting these conditions will help maintain the strength of the shear walls.

Figure 14-5
Deteriorated wood sill plate.

14.5 Retrofit Opportunities

Retrofit opportunities will present themselves every time maintenance work is required for a major element of the building. Improvements to the building that are made to increase resistance to the effects of natural hazards should focus on those items that will potentially return the largest benefit to the building owner. Retrofit improvements should be considered for the following building elements if the existing building is considered inadequate to resist natural hazard loads and opportunities for improvements present themselves:

- roof
- siding
- decks and porches
- exterior metal
- windows and doors
- foundation
- exterior equipment

WARNING

Enlarging existing openings in shearwalls or creating new openings can reduce the structual capacity of the wall and building.

DEFINITION

Retrofitting is the combination of adjustments or additions to existing building features that are intended to eliminate or reduce the possibility of flood, wind, or seismic damage.

NOTE

In retrofitting, the most cost-effective techniques will normally involve fixing the weakest structural links and improving the water penetration resistance of the building envelope. To identify the weakest links, start at the top of the building and work down the load path.

Developing a maintenance schedule for a coastal building, based on normal life expectancies of building materials, will give the owner an idea about when certain retrofit projects could be contemplated (assuming a natural hazard event does not accelerate the schedule). A schedule can be developed from the life expectancies of various building elements presented in Table 14.2

Table 14.2 Life Expectancies for Elements of Coastal Buildings

Building Element	Range of Expected Life (Years)
Roof:	
☐ asphalt shingles	15 - 20
☐ wood shakes	25 - 40
☐ metal	40 - 60
Siding:	
☐ wood	20 - 50
☐ vinyl	15 - 25
☐ EIFS	10 - 15
☐ Masonry/stucco	40 - 50+
Decks/porches	10 - 20
Exterior metal (handrails, connectors, etc.)	5 – 10
Windows/doors:	
☐ glazing	10 – 30
☐ frames	10 – 40
☐ mechanisms	10 – 15
Foundation:	
☐ wood piles	25 – 40
☐ masonry piers	30 – 80
☐ concrete piles or piers	40 – 80
Exterior equipment (HVAC, lights, etc.)	8 - 15

Table 14.2 suggests that retrofit opportunities exist for the building elements listed below. It should be noted that opportunities for retrofitting may also be created by the need to repair damage caused by a natural hazard event.

- When the roof is replaced, the attachment of the sheathing to the trusses or rafters can be checked, and hurricane/seismic connectors can be installed at the rafter-to-wall or truss-to-wall connections.

- Gable ends can be braced in conjunction with other retrofits, or by themselves.
- If siding or roof sheathing has to be replaced, hurricane/seismic connectors can be installed at the rafter-to-wall or truss-to-wall connections, the exterior wall sheathing attachment can be checked, and structural sheathing can be added to shearwalls. Adding wall-to-foundation ties may also be possible.
- Exterior siding attachment can be improved with more fasteners at the time the exterior is re-coated.
- Windows, doors, skylights reinforcement and attachment can be improved whenever they are accessible.
- When windows and doors are replaced, glazing and framing can be used that is impact resistant and provides greater UV protection.
- Floor framing-to-beam connections can be improved whenever they are accessible.
- Beam-to-pile connections can be improved whenever they are accessible.
- At any time, deficient metal connectors that are accessible should be replaced with stainless steel or hot-dip-galvanized connectors.
- When HVAC equipment is replaced, the replacements should be more durable, so that they will last longer in a coastal environment, and they should be elevated to or above the Design Flood Elevation (DFE).
- Utility attachment can be improved when the outside equipment is replaced or relocated.
- At any time, in the attic space, straps should be added to rafters across the ridge beam, straps should be added from rafters to top wall plates, and gable wall framing should be braced. In addition, the uplift resistance of the roof sheathing can be increased through the application of adhesive at the roof sheathing-to-roof rafter joint (see Figure 14-6 for an illustration of the adhesive attachment).
- At any time, garage doors should be reinforced as shown in Figure 14-7, or replaced with new wind- and debris-resistant doors.
- At any time, metal light fixtures should be replaced with fixtures that have either wood or vinyl exteriors.
- At any time, carbon steel handrails should be replaced with vinyl coated, plastic, stainless steel, or wood handrails.

Figure 14-6
Typical 1/4-inch bead of adhesive between roof sheathing and roof rafter.

Figure 14-7
Garage door on south Florida house reinforced with 2x4 wood girts and metal mullions.

14.6 Retrofit Costs

Retrofit costs will vary widely from region to region because of one or more of the following:

- structural conditions in the building
- price variations of the material and labor
- familiarity with retrofit techniques on the part of the contractor
- building layout complexities
- age of the building

However, the cost to retrofit will normally fall within an expected range that is useful for estimating purposes. Before any work is performed, the contractor should be asked to provide a written detailed price proposal so that all costs can be verified. There are significant uncertainties in retrofitting that must be considered in estimating the cost and in defining the scope of a retrofitting project with a contractor. Table 14.3 presents expected ranges of costs for the retrofit opportunities listed in Section 14.5. **The costs are based on the assumption that each building element discussed has been exposed to provide easy access to the structure.**

Table 14.3
Cost Estimates for Retrofitting

Retrofit Opportunity	Cost*
Roof:	
☐ Reattach sheathing	$0.05 - $0.10/ft^2
☐ Install metal straps at ridge beam	$5 – $6/each
☐ Brace gable wall framing	$80 – $100/gable end
☐ Install adhesive between sheathing and rafters	$0.10 - $0.20/ft^2
Siding:	
☐ Reattach sheathing to shear wall	$0.05 - $0.10/ft^2
☐ Add sheathing to shear wall	$0.65 - $0.80/ft^2
☐ Add wall/foundation ties	$6 – $10/each
☐ Install hurricane connector at truss/ wall connection	$0.20 - $0.30/ft^2
Replace glass with impact-resistant glazing	$15 - $30/ft^2
Replace metal connectors	$5 – $8/each
Replace metal handrails	$10 – $30/linear ft
Replace metal light fixtures	$10 – $30/fixture
Reinforce garage doors	$150 – $200/8-ft door

* Estimates based on 1999 prices

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