14 Maintaining the Building

This chapter provides guidance on maintaining the building structure and envelope.

For maximum performance of a building in a coastal area, the building structure and envelope (i.e., exterior doors, windows, skylights, exterior wall coverings, soffits, roof systems, and attic vents) must not be allowed to deteriorate. Significant degradation by corrosion, wood decay, termite attack, or weathering increases the building's vulnerability to damage from natural hazards. Figure 14-1 shows a post that appears on the exterior to be in

CROSS REFERENCE

or resources that augment the guidance and other information in this Manual, see the Residential Coastal Construction Web site (http://www.fema.gov/rebuild/mat/fema55.shtm).

Figure 14-1.
Pile that appears acceptable from the exterior but has interior decay

acceptable condition but is weakened by interior decay, which can be determined only through a detailed inspection. This post failed under the loads imposed by a natural hazard event.

Long-term maintenance and repair demands are influenced directly by decisions about design, materials, and construction methods during building design and construction. Using less durable materials will increase the frequency and cost of required maintenance and repair. The design and detailing of various building systems (e.g., exposed structural, window, or roof systems) also significantly influence maintenance and repair demands.

COST CONSIDERATION

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

14.1 Effects of Coastal Environment

The coastal environment can cause severe damage to the building structure and envelope. The damage arises primarily from salt-laden moisture, termites, and weathering.

14.1.1 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 penetrate any opening in the building. The need to protect metal surfaces through effective design and maintenance (see Section 14.2.6 for maintenance of metal connectors) is very important for the long-term life of building elements and the entire building. Stainless steel is recommended because many galvanized (non-heavy-gauge) products and unprotected steel products do not last in the harsh coastal environment.

Corrosion is most likely to attack metal connectors (see Section 14.2.6) that are used to attach the parts of the structure to one another, such as floor joists to beams and connectors used in cross-bracing below the finished lowest floor. Galvanized connectors coated with zinc at the rate of 0.9 ounce per square foot of surface area (designated G-90) can corrode in coastal environments at a rate of 0.1 to 0.3 millimeter/year. At this rate, the zinc protection will be gone in 7 years. A G-185 coated connector, which provides twice as much protection as G-90, can corrode in less than 20 years. More galvanized protection (more ounces of zinc per square foot of surface area to be protected) increases service life.

CROSS REFERENCE

For additional information on corrosion, see Section 9.4.5 in this Manual and FEMA Technical Bulletin 8-96, *Corrosion Protection of Metal Connectors in Coastal Areas for Structures Located in Special Flood Hazard Areas* (FEMA 1996).

Corrosion can also affect fasteners for siding and connectors for attaching exterior-mounted heating, ventilation, and air-conditioning units, electrical boxes, lighting fixtures, and any other item mounted on the exterior of the building. These connectors (nails, bolts, and screws) should be stainless steel or when they must be replaced, replaced with stainless steel. These connectors are small items, and the increased cost of stainless steel is small.

14.1.2 Moisture

There are many sources of exterior moisture from outside the home in the coastal environment. Whenever an object absorbs and retains moisture, the object may decay, mildew, or deteriorate in other ways. Figure 14-2 shows decay behind the connection plate on a beam.

Significant sources of interior moisture, 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 behind a metal beam connector

Connectors should be designed to shed water to prevent water from accumulating between the connector and the material the connector is attached to. Trapped moisture increases the moisture content of the material and potentially leads to decay. Moisture is most likely to enter at intersections of materials where there is a hole in the building envelope (e.g., window, door) of where two surfaces are joined (e.g., roof to wall intersection). If properly installed, the flashings for the openings and intersections should not require maintenance for many years. However, flashings are frequently not properly installed or installed at all, creating an ongoing moisture intrusion problem.

The potential for wood framing in crawlspaces in low-lying coastal areas to decay is high. 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-millimeter polyethylene. Where required by the local building code, wood framing in the crawlspace should be preservative-treated or naturally decay-resistant. The building code may have ventilation requirements.

Many existing crawlspaces are being converted to "conditioned crawlspaces." A moisture barrier is placed on the floor and walls of the crawlspace interior, insulation is added to the floor system (commonly sprayed-on polyurethane foam), and conditioned air is introduced into the space. In order for a conditioned crawlspace to be successful in low-lying coastal areas, moisture control must be nearly perfect so that the moisture content of the floor system does not exceed 20 percent (the minimum water content in wood that promotes mold growth). Conditioned crawlspaces are typically not practical in a floodplain where flood vents are required.

Sprinkler systems used for landscaping and other exterior water distribution systems (e.g., fountains) must be carefully tested so they do not create or increase water collection where metal connectors are fastened. Water collection can be prevented easily during installation of the exterior water distribution system by making sure the water distribution pattern does not increase the moisture that is present in the building materials.

14.1.3 Weathering

The combined effects of sun and water on many building materials, particularly several types of roof and wall coverings, cause weathering damage, including:

- Fading of finishes
- Accelerated checking and splitting of wood
- Gradual loss of thickness of wood
- Degradation of physical properties (e.g., embrittlement of asphalt shingles)

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. Even finishes intended to protect exterior materials fade in the sun, sometimes in only a few years.

14.1.4 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, specifically:

- Storing firewood and other wood items that are stored on the ground, including wood mulch, well away from the building
- Keeping gutters and downspouts free of debris and positioned to direct water away from the building
- Keeping water pipes, water fixtures, and drainpipes in good repair
- Avoiding dampness in crawlspaces by providing adequate ventilation or installing impervious ground cover membranes
- Avoiding frequent plant watering adjacent to the house and trimming plants away from the walls

If any wood must be replaced under the house in or near contact with the ground, the new wood should be treated. Removing moisture and treating the cellulose in wood, which is the termite's food source, are the most frequently used remedies to combat termites.

14.2 Building Elements That Require Frequent Maintenance

To help ensure that a coastal building is properly maintained, this Manual recommends that buildings be inspected annually by professionals with the appropriate expertise. The following building elements should be inspected annually:

- Building envelope – wall coverings, doors, windows, shutters, skylights, roof coverings, soffits, and attic vents
- Foundation, attic, and the exposed structural frame
- Exterior-mounted mechanical and electrical equipment

Table 14-1 provides a maintenance inspection checklist. Items requiring repair or replacement should be documented and the required work scheduled.

Table 14-1. Maintenance Inspection Checklist

Item	Element	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 or corroding reinforcing steel, ≥ 1/4-inch vertical cracks or horizontal cracks with lateral shift in the concrete across the crack					
Exterior Walls	**Siding** – deterioration, nail withdrawal, discoloration, buckling, attachment to studs (nails missing, withdrawn, or not attached to studs), sealant cracked/dried out					
	Trim – deterioration, discoloration, separation at joints, sealant cracked/ dried out					
Porches/ Columns	**Top and bottom connections to framing** – corrosion in connectors					
	Base of wood columns – deterioration					
Floors	**Joists or beams** – decay, termite infestation, corrosion at tiedown connectors, splits, excessive holes or notching, excessive sagging					
	Sheathing – deterioration, “squeaky” floors, excessive sagging, attachment to framing (nails missing, withdrawn, or not attached to framing)					

Table 14-1. Maintenance Inspection Checklist (concluded)

Item	Element	Condition			Repair/Replace	
		Good	Fair	Poor	Yes	No
Floors	**Sheathing under floors** – attachment to framing, nail corrosion fastening sheathing to floor joists, buckling/warping caused by excessive moisture					
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					
	Shutters – permanent shutters should be operated at least twice/year and temporary panels should be checked once/year for condition					
Roof	**Asphalt shingles** – granule loss, shingles curled, nails withdrawing from sheathing, de-bonding of tabs along eaves and corners					
	Wood shakes – splits, discoloration, deterioration, moss growth, attachment to framing (nails missing, withdrawn, or not attached to framing)					
	Metal – corrosion, discoloration, connection of fasteners or fastening system adequacy					
	Flashings – corrosion, joints separated, nails withdrawing					
Attic	**Framing** – condition of truss plates sagging or bowed rafters or truss chords, deterioration of underside of roof sheathing, evidence of water leaks, adequate ventilation					

Other items that should be inspected include cavities through which air can freely circulate (e.g., above soffits and behind brick or masonry veneers) 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 damage. Depending on visual findings, it may be prudent to determine the condition of concealed items through nondestructive or destructive tests (e.g., test cuts).

The following sections provide information on the building elements that require frequent maintenance in coastal environments: glazing, siding, roofs, outdoor mechanical and electrical equipment, decks and exterior wood, and metal connectors.

14.2.1 Glazing

Glazing includes glass or a transparent or translucent plastic sheet in windows, doors, skylights, and shutters. Glazing is particularly vulnerable to damage in hurricane-susceptible coastal areas because high winds create wind-borne debris that can strike the glazing. Maintenance suggestions for glazing include the following:

- Checking glazing gaskets/sealants for deterioration and repairing or replacing as needed. Broken seals in insulated glass are not uncommon in coastal areas.
- Checking wood frames for decay and termite attack, and checking metal frames for corrosion. Frames should be repainted periodically (where appropriate), and damaged wood should be replaced. Maintaining the putty in older wood windows minimizes sash decay. Metal frames should be cleaned of corrosion or pitting and the operation of the windows tested on some frequency.
- Checking vinyl frames for cracks especially in the corners and sealing any cracks with a sealant to prevent water entry into the window frame. Vinyl may become discolored from the ultraviolet (UV) rays of the sun.
- Checking for signs of water damage (e.g., water stains, rust streaks from joints) and checking sealants for substrate bond and general condition. Repair or replace as needed.
- Checking glazing for stress cracks in corners. Stress cracks might be an indication of either settlement of the house or of lateral movement that is causing excessive stress in the lateral load system.
- Checking shutters for general integrity and attachment and repainting periodically where appropriate.
- Replacing or strengthening the attachment of the shutter system to the building as appropriate.
- Checking the shutters for ease of operation. Sand can easily get into the hinges and operators and render shutters inoperable.
- Checking 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 improves the operation of these mechanisms over the short term.
- Installing double hung and awning windows, which generally perform better than sliding or jalousie windows in the coastal environment, primarily because the sliding and jalousie windows allow more water, sand, and air infiltration because of the way the windows open and close.
- Replacing sliding and jalousie windows to reduce infiltration.

14.2.2 Siding

Solar UV degradation occurs at a rate of about 1/16 inch over 10 years on exposed wood. This rate of degradation 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, the loss will be significant over time. Maintenance suggestions for siding materials include the following:

- Protecting plywood from UV degradation with pigmented finishes rather than clear finishes. Pigmented finishes are also especially recommended for exposed shearwall sheathing.
- Protecting wood siding with a protective sealant—usually a semi-transparent stain or paint. The coating should be re-applied regularly because the degradation will occur nearly linearly if re-application is done but will progress faster if allowed to weather with no regular sealing.
- Keeping siding surfaces free of salt and mildew and washing salt from siding surfaces not washed by rain, taking care to direct the water stream downward. Mildew should be washed as needed 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). Power washing is another technique to keep the siding clean as long as the siding sealant is not removed. Mildew grows on almost any surface facing north, no matter how small the surface.
- Caulking seams, joints, and building material discontinuities with a sealant intended for severe exterior exposures and renew the sealant every 5 years at a minimum or when staining or painting the siding and trim. Sealant applied at large wood members should be renewed about 1 year after the wood has shrunk away from the caulked joint.
- Caulking carefully to avoid closing off weep or water drainage holes below windows or in veneers that are intended to drain will prevent sealing the moisture inside the wall cavity, which can lead to significant, long-term deterioration.
- Renailing siding when nails withdraw (pop out) and renailing at a new location so the new nail does not go into the old nail hole.
- Ensuring vinyl siding has the ability to expand and contract with temperature changes. Buckling in the siding is an indication that the siding was installed too tightly to the wall sheathing with an insufficient amount of room under the siding nails to allow for the normal horizontal movement of the siding.

14.2.3 Roofs

Roof coverings are typically the building envelope material most susceptible to deterioration from weathering. 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 elements. Maintenance suggestions for roof materials include the following:

- Checking the general condition of the roof covering. Granule loss from asphalt shingles is always a sign of some deterioration, as is curling and clawing (reverse curling) although some minor loss is expected even from new shingles.
- Dabbing 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.
- Dabbing roofing cement under any shingle tabs that have lifted up from the existing tack strip.
- Checking the nails that attach the shingles to the roof for corrosion or pullout.
- Checking metal flashings and replacing or repairing as necessary.
- Cleaning dirt, moss, leaves, vegetative matter, and mildew from wood shakes.

- Cleaning corroded surfaces of ferrous metal roofs and applying an appropriate paint or sealer.
- Checking the attachment of the roof surface to the deck. Screws and nails can become loose and may require tightening. Gasketed screws should be added to tighten the metal deck to the underlayment. Some roofing systems are attached to the underlayment with clips that can corrode—these clips should be inspected and any corroded clips replaced, but in many cases, the clips will be concealed and will require some destructive inspection to discover the corroded clips.
- Removing debris from the roof and ensuring that drains, scuppers, gutters, and downspouts are not clogged.
- Removing old asphalt shingles before recovering. This is recommended because installing an additional layer of shingles requires longer nails, and it is difficult to install the new asphalt shingles so that they lay flat over the old. New layers installed over old layers can therefore be susceptible to wind uplift and damage, even in relatively low wind speeds. New layers installed over old shingles could void the warranty for the new shingles.
- Checking attachments of eave and fascia boards. Deterioration in these boards will likely allow flashings attached to them to fail at lower than design wind speeds.

14.2.4 Exterior-Mounted Mechanical and Electrical Equipment

Most outdoor mechanical and electrical equipment includes metal parts that corrode in the coastal environment. Life expectancy improves if the salt is washed off the outside of the equipment frequently. This occurs naturally if the equipment is fully exposed to rainwater, but partially protected equipment is subject to greater corrosion because of the lack of the natural rinsing action.

Using alternative materials that do not include metal parts can also help reduce the problems caused by corrosion. In all cases, electrical switches should be the totally enclosed type to help prevent moisture intrusion into the switch, even if the switch is located on a screened porch away from the direct effects of the weather. Building owners should expect the following problems in the coastal environment:

- Electrical contacts can malfunction and either short out or cause intermittent operation
- Housings for electrical equipment; heating, ventilation, and air-conditioning condensers; ductwork; and other elements deteriorate more rapidly
- Fan coils for outside condensers can deteriorate more rapidly unless a coastal environment is specified
- Typical metal fasteners and clips used to secure equipment can deteriorate more rapidly in a coastal environment than a non-coastal environment

14.2.5 Decks and Exterior Wood

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

use of water-repellent finishes. Installation of horizontal 2x members with the cup (concave surface) down minimizes water retention and wood deterioration.

- 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 southern and western 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 when water no longer beads on the finished surface.
- Wood deck surfaces can be replaced with synthetic materials, which are sold under a variety of trade names. Many of these products should be attached with stainless screws or hidden clips to preservative-treated framing.
- Moisture-retaining debris can collect between deck boards and in the gaps in connections. Periodic cleaning of this debris from between wood members, especially at end grains, allows drying to proceed and inhibits decay.
- Larger timbers can also be vulnerable to checks, splits, and other weather-related problems. 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 (given sufficient headroom) during a rain with the prevailing wind blowing to see where the water goes. Measures, such as preservative treatments, can then be taken or renewed to minimize the effect of this water on the larger timbers.
- Connections of deck band boards to the structure should be inspected periodically for moisture intrusion. These connections frequently leak from wind-driven rain and moisture accumulation. Leakage can occur at the flashing to structure interface or at the bolts connecting the band board to the structure.

14.2.6 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.

- Galvanized connectors may have corrosion issues. 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

CROSS REFERENCE

The selection of metal connectors for use within the building envelope and in exposed locations is addressed in Section 9.4 of this Manual.

been consumed and the corrosion rate of the unprotected steel can be expected to accelerate by up to a factor of 50 times. Figure 14-3 illustrates severe corrosion under an exterior deck.

- Sheet-metal connectors can be susceptible to rapid corrosion and are frequently without reserve strength. 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. However, 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.

WARNING

Using corrosion-prone sheet metal connectors increases maintenance requirements and potentially compromises structural integrity.

- Salt-laden air can increase corrosion rates in building materials. Covering exposed connectors with a sheathing material reduces their exposure and therefore increases their life expectancy.

Figure 14-3. Severely corroded deck connectors

14.3 Hazard-Specific Maintenance Techniques

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.

14.3.1 Flooding

When designing for the lateral force capacity of an unbraced or braced pile foundation, the designer should allow for a certain amount of scour. Scour in excess of the amount allowed for reduces the embedment of the piles and causes 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.

14.3.2 Seismic and Wind

Many seismic and wind 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 loosens 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 that do this automatically are available.

Shearwall sill plates bearing directly on continuous footings or concrete slabs-on-grade, if used in coastal construction, are particularly susceptible to decay in moist conditions. Figure 14-4 shows a deteriorated sill plate. Even if the decay of the preservative-treated sill plate is retarded, the attached untreated plywood can easily decay and the shearwall will lose strength. Conditions that promote 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 helps maintain the strength of the shearwalls.

Figure 14-4. Deteriorated wood sill plate

14.4 References

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