Chapter 4: Fundamentals

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Fundamentals

4.1 Introduction

In coastal areas, a building can be considered a ***success*** only if it is capable of resisting damage from coastal hazards and coastal processes over a period of decades. This statement does not imply that a coastal residential building must remain undamaged over its intended lifetime. It implies that the impacts of a design level flood, storm, wind, or erosion event (or series of lesser events with combined impacts equivalent to a design event) will be limited to the following:

- The building foundation should remain intact and functional.
- The envelope (lowest floor, walls, openings and roof) should remain structurally sound and capable of minimizing penetration by wind, rain, and debris.
- The lowest floor elevation must be sufficient to prevent floodwaters from entering the elevated building envelope during the design event.
- The utility connections (e.g., electricity, water, sewer, natural gas) should remain intact or be restored easily.
- The building should be accessible and usable following a design-level event.
- Any damage to **enclosures** below the design flood elevation (DFE) should not result in damage to the foundation, the utility connections, or the elevated portion of the building.

Note that success during a design seismic event is defined differently than in flood, storm, wind, and erosion events:

- The building should protect life and provide safety, even though the structure itself may sustain significant damage.

The above definitions of "building success" can be met through various methods, but they all have one thing in common—careful consideration and use of siting, design, construction, and maintenance practices. Failure to address even one of these four concerns can lead to building damage, destruction, or loss of use. Hence:

- A design and construction success can be negated by a failure to site the building properly (see Figures 4-1, 4-2, and 4-3). The house shown in Figure 4-1 appears to be a structural success, but long-term erosion has left it standing permanently in the water. As a result, it is now uninhabitable. The three houses in Figure 4-2 were built between January 1995 and January 1996, approximately 2 years before the

NOTE

Design of a "successful" coastal building must consider the effects of coastal hazards and coastal processes over a period of decades.

DEFINITION

For the purposes of this manual, an **enclosure** is that portion of an elevated building below the design flood elevation (DFE) that is partially or fully surrounded by solid (including breakaway) walls. See the warning on page 4-12 of this chapter, and Sections 6.4.3.3 and 9.3.1.1, in Chapters 6 and 9, respectively, for more information about enclosures and the use of space below elevated buildings.

NOTE

A conservative approach to siting and design of coastal residential buildings is recommended—even expert opinion can underestimate the hazards to which a building will be exposed over its lifetime.

photograph was taken (July 1997). They were built 100 or more feet landward of the vegetation line, but rapid erosion associated with a nearby tidal inlet has left the houses standing on the beach. The shoreline will probably return to its former location, taking several years to do so. Although the buildings are structurally intact, their siting can be considered a failure. The townhouses shown in Figure 4-3 were built as little as 10 feet landward of a 170-foot-high bluff in 1991–92. By late 1997, storm- and inlet-related erosion at the base of the bluff destabilized the bluff face and threatened some of the buildings. Although experts assured the local government that the site was safe, it was not.

Figure 4-1
Although this North Carolina house appears to be a structural success, long-term erosion has left it standing on the beach.

Figure 4-2
These three South Carolina houses were built at least 100 feet landward of the vegetation line, but rapid erosion associated with a nearby tidal inlet has left the houses standing on the beach. Although these buildings are structurally intact, their siting can be considered a failure. (July 1997 photograph)

Figure 4-3
These Oregon townhouses were built as little as 10 feet landward of a 170-foot-high bluff, after an expert assured the local government that the site was suitable. Storm- and inlet-related erosion at the base of the bluff has destabilized the bluff and threatened some of the buildings. (April 1998 photograph)

- A siting success can be overshadowed by poor design, construction, or maintenance. The house shown in Figure 4-4 was set back from the shoreline, and safe from long-term erosion. However, it could not resist wind from Hurricane Fran.

Figure 4-4
Hurricane Fran (1996). This North Carolina house was set back from the shoreline, and safe from long-term and storm-induced erosion. However, high winds from the storm caused heavy damage to the porch walls and roof. (September 1996 photograph)

It must be recognized that lack of building damage during a high-probability (low-intensity) storm, flood, or other event cannot be construed as a building success – success can only be measured against a design event or against a series of lesser events with the cumulative effect of a design event.

Finally, before focusing on siting, design, construction, and maintenance issues, this manual must address more fundamental issues, such as those associated with hazard identification, hazard vulnerability, risk assessment, and risk management.

4.2 Hazards, Risk Assessment, and Risk Management

The coastal construction process described in this manual is intended to reduce damage caused by natural hazards in coastal areas. These hazards include not only those associated with widely recognized, discrete events that recur over time, such as hurricanes, coastal storms, earthquakes, and earthquake-induced landslides and tsunamis, but also continuous and less-obvious coastal phenomena such as long-term erosion, shoreline migration, and the corrosion and decay of building materials. The effects of hazards associated with recurring events are often immediate, severe, and readily apparent, while those associated with long-term processes are more likely to become apparent only after having accumulated over time.

Sound coastal construction, therefore, depends upon an understanding of the natural hazards that affect coastal areas, an accurate characterization of the variety of risks to which coastal construction is exposed, and an understanding of various risk management techniques. For the purposes of this discussion, several key terms will be defined (a more detailed discussion of these terms and related terms may be found in *Multi-Hazard Identification and Risk Assessment, A Cornerstone of the National Mitigation Strategy* [FEMA 1997]).

Hazard Identification means the process of defining and describing a hazard (including its physical characteristics, magnitude, severity, frequency, and causative factors) and the locations or areas it affects.

Risk means the potential losses associated with a hazard, defined in terms of expected probability and frequency, exposure, and consequences.

Risk Assessment means a process or method for evaluating risk that is associated with a specific hazard and defined in terms of probability and frequency of occurrence, magnitude and severity, exposure, and consequences.

Risk Management means measures taken to reduce, modify, offset, or share risks associated with development in areas subject to coastal hazards. In the context of coastal residential construction, risk management is usually accomplished through mitigation (see below) or insurance.

Mitigation means sustained action taken to reduce or eliminate long-term risk to people and property from hazards and their effects. In the context of coastal residential construction, mitigation usually takes the form of siting, design, construction, and maintenance of the building itself, and (sometimes) the form of protective works (e.g., dune or bluff stabilization, erosion control structures, beach nourishment). Mitigation distinguishes actions that have a long-term impact from those that are more closely associated with preparedness for, immediate response to, and short-term recovery from a specific event.

4.2.1 Risk Assessment

For the purposes of this manual, *risk assessment* is the process of quantifying the total risk to a coastal building (i.e., the risk associated with all the significant natural hazards that may act on the building.) The *risk* associated with any one hazard is defined by the combination of two factors:

1. the probability that an event of a given recurrence interval will affect the building within a specified period
2. both the short-term and long-term consequences of that event for the building

NOTE

Risk Assessment must consider the occurrence and effects of multiple events, not just a single event. For example, it is not uncommon for an area to be struck by several minor storms in a short period of time, and for those storms to cause more damage than a major storm.

4.2.1.1 Probability and Recurrence Interval

In most coastal areas of the United States, buildings must meet minimum regulatory and code requirements intended to provide protection from natural hazard events of specified magnitudes. These events are usually identified according to their recurrence intervals. Examples are the 100-year flood (the flood that has a 1-percent probability of being equaled or exceeded in any given year) and the 50-year wind (the wind that has a 2-percent probability of being equaled or exceeded in any given year).

To determine the probability that a building will be affected by a specific natural hazard event, the designer must know not only the recurrence interval of the event, but also the period during which the building will be exposed to the hazard. The length of this period is determined by the designer, but it should not be arbitrary; it should be based on some amount of time relevant to the building, such as the assumed useful life of the building.

NOTE

While designers may assume a “useful life” for coastal buildings, owners typically view the habitation of the site as permanent (although the building itself may be renovated or replaced several times). Thus, designers may wish to consider two useful lives, one for the building itself and a longer lifetime for siting and setback purposes.

When the recurrence interval of a natural hazard event is known, the designer can determine the probability of one or more occurrences of that event or a larger event during the specified period. Table 4.1 illustrates this concept for natural hazard events with recurrence intervals of 10, 25, 50, 100, and 500 years. Of particular interest in this example is the 100-year event, because the 100-year flood serves as the basis for the floodplain management and insurance requirements of the National Flood Insurance Program (NFIP) regulations.

As noted above and shown in Table 4.1, the 100-year flood has a 1-percent probability of being equaled or exceeded during a 1-year period. As the length of the period increases, so does the probability that a flood of this magnitude or greater will occur. For example, during a 30-year period (equivalent to the length of a standard mortgage), the probability increases to 26 percent. And during a 70-year period, which may be assumed to be the useful life of many buildings, the probability increases to 50 percent. The same principle applies to other natural hazard events with other recurrence intervals.

Table 4.1 Natural Hazard Probabilities During Periods of Various Lengths*

LENGTH OF PERIOD (YEARS)	FREQUENCY – RECURRENCE INTERVAL				
	10- YEAR EVENT	25- YEAR EVENT	50- YEAR EVENT	100- YEAR EVENT	500- YEAR EVENT
1	10 %	4 %	2 %	1 %	0.2 %
10	65 %	34 %	18 %	10 %	2 %
20	88 %	56 %	33 %	18 %	5 %
25	93 %	64 %	40%	22 %	5 %
30	96 %	71 %	45 %	26 %	6 %
50	99+ %	87 %	64%	39 %	10 %
70	99.94+ %	94 %	76 %	50 %	13 %
100	99.99+ %	98 %	87 %	63 %	18 %

*The percentages shown represent the probabilities of one or more occurrences of an event of a given magnitude or larger within the specified period. The formula for determining these probabilities is $P_n = 1-(1-P_a)^n$, where P_a = the annual probability and n = the length of the period.

WARNING

Designers along Great Lakes shorelines should be aware that flood probabilities shown in Table 4.1 may underestimate actual probabilities during periods of high lake levels. For example, Potter (1992) calculated that during rising lake levels in 1985, Lake Erie had a 10-percent probability of experiencing a 100-year flood event in the next 12 months (vs. 1-percent as shown in Table 4.1)

4.2.1.2 Consequences of the Hazards

The nature and severity of an event's consequences for a given building will depend on the hazard forces associated with the event, over which the designer has no control, and on the siting, design, construction, and maintenance of the building, which are largely within the control of the designer.

Because most coastal areas of the United States are subject to multiple hazards, the designer must identify all significant hazards at the construction site and determine the vulnerability of the building to those hazards. The risk assessment must account for the short-term and long-term effects of each hazard, including the potential for cumulative effects, and the combination of effects from different hazards. Overlooking a hazard or underestimating its long-term effects can have disastrous consequences for the building and its owner.

4.2.1.3 Safety Factors and the Consequences of Exceeding a Design Condition

The selection of specific design conditions for an individual building should consider the safety factors inherent in the design, construction, and regulatory process and the consequences of a hazard exceeding the design condition. A good example is the difference in return frequencies used nationally for minimum wind and flood standards.

Minimum wind regulations are generally based on a 50-year return frequency. For a house in use for 70 years, it is likely (a 76-percent probability from Table 4.1) that a faster wind will occur. However, the design process for wind applies safety factors in the estimation of both the force of the wind on the structure and the strength of the materials intended to resist the wind force. If a house is properly designed and constructed, a net safety factor of at least 1.5 in the wind-resisting strength of the building can be expected. The safety factors for a house designed for 120-mph winds should mean that there will be no damage at 121 mph or even considerably faster. The consequences of a wind speed somewhat higher than design wind is very small—a relatively low risk of additional damage.

In comparison, flood regulations include no safety factors but partially compensate by using a longer return frequency of 100 years. From Table 4.1, the 70-year-old house is at lower risk to flood than wind, only a 50-percent chance of experiencing a worse flood, versus 76 percent for wind. However, the consequences of flooding slightly above the standard are severe. A water level a few inches above a minimum floor elevation can result in damaged walls, flooded carpets, warped flooring, and the loss of floor insulation, wiring, and ductwork. **Safety factors for flood resistance are not inherent in the design process but must be specified by the designer or owner.**

Wind and flood standards are based on reducing building damage. In contrast, fire safety regulations are based on life safety issues. The protection of human life is held to much higher standard than the risk of property damage. Similarly, high-occupancy publicly used buildings are held to even higher standards (e.g., the requirement for sprinkler systems) because more many lives are at risk.

Safety factors are not only used for wind, flood, seismic, and other design loads, but are also used by geotechnical engineers to determine the risk of slope failures to blufftop buildings. The ratio of soil strength to soil stresses is commonly used as the safety factor in such cases. The choice of a safety factor depends on the type and importance of blufftop development, the bluff height and the nature of the bluff failure (e.g., deep rotational failure vs. translational failure), and the acceptable level of risk associated with a bluff failure. Studies in the Great Lakes (Valejo and Edil 1979, Chapman et al. 1996, and Terraprobe 1994) provide guidance for the selection of appropriate safety factors.

NOTE

Safety factors are critical when bluff stability and setback distances are calculated.

Risk assessment for siting and design conditions should consider the return frequency of the hazard and any safety factors inherent in the design process, or safety factors should be explicitly added. In addition, the design should consider the severity of the consequences that would result if the design conditions are exceeded

4.2.2 Risk Management

Risk management refers to the process of reducing or offsetting risks. Therefore, risk management for coastal construction requires an understanding of the following:

- the ways in which siting, design, construction, and maintenance decisions can mitigate or exacerbate the consequences of individual hazard events
- the role of hazard insurance
- the acceptable level of residual risk (i.e., risk not offset through siting, design, construction, maintenance, and insurance)

COST CONSIDERATION

There are costs associated with all decisions made regarding coastal construction. Some costs are readily apparent, while others are not.

Risks can be managed physically—through the protection provided by siting, design, construction, and maintenance—and financially through the protection provided by insurance. Some risks can also be managed through protective works (where permitted by local and state jurisdictions). But eliminating all risk is impossible; therefore, inherent to residual risk management is the concept of an *acceptable level of residual risk*—that is, the level of risk that is not offset and that must be accepted by the property owner. The principle of residual risk management, including the acceptable level of residual risk, underlies the entire coastal construction process.

4.2.2.1 Risk Management Through Hazard Mitigation

Building codes and Federal, state, and local regulations establish minimum requirements for siting, design, and construction. Among these are requirements that buildings be constructed to withstand the effects of natural hazards with specified recurrence intervals (e.g., 100-year flood, 50-year wind, 500-year earthquake). Therefore, when building code and regulatory requirements are met, they can help reduce the vulnerability of a building to natural hazards and, in a sense, provide a baseline level of risk management. It should be noted, however, that **meeting minimum regulatory requirements for the siting, design, and construction of a building does not guarantee that the building will be "safe."**

NOTE

Meeting only minimum code and regulatory requirements may result in designs based on different levels of risk for different hazards. The hazard levels addressed by such requirements should therefore be carefully considered during the design process.

Property owners, developers, and builders have the ability to further manage risks by providing an increased level of hazard mitigation. For example:

- A building can be sited further landward than the minimum distance specified by state or local setback requirements.
- A building can be elevated above the level required by NFIP, state, and local requirements.
- Supporting piles can be embedded deeper than required by state or local regulations.
- Structural members or connections can be used that exceed code requirements for gravity, uplift, and/or lateral forces.
- Improved roofing systems can be used that provide greater resistance to wind than that required by code.
- Building and roof shapes (e.g., hip roofs) can be selected that reduce wind loads.
- Openings (e.g., windows, doors) can be protected with permanent or temporary shutters or covers, whether or not such protection is required by code
- Construction of enclosures below an elevated building can be eliminated or minimized. Enclosures will be vulnerable to flood damage (even during minor flood events), are not covered by the Standard Flood Insurance Policy, and will increase flood insurance premiums for the building.

Consider the following example of how just one decision left to the designer, builder, or homeowner can affect risk. Local floodplain management requirements that comply with the NFIP regulations require that any building constructed in the V zone be elevated so that the bottom of the lowest horizontal structural member is at or above the Base Flood Elevation (BFE) (100-year flood elevation, including wave effects). Meeting this requirement should protect the elevated portion of the building from the 100-year and lesser floods. However, the elevated part of the building is still vulnerable to floods of greater magnitude. As shown in Table 4.1, the probability that the building will be subjected to a flood **greater** than the 100-year flood during an assumed useful life of 70 years is 50 percent. But during the same 70-year period, the probability of a 500-year or greater flood is only 13 percent. Therefore, raising the lowest horizontal structural member to the elevation of the 500-year flood would significantly reduce the risk for that building. If elevating to the level of the 500-year flood is not possible, because of cost or other considerations, elevating by some lesser amount above the BFE will still reduce the risk.

WARNING

Regulations require a minimum standard, but do not imply that any building that meets the standard is "safe." For example, a 30-year erosion setback does not imply that a building will be safe from erosion at that location. In fact, it is an estimation of future erosion based on historical erosion rates. A building located at the 30-year setback may be threatened long before 30 years pass.

CROSS-REFERENCE

BFEs and the elevations of floods with other recurrence intervals (e.g., 500-year flood) are shown in FEMA Flood Insurance Study (FIS) reports (see Chapters 3 and 6) .

Like the decision described above, decisions made concerning the placement and orientation of the building, its size and shape, and the materials and methods used in its construction can decrease (or increase) potential damage from natural hazard events. However, these decisions can also affect initial and long-term costs (see Section 4.3), aesthetic qualities (e.g., the appearance of the finished building, views from within), and convenience for the homeowner (e.g., accessibility). The tradeoffs among these factors involve objective and subjective considerations that are often difficult to quantify and are likely to be assessed differently by developers, builders, homeowners, and community officials. Ultimately, however, a balance must be struck between cost, siting, and design decisions on the one hand and the amount of protection provided on the other.

COST CONSIDERATION

In some areas, mortgage lenders may require that borrowers obtain specific types of hazard insurance.

4.2.2.2 Risk Management Through Insurance

Insurance provides a property owner with a financial tool for managing risk. For houses in coastal areas, the risks associated with flooding, high winds, and, in some areas, earthquakes are of particular concern. These risks can be addressed through a variety of insurance mechanisms, including the NFIP, homeowners insurance, insurance pools, and self-insurance plans.

NOTE

In the past, homeowners have relied on insurance for replacement costs when a natural hazard occurred, without regard to the inconvenience and disruption of their daily lives. Little thought was given to mitigation. Taking a mitigation approach can reduce these disruptions and inconveniences.

Flood Insurance

Federally backed flood insurance is available for both existing and newly constructed buildings in communities that participate in the NFIP. To be insurable under the NFIP, a building must have a roof, have at least two walls, and be at least 50 percent above grade. Like homeowner's insurance, flood insurance is obtained from private insurance companies. But an important distinction is that insurance companies that issue homeowner's policies occasionally deny wind and earthquake coverage to buildings in areas where the risks from these hazards are high. Flood insurance, because it is federally backed, is available for buildings in all coastal areas of participating communities, with the following exceptions:

- buildings constructed entirely over water or seaward of mean high tide after October 1, 1982
- buildings newly constructed, substantially improved, or substantially damaged on designated undeveloped coastal barriers included in the Coastal Barrier Resources System after October 1, 1983 (see Section 6.6 in Chapter 6 of this manual)
- portions of boat houses located partially over water (e.g., the ceiling and roof over the area where boats are moored)

COST CONSIDERATION

Unless large numbers of buildings perform reasonably well, insurance availability or affordability can be jeopardized; therefore, enhancing performance through mitigation is important.

As discussed in Chapter 9, the flood insurance rates for buildings in participating communities vary according to the physical characteristics of the building, the date the building was constructed, and the magnitude of the flood hazard at the site of the building. The flood insurance premium for a building is based on the rate, standard per-policy fees, the amount of the deductible, applicable NFIP surcharges and discounts, and the amount of coverage obtained.

Wind Insurance

Homeowner's insurance policies normally include coverage for wind. However, as noted previously, wind coverage is not always available, especially in coastal areas subject to a significant hurricane or typhoon risk, where wind hazards are usually high. At the time this manual was prepared, underwriting associations, or "pools," were a last resort for homeowners who need wind coverage, but could not obtain it from private companies. Eight states have established windstorm insurance plans: Alabama, Florida, Louisiana, Mississippi, New York, North Carolina, South Carolina, and Texas. In addition, New Jersey operates the Windstorm Market Assistance Program (Wind-MAP) to help residents in coastal communities find homeowner's insurance in the voluntary market. When Wind-MAP does not identify an insurance carrier for a homeowner, the New Jersey FAIR Plan may provide a policy for perils only.

Earthquake Insurance

A standard homeowner's insurance policy can often be modified through an endorsement to include earthquake coverage. However, like wind coverage, earthquake coverage may not be available in areas where the earthquake risk is high. Moreover, deductibles and rates for earthquake coverage (of typical coastal residential buildings) are usually much higher than those for flood, wind, and other hazard insurance.

Self-Insurance

Where wind and earthquake insurance coverage is not available from private companies or insurance pools—or where property owners choose to forego available insurance—owners with sufficient financial reserves may be able to insure themselves (i.e., assume complete financial responsibility for the risks not offset through siting, design, construction, and maintenance). It is imperative, however, that property owners who contemplate self-insurance understand the true level of risk they are assuming.

4.3 Cost Considerations

Coastal residential buildings, like all buildings, have initial, long-term, and operational costs.

> **Initial costs** include property evaluation and acquisition costs, and the costs of permitting, design, and construction.
>
> **Long-term costs** include costs for preventive maintenance and for repair and replacement of deteriorated or damaged building components.
>
> **Operational costs** include costs associated with the use of the building, such as the costs of utilities and insurance.

In general, the decision to build in any area subject to significant natural hazards—especially coastal areas—increases the initial, long-term, and operational costs of building ownership. Initial costs increase because the natural hazards must be identified, the associated risks assessed, and the building designed and constructed to resist damage from the natural hazard forces. Long-term costs are likely to be greater because a building constructed in a natural hazard area will usually require more frequent and more extensive maintenance and repairs than a building sited elsewhere. Operational costs can increase for buildings in hazard areas because of higher insurance costs and, in some instances, higher utility costs.

Once a site has been selected, decisions must be made concerning the placement and orientation (siting or location) of the building and its design. These decisions are driven primarily by the following:

- owner, designer, and contractor awareness of natural hazards
- risk tolerance of the owner
- aesthetic considerations (e.g., the appearance of the building, its proximity to the water, views from within the building, sizes and numbers of windows)
- building use (e.g., full-time residence, part-time residence, rental property)
- requirements of Federal, state, and local regulations and codes
- initial costs and long-term costs

The interrelationships among aesthetics, building use, regulatory and code requirements, and initial cost become apparent during siting and design, and decisions are made according to the individual needs or goals of the property owner, designer, or builder. What is often lacking in this process is an understanding of the effect of these decisions on long-term and operational costs. The consequences can range from increased maintenance and utility

WARNING

Improper construction of enclosures below elevated V-zone residential buildings and post-construction conversion of enclosed space to habitable use (in A zones and V zones) are the biggest compliance problems faced by the NFIP. Designers and owners should realize that (1) enclosures and items within them are subject to flood damage (even during minor flood events), (2) enclosures—and most items with them—are *not covered* by flood insurance and can result in significant costs to the building owner, and (3) even the presence of properly constructed enclosures will increase flood insurance premiums for the entire building (the premium rate will increase as the enclosed area increases). Including enclosures in a building design can have significant cost implications.

This manual recommends the use of insect screening or open wood lattice instead of solid enclosures beneath elevated residential buildings. Note that some designers have incorporated open lattice with layers of translucent, reinforced plastic to overcome the most common objection by property owners—passage of salt spray and blowing sand through open lattice.

costs to the ultimate loss of the building. The following examples illustrate some of the effects that siting and design decisions can have on long-term and operational costs.

Cost Implications of Siting Decisions

- The closer buildings are sited to the water the more likely they are to be affected by flooding, wave action, erosion, scour, debris impact, overwash, and corrosion. In addition, wind speeds are typically higher along coastlines, particularly within the first several hundred feet inland. **Repeated exposure to these hazards, even when buildings are designed to resist their effects, can lead to increased long-term costs for maintenance and damage repair.**
- Erosion—especially long-term erosion—poses an especially serious threat to buildings near the water, even those situated on high bluffs above the floodplain. Storm-induced erosion can lower ground elevations around coastal buildings, exposing V-zone buildings to higher than anticipated forces, and exposing A-zone buildings to V-zone flood hazards. **Maintenance and repair costs will be high for buildings in erosion hazard areas, not only because of damage to the building, but also because of the need for remedial measures (e.g., building relocation or erosion protection projects, such as seawalls, revetments, or beach nourishment, where permitted).** Note that the average annual maintenance cost for shore protection can equal 5 to 10 percent of construction cost or the cost of building relocation.
- Sites nearest the water are more likely to be in a V zone, where building foundations, access stairs, parking slabs, and other components below the building are especially vulnerable to flood, erosion, and scour effects. As a result, **the potential for repeated damage and repair costs is greater for V-zone buildings, and the buildings have higher flood insurance rates and increased operational costs.** In addition, although elevating a building can protect the superstructure from flood damage, it may make the entire building more vulnerable to earthquake and wind damage.

Cost Implications of Design Decisions

- For aesthetic reasons, the walls of coastal buildings often include a large number of openings for windows and doors, especially the walls that face the water. **Designs of this type lead to greater initial costs for strengthening the walls and for protecting the windows and doors from wind and windborne debris (missiles)**. If adequate protection in the form of shutter systems or impact-resistant glazing is not provided, long-term costs will increase because of (1) the need to repair damage to glazing and secondary damage to the building caused

CROSS-REFERENCE

See Sections 6.4.3.3 and 9.3.1.1, in Chapters 6 and 9, respectively, for additional information about enclosures, the use of space below elevated buildings, and flood insurance.

CROSS-REFERENCE

Chapter 8 of this manual discusses the siting of coastal residential buildings.

COST CONSIDERATION

Designers and homeowners should recognize that erosion control measures can be expensive, both initially and over the lifetime of a building. In some instances, erosion control costs can equal or exceed the cost of the property or building being protected.

CROSS-REFERENCE

Chapter 12 of this manual discusses the design of coastal residential buildings.

by the entry of wind-driven rain and sea spray and/or (2) the need to install retrofit protection devices at a late date.

- As explained in Chapter 6 of this manual, NFIP regulations allow buildings in coastal A zones to be constructed on perimeter wall (e.g., crawlspace) foundations or on earth fill. Open (pile, pier, or column) foundations are required only for V-zone buildings. Although a coastal A-zone building on a perimeter wall foundation or fill may have a lower initial construction cost than a similar building on an open foundation, it may well be subject to damaging waves, velocity flows, and/or erosion scour over its useful life. As a result, **the long- term costs for a building on a perimeter wall foundation or fill may actually be higher because of the increased potential for damage**.
- Designers, in an effort to reduce initial construction costs, may select building materials that require high levels of maintenance. Unfortunately, two things tend to counteract any initial savings: (1) coastal buildings, particularly those near bodies of salt water, are especially prone to the effects of corrosion, and (2) owners of coastal buildings frequently fail to sustain the continuing and time-consuming levels of maintenance required. **The net effect is often increased building deterioration and, sometimes, a reduced capacity of structural and non-structural components to resist the effects of future natural hazard events**.

4.4 References

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