So far the discussion of the progression of damage for flood load has considered elevated structures subjected to wave loads. The progression of damage for structures supported by slabs-on-grade is truncated; the damage begins with the walls. It is more common to find slab-on-grade structures farther away from the coast, and the damage to these buildings is more often due to inundation and minimal, if any, wave action. There are cases, however, in which these structures have been subjected to wave loads or loads from flood velocity. Examples include buildings that are located adjacent to overtopped levees or older buildings located near the coast. When waves are present, wood-frame buildings supported by slab-on-grade experience "wash-through," (or the removal of wall panels), failure of stud-to-sole plate connections, or complete collapse of walls (Figure 5-13). In the latter case, building roofs can be transported some distance from the original location.

Metal buildings exhibit a unique type of damage when subjected to storm surge and wave loads. The metal panel wall cladding is often torn along a distinct horizontal line at one of the wall girts. Figure 5-14 illustrates this mechanism.

Figure 5-13. Wash-through of walls on a residential slab-on-grade structure subject to storm surge flooding from Hurricane Katrina in 2005

Source: Photograph by Samuel Amoroso

Figure 5-14. Failure of wall panels on a metal building due to storm surge flood load from Hurricane Katrina in 2005

Source: Photograph by Samuel Amoroso

5.5 SUMMARY AND KEY THOUGHTS

This chapter discusses the interaction of wind, storm surge, flood, and waves with low-rise structures in the context of structural load paths and damage signatures. Wind-only damage is generally characterized as top-down, with the roof cover commonly the most likely component to suffer damage. As the wind intensity increases, windows, roof sheathing, gable ends, and walls become vulnerable. Conversely, storm surge, flood, and wave damage is characterized as bottom-up. The load only acts on the portions of the structure immersed in the moving water, and thus walls, windows, and cladding are vulnerable. The force of moving water is such that elevating the structure may be the only economical design to resist storm surge, flood, and waves. The photographs in this chapter illustrate these damage signatures and the relative force of storm surge and wind in a region in Mississippi impacted by Hurricane Katrina.

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Chapter 6

Planning and Managing Investigations

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Planning and managing hurricane damage investigations presents many logistical challenges for the engineering firm, particularly when the assessment of many properties within a short timeframe is required. These are compounded by technical challenges that arise when many different engineers from one firm perform these damage assessments due to the need for quality control and consistency among the engineering opinions issued. Another consideration for hurricane damage investigations is whether individuals need to be licensed in the state where a property is located. That need is determined by state law, client requirements, and the internal policies of the engineering firm.

In addition to these logistical and technical challenges, accurate and timely communication with property owners, clients, colleagues and other interested parties is important to create an environment in which sound engineering opinions can be formed and communicated. These issues are best addressed by effective project management strategies that are established at the onset of any hurricane damage investigation, or better, by strategies that have been developed well in advance of a particular hurricane event.

6.1 ROLES OF PROJECT PERSONNEL

As with any engineering project, a clear understanding of roles and responsibilities among personnel is critical to the effective and efficient execution of the project. Most hurricane damage investigations will include personnel in the following roles:

- Field inspectors: personnel responsible for collecting and documenting on-site data;

- Data analysts: personnel responsible for collecting and interpreting meteorological data, as well as personnel responsible for performing engineering calculations;

- Supervising professional engineers: personnel responsible for overseeing all technical work and for formulating engineering opinions;

- Report authors: personnel responsible for summarizing and interpreting data, interpreting calculations, and providing engineering opinions in written format; and

- Project managers: personnel responsible for communicating with the client and coordinating between all other project personnel.

In some cases, a single engineer may fulfill many or all of the roles described above. In the case where numerous damage assessments will be performed by an engineering firm, this may not be practical.

6.2 RESPONSIBILITIES OF PROJECT PERSONNEL

6.2.1 Field Inspectors

The accuracy of a hurricane damage assessment can be significantly affected by the quality of on-site data collection and documentation. Field inspectors should be familiar with the types of data relevant to the technical questions to be addressed by the damage assessment, and should be systematic in their documentation of those data. Details related to the collection of on-site data are addressed in Chapter 7.

The engineering qualifications for field inspectors may vary by project and depend on engineering licensing requirements in a particular state, as discussed in Section 6.3. In some cases, a client may request that the supervising professional engineer for the project perform the field investigation. In other cases, the field inspectors may be individuals who work under the responsible charge of the supervising professional engineer. Particularly in the latter case, clear and systematic documentation of on-site data is critical, and discussions between the field inspectors and supervising professional engineer should occur prior to, during (as necessary), and after site visits, particularly during the formulation of engineering opinions.

Field inspectors should understand their role in communicating information to property owners and other interested parties. Engineering opinions should be issued only by the supervising professional engineer and, except in the case of immediate safety concerns, should be disseminated according to the lines of communication established for the project. In general, the field investigation is primarily a data gathering endeavor and engineering opinions will be based on other considerations in addition to that data. For this reason, engineering opinions are generally not communicated during the field investigation, even when the field investigation is performed by the supervising professional engineer.

6.2.2 Data Analysts

An analysis of regional and site-specific meteorological data is often performed to explain patterns of damage observed at a property. In some cases, load calculations may be performed to assess the demand on structures imposed by wind or flooding, and resistance calculations may be performed to assess the capacity of structures to withstand those demands. Sources of meteorological data are addressed in Chapter 8 and engineering load and resistance calculations are addressed in Chapter 5.

Data analysts should be familiar with the application of meteorological and engineering principles to damage assessments of structures. For example, wind speeds of interest likely will be those consistent with the exposure and elevation of the structure under consideration. In the case of structural resistance calculations, design level resistances are typically much lower than the actual structural resistance at the time of failure. The uncertainty associated with both meteorological data and engineering calculations should be acknowledged by the data analyst. The level of analysis should be appropriate given the technical questions to be addressed by the damage assessment and should be coordinated with the supervising professional engineer.

6.2.3 Supervising Professional Engineer

Engineering opinions related to the causation, timing, extent, and appropriate repair of hurricane damage are issued by the supervising professional engineer. Ultimately, the supervising professional engineer is responsible for the engineering opinions and the technical bases on which they are formed. Thus, coordination between the supervising professional engineer and both the field inspectors and data analysts should occur throughout the damage assessment. In addition, engineering reports are issued only when approved by the supervising professional engineer.

The supervising professional engineer must be appropriately licensed in the jurisdiction of the damaged property and should be experienced in the assessment of hurricane damage. He or she should oversee the technical work performed by other members of the project team throughout the damage assessment and should be well-versed in the technical issues that form the foundation of any conclusion resulting from the damage assessment. The supervising professional engineer must be prepared to defend all opinions included in the engineering report and the process whereby those opinions were formed.

6.2.4 Report Authors

Conclusions resulting from the hurricane damage assessment typically are presented as engineering opinions summarized in an engineering report. The report authors are responsible for summarizing those opinions and the relevant information that supports them in a clear and concise manner, in language appropriate for the intended audience. Details related to hurricane damage assessment reports are addressed in Chapter 10.

Report authors should coordinate the general format of the engineering report with the project manager and supervising professional engineer in the early phases of the damage assessment. Ongoing communication between the report authors and other members of the project team is necessary to insure that field data are accurately summarized, analysis results are appropriately presented and, most important, engineering opinions are clearly and accurately stated. As noted previously, engineering reports are issued only when approved by the supervising professional engineer.

6.2.5 Project Managers

Effective project management facilitates the work of all project team members discussed above, as well as the integration of individual contributions into a work product that is communicated clearly and in a timely manner to the client. Just as the supervising professional engineer is ultimately responsible for all engineering opinions, the project manager is responsible for all coordination and logistics required to form and communicate those opinions. It is often desirable to designate specific personnel as project managers rather than to combine this responsibility with other roles.

Since a project manager will help coordinate all aspects of the damage assessment, he or she should be familiar with the roles of all project team members and, ideally, should have performed some of those roles during past damage assessments. A project manager who has conducted field inspections, for example, will be better able to anticipate logistical challenges facing field inspectors. Finally, the project manager facilitates internal communications among project team members and external communications with the client and other interested parties.

6.3 LICENSING ISSUES

State laws vary with respect to the requirement for engineering licensure. Many states define the practice of engineering narrowly, and limit it to services that safeguard life, health, or property. In those states, an engineering license may not be required to perform an investigation of a damaged structure if the investigation does not provide recommendations that safeguard life, health, or property. Other states define the practice of engineering more broadly. In those states, any engineering investigation will require the involvement of a state-licensed individual and, in some cases, may even require that the field inspection be performed by such an individual.

Some states explicitly include expert technical testimony in their definition of the practice of engineering, which should be considered if there is a possibility that the project will involve such testimony. Finally, many states require that the engineering firm be appropriately registered to provide engineering services. Since states vary in the interpretation of regulations, it is prudent to be aware of local precedent. It is imperative to thoroughly review and understand state licensing requirements prior to accepting an assignment.

An additional consideration is the requirement of the individual client, who may have more stringent requests than state licensing requirements. For example, a client may require that a state-licensed engineer personally inspect the damaged property and sign and seal the engineering report. Finally, the engineering firm’s internal policies may be more stringent than state law or the client’s requirements.

6.4 TOOLS FOR PROJECT MANAGEMENT AND ORGANIZATION

This discussion introduces practical tools to assist in managing and organizing hurricane damage assessments. These tools help to organize and track the progress of all phases of the damage assessment; facilitate the work of all project team members; and promote consistency and quality control in the formulation and communication of engineering opinions. Project management and organization discussed in this chapter is most relevant in cases where many damage assessments resulting from a single hurricane event are performed concurrently by an engineering firm. Variations on the formats presented allow these tools to be tailored to the needs of a particular engineering firm.

6.4.1 Project Master Spreadsheet

The project master spreadsheet tracks the progress of a hurricane damage assessment. It is used by the project manager as well as other members of the project team. Data can include firm and client project reference information, basic property information, project personnel assigned to various tasks, key project dates and deadlines, and any other information pertinent to the specific project, as shown in Figure 6-1.

Ref #	Address	Insp. Team	Data Analyst	Author	Sup. Engr.	Inspect. Date	Draft Report	Report Appr.	Report Sent
X_01	1 Main St	JS, MT	RA	FJ	BL	8/1/05	8/22/05	8/29/05	8/29/05
X-02	3 Cherry	JS, MT	MS	DO	BL	8/11/05	9/1/05		
X-03	6 First St	CM, GA	KG	PI	BL	8/21/05			

Figure 6-1. Project master spreadsheet

The project master spreadsheet can be used by the field inspectors to receive inspection assignments from the project manager and to notify the project manager of scheduled inspection dates. Data analysts can use property address and latitude/longitude data to generate property specific estimates of wind speed and flood depth. Supervising professional engineers and report authors can track the progress of the inspection and data analysis phases to schedule their respective tasks. Finally, the project master spreadsheet provides the project manager a convenient tool to assign project tasks and to track the progress of a damage assessment. This ability to track progress and predict completion dates benefits the project manager in his or her communications with the client.

6.4.2 Field Inspection and Technical Information Databases

A central field inspection database, including site inspection photographs and field notes, is particularly useful when the roles of field inspector, supervising professional engineer, and report author are not performed by a single individual. A common folder structure and file naming convention will enhance the efficiency of analyzing and summarizing field data, and will facilitate communication between the field inspector, data analyst, and supervising professional engineer. Hyperlinks to folders within the field inspection database can be included in the project master spreadsheet. Figure 6-2 provides an example of a common folder structure for a field inspection database.

A similar technical information database can be used to organize meteorological data related to the hurricane, engineering calculations, building code excerpts relevant to repair of hurricane-related damage, and technical literature. Data analysts and supervising professional engineers can use this database to document technical information used in the formation of engineering opinions. Some portions of the technical information database can be used in support of many individual property-level damage assessments, while other portions may be applicable to damage assessments of only one property. The folder structure of the technical information database can be created accordingly. Figure 6-3 provides an example of a common folder structure for a technical information database.

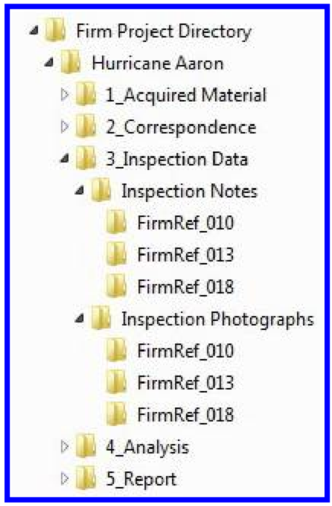

Figure 6-2. Field inspection database folder structure

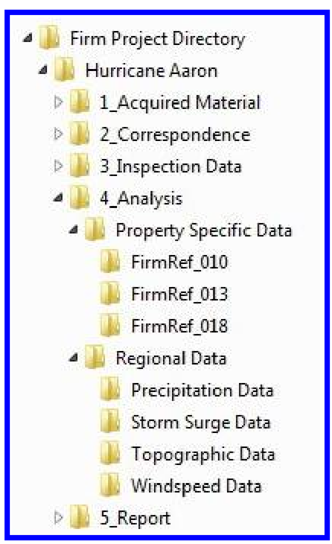

Figure 6-3. Technical information database folder structure

6.4.3 Geographic Information Systems

The efficiency of field inspections can be enhanced via geographic information systems (GIS) by identifying properties in close proximity and assigning them to a single field inspection team. Simple internet-based mapping tools can be used for this purpose. Publically available GIS software, such as Google Earth™, can be used in hurricane damage assessments by any engineering firm; more sophisticated GIS platforms may be used by firms that regularly employ GIS for other aspects of their business.

A more sophisticated use of GIS involves the analysis of spatial distributions of meteorological, topographic, and inspection data to identify patterns of damage and to fill data gaps at a particular property. For example, flood depth measurements at many properties along the coastline can be used to generate contours of storm surge flooding and to estimate flood depths at properties where other indicators of flood depth are absent. Patterns of wind damage near properties destroyed by flooding can be used to predict the likely extent of wind damage absent such flooding. Spatial distributions of data can be used to explain local anomalies in damage patterns, such as the poor performance of buildings in older neighborhoods or lack of flood damage to properties in areas of locally higher ground.

GIS also provides a method to promote consistency among engineering opinions. Basic conclusions related to the damage assessment can be color-coded and mapped to identify outliers among several nearby properties. Those outliers can be flagged for review by the supervising professional engineer. Data analysts working on nearby properties can share information relevant to a particular geographic area, thereby enhancing both the consistency and the efficiency of the damage assessments.

6.5 PRACTICAL CONSIDERATIONS FOR PLANNING AND MANAGING INVESTIGATIONS

6.5.1 Logistical Challenges

Since many logistical challenges occur in the early phases of a hurricane damage assessment due to the damaging effects of a hurricane on a region's infrastructure, project management strategies should be implemented when the first request for a hurricane damage assessment is received from a client. Some logistical challenges that must be addressed prior to the assignment of the field inspection team include:

- Lodging: hotels near damaged properties frequently are closed following a hurricane due to direct physical damage or interruption of utilities. Other nearby hotels may book quickly due to an influx of repair contractors and damage investigators. Hotel rooms for the field inspection team should be reserved as soon as possible and should be located in an area as central as possible to the affected region. Monthly apartment rentals may be preferable if inspections will continue for several weeks.