OAK RIDGE National Laboratory

SERRI Report 80024

Floodproof Construction: Working for Coastal Communities

SERRI Project: Floodproof Commercial Construction and Fortified Residential Construction for Neighborhood-Scale, Mixed-use Buildings

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SERRI Southeast Region Research Initiative

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FLOODPROOF COMMERCIAL CONSTRUCTION: WORKING FOR COASTAL COMMUNITIES

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ACRONYMS

ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
BFE	Base Flood Elevation
BHA	Biloxi Housing Authority
CFR	Code of Federal Regulations
CMU	Concrete Masonry Unit
DFE	Design Flood Elevation
DFIRM	Digital Flood Insurance Rate Map
FEMA	Federal Emergency Management Agency
FFE	Finished Floor Elevation
FIS	Flood Insurance Study
FIRM	Flood Insurance Rate Map
GCCDS	Gulf Coast Community Design Studio
IBHS	Insurance Institute for Business and Home Safety
ICF	Insulated Concrete Formwork
MWFRS	Main Wind Force Resisting System
NFIP	National Flood Insurance Program
SIPs	Structural Insulated Panels
RFD	Regulatory Flood Datum

USACE	United States Army Corps of Engineers

SOUTHEAST REGION RESEARCH INITIATIVE

In 2006, the U.S. Department of Homeland Security commissioned UT-Battelle at the Oak Ridge National Laboratory (ORNL) to establish and manage a program to develop regional systems and solutions to address homeland security issues that can have national implications. The project, called the Southeast Region Research Initiative (SERRI), is intended to combine science and technology with validated operational approaches to address regionally unique requirements and suggest regional solutions with potential national implications. As a principal activity, SERRI will sponsor university research directed toward important homeland security problems of regional and national interest.

SERRI's regional approach capitalizes on the inherent power resident in the southeastern United States. The project partners, ORNL, the Y-12 National Security Complex, the Savannah River National Laboratory, and a host of regional research universities and industrial partners, are all tightly linked to the full spectrum of regional and national research universities and organizations, thus providing a gateway to cutting-edge science and technology unmatched by any other homeland security organization.

Because of its diverse and representative infrastructure, the state of Mississippi was chosen as a primary location for initial implementation of SERRI programs. Through the Mississippi Research Initiative, SERRI plans to address weaknesses in dissemination and interpretation of data before, during, and after natural disasters and other mass-casualty events with the long-term goal of integrating approaches across the Southeast region.

As part of its mission, SERRI supports technology transfer and implementation of innovations based upon SERRI-sponsored research to ensure research results are transitioned to useful products and services available to homeland security responders and practitioners. Concomitantly, SERRI has a strong interest in supporting the commercialization of university research results that may have a sound impact on homeland security and encourages university principal investigators to submit unsolicited proposals to support the continuation of projects previously funded by SERRI.

For more information on SERRI, go to the SERRI Web site: www.serri.org.

EXECUTIVE SUMMARY

Dry floodproofing is one of several methods for mitigating flood risk. Each local jurisdiction can determine the standards for dry floodproofing to best suit their floodplain management plan. Typically, a dry floodproofed building is a non-residential structure which has been certified by an architect or engineer of record as substantially impermeable to the passage of water and capable of resisting flood forces.

The scope of opportunity to use dry floodproof construction is small; it is constrained by regulatory, technical and economic limits. However strategic use of dry floodproof construction as part of an overall mitigation plan can promote economically and socially resilient neighborhoods by achieving levels of design integration and building accessibility other mitigation techniques cannot.

After Hurricane Katrina, many commercial corridors in communities devastated by the storm surge were also negatively affected by being included in the newly expanded FEMA Special Flood Hazard Area (SFHA). The many difficulties of building commercial space in a SFHA, such as insurance challenges and lack of technical expertise have drastically stalled commercial development in these areas.

The Gulf Coast Community Design Studio (GCCDS) and its community partners observed that small-to-medium scale commercial development in communities along the Mississippi Gulf Coast were struggling to build after the storm. This was in part to a need for contemporary information on options for dry floodproof construction. With funding from the Southeastern Regional Research Initiative (SERRI), the GCCDS sought to investigate and report on the policy, methods and effects of dry floodproof construction and to increase interest in dry floodproof construction.

The research was classified into four tasks:

- Understand Hazards: a survey of precedent studies & policy history
- Plan Neighborhood Land Use: a planning & urban design study
- Investigate Materials and Assemblies: full scale construction testing
- Design a Mixed-Use Building: schematic design & budgeting

In the area of planning, GIS technology was used to identify commercial properties that have suitable characteristics for both the physical and regulatory requirements of dry floodproofing. Using similar techniques interested communities could create land use and zoning policies which aid in the development of dry floodproof commercial property. Dry floodproof construction allows commercial spaces to be built closer to grade, thereby increasing building accessibility, the quality of commercial corridors and the value of property.

Buildings and structures are built everyday to resist a wide range of hydrostatic forces. Beyond the question of achievability, this research explored whether floodproof building performance could be achieved using materials and techniques already used along the Mississippi Gulf Coast. The result was a focus on common building materials and techniques for the research.

The GCCDS developed and tested a variety of different wall assemblies in several full-scale test models through a series simulated floods of 3′ depths in an outdoor flood tank. Using

observations taken from the first flood simulation and data gathered from a subsequent drying period, the GCCDS revised several wall assemblies to improve dry floodproof performance. Through simulation testing, multiple construction types were identified as viable options for dry floodproof construction, including concrete masonry blocks with sprayed- and sheet-applied water resistive membranes, Insulated Concrete Formwork (ICF), and metal Structural Insulated Panels (SIPs). Finding a variety of options for dry floodproof construction was a goal of the project due to need for system flexibility when dealing with differing regulatory, technical and economic development limits.

Included in the research project was a designed study for a mixed-used building in the SFHA, done in collaboration with the Biloxi Housing Authority. The process of schematic design and cost estimating for this mixed-use building focused on combining all the gained knowledge from earlier material and planning research with a community based scenario. The direct and indirect cost of building and maintaining a dry floodproof building was considered within context of building cost, operation and insurance.

Through this research, several technical solutions for dry floodproof construction along with several planning and urban design techniques were identified. Combining current construction techniques with progressive can allow for the strong community impacts from dry floodproof construction projects despite its limited role in a larger mitigation plan.

1. INTRODUCTION

Hurricane Katrina affected existing commercial corridors along the Gulf Coast by physically destroying or severely damaging buildings. As a result of this disaster, the Flood Insurance Rate Maps (FIRMs), which assign flood zones and Base Flood Elevation (BFE) heights were revised to include large areas that were not previously located within Special Flood Hazard Areas. The revision of these maps significantly impacted the rebuilding and development opportunities for property owners. Additional elevation requirements derived from the revisions of the FIRMs have made it difficult to build new commercial buildings in areas that have historically been economically viable. The Federal Emergency Management Agency (FEMA) has provisions to allow non-residential buildings to be built below the BFE, using dry floodproof construction. Dry floodproof construction is defined as being substantially impermeable to water. This alternative can be employed to relieve the strain of elevating commercial development in established coastal neighborhoods.

However, the limited applicability and knowledge of dry floodproof construction has resulted in a very small number of projects successfully taking advantage of this alternative. In areas subjected to high elevation requirements, dry floodproof construction may not be economically or architecturally feasible. Other factors impacting the applicability of dry floodproof construction include building performance specifications and urban design issues pertinent to commercial corridors, which are discussed in Chapters Two and Three of this report.

It is not surprising that many Gulf Coast stakeholders are unfamiliar with the opportunities associated with the option of dry floodproof construction; the complexities of dry floodproof construction involve collaboration between property owners, developers, engineers and architects, zoning officials, and municipal floodplain managers, all under the direction of federal policy. At the time of this research, many parties that could be involved in the development of new dry floodproof commercial spaces do not appear to understand the regulatory or performance requirements of this type of mitigation. Of those that seem to be aware, none appear to have had sufficient experience with designing, building, cost estimating, and insuring dry floodproof buildings.

For coastal communities to build back in a resilient manner, small business owners, local builders, architects and engineers must be better informed of the available range of technically sound and affordable methods of building dry floodproof buildings. The Gulf Coast Community Design Studio (GCCDS) has leveraged its association with a variety of local groups to research and disseminate information regarding the advantages of dry floodproof construction. Mitigation through dry floodproof construction allows businesses and cities a wider range of flexibility to act as a steward for existing commercial streets, thereby promoting economic resiliency and sustainability.

1.1 Problem Statement and Objectives

The purpose of this project is to research and combine knowledge of technical and regulatory requirements with construction practices and material specifications to better understand dry floodproof construction as a viable method for flood mitigation on the Gulf Coast. In order to synthesize the research, a sample mixed-use building was designed for an existing site within the flood plain in Biloxi, Mississippi, using the knowledge gathered.

This research is intended to address FEMA Knowledge Gap RA5 "*Advanced Materials and Design of Sustainable Commercial Construction in the Coastal Environment*".

The following questions guided the research:

a) What new advancements in commercial construction methods or technology will make dry floodproofing more effective or more affordable than current practice or written sources suggest?
b) How can dry floodproof construction, in combination with good urban design, improve the physical and economic resiliency of Mississippi Gulf Coast communities and cities?
c) What information needs to be clarified and communicated to those in the business, construction, and government sectors to encourage the use dry floodproofing?

1.2 Scope of Research

Several methods of research were used to complete this project, including compiling source materials, physically testing materials and assemblies, and designing a sample building. Architectural design is a form of research; it requires systematic investigation of the assembly and configuration of a building through diverse and interrelated parameters. Advantages, disadvantages and idiosyncrasies of various materials and construction strategies are discovered, as the process, performance, program and maintenance of the building are all considered simultaneously. GCCDS staff worked with stakeholders and professionals with expertise in mitigation, engineering, construction, community development, financing and insurance to complete the research process.

1.2.1 Task One: Understand Hazards

Physical hazards that can damage buildings during a coastal flood event were researched using reports from previous storms, along with guidance from local engineers and consultants. Resulting forces were calculated from this research. The information gathered during this research was then presented to stakeholders through community presentations and web posting.

1.2.2 Task Two: Investigate Materials and Assemblies

Investigating materials and assemblies was a multi-stage process. Working closely with local builders and engineering firms, along with input from local mitigation specialists, distinct wall assemblies were investigated and developed. Six test wall assemblies were then constructed in an outdoor tank. A 24-hour flood simulation tested the wall assemblies against conditions similar to a coastal flood event. Visual observations, water depth measurements and electronic moisture measurements were recorded before, during, and after the flood simulation. Results from the flood simulation were used to inform a series of assembly revisions, which were then subjected to an additional flood simulation with similar observations and measurements taken.

1.2.3 Task Three: Plan Neighborhood Land Use

Sets of data from topographic maps, Digital Flood Insurance Rate Maps (DFIRMs), and land use maps were overlaid to produce a series of analytical maps. These maps revealed sites where opportunity for dry floodproof commercial construction on the Mississippi Gulf Coast is feasible, in the context of regulation and existing social and environmental conditions.

1.2.4 Task Four: Design a Mixed-Use Building

A sample mixed-use building was designed in collaboration with the Biloxi Housing Authority (BHA). The design was a vehicle for research regarding the financing, constructing and insuring a dry floodproof commercial property in the case study community of East Biloxi, Mississippi.

1.2.5 Task Five: Inform the Development Community

The development community was engaged through partnerships, informational events, community presentations, and web-based publishing. This engagement will continue as knowledge gained is integrated into the existing and future work of the GCCDS.