Recommendations

The recommendations of this report are intended to assist the Government of Puerto Rico in shaping its post-Hurricane Georges construction strategy and assist designers, contractors, and building owners in the construction of hazard-resistant buildings. These recommendations are based solely on the BPAT's observations, an evaluation of relevant codes and regulations, and meetings with the Government of Puerto Rico. The recommendations apply primarily to the building code used in Puerto Rico at the time Hurricane Georges occurred and the newly adopted 1997 UBC. They also apply specifically to residential buildings, specific nonresidential buildings observed during the course of the investigation, and mid- and high-rise building envelopes.

9.1 General Recommendations

A disaster in a community offers an opportunity to reflect on the things that are important in our lives. Out of this reflection, a community can decide to take a stand against future natural disasters and promote sustainable development and disaster-resistant communities by committing to rebuild their homes, schools, businesses, and infrastructure consistent with effective mitigation techniques and approaches.

As the people of Puerto Rico rebuild their lives, homes, and businesses there are a number of ways they can avoid the effects of future natural hazards. Some of these opportunities include:

- Buildings designed to the new building regulations that provide greater protection against hurricanes and earthquakes.
- New buildings permitted, built, and inspected to meet the new building regulations.
- An upgraded electric power system so that power is quickly restored and critical services such as water and sewage treatment can continue to be provided.
- A retrofit of existing buildings so their envelopes are not breached during a hurricane and do not collapse in an earthquake.
- Special building precautions in areas with known hazards (such as floods, landslides, and tsunamis) or avoiding these areas altogether.

More specific recommendations are included in the following subsections. Mitigating future losses, however, will not be accomplished by simply reading this report; mitigation is achieved when a community actively seeks and applies methods and approaches that will lessen the degree of damage sustained from natural hazards. Figure 9-1 illustrates a full range of successes and failures observed in a single community after Hurricane Georges.

FIGURE 9-1 This photograph illustrates successes and failures in residential buildings observed after Hurricane Georges. A residential concrete building with no structural damage is seen in the center of the picture. At top right is a wood-frame building that is completely destroyed around a center room that was constructed of masonry. Other buildings in the photograph have damage that ranges from the total loss of the wood-frame building to the success of the concrete building.

9.2 Training and Continuing Education

The success and failure of buildings observed during Hurricane Georges offers important learning opportunities for Puerto Rico. Of greatest importance is the assurance that all buildings are permitted and appropriately designed, inspected, and constructed. The Government of Puerto Rico has adopted as emergency regulation the 1997 UBC, which more completely addresses the natural hazard risks of Puerto Rico than Planning Regulation 7. Adopting the 1997 UBC is a significant change for government officials, design professionals, and contractors involved in the building industry and requires a significant training effort for these groups.

9.2.1 Government of Puerto Rico Personnel

To facilitate training of government personnel, ARPE completed a peer review by an independent third party, ICBO, the authors of the UBC. This peer review identified existing training courses and materials currently available that meet, or can be altered to meet, the immediate training needed by ARPE to implement the 1997 UBC. Training includes train-the-trainer courses so that ARPE can develop its own internal training resources.

9.2.2 Design Professionals and Building Contractors

The Government of Puerto Rico should continue to support positive mitigation education efforts undertaken by the Puerto Rico Civil Defense, Colegio de Ingenieros y Agrimensores,

Colegio de Arquitectos, and the University of Puerto Rico College of Engineering in Mayaguez. The recently published *Huracanes en Puerto Rico: Guía de Mitigación de Daños* provides useful information for design professionals and local homebuilders. This document should be reviewed and updated to ensure that it is compliant with the new building code and regulations. It should be reissued so that all parties involved in the building industry, from the design professional to the homeowner, will have accurate and useful information to mitigate against natural hazards.

Programs such as the conferences sponsored by the Colegio de Ingenieros y Agrimensores on building envelope protection systems should be continued. New programs educating design professionals and builders should be developed to share state-of-the-art mitigation techniques that are being used throughout the United States for all natural hazard events (flood, wind, and seismic).

ARPE the Colegio de Ingenieros y Agrimensores, the Colegio de Arquitectos, FEMA, and ICBO are working together to develop a training schedule for the sections of the 1997 UBC that address natural hazards.

9.3 Codes and Regulations

Important improvements and revisions to the building code and planning regulations of Puerto Rico have taken place since Hurricane Georges. However, additional mitigation should still be implemented to improve the built environment.

9.3.1 Planning Regulation 7

ARPE and the Government of Puerto Rico have had numerous meetings with FEMA to discuss the preliminary findings of the BPAT and to identify ways to improve the building regulations and the enforcement of these regulations. As part of these efforts, the Government of Puerto Rico has adopted the 1997 UBC with local amendments as emergency regulation. In addition, Puerto Rico is also proceeding with legislation that will remove the exceptions that allowed some buildings to be built without a permit.

ARPE anticipates that this new Certification and Building Board of Puerto Rico, under proposed legislation, will be in place by March 1999. One of the Board's responsibilities will be to consider and adopt updated building regulations, including the formal adoption of the 1997 UBC, with amendments, as the new building code for Puerto Rico.

Furthermore, the BPAT agrees with the Government of Puerto Rico's decision to adopt the 1997 UBC as an interim step toward adopting the International Building Code (IBC) when it becomes available. The following local amendments are also recommended for consideration to ensure that the 1997 UBC fully addresses factors affecting the built environment in Puerto Rico:

1. In Chapter 15, Roofing: Require uplift testing, including prescriptive criteria for corrugated metal roofing, prohibit aggregate surfaced roofs (unless they are double surfaced or the parapet is of a minimum height), and provide prescriptive criteria for metal edge flashings copings. Tile roofs should be prohibited because of the large volume of windborne debris they can create. If this is not acceptable, add provisions from the SBC, plus prescriptive criteria.
2. Appendix Chapter 34, Repairs after a natural disaster: This should be looked at to determine if Puerto Rico wishes to expand this to address nonstructural envelope damage that frequently occurs following hurricanes.

3. Adopt the *Uniform Code for the Abatement of Dangerous Structures.*
4. Appendix Chapter 15, Reroofing: Normal re-roofing during the life of a building offers attractive opportunities for hazard mitigation of hurricanes. This appendix chapter should be adopted.
5. Chapter 23, Wood: Require preservative treatment or naturally decay-resistant wood be used for termite resistance.
6. Chapter 24, Glass: Require wind-resistance testing per ASTM E 1233. Add provisions related to missile impact resistance (use load criteria from Southern Building Code Congress International (SBCCI) STD 12 and test per ASTM E 1886).[1]

9.3.2 Floodplain Management Provisions of Planning Regulation 13

ARPE and the Puerto Rico Planning Board should use information gathered by the CAV in May 1998 and from the damage of Hurricane Georges to continue to educate homeowners on the risks involved in building in floodprone areas. A renewed effort in enforcement of Planning Regulation 13, specifically in the permitting process and during the rebuilding process, may result in a significant reduction in property loss from future flood events.

Procedures should also be in place to address situations when homeowners enclose ground level areas of buildings that were once properly elevated and flood resistant but are now non-compliant. In addition, a renewed effort is necessary for enforcement of Planning Regulation 13. Specific improvements should be made in the permitting and inspection processes during non-disaster times, but this is also especially important during the post-hurricane rebuilding process. During rebuilding efforts homeowners understandably rush to repair the damage to their houses, but their repairs often are not in compliance with the NFIP and Planning Regulation 13. Proper new construction, retrofitting of existing structures, and rebuilding of damaged buildings will result in significant reduction in property loss and human suffering from future flood events.

Approximately 434,000 people live in identified floodplains in Puerto Rico. But there are approximately only 41,000 flood insurance policies currently in force, covering about 135,000 individuals[2]. Hurricane Georges has provided Puerto Rico with an important opportunity to increase public awareness of flood risks. Purchasing flood insurance is one of the simplest actions communities and businesses can take to mitigate flood risk. It should be noted, however, that despite previous flood events, few of the eligible individuals in Puerto Rico have taken advantage of the NFIP group policies that were purchased following previous Presidentially-declared disasters under the Individual and Family Grant Program. FEMA and the Government of Puerto Rico must explain more effectively the benefits afforded by current flood insurance group policies in affected communities.

[1] A new ASTM missile load standard is nearing completion. When it becomes available it is recommended in lieu of STD 12.

[2] According to the 1990 census, average people per home and average people per family are as follows: 3.31 people per home and 3.69 people per family. Source: Census Office of the Planning Board.

9.3.3 Evaluation, Submittals, and Product Approval

A number of the BPAT's recommendations relate to building construction but they are more appropriately addressed outside the building code. The BPAT recommends that the planning board evaluate the merit of the following recommendations:

1. Issue a guideline for determining wind loads related to loads on rooftop heating, ventilation, and air conditioning (HVAC) equipment (guidance for this is not provided in ASCE 7-95).
2. Consider product approval submittals for components and cladding. Exterior Insulated Finishing Systems should require testing per ASTM E 1233 and perhaps include prescriptive criteria.
3. Corrosion protection for clips, fasteners, metal panels, and flashing within 3,000 feet of salt water could be addressed through product approval. It could also be addressed through an amendment to the building code.

9.4 Essential Facilities

Puerto Rico's essential facilities should be evaluated for their vulnerability to natural hazard events. These facilities are critical to government response following a natural hazard event. The BPAT recommends that these buildings be evaluated under the provisions of the new building code in an effort to minimize the possibility of these facilities experiencing failures and loss of services during natural hazard events. Structures observed to perform at an unacceptable level should be retrofitted to improve building performance. This study should not be limited to such facilities as fire stations, police stations, and emergency operations centers, but should also include hospitals, emergency shelters (short- and long-term), and all buildings classified as essential facilities in ASCE 7-95.

9.5 Residential Buildings

The BPAT recommends the Government of Puerto Rico address vulnerabilities in residential construction through final adoption of the building code, as well as aggressive enforcement of these new regulations, to greatly improve the disaster resistance of residential buildings. Specifically, the design and construction of wood-frame buildings must be updated to greatly reduce the widespread damage that occurred to these structures during Hurricane Georges. Proper construction techniques and materials incorporated into the construction of these wood-frame buildings will greatly reduce their vulnerability to damage during natural hazard events. Construction of concrete and masonry structures should be regulated and inspected to ensure that they meet the new building code requirements, especially those regarding structural seismic issues. Finally, siting of residential buildings out of floodprone areas or requiring proper elevation through permitting enforcement will help to prevent damage and loss of property due to flooding.

9.6 Structural and Architectural Performance

The new building code will provide the building community with the tools to guide, evaluate, and regulate the construction and improvements of buildings in Puerto Rico. Based on the BPAT's recommendations, the Government of Puerto Rico has adopted through emergency regulation a number of changes to the building codes and regulations that will improve the disaster resistance of both structural and architectural building systems. Puerto Rico must continue its proactive approach to updating such codes and regulations to minimize the damage that may occur during

future flood, wind, or seismic events. Failure to update and improve the building environment, and the regulations that govern it, may result in repetitive damage and cost to Puerto Rico that otherwise could have been prevented.

Model building codes often quantify loads that act on structures based on the recurrence interval of a particular natural hazard event: flood, wind, or earthquake. For natural hazard events, design flood conditions are based upon 100-year recurrence interval events. Design wind events are based on 50- or 100-year recurrence interval events. Design seismic events are based typically on 50-, 200-, or 500-year recurrence interval events. Although recurrence intervals are a useful concept to define natural hazards, they are frequently misapplied to explain risk. Table 9-1 shows the risk (the probability of experiencing different events during specified yearly periods) and compares it to recurrence intervals. This, or similar tables, can be used by building owners to identify acceptable risks. Once the owner has determined an acceptable risk, the designer can choose the appropriate recurrence interval to use in design based on the life of the building. Based on an acceptable risk to the owner, the designer may choose a design event that is less frequent than required by the building code. For example, if the owner is building a 30-year building and wants a less than 6% chance of it failing in a hurricane, the designer would design for a 500-year recurrent interval.

TABLE 9-1 The probability of experiencing different events during specified yearly periods.

Life of Building or Length of Period (Years)	Frequency/Recurrence Interval (Year Event)				
	10	**25**	**50**	**100**	**500**
10	65%	34%	18%	10%	2%
20	88%	56%	33%	18%	5%
30	96%	71%	45%	26%	6%
50	99+ %	87%	64%	39%	10%
100	99.9+ %	98%	87%	63%	18%

This table can also be used to broadly identify risk during a period of time. For example, during the next 20 years, there is a 45% chance that there will be an event with a recurrence interval of equal to or greater than a 50-year event. Puerto Rico has a 45% chance of seeing a hurricane as severe or more severe than Hurricane Georges in the next 30 years.

9.7 Electric Power Distribution

The BPAT recommends that the Government of Puerto Rico perform a study on the electrical power distribution system. The present system was improved after hurricanes in the 1990's severely damaged the system. However, considerable damage was noted throughout the entire system after Hurricane Georges, indicating that improvements can still be made to reduce the system's vulnerability to natural hazard events.

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Presidential Disaster Declarations In Puerto Rico

Declaration Date	Cause	Declaration Number	Emergency Number
8/1 56	Hurricane	62	
5/26/64	Extreme Drought Conditions	170	
10/12/70	Heavy Rains and Flooding	296	
8/29 74	Extreme Drought Conditions		3002
11/30/74	Flooding	455	
9/19/75	Tropical Storm Eloise	483	
9/2/79	Hurricane David	597	
5/31/85	Storms, Mud/land slides, Flooding	736	
10 10/85	Severe storms, Mudslides, Flooding	746	
7/10.86	Heavy Rains, Flooding, Mudslides	768	
12/17/87	Severe Storms, Flooding	805	
9/21.89	Hurricane Hugo	842	
1/22 92	Severe Storms, Flooding	931	
9/16 95	Hurricane Marilyn	1068	
9/11 96	Hurricane Hortense	1136	
11 21/96	Gas Leak Explosion		3124
9/21 98	Hurricane Georges	1247	3130

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