CHAPTER 6

RETROFITTING OF HEALTH CARE FACILITIES FOR MULTIPLE HAZARDS

6.1 INTRODUCTION

In the Commonwealth Caribbean, there already exists much of the complement of health care facilities required to meet foreseeable needs. The use of most of these facilities is envisaged for some time to come.

It is likely that several of the existing facilities are vulnerable in varying degrees to damage form seismic forces or hurricane force winds. However, the opportunity exists to effect improvements to them. From experience, there have been cases where the implementation of relatively inexpensive measures has realised significant improvements in the security of structures. For greatest benefit, the retrofitting of existing facilities should be undertaken in a systematic way.

Many existing buildings do not fulfill the current technical requirements. This means that their vulnerability to natural hazards may be so high that their associated risk largely exceeds currently accepted levels. Rational actions based on scientific knowledge must therefore be taken in order to reduce risk and assure adequate performance. This retrofitting must be referred to existing engineering requirements and in the case of the Commonwealth Caribbean countries, CUBiC requirements should be adopted.

6.2 EVALUATION OF VULNERABILITY

6.2.1 General Considerations

Those responsible for health care facilities need to investigate the local vulnerability to hurricanes, earthquakes and flood actions in order to get precise estimations of the degrees of hazard. Once this is done, they will have the proper information in order to decide how much risk they are willing to accept.

In many cases, a non-engineer can at least make a preliminary assessment of the approximate degree of risk by use of the information presented here and by keeping in mind two basic questions as each nonstructural item is considered:

(1) would anyone get hurt by this item in a earthquake or hurricane?

(2) would interruptions and outages be a serious problem?

This will produce a preliminary list of items for a more detailed consideration. At this stage of planning, it is better to be conservative and overestimate vulnerabilities than to be too optimistic. An example is given in Table 6.1 to show how this information can be summarised in respect of earthquakes. A general sample form is also shown at Annexe 2 that can be used to highlight the critical factors for hurricanes and earthquakes.

There are basically two types of elements to be evaluated within this intrinsic aspect of disaster mitigation: the building with its contents, and the infrastructure.

6.2.2 <u>Buildings and Contents</u>

To identify the elements at risk, firstly identify the prevalent types of construction; secondly analyze the strength and stability of the building elements and joints; and thirdly evaluate vulnerability of equipment and installations.

<u>Structure</u>

Common building types in the Caribbean are reinforced concrete buildings, brick masonry buildings with light roofing, and wooden buildings with light roofing. Specialized engineering efforts are required in order to properly evaluate structural vulnerability.

<u>Non-structural Elements</u>

The non-structural elements include exterior non-loadbearing walls, infill walls, interior partition systems, windows, ceiling systems, elevators, mechanical equipment, electrical and lighting systems, and the contents of the building.

Illustration of Use of Blank Form of Figure 17

Facility: XYZ OFFICE   Assumed Intensity: Severe

PRIORITY	NONSTRUCTURAL ITEM	LOCATION	QUANTITY	VULNERABILITY			ESTIMATED RETROFIT COST, EACH ITEM	ESTIMATED RETROFIT COST, SUBTOTAL	NOTES
				✚	$	▦			
4	air conditioner	roof	1	mod	25-75%	mod	$100	$100	sits on springs; no seismic restraints;
5	suspended ceiling	throughout	5000 sq. ft.	mod	100 %	mod	$.20/sq. ft.	$1,000	no diagonal wires
1	water heater	utility room	1	high	100 %	high	$50	$50	gas fired; no flexible pipe; no anchorage
3	tall shelving	employee storage	40 lin. ft.	high	100	low*	$5/lin. ft.	$200	* low because contents not essential; unanchored; 8 ft. high
6	freestanding partitions	secretarial stations	20 @ 6 ft	low	0-5%	low	-0-	-0-	stable layout (returns)
2	fluorescent lights	offices and lobby	50	high	25-100 %	mod	$30	$1,500	fixtures just rest loosely on ceiling grid
							TOTAL	$2,850	

✚ LIFE SAFETY HAZARD $ % OF REPLACEMENT VALUE DAMAGED   ▦ POST-EARTHQUAKE OUTAGE

Non-structural damage has been more frequently than not the cause of heavy losses, particularly in earthquakes. Damage to non-structural components may be severe, even if the building structure remains essentially intact.

Cost implications may also be heavy, given that the building structure only represents 15% to 20% of the cost of the building. Therefore the more vulnerable the non-structural elements are to earthquake and hurricane actions, the higher will be the risk to the occupants and the larger will be the expected losses.

The disruption may be aggravated by the fact that earthquake and hurricane resistant design building codes do not usually have formal provisions governing the design of mechanical and electrical systems.

Experience has shown that secondary effects from non-structural damage may also exacerbate the situation. For example, ceiling planks or wall finishes that fall on corridors or stairs will hamper traffic, and fires, explosions and spilled chemicals will be hazardous to life. Also, damage to utility systems may make the modern hospitals virtually useless because it depends on these systems for its ability to function properly.

Much of the contents of a health care facility are essential to its function. Items from costly equipment to patient records cabinets are all needed immediately after an earthquake or hurricane. Normal building codes do not cover such items, therefore protective measures must be undertaken by building management and by occupants.

Observed incidents in past earthquakes may illustrate the types of problems to be considered:-

(i) overturning of slender and loose oxygen and flammable gas bottles, with uncontrolled leakage creating highly dangerous situation;

(ii) overturning of the back-up generator due to rusted and weakened anchorage to its foundation, causing interruption of the emergency power supply and creating a potential fire situation;

It must be emphasised that even if the non-structural damage prevents normal operation of the facility, the building may still be in a good enough condition to be used for providing essential emergency services. It is therefore important and necessary that in such situations, an immediate structural inspection be done by trained professionals.

Many of the problems that are outlined in this manual stem from lack of attention to expected actions from natural hazards. Even though designs of buildings which are in accord with modern codes, such as CUBiC, cannot guarantee lack of damage, they will ensure a basic level of safety that is difficult to obtain in any other way. Codes establish minimum requirements that can be increased according to the importance of the facility.

6.2.3 Infrastructure

The infrastructure includes the physical external resources on which the hospital depends, such as the communication, water supply, sewage, energy and information systems of the facility.

The impact of natural hazards on these resources is briefly discussed:-

(a) Telecommunications - telephone exchanges and overhead lines can be seriously damaged by natural hazards; underground lines are not susceptible to hurricanes, and are usually well insulated and flexible enough to resist damage by floods and earthquakes.

(b) Water Supplies - the main water supply system normally consists of pumping stations, water treatment plants and underground pipelines. It may suffer disruption due to pumping failures or, more often, due to piping breakages. This is a good reason for hospitals to have reserve tanks. Tanks should be incorporated in the daily supply system in order to ensure that the water is in good condition whenever an emergency occurs.

(c) Power Supply - a power supply system consists of generators, high tension lines and sub-stations etc. Installations on the ground are among the most vulnerable parts of the system. Transformers and porcelain equipment are weak points of the system, since their failures by damage may start fires. poles carrying overhead lines are particularly vulnerable to high winds. These are good reasons why health care facilities should have serviceable back-up generators which can be put into use at any moment. A good practice is to test them once a week. Precautions must also be taken to ensure that they are properly anchored to their foundations.

(d) Sewage System - if storm drainage is combined with domestic effluent, vulnerability may be high during floods. In an earthquake, the vulnerability of open-air channels will be lower than that of underground high-pressure systems. The vulnerability of underground systems can be decreased by the use of flexible joints. Detailed analysis of site conditions is necessary in earthquake prone areas.

(e) Gas and Oil Supplies - during earthquakes, the vulnerability of oil/gas pipelines depends on their strength and flexibility. High flexibility of the pipes may prevent breakdown in a moderate earthquake; differential settlement can be compensated for, and ground displacement will not necessarily lead to a breakdown. open attencion must be directed to connections to the buildings, and special design criteria are necessary in such cases.

6.3 IMPLEMENTATION STRATEGIES

6.3.1 Physical Considerations

How should upgrading be implemented? The answer depends upon the nature of the physical conditions in the facility and also the characteristics of the organization.

For example, in simple terms, the retrofitting program of the Veterans Administration (VA) hospitals has followed a self-help implementation with the collaboration of consultant experts[9]. Firstly, a vulnerability analysis was conducted to review the facilities and assess the site hazards, secondly specific actions were established, and finally cost estimates were prepared.

A vulnerability analysis would commence with a visual survey of the facilities and the preparation of a preliminary evaluation report. A typical form for use in this regard is presented at Annexe 2.

This overview would enable areas which require attention to be identified. The report would then be discussed by the consultants and the facility authorities with a view to setting priorities and timetables for carrying out further work.

Once the retrofitting programme has been designed, further surveys and analyses would be conducted of the individual areas identified for upgrading.

It will generally be possible to divide the resulting recommendations into two categories :-

(1) Those that can easily be implemented in the short term: These would include the provision of storm shutters to windows and braces to doors, the installation of additional fixings to roof sheets, the bolting down of the external plant, the relocation of important stores to more secure buildings if currently housed in vulnerable buildings. These works can usually be undertaken by the facility's own maintenance staff or by small contractors.

(2) Those requiring additional specialist advice, significant capital, extensive modifications or new construction for implementation in the medium to long term.

[9] Veterans Administration : "Study to Establish Seismic Protection Provisions for Furniture, Equipment and Supplies for VA Hospitals" - Office Of Construction, Washington D.C., Feb 1980.

In the VA example, decisions have ranged from building demolition and substitution to minor interventions. In many cases, implementation has been the responsibility of maintenance staff. Major advantages for involving maintenance personnel derive from their knowledge of the site and their availability for periodic monitoring of the measures adopted. Indeed, the upgrading of existing buildings and structures can be coordinated to good advantage with routine repairs and maintenance. For example, existing nail fixings to roof sheets can be conveniently replaced with screw fixings when the sheets are being replaced at the end of their lifespan. Also, in the routine replacement of roof sheets, a thicker gauge could be used.

6.3.2 Cost Considerations

The additional cost necessary to make a building resistant to hurricanes, earthquakes and floods can be considered to be a kind of insurance. Comparative studies have demonstrated that the increased cost associated with a fully "Code resistant building" compared to the cost of a building where the code has been ignored, may range between 1 to 4% of the cost of the building. If the cost of hospital equipment is included, the percentage would be much lower, since equipment costs can be as high as 50% of building costs.

If the problem is now analyzed in terms of the cost to protect a given piece of equipment, the differences will also be striking. For instance, the difference between disruption of electricity in a hospital due to severe damage to a US$50,000 emergency power generator and continuous service may lie in the installation of seismic snubbers or restraints for an additional US$250.

Cost estimates can only be considered as rough guides, since it is not possible to account for all of the specific differences in construction conditions found in buildings, or to allow for the variation in costs between different contractors. The cost of each of the items on the list of requirements must be added together to produce an estimated total retrofit cost for the entire facility. Normally, if nonstructural protection measures are taken into account early in design, the cost will be less.

ODIFIED MERCALLI INTENSITY SCALE

Not felt. Marginal and long period effects of large earthquakes.

I. Felt by persons at rest, on upper floors, or favorably placed.

II. Felt indoors. Hanging objects swing. Vibration like passing of light trucks. Duration estimated. May not be recognized as an earthquake.

IV. Hanging objects swing. Vibration like passing of heavy trucks or sensation of a jolt like a heavy ball striking the walls. Standing cars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frames creak.

V. Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.

VI. Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Knickkknacks, books, etc., off shelves. Pictures off walls. Furniture overturned. Weak plaster, Masonry D[1] cracked. Small bells ring (church and school). Trees, bushes shaken visibly or heard to rustle.

VII. Difficult to stand. Noticed by drivers. Hanging objects quiver. Furniture broken. Damage to Masonry D, including cracks. Weak chimneys broken at roof line. Fall of plaster, loose bricks, stones, tiles, cornices also unbraced parapets and architectural ornaments. Some cracks in Masonry C. Waves on ponds, water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged.

VIII. Steering of cars affected. Damage to Masonry C; partial collapse. Some damage to Masonry B; none to

Masonry A. Fall of stucco and some masonry walls. Twisting, fall of chimneys, factory stacks, monuments, towers, elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.

IX. General panic. Masonry D destroyed; Masonry C heavily damaged, sometimes with complete collapse; Masonry B seriously damaged. General damage to foundations. Frame structures, if not bolted down, shifted off foundations. Frames racked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in the ground. In alluviated areas, sand and mud ejected, earthquake fountains and sand craters.

X. Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.

XI. Rails bent greatly. Underground pipelines completely out of service.

XII. Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown in the air.

[1]Masonry definitions from C. F. Richter's 1958 book, *Elementary Seismology* (W. H. Freeman and Company, San Francisco, California), are as follows: Masonry A--good workmanship, mortar, and design; reinforced, especially laterally; bound together by using steel, concrete, etc.; designed to resist lateral forces. Masonry B--Good workmanship and mortar; reinforced but not designed in detail to resist lateral forces. Masonry C--Ordinary workmanship and mortar; no extreme weaknesses like failing to tie in at corners but not reinforced or designed against horizontal forces. Masonry D--Weak materials such as adobe, poor mortar, low standards of workmanship; weak horizontally.

ANNEXE 2

BUILDING ______________________________

GEOMETRY

Stories ______________ Height ______________ metres

Maximum Plan Dimensions - metres

	Length	Width	Area
Ground Floor			
First Floor			
Second Floor			
Total Area			
Approximate Age			

DESCRIPTION OF BUILDING

Indicate condition in box G - good F - fair P - poor

FRAME

Reinforced Concrete	Structural Steel	Timber	Loadbearing Walls	Other (specify)

FLOORS

	Reinforced concrete	RC slab on steel deck	Timber	Other (specify)
Ground				
First				
Second				

	Column size mm	Beam size dxb mm	Slab depth mm	Beam span m	Slab span m
Ground					
First					
Second					

ANNEXE 3

SUMMARY OF RECOMMENDATIONS

1. The CUBiC code for building construction should be made mandatory in all Commonwealth Caribbean Countries.
2. Health Service Administrators and Construction and Maintenance Personnel should have at least a basic knowledge of the engineering requirements for hazard resistant construction.
3. Vulnerability Analyses should be carried out on all health service buildings.
4. Performance specifications should be part of purchasing procedures for critical hospital equipment.
5. Hospital Disaster Preparedness Plans should be revised where necessary to include response procedures for earthquakes, and should also include vulnerability analysis as part of the requirements for retrofitting of the facility.
6. Disaster response exercises should be mandatory for hospitals and should be held at least once a year.
7. Countries without hazard evaluations in respect of earthquakes, hurricanes, and floods should seek to obtain this information as soon as possible for use in the vulnerabity analyses.
8. Hospitals should keep available in safe custody updated architectural and engineering drawings of their buildings.

REFERENCES

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7. Barbados Water Resources Study, 1977-78.

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9. Veterans Administration : " Study to Establish Seismic Protection Provisions for Furniture, Equipment and Supplies for VA Hospitals " - Office of Construction, Washington D.C., Feb 1980.

Recommmended Reading

1. Federal Emergency Management Agency - " Seismic Considerations: Health Care Facilities ". Earthquake Hazards Reduction Series 35 FEMA 150, Washington, D.C. 1987

2. PAHO Scientific Publication No.443, 1983 : " Health Services Organization in the Event of Disaster ".

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