DIPECHO

Pan American Health Organization

Emergency Preparedness & Disaster Relief Programme

VULNERABILITY REDUCTION PROJECT
DUNCAN WARD – GENERAL HOSPITAL
ST. GEORGE'S, GRENADA

FINAL REPORT

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CEP

CONSULTING ENGINEERS PARTNERSHIP LIMITED

P.O. BOX 283, Lagoon Road, St. George's, GRENADA. West Indies. Tel: (473) 440-2233; Fax: (473) 440-4144

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BACKGROUND

1.1 *Previous Studies*

In 1996, PAHO commissioned a Hospital Vulnerability Assessment Project for the General Hospital in St. George's, Grenada.

The study considered three main natural hazards namely; hurricanes, earthquakes and torrential rains. The study also touched briefly on storm surge and tsunami and concluded that the effect of storm surge could be ignored because of the height of the hospital facility above sea level. The effect of a tsunami was outside the scope of the study.

The study resulted in a report, to PAHO, which concluded that the hospital facilities were in a generally poor condition and that, in their then current states, the facilities were likely to suffer severe damage if impacted on by a hurricane or an earthquake.

The report noted that there was widespread evidence of inadequate maintenance, and that all the buildings were likely to suffer serous damage in a severe hurricane through loss of their roofs (or roof coverings) and water damage from ingress of rain through unsecured doors and windows.

All the buildings were also likely to be affected by a serious earthquake. Particular mention was made of the likelihood of medicines, drugs and light equipment falling off shelves and out of cupboards during the shaking cause by an earthquake.

In a nutshell, the report concluded that the hospital was unlikely to be able to provide, efficiently or adequately, the services for which it would be required during and immediately after a major hurricane or a strong earthquake.

1.2 *Short-term Recommendations*

The physical condition of the St. George's General Hospital was bad enough to warrant both long term remedial measures as well as corrective measures that should be taken in the short to immediate term.

The report therefore recommended certain actions, which, if taken in the short term, would substantially reduce the susceptibility of the existing facilities to hurricanes or earthquakes.

The following short-term measures were recommended:

- Hurricane straps should be fitted to all trusses and rafters

- Roof sheeting on all roofs should be replaced with 24 gauge, aluzinc sheeting. Fixings should be spaced at every other corrugation generally, and at every corrugation at eaves, ridges, hips and gable ends. Fixings should be fitted with washers matching the profile of, and wide enough to cover, the ridge of the profile.

- Plywood sheets should be cut to size and stored in an easily retrievable location to be used as window shutters. Each sheet should be marked to identify its proposed window location for installation in the event of a hurricane warning.

- Barrel bolts should be installed at the top and bottom free corners of the inside faces of all external doors.

- All large trees in the vicinity of buildings and utility poles and wires should be trimmed.

- The cross culvert at the entrance to the hospital compound should be cleared and the upstream end fitted with a removable welded mesh of ½" diameter reinforcing bars to inhibit future blockage of the culvert.

- Careful attention should be paid to the manner of re-fixing the existing solar heating panels to the roof structure of the kitchen, after the roof sheeting is replaced.

- The bridge between Duncan Ward and the main core of the hospital should be strengthened against horizontal wind and earthquake forces.

- The doctors' residence and its adjoining out-house should be demolished.

- The old lift shaft should be demolished. Investigations into the effect of this demolition on the main building structure are, however, an important prerequisite.

- All freestanding cupboards and shelves, particularly those containing medicines or other potentially hazardous material should be properly fixed to wall or floors.

1.3 *Project Objectives*

As a follow-up to the 1996 Vulnerability Survey of the St. George's General Hospital, DIPECHO and PAHO developed a project with the aim of demonstrating relatively simple methods of retrofitting hospital facilities to improve their resistance to the forces of natural hazards. The project was aimed specifically at reducing the non-structural vulnerability of the hospital and, as a direct result of this exercise, to:

a. Contribute to vulnerability reduction of St George's General Hospital.
b. Demonstrate the process of retrofitting for vulnerability reduction for natural hazards.
c. Widen the mitigation fraternity by the exposure, involvement and training of local engineers in the processes of retrofitting.
d. Document the project for use as a case study in other facilities in Grenada and in other countries
e. Promote vulnerability reduction through retrofitting of existing facilities

The consultants were commissioned to review available existing information and prepare the necessary documentation for a retrofit project at the Hospital.

This report, on the retrofit project, is written in non-technical language as it is intended for the use of hospital administrative staff in assisting them to understand the reason for certain retrofit activities and also to assist them in prioritizing these activities to obtain optimum value for the retrofit dollar.

DIPECHO'S stated objectives for the project and the objectives of this resulting report are:

- To sensitize the hospital administration to the non-structural vulnerability of hospitals and health centres to risks that can occur as a result of natural hazards such as hurricanes and earthquakes.

- To enable the hospital administration to make simple assessments of the non-structural vulnerability of the facilities they manage.

- To enable the hospital administration to identify mitigation measures, applicable to non-structural building elements that will improve the safety of the facilities for both patients and staff.
- To enable the hospital administration to prepare a logical and achievable mitigation programme for their facilities.

2. MITIGATION REQUIREMENTS

2.1 Hurricanes

Grenada lies in the North Atlantic Ocean, one of the six main tropical areas of the earth where hurricanes may develop every year. Within the 100 years between 1886 and 1986, 66 tropical storms passed within 150 miles of Grenada. Of these, 16 passed within 30 miles. Of the 16 that passed within 30 miles, 13 attained hurricane strength.

The destructive potential of a hurricane is significant due to high wind speeds, torrential rains that produce flooding and the occasional storm surge with height of several feet above normal sea level. Because of the elevation of the hospital site above sea level, storm surge is not expected to be an issue at the hospital.

Five categories of hurricanes are defined based on their potential for damage as follows:

Category	Wind Speed (Mph) (1-minute average)	Potential Damage
HC1	74 to 95	Minimal
HC2	96 to 110	Moderate
HC3	111 to 130	Extensive
HC4	131- 155	Extreme
HC5	>155	Catastrophic

The normal criterion for the design of a building to resist hurricane force winds is the 1-in-50-year wind, i.e. a wind which on average is not expected to be exceeded more than once in 50 years. For Grenada, this produces a 1-minute average wind speed of about 90mph. This represents a Category 1 Hurricane.

For buildings of a critical nature, such as a hospital, it is common practice in hurricane resistant design to apply an importance factor to the wind speed or to the wind load. The result of applying this importance factor can be seen, in effect, as increasing the design wind speed and therefore designing the building to withstand a higher category hurricane. For example, an importance factor of 1.5 applied to the wind load will correspond to an increase of wind speed of $\sqrt{1.5}$= 1.22. This, in the context of Grenada, is equivalent to a Category 2 to Category 3 hurricane with a 1-in-200-year wind.

In the case of the St. George's General Hospital, the 1996 study concluded that the elements most susceptible to damage due to hurricane force winds were the roofs, doors and windows of all the buildings. This mitigation demonstration project therefore sought to focus attention on these areas of the hospital.

2.2 *Earthquakes*

Seismic activities in the Eastern Caribbean, where Grenada is located, are principally associated with a subduction zone at the junction of the Caribbean Plate. The most recent earthquake to have caused significant damage in Grenada occurred on 10th January 1888 with a Richter magnitude of 7.5 and a Modified Mercalli Intensity of VII.

The Caribbean Uniform Building Code (CUBiC), which is the base document for the Grenada Building Code, recommends a Z-factor of 0.5 for Grenada. This is generally at the lower end of Z-factor for the Eastern Caribbean with the Leeward Islands and northern Windward Islands having a Z-factor of 0.75. A Z-factor of 0.5 is recommended for St. Vincent, Grenada and parts of Trinidad & Tobago.

The level of seismicity in Grenada is therefore considered to be relatively low. However, it is sufficiently important not to be ignored.

The St. George's General Hospital facility comprises mostly one and two storey buildings. The roofs and floors are generally lightweight. However, the walls are mainly heavy weight. It is expected that these buildings would attract significant horizontal forces if subjected to the "design earthquake", and structural damage would also be expected as a result. Mitigation against, and therefore retrofitting for, this type of structural damage was, however, outside the scope of this project. The shaking produced by the "design earthquake" is also likely to cause items on shelves to slip off and to cause cupboards and cabinets that are not fixed to the walls or floors to topple over. This could result in spills of hazardous materials and also cause minor chaos if cupboards and cabinets were to fall over.

As a result, the short-term measures for mitigation against earthquake damage was focussed on the latter above-mentioned areas.

3. DEVELOPING A SCOPE OF WORK FOR THE PROJECT

The initial intention was to carry out as many of the short-term recommendations, as the project budget would allow.

This was impractical as the Government is in the process of rebuilding the hospital. Several consultations were held with Ministry of Health and with the Hospital Design Team to determine the buildings that were to remain as part of the overall master plan and that could be retrofitted without having any adverse effect on the hospital rebuilding process.

After several time consuming negotiations, it was finally decided that retrofit work could be carried out on the Duncan Ward and the Ophthalmology Building.

It was also agreed that the earthquake damage mitigation would be confined to a single room (the Clinical Chemistry Room) of the Laboratory Building.

A visual survey of the Duncan Ward and Ophthalmology Building (Eye Clinic) was carried out to arrive at a preliminary scope work for the project as follows:

Duncan Ward

- Strengthen roof structure
- Replace roof sheeting with 24 gauge material
- Fit storm shutters to all windows
- Replace all external doors and door frames.

Ophthalmology Clinic

- Strengthen roof structure
- Replace roof sheeting with 24 gauge material

Clinical Chemistry Room

- Secure cupboards and cabinets to floors and walls
- Add lips to open shelving
- Install security straps to certain desktop equipment and the like.

4. ANALYSIS OF REQUIREMENTS FOR RETROFITTING

In addition to the visual survey referred to in the previous section, measurements were also made of the two existing buildings to enable calculations to be carried out to determine the level of structural strengthening required for the roofs of the building.

In the case of Duncan Ward, the visual survey suggested that the structural roof members were in reasonably good condition. Calculations also confirmed that the close spacing of the roof trusses and the steep angle of the main roof combined to produce a roof structure that would perform adequately under hurricane conditions.

The spacing of the sheeting-to-purlin fixings disclosed that the purlin spacing was too wide. Also, since they could not be seen, it was decided that the rafter-to-wall-plate connections should be strengthened. The rear part of the roof was constructed at a much shallower slope than the main roof. This side of the building is however sheltered by the Fort George hill for a critical wind direction and it was decided to maintain the shallow roof slope while reducing the rafter and purlin spacing.

With regard to the Ophthalmology Clinic, the visual survey indicated that the roof slope was less than optimal for wind resistance. This building has a dropped ceiling. However, the trusses could be seen through a trap door. The trusses are constructed of rough timbers (giving the full nominal width and height) and all connections were steel plated. As in the case of Duncan Ward, calculations showed that the roof structure would perform adequately under hurricane wind load.

It was therefore decided that only the roof sheeting needed to be replaced and purlin spacing would be reduced.

5. IMPLEMENTATION OF MITIGATION MEASURES

In accordance with DIPECHO/PAHO requirements, the construction contract was awarded through the standard competitive tendering process. A complete set of bidding documents was prepared. This included detailed drawings, technical specifications, bills of quantities, conditions of contract, form of agreement and tender and instructions to bidders. Four prequalified contractors were invited to bid and after assessment of the tenders submitted, the contract was awarded to the contractor whose tender was deemed most advantageous to DIPECHO/PAHO following the advice of the consultants.

Regular visits were made to the project site by the local consultant to ensure that the work was being carried out in accordance with the drawings and specifications. These site visits were also used to photo-document the retrofit process at all stages of construction. The photo-documentary is included as an appendix to this report.

Note was also taken of all changes to the contract drawings that were required as a result of differing site conditions and other unforeseen circumstances. The project drawings were up-dated to produce a set of as-built drawings showing the mitigation work that was actually undertaken on the project. These as-builts are also attached as an appendix to the report.

On completion of the project the supervising Consultant carried out a final inspection of the works.

The project has a three-month defects correction period. Any defects that appear within three months after project completion will be repaired by the contractor at his expense.

For reasons explained in the next section of this report, the hurricane retrofit work was confined to the Duncan Ward.

Features of the mitigation work include the following.

In Duncan Ward:

- All roof truss connections were fitted with metal hurricane straps or metal plates
- All roof trusses were structurally connected to the building walls.
- Roof overhangs were kept to a minimum
- The roof sheeting was fixed to the roof purlins with screws (and not nails).
- The frequency of sheeting fixings was increased at the eaves, hips and ridges of the roof as these locations are known to attract higher wind forces.
- All external doors and frames were replaced. Doorframes were fixed to the building walls with specially selected masonry screws. All external doors are made of solid timber and are fitted on the insides with barrel bolts.
- All windows that are not reachable from the ground (together with others, where practical) were fitted with permanently hung timber storm shutters. Where this was not practicable, plywood sheets were custom made to fit the windows. These sheets were all marked for use on specific windows, and are currently stored in the building to permit easy retrieval and installation.
- Liquid petroleum gas and oxygen gas bottles were strapped to the building walls.

In the Clinical Chemistry Room

- All shelves were fitted with Perspex lipping to prevent slip-off of medicines and the like during an earthquake.
- Counter tops were fitted with non-slip covering
- Equipment on countertops was fixed to the counters with removable clamps.
- Dispensing bottles are strapped to walls with easily removable rubber restraints.

6. VARIATIONS TO THE SCOPE OF WORKS

The onset of construction work on the project immediately disclosed two factors. Firstly, little or no maintenance work had been carried out on Duncan Ward over

the past several years. Secondly, deterioration of the structure was masked by the application of several coats of paint.
When the contractor commenced removal of the existing roof sheeting, it become clear that very substantial deterioration of the roof structure had taken place. Much of the timber roof structure had been reduced to shells of timber covered with paint and it was obvious that the entire roof structure needed replacement.

Removal of the roof structure disclosed dangerously exposed electrical wiring. The entire building therefore needed re-wiring and replacement of electrical panels, junction boxes, socket outlets and light switches.

The need to erect scaffolding on the first floor to rebuild the roof structure led to an inspection of the first floor timber structure. Much of the floor boarding (covered with vinyl tiles) was found to be in various stages of decay.

In effect, the commencement of construction work set off a chain reaction and what started out as a retrofit project ended up as a complete refurbishment project for the Duncan Ward.

The project as originally designed could not be completed within the budget constraints. The local consultant therefore recommended the deletion of all work on the Eye Clinic from the project and re-allocation of the funds to Duncan Ward. This recommendation was accepted and the scope of work was accordingly amended.

The revised project for Duncan Ward therefore included

- Replacement of the entire roof structure
- Replacement of all external doors
- Repairs to the first floor structure
- Replacement of selected first floor partitions
- Complete re-electrification of the building
- Repainting of the building
- Repairs/replacement of cupboard, counter tops and shelves
- Retiling of upper and lower floors
- Repairs to masonry work.

Earthquake mitigation requirements for the Clinical Chemistry Room of the Laboratory Building were maintained in the overall project.

A positive factor resulting from the requirements to replace the entire roof structure was that this afforded the opportunity for improving the shape characteristics of the roof thereby making it inherently more wind resistant.

All this extra work was completed within the budget plus a ten percent (10%) contingency that was made available by DIPECHO/PAHO.

7. DIFFICULTIES ASSOCIATED WITH RETROFITTING (and suggested solutions)

As it related to this project in particular and similar retrofit projects in general, one of the main problems that will be encountered is that of inadequate normal building maintenance during the life of a building.

Retrofitting is a fairly new concept in the Caribbean and the concept should not be confused with refurbishment and general maintenance. It should be noted, in previous sections of this report, that much of this project's budget had to be reallocated in order to carry out work that is better classified as maintenance, or repairs or refurbishment. If a building has not been adequately maintained the retrofitting process will be substantially more expensive and extensive, because of other work that will be required as a necessary part of executing the retrofit programme.

As a result of the above, it must be recognized that in the case of older buildings, where maintenance is known to be lacking, retrofitting should not be considered as project in itself. It should be considered as a sub-project of the overall refurbishment or repair project, and budgeted for as a separate group of work items to be carried out as part of the larger project.

For newer, well maintained, buildings retrofitting for disaster mitigation is generally a much simpler exercise and can be completed at a fraction of the cost of the repairs that would be required after a natural hazard event, if retrofitting is not implemented.

8. SUMMARY

The following points highlight the major aspects of this project and also give some food for thought when considering future retrofit projects.

- In general, the areas of the hospital building that are most susceptible to hurricane damage are roofs, doors and windows.

- Installing hurricane straps to all rafters and truss connections, increasing the frequency of roof sheeting fixings to purlins, securing external doors, and fitting storm shutters to all windows will greatly enhance a building's resistance to damage during a hurricane.

- Retrofitting the structural components of a building to satisfy earthquake code requirements is generally a project that demands an in-depth analysis of the existing structure. That was outside the scope of this project that called for mitigation against non-structural damage. However, in a hospital environment, open shelves should be lipped to prevent medicines from

slipping-off, and cupboards and cabinets should be fixed to floors or walls to prevent toppling.

- The original scope of work on the project had to be substantially curtailed in order to carry out critical work of a non-retrofit nature.

- Experience on this project indicates that retrofit programmes should not be carried out on older, poorly maintained buildings, except as a sub-programme of a larger overall repair programme.

- Separate budgets should be prepared for each retrofit programme, even when they are sub-programmes of larger repair programmes.

- Although not specifically addressed in this project consideration should also be given to mitigation measures for torrential rains and storm surge. Measures for torrential rains include provision of adequately sized and free flowing storm water drains. Measures for storm surge relate primarily to facilities in low-lying coastal areas. They generally require major governmental intervention and are outside the scope of this report.

Appendix A

Photographic Record

DUNCAN WARD BEFORE RETROFIT