5 INTERACTION WITH OTHER ENGINEERS

5.1 Saint Lucia

During the 1993 Vulnerability Assessment Eng Gibbs worked with Eng Lyndell Gordon of St Lucia. Eng Gordon accompanied Eng Gibbs on all of his field visits to Victoria Hospital and reviewed the draft Report. Eng Cromwell Goodridge was, at that time, employed as consulting engineer for the 1993/94 construction programme and discussions were held with him on retrofitting proposals. He also attended one of Eng Gibbs' site visits.

For the present exercise Eng Goodridge has again been kept in the picture to the extent that he found it convenient to be involved. Discussions were also held with Mr Conrad Emmanuel, a technician in Eng Goodridge's office.

5.2 Other Commonwealth Caribbean Countries

Eng Stephen Sandiford participated fully in the field investigations for the present assignment. The short-term recommendations were also developed in collaboration with him. The drafting of sketches for those recommendations were done in collaboration with technician Bernard Folkes and Eng Sandiford. Messrs Folkes and Sandiford are from Barbados.

Contemporaneous with the Victoria Hospital exercise is a vulnerability assessment of the General Hospital in Grenada. There Eng Gibbs is working closely with Eng Selwyn Woodroffe of Grenada. In advance of that assignment Eng Woodroffe was given several pertinent publications (including PAHO's "Mitigation") to study. He also had available the 1993 Victoria Hospital Report.

Some discussions were also held in Barbados with the Mr Mark Gittens, Senior Technical Officer of the Queen Elisabeth Hospital, principally on maintenance issues.

5.3 Non-Commonwealth Caribbean

As part of the present assignment Eng Gibbs was required to brief Dr José Grases of Venezuela on local aspects of hazards and construction practices

in Saint Vincent. Dr Grases was conducting a vulnerability survey of the General Hospital in Kingstown. The briefing was meant to take place in Barbados but there were logistical difficulties and a long telephone conversation, supplemented by faxed documents, had to suffice.

Information was provided on the hurricane hazard; the earthquake hazard; concrete-block, masonry construction and common practices in the fastening of timber roof members.

Dr Grases was also given the names of two professionals (an engineer/architect and an architect with hospital experience in seismic zones) who are living and working in St Vincent. These persons were available for supplementary consultations on local matters.

6 MAINTENANCE AS A TOOL FOR MITIGATION

6.1 General

The physical condition of the Victoria Hospital is poor. The main buildings are of 19th century brick walls with timber trusses and galvanised metal sheeting covering the roofs. Windows and doors show lack of maintenance and repair and priority in the maintenance efforts has apparently been given to the maintenance of equipment. It is considered that a major effort should be taken to bring the condition of the buildings to the standard where a normal maintenance crew can be expected to deal with the routine maintenance requirements of the facility. It is considered, also, that the existing staff and maintenance budget would be insufficient to provide for proper maintenance.

It is normal that for public buildings with the heavy usage of a hospital, the annual maintenance budget amount to about 4% of the contemporary capital cost of the building and equipment, assuming that the facilities are in good condition to start with. For the Victoria Hospital, it is estimated that the replacement cost of the 156-room facility would be about EC$56 million. The maintenance allocation should therefore be no less than EC$2.25 million per year. The Consultant was informed that the present budget is:

- Staff emoluments EC$ 161,000
- Operating and maintenance EC$ 375,000

- Professional and consulting services EC$ 55,000

In addition, an amount of EC$421,200 has been proposed by an outside agency for the maintenance of biomedical equipment, **X**-ray equipment, the intensive care unit (ICU) and the laboratories. The total of these amounts is EC$1,012,200 which, if made available, should go some way towards effecting improvement in the maintenance of the hospital. It would be necessary however for the hospital to be in a position to budget about EC$2.25 million annually for maintenance.

The maintenance of a hospital facility, rather than being a one-off activity as is the construction of the hospital or the installation of plant and equipment, is a continuous daily operation of the institution and is an important ingredient in the health care of the persons being treated at the facility.

A good maintenance system is also a good disaster mitigation system, as the review of damage caused by recent hurricanes and floods in St. Lucia and elsewhere has shown. To some extent the damage to buildings was due to lack of sustained maintenance of critical items. Also, a well operated system of maintenance for buildings and equipment has the effect of being a very effective disaster mitigation measure in terms of cost and facility usage. It ensures the most economic way to keep the building and equipment in the best of form for normal use, given the original design and materials. It is essential that a maintenance plan be included in disaster mitigation plans.

This report therefore stresses the need for continuous attention to all parts of the building and equipment from sweeping of the floors to care of the grounds. The maintenance and care of specialised hospital equipment such as **X**-ray machines and bio-medical equipment has not been dealt with, as this is a very specialized area, normally well beyond the expertise and training of the hospital maintenance staff. It is expected that the hospital administrator has made adequate plans for effecting such maintenance through annual maintenance contracts with specialist firms.

The report does not deal with the maintenance needs of off-site electricity, all telephone and off-site water supply as maintenance of these life lines are carried out by the utility organisations concerned. On the other hand, standby electricity plant and water systems (storage tanks and pumps) must be maintained by the hospital maintenance organisation.

6.2 Proposed Maintenance System

The purposes for maintaining a building and its associated plant are to ensure that the facility can:

- function at its designed level at all times;
- function for the normal life spans of the building and of the plant;
- resist the effects of extreme natural events such as hurricanes, floods, and earthquakes without damage to its occupants and with minimal repair or rehabilitation necessary after the passing of the event (provided that the original design and construction were satisfactory for this purpose).

All maintenance activities should be systematised and proactive and not merely reactive. It is important to recognise that maintenance is not necessarily repair. Too often repair is considered to be main purpose of the maintenance system rather than the prevention of the need for repair. The scheduled oiling of door hinges and window operators or the painting of exterior wooden members is necessary to prevent failure of the equipment or rotting of the wooden members.

It is recommended therefore that a comprehensive maintenance system be instituted by the hospital. This system should comprise:

- An organisational structure with clearly defined duties and responsibilities.
- An operation maintenance manual and procedures reference for the buildings and equipment.
- A management information system which will produce reports on budget, stocks, inventories of equipment, staffing requirements, etc.
- A preventative maintenance plan for equipment.
- A building maintenance plan - including roofs, walls, electricity, water lines.

- A continuous maintenance training plan for selected maintenance personnel.

6.3 Planning of Maintenance Activities

The planning of the maintenance activities will normally be carried out by the hospital engineer but this planning, which should include the development of a detailed annual maintenance budget, can only be effective if there is a detailed list of areas, spaces, materials and equipment to be maintained and a list of defects to be corrected. The maintenance staff must therefore be trained to examine all parts of the buildings and plant in their care and to record deficiencies. Such lists must be prepared on an annual basis, but this does not preclude the immediate attention to problems which are endemic in a hospital of this size.

It must be emphasised that a careful record of all maintenance activities is essential, and every effort must be taken to avoid returning to the situation where *ad hoc* repair is the norm. The check list given in this report is a guide for the detailed examination of all parts of the facility and should be reviewed by the hospital engineer and hospital administrator to ensure that maintenance is indeed being carried out efficiently.

Reporting of work done is also an essential part of the maintenance system. A simple reporting form is included in this report but the hospital engineer may wish to devise his own form which may be more responsive to the problems in the hospital. It is considered, however, that the simpler the form the better will be the chances of having the form properly filled out and submitted monthly.

6.4 Maintenance as a Part of Disaster Mitigation

If a good system for maintenance is not properly organized, funded, staffed and carried out, then all other disaster mitigation methods could prove insufficient. Experience indicates that roofs, walls, and equipment in general are more vulnerable to failure if normally operated at near breakdown or at any level of technical deficiency.

While a properly designed and maintained building would be resistant to natural hazards yet experience shows that some additional precautions

may have to be taken to secure the hospital and allow it to function during and immediately after such events. The principal areas to be examined for maintaining hurricane resistance (in particular) of the hospital and the corrective measures to be taken are:

6.4.1 Roofs

- All corroded roof sheets should be replaced.
- Examine the purlins and rafters and replace the rotten ones. Make sure that the drive screws are driven into solid material and cannot be pulled out easily.
- Make sure that the ridge cap is solidly fixed to the roof sheet and that the wind cannot peel the ridge cap off.
- Check the wall plate to be sure that it is not rotten. If so, replace it and secure the plate to the wall by bolts.

6.4.2 Doors and Windows

- Examine the doors and windows. They must close tightly.
- Ensure that the operators on louvred windows are all working
- Replace all broken glass in windows.

6.4.3 External Areas

Flooding often follows a hurricane. Check to see how high the water reached in previous heavy rain storms and ensure that drains are cleared to carry the rain water away from the building and that no storm water can get into the building.

6.5 Proposed Maintenance Organisation and Staffing

Basic assumptions:

- The Hospital Administrator is responsible to the Ministry for the efficient operation of the hospital (including the general staff matters, buildings, equipment and grounds) and for the expenditures

authorized in the annual estimates.

- The Hospital Engineer is responsible for the maintenance of all buildings and plant and for providing advice to the Hospital Administrator on capital requirements and on the condition of the buildings and plant.

- The technical staff reporting to the Hospital Engineer at present includes:

  - 3 carpenters
  - 1 plumber
  - 1 electrician
  - 1 painter

- The gardeners and cleaning staff report to the Hospital Administrator.

- Other requirements and technical personel for examination and repair of lifts, X-ray and other such equipment are not included in the work of the in-house hospital maintenance establishment.

- Major repair or renovation projects must be specifically authorized by the Hospital Engineer and the Hospital Administrator depending on the budget requirements, but normal maintenance and minor repair can be carried out by the maintenance staff without specific authorization.

The following comments are appropriate at this point:

- Annual inspections of the buildings and plant must be carried out. (The recommended time for such inspections is August so the annual estimates can be prepared.)

- Inspections of the windows, doors, roofs and drainage ditches must be carried out in April and repairs effected before the hurricane season.

- The budget estimates for effective maintenance must be based on detailed examination of the buildings and plant supplemented by reports from the users of the buildings and plant - doctors, nurses,

other staff and patients.

- The Hospital Engineer must make monthly reports to the Hospital Administrator detailing the work carried out, the cost of the work, the staff available and the problems to be dealt with during the financial year and those requiring further examination and/or funding.

It is considered that the existing staff complement should be augmented, as a minimum, by:

- the addition of a maintenance foreman reporting to the Hospital Engineer. This will relieve the Engineer of detailed supervision of the maintenance work and allow him to concentrate on examination of the defects and the planning of scheduled and preventative maintenance.

- one additional plumber and one plumber's mate. It has been found that lack of maintenance of toilet equipment - WCs and lavatory basins produce the most immediate problems. It is considered that an additional plumber for normal maintenance will ensure that complete breakdowns of the systems do not occur.

It is expected that major renovation work which may be necessary will be contracted out and not carried out by the maintenance staff.

6.6 Check Lists and Frequencies for Maintenance Operations

Three tables are presented covering:

- The building interior;
- The building exterior;
- The compound.

The following abbreviations are used in the tables:

Frequency		*Operator*	
I:	Immediately	**C**:	General cleaners
D:	Daily	**MS**:	Maintenance staff
W:	Weekly	**HE**:	Hospital Engineer
Q:	Quarterly	**HA**:	Hospital Administrator
A:	Annual	**G**:	Gardener

Notes:
1. For *frequency* the maximum period is given
2. For *operator* the person named is the one responsible for seeing that the operation is carried out.

6.6.1 Building Interior

Spaces	Frequency	Operator
Washrooms and Toilet		
Inspect and report deficiencies	**D**	**C/MS**
Wash floors, toilet bowls, urinals, wash basins with disinfectant and deodorant	**D**	**C**
Order replacements	**I**	**HE/HA**
Replace broken elements	**Q**	**MS**
Repair	**I**	**HE**
Paint	**A**	**MS**
Corridors and Wards		
Inspect and report deficiencies	**D**	**C**
Wash walls	**W**	**C**
Ceilings, Interior Roofs, Canopies		
Inspect and report deficiencies	**A**	**MS**
Repaint	every 4 years	**MS**
Laboratories and other Technical Areas		
Clean all counters, floors and walls	**D**	**MS**
Plumbing		
Inspect and report deficiencies	**D**	**MS**
Repair or replace defective pieces	**I**	**HE**
Internal Communication System		
Inspect all internal communications to ensure that the system is functioning properly and report defects.	**Q**	**HE**
Electricity		
Inspect electricity wiring on a room by room basis and report deficiencies	**Q**	**MS**
Furniture		
Repair or replace broken elements	**A**	**MS**

6.6.2 Building Exterior

Spaces/Materials	Frequency	Operator
Wood		
Inspect panels, louvres, railings and report deficiencies	**A**	**MS**
Replace all broken wood louvres	**D**	**HE**
Replace other damaged elements	**Q**	**HE**
Clean and paint marked surfaces	**A**	**MS**
Windows		
Inspect and report deficiencies	**D**	**MS**
Remove broken glass louvres or panes (see above also)	**I**	**MS**
Order replacements for broken glass and other elements	**I**	**HE**
Replace broken elements	**Q**	**MS**
Grease and oil louvre operators or handles	**A**	**MS**
Replace broken wire-mesh grills	**Q**	**HE/MS**
Wash windows	**Q**	**C/MS**
Doors and Frames and Partitions		
Inspect and report deficiencies	**Q**	**MS**
Oil hinges etc.	**A**	**MS**
Replace defective and broken hardware	**I**	**HE**
Repair or replace defective doors and/or frames	**I**	**HE**
Stairs and Balconies		
Sweep stairs and balconies	**D**	**C**
Wash stairs, walls and rails	**Q**	**C**
Clean metal work of rust and coat with primer and paint	**A**	**MS**
Sand and paint wood railings or posts	every 2 years	**MS**
Roofs and Gutters		
Inspect and report deficiencies	**A**	**MS**
Repair and replace roof sheets and gutters as required	**W**	**HE**
Metal Panels		
Inspect	**A**	**MS**
Wash and remove graffiti	**A**	**MS**
Clean rust and repaint	every 2 year	**MS**

6.6.3 Compound

Spaces/Materials	Frequency	Operator
Gardening		
Clean flower beds	**W**	**G**
Watering and fertilise plants	**D**	**G**
Remake plant beds	**Q**	**G**
Prune plants, trim hedges	**M**	**G**
Grass playing fields	As required	**G**
Cut grass	**W**	**G**
Fence		
Inspect and report deficiencies	**Q**	**MS**
Repair	**Q**	**MS**
Paint	every 2 years	**MS**
Walkways and Courtyards		
Sweep	**D**	**C**
Clear litter and rubbish	**D**	**C**
Drainage Ditches		
Clean routinely	**W**	**C**
Clear blockages caused by excessive rain	**I**	**MS**
Repair damaged drains	**A** (in August)	**MS**
Water Mains		
Inspect and report deficiencies	**Q**	**MS**
Maintain earth cover	**Q**	**MS**
Repair breaches/leaks	**I**	**HE**
Septic Tank		
Inspect and report deficiencies	**A** (In August)	**MS**
Clean and flush out	Every 4 years	**MS**
Repair	**I**	**HE**
Erosion near Structures		
Inspect and report deficiencies after heavy rainfall	**Q** and as required	**MS**
Return soil, grass area, re-direct water source	**Q** and as required	**MS**
Repair eroded area	**I**	**HE**
Rubbish bins		
Empty drums and burn (or carry away) rubbish	**D**	**C**
Inspect and replace bins if necessary	**A**	**MS**

6.7 Proposed Monthly Report Form

To: Hospital Administrator

Report of the Maintenance Division

For the month of: _____

Submitted by: _____

Date: _____

Trade	Area or Ward	Work done	Material cost	Labour cost	Remarks
Carpentry Doors Windows Roof Floors					
Masonry					
Electricity					
Plumbing					
Painting					
Other trades					

7 CONCLUSIONS

7.1 Broadening the Support Group

Disaster mitigation is a team effort. This effort should involve, not only technical personnel, but also administrative officers and directors or decision makers. It is not easy, indeed it is not really possible, for safe buildings to be designed and constructed simply through the efforts of committed engineers. The task cannot be left for the engineers alone. They need support. That support needs to come from architects, quantity surveyors, hospital administrators, project managers, permanent secretaries and government ministers.

A case in point is the renovation of the east leg of the L-Block of Victoria Hospital in 1993/94. This took place immediately after the PAHO Vulnerability Assessment. That study identified the need for a ring (or belt) beam to be constructed on top of the existing walls to provide additional resistance to wind and earthquake forces. The consulting engineer for the construction project endorsed the recommendation and attempted to implement the proposal. This was vetoed by the architect. The engineer had insufficient support from the others involved with the project. The result was that the ring beam was not included in the works.

Safety is everybody's business. That is why it is desirable for all parties to understand that the hazards are real and that success in counteracting them is possible.

7.2 Turning Disasters into Opportunities

Whenever there is the need for a renovation, reconstruction or extension of an existing building there is the opportunity for the reduction of vulnerability to natural hazards. Sometimes, regrettably, that need is brought about by a disaster. Such a disaster occurred at Victoria Hospital in November 1995 when a fire destroyed much of the north leg of the L-Block.

In the reconstruction improvements are being made to the wind and earthquake resistance of the building. However more could have been done. For example, the 19th century walls could have been substantially strengthened without destroying their essential historic appearance. Some

nominal strengthening is being provided by a reinforced mortar layer on the inside of the walls. What is really needed is a reinforced concrete wall of more than nominal strength (of the order of 100 millimetres in thickness) to work compositely with the existing walls by being cast against these walls and by being connected by ties and dowels to these walls.

The argument often used against such additional strengthening measures is that the old walls have stood "for a hundred years" so they must be good enough. However, the events we must design for may not have occurred within the last hundred years. The Great Hanshin earthquake of January 1995 was the first serious seismic event to have occurred in that region of Japan for 499 years! Also, 19th century lime mortar (used in the construction of the old Victoria Hospital walls) deteriorates with age and weathering. So that the walls are now less able to resist severe forces than they were in the past.

7.3 A Candid Approach to Budgeting

In discussion with those in charge of maintenance at the general hospitals in St Lucia, Grenada and Barbados over the past month the matter of the preparation of budgets was raised on several occasions. It appears as though the sums requested by hospitals from the ministries of finance are consciously or subconsciously moderated by perceptions as to the levels of funding available. This inevitably means that the hospitals ask for less funds than they know are required. The corollary is that the ministries of finance never know what the real requirements of the hospitals are for the adequate maintenance of their premises.

It would be much better if candid and complete costs are prepared. The next step would be to list in order of priority the needs, since some things are always more important than others. The finance ministries would then be aware of the "truths" and the hospitals may, possibly, get allocations closer to their requirements.

7.4 Building on Small Successes

Very often, vulnerability surveys and follow-up reports (such as this one) are consigned to the document shelves never to be used. This is a pity since the recommendations contained in many of these reports are often feasible, practicable, inexpensive and painless.

The case of the Victoria Hospital is encouraging. It is clear that the 1993 PAHO study was not ignored. Indeed, at the PAHO conference in Mexico in February 1996, Mr Augustine Compton presented a paper on "The Disaster Mitigation Situation in Health Facilities" in which the 1993 Report was extensively quoted. More importantly, there is much evidence that several of the recommendations in that Report have been implemented in part or in whole.

Momentum has developed. The task now is to build on that momentum and maintain the thrust.

7.5 Guidance for Clients and their Administrative Officers

7.5.1 The Role of the Client

It is the role of the client to demand that facilities be designed, built and maintained to function during and immediately after hurricanes, earthquakes, torrential rains and other natural hazards of the levels of the agreed design events. The technical professionals are responsible for advising the client of the hazards to which the facility will be exposed and for explaining the implications of choosing the various levels of design criteria for the expected hazards.

The client is ultimately responsible for the facility and must therefore understand the implications of failure.

The client oversees the procurement of goods and services and thereby has the potential to influence the quality of the product. These issues usually deserve discussion between the administrators of the facility (hospital administration) and its directors (permanent secretaries and ministers).

7.5.2 Maintenance, Repairs, Replacements

The maintenance budget for a property in good condition should be of the order of 4% of the contemporary value of the building/facility per annum. In preparing budgets consideration should be given to metal-work and timber-work; the regular testing of equipment for occasional (stand-by) use; repairs incorporating moderate improvements; replacements incorporating significant improvements and even regular staff training in the use and operation of equipment.

7.5.3 Archives

The client should ensure that as-built drawings are produced for all new construction and that all repairs and replacements are documented. There should be duplicates of as-built drawings so that a clean set could be kept in the archives and from which working sets can be reproduced. Reliable documentation is useful for vulnerability assessments, repairs, additions, alterations and post-damage assessments of facilities.

7.5.4 Annual Reviews

After the initial vulnerability survey has been undertaken and its recommendations implemented it is appropriate to plan and commission annual reviews. These annual reviews are to check the implementation of recommendations; identify overlooked items; benefit from new knowledge; identify deterioration and review maintenance procedures. For all of this to happen it is essential that the preparation of the annual budget consciously allows for this review process.

7.5.5 The PAHO Manual - "Mitigation"

This publication, first issued in 1993, provides useful background on the natural hazards of the Caribbean. It provides a lay person's guide to design and surveys and addresses the important issue of designing against the multiple hazards of this region. The Manual includes, in summary form, recommendations for achieving less-vulnerable, health-care facilities.

7.5.6 Checklist for New Facilities

Soon after a decision has been taken to construct a new facility there comes the time to select consultants. In doing so it is important to consider the qualification and experience of firms and/or principal players; their specific knowledge of designing against natural hazards; the capacity and work-load of the prospective consultants; their local knowledge and presence and, lastly, the cost of services.

In briefing the consultants there should be specific discussion on natural hazards and agreement of performance expectations for the facility.

The monitoring of the consulting team is also important. This is facilitated by requiring from the consultants an inception report and,

subsequently, a preliminary design report with cost estimates. The client review of the preliminary design report should lead to a formal agreement of natural-hazard, damage-mitigation measures.

The final and important act of a capital-works project should be the delivery by the consultants of all maintenance and operating manuals and "as-built" drawings.

7.5.7 Resource Centres

There is much assistance available to clients who desire facilities which would perform well during, and immediately after, natural hazard events. Some agencies equipped to provide such assistance are listed below:

- Pan American Health Organisation (PAHO) - Emergency Preparedness & Disaster Relief Coordination Programme
- The Organisation of American States (OAS)
- Caribbean Disaster Emergency Response Agency (CDERA)
- University of the West Indies (UWI)
- The University of Technology (UTEC) and the University of Guyana (UG)
- Council of Caribbean Engineering Organisations (CCEO) and its constituent member bodies
- Association of Commonwealth Societies of Architects in the Caribbean (ACSAC) and its constituent member bodies
- Consulting firms specialising in natural hazards
- Individual specialists in the relevant fields
- Building Research Establishment (BRE) and other international organisations
- Statutory bodies and government agencies

7.5.8 Other Important Issues

Clients should demonstrate an interest in regional code development and enforcement; research into natural hazards and educational programmes for construction industry practitioners.

Natural hazard impact assessments should be encouraged as prerequisites to important capital works projects in the same way that environmental impact assessments have become almost routine.

Liaison with donor and lending agencies so as to have mutual agreement on the safety goals for projects is desirable.

Lastly, serious consideration should be given to adopting the French approach to monitoring design and construction standards through the use of independent auditors or *bureaux de contrôle*.