# STRUCTURAL ASSESSMENT
# HOSPITAL ROOFS

# NATIONAL CHEST HOSPITAL
# AND
# SIR JOHN GOLDING REHAB CENTRE

**ST. ANDREW**

**JAMAICA**

## ENGINEERING REPORT

**OCTOBER 2018**


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Ref: 1819/12

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# EXECUTIVE SUMMARY

This report presents the findings of a visual structural inspection and structural analysis carried out on roofs of three buildings at two hospitals to determine the ability of the roofs to support photo voltaic panels and resist the consequential additional hurricane and earthquake forces.

The report concludes that the roof of the Casualty/Physiotherapy Building at National Chest Hospital is capable of supporting the solar panels by connecting directly to the joints of the existing timber roof trusses. These trusses span the width of the building. The central vertical truss member (the king post) and the top chords of the truss are to be stiffened and strengthened by attaching wooden strips on two faces so as to widen their narrower dimension. Some truss joints are recommended for bolting and some others that could not to be visually inspected due to inaccessibility are recommended for detailed examination prior to or during construction and strengthening if necessary.

The roofs of the Henriques Ward Block and the Conference Centre Building at Sir John Golding Rehab Centre are not recommended for supporting solar panels. However solar panels for these buildings could be supported above and clear of the roof by independent structural frames.

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# 1. INTRODUCTION

By Purchase Order #005249 dated July 6, 2018, Petroleum Corporation of Jamaica (**PCJ**) engaged H. L. Jones & Associates, civil & structural consulting engineers, to carry out a structural integrity assessment for the roofs of three (3) buildings, viz, one at the **National Chest Hospital** (**NCH**) and the other two at the **Sir John Golding Rehab Centre** (**SJGC**).

The Structural Integrity Assessment (SIA) is prescribed to be carried out in accordance with Terms of Reference provided by PCJ as annexed to Requests for Quotations dated June 12, 2018.

The SIA is required to :

i) Determine if there are existing inadequacies in the roofs

ii) Verify the structural integrity and soundness of the roof structures and their components to support the installations of roof mounted solar panels and metal mounting frames for grid-tied solar photovoltaic (PV) systems

iii) Provide recommendations for improvements to the roofs where necessary

Primary inspections were carried out on July 17 and 24, 2018 with additional secondary inspections during August 2018.

The report of the findings is as below.

# 2. BACKGROUND INFORMATIOM

## 2.1 Description of Site & Buildings

### *National Chest Hospital*

The National Chest Hospital which was constructed in 1938 is located at 35 1/2 Barbican Road, Kingston 6. There are a number of buildings on the complex. The subject building is **The Casualty/Physiotherapy Building**.

**The Casualty/Physiotherapy Building** is a two storey building, rectangular in plan measuring 99.7 metres by 14.2 metres (327 ft. x 46.5 ft.)

The building has a basement at its western end with height of the basement from floor level to ceiling of approximately 2.1m (7 ft.). The height of the building from ground floor to eave is approximately 9.0m (30 ft.) and another 3.6m (12 ft.) from eave to the apex of the roof.

It is constructed of block walls, reinforced concrete column and beam framing, reinforced concrete floor slab and timber roof truss with metal sheeting cover.

It has a basic hipped end roof with blank dormer windows on both long faces of the roof.

**Drawings 1819/01 to 03** attached illustrate the arrangement of the building.

A building of similar size, shape and structure is aligned with this building and located to the south of this building, a clear distance 50m (150 ft.) away. There are other smaller buildings on the property.

***Sir John Golding Rehab Centre***

The John Golding Rehab Centre is a hospital facility located at 7 Golding Ave., Mona, Kingston 7. There are a number of buildings on the complex. The subject buildings are the **Henriques Ward Block** and the **Conference Centre Building**.

The **Henriques Ward Block** is an 'L' shaped building, part one storey and part two storey, with extreme dimensions of 63.1m by 41.8m (207 x 137 ft.). Construction is of reinforced concrete beam and column framing, reinforced concrete floor slab, block walls and sheeted metal roof with timber framing.

Ground to eave is approx. 6.0m (20 ft.) and eave to roof apex another 3.9m (13 ft.).

**Drawings 1819/21 to 24** attached illustrate the arrangement of the building.

The **Conference Centre Building** is a rectangular single storey building assembled from three (3) shipping containers and measuring 7.3m x 12.2m (24 x 40 ft.) in plan. There is a shallow timber framed gable roof constructed on the assembly with sheeted metal cover.

**Drawing 1819/25A** attached illustrates the arrangement of the building.

## 2.2 Structural Assessment Methodology

Visual inspections were carried out.

The roof of the **Casualty/Physiotherapy Building** at NCH was inspected by climbing into the roof cavity and inspecting using a flashlight. It was unsafe to attempt moving around the roof cavity so the inspection was carried out from the one access point.

The roof cavity of the Henriques Ward Block at SJGC was inspected by standing on a ladder and observing through ceiling access hatches at two (2) locations, also viewed using a flashlight.

The interior of the roof of the Conference Centre Building at SJGC was not accessible for viewing but we contacted the carpenter who built it and he described the construction arrangement.

Roof inspections consisted of looking at wooden rafters, purlins, laths, sarking, truss members, member connections and anchor points to building to observe member sizes, condition, deflection, warping, splitting, misalignments, moisture ingress or presence of termites.

Structural analysis for load carrying capacity of wooden trusses and wooden roof members was carried out assuming No. 2 grade southern pine lumber,

### 2.3 Orientation of Buildings

Orientation of buildings in relation to North are shown on the drawings.

***National Chest Hospital***

The **Casualty/Physiotherapy Building** has its long axis orientated approx. N 79º 30' E.

***Sir John Golding Rehab Centre***

The **Henriques Ward Block** has the long axis of the female ward area orientated approx. N 10º E.

The **Conference Centre Building** has its long axis orientated approx. N 10º E.

# 3. SUPPORTING INFORMATION

NOTE:

The following Items **3.1** to **3.8** are responses to Items 2.1 to 2.8 of the Terms of Reference.

### 3.1 Building Survey/Visual Inspection

The building structure, (i.e. framing, walls and floors), of all three buildings were visually inspected for structural defects. Little or no wall cracks were observed. No settlement, distortion or other unusual deflection or was observed. No significant structural defect was found.

The roof slopes of the buildings are as illustrated on the drawings.

Orientations of the subject buildings are as stated at **Item 2.3**

## 3.2 Evaluation of Current Condition of Roofs

***National Chest Hospital***

The roof of the Casualty/Physiotherapy Building is constructed of twenty five (25) timber trusses at 4.1m (13.5 ft.) centres that span the 14.2m width of the building.

The trusses support timber sarking (assumed to be 20mm dressed thickness) on which the metal sheet roof is fixed. Trusses also carry the weight of ceiling and ceiling bed.

Refer to **Drawing 1819/02** which illustrates the truss details.

Timber members of the truss appear to be in good condition.

Observe the joint numbers of the truss on the drawing. Members meeting at Joints 1, 2 and 3 are bolted. Bolts seem to be in good condition.

**Members meeting at Joints 4 do not seem to be bolted together and the method of fixing is concealed.** It is important that members meeting at Joint 4 be bolted together since the web members from Joint 3 to Joints 4 will be taking tension due to uplift wind forces on the roof.

It was not possible to closely inspect Joints 1 due to the geometric arrangement of the roof. **Joints 1 will need to be closely inspected and checked before or during construction to ascertain the strength and suitability of both the joint connection and the truss anchorage to the building against uplift**.

***Sir John Golding Rehab Centre***

- *Henriques Ward Block*

The roof of the Henriques Ward Block is very complex. The original roof throughout the building has been replaced by a roof assembly that has been installed over the original roof. The new roof assembly is composed of timber rafters bearing on walls and in some cases bearing on inadequate horizontal timber members installed to function as crossbeams. Further, these "crossbeams" are supported by rafter sized members used as posts to transfer load to walls.

The assembly is haphazard in its makeup and the roof structure is very suspect in being able to resist wind loads to which it would be subject in a strong hurricane.

- *Conference Centre Building*

Interior details of the roof of the Conference Centre Building could not be seen but inspection of the external elements and information obtained from telephone discussions with the carpenter who built it confirmed that the roof was properly and adequately constructed.

## 3.3 Determination of the Service Life of the Roofs

***National Chest Hospital***

The service life of the roof members of the **Casualty/Physiotherapy Building** is estimated to be an additional forty (40) years.

***Sir John Golding Rehab Centre***

- *Henriques Ward Block*

The service life of the roof of the Henriques Ward Block was not assessed because the roof is not recommended for the mounting of solar panels.

- *Conference Centre Building*

The service life of the roof of the Conference Centre Building is estimated to be an additional forty (40) years.

## 3.4 Determination of Seismic Load

Using the *Jamaica Spectral Seismic Hazard Maps* as produced by the University of the West Indies, Mona, Earthquake Unit, in conjunction with *ASCE 7-05 Minimum Design Loads for Buildings and Other Structures, Chapter 13 - Seismic Design Requirements for Nonstructural Components*, the seismic design force for nonstructural components fixed to buildings is computed.

The National Chest Hospital's Casualty/Physiotherapy building is used as the computation model.

- *Horizontal Seismic Force on Chest Hospital*

For earthquake in Kingston, the horizontal seismic design force computes to 0.66 times the weight of the component fixed to the roof of the building.

Typical PV panel sizes are 1650mm x 991mm with mass 19 kg. This computes to a unit mass of 11.6 kg/sq m. (2.38 pounds per sq. ft.). Solar panels with mounting hardware weigh up to 20 kg/sq.m (4 pounds per sq. ft.).

Thus, PV panels with mounting hardware, mounted to the Casualty/Physiotherapy roof at the National Chest Hospital would therefore exert a horizontal seismic force of up to 0.66 x 20 kg/sq.m or 13.2 kg/sq.m (0.13 kN/sq. m) (2.70 pounds per sq. ft.) on the building roof.

*Vertical Seismic Force on Chest Hospital Roof (Casualty/Physiotherapy)*

The vertical seismic design force computes to 0.132 times the weight of the component. i.e. a vertical force of 0.132 x 20 kg/sq.m or 2.64 kg/sq.m (0.026 kN/sq. m) ( 0.54 pounds per sq. ft.)

This is a rather small vertical seismic force on the building which can be ignored.

## 3.5 Determination of Thickness of Concrete Slab or Roof Framing

There is no concrete slab roof under consideration for the subject buildings.

The sizes of wooden members framing the roofs vary and are illustrated on the drawings.

## 3.6 Determination of Roof Appropriateness for PV Panels Installation

***National Chest Hospital***

**The framing for the solar panels to be mounted on the roof of the Casualty/Physiotherapy Building are to be connected to the truss top chord at the joint locations**. **The solar panel framings are not to be connected to the purlins.**

The holes to be punched through the roof sheeting to accommodate these connections will need to be adequately sealed.

***Sir John Golding Rehab Centre***

- *Henriques Ward Block*

This roof is not considered suitable for supporting solar panels.

- *Conference Centre Building*

**The framing for solar panels of the Conference Centre Building is to be mounted on the walls of the container building or on columns anchored to concrete pads at ground that are sufficiently heavy to resist wind uplift.**

**Drawing 1819/25A illustrates a possible method of installing the framing.**

## 3.7 Assessment of Structural Loading Capacity (Dead & Live) for roofs

***National Chest Hospital- Casualty /Physiotherapy Building***

- *Roof Purlins*

The roof purlins of the Casualty/Physiotherapy Building are rectangular wooden members of size 76 x 203mm (3" x 8") spaced at 914mm (3'-0") centres that span 4.12m (13'- 6") between trusses. The purlins carry the dead load of sarking and roof sheeting but do not carry the weight of the ceiling.

Estimated dead load to purlin is 6 pounds per square foot of roof area supported.

Code prescribed design roof live load to purlin is 18 pounds per square foot of roof area supported.

Structural analysis carried out indicated that the purlins are capable of carrying loads in excess of the dead and live loads requirement.

- *Roof Trusses*

The roof trusses of the Casualty/Physiotherapy Building provide support for the purlins. There are specific Code prescriptions for the dead and live load forces that the trusses must resist.

Structural analysis carried out indicated that the trusses are capable of carrying loads in excess of the dead and live load requirement.

***Sir John Golding Rehab Centre – Conference Centre Building***

The roof of the Conference Centre Building is required by Code to support 20 psf.

Structural analysis carried out indicated that the roof structure is capable of carrying loads in excess of its dead and the live loads prescribed.

## 3.8 Wind Loads

- *Roof Truss*

For analysis of the roof trusses of the National Chest Hospital Casualty/Physiotherapy Building, the recommended design wind pressures under Category 4 hurricane winds is an upward pressure of **45 pounds per sq. ft. on the roof.**

- *PV Panels*

The wind load calculations are carried out using the prescriptions of ASCE 7-05 Chapter 6.

For Category 4 winds, solar panels mounted on the roofs of the buildings would experience the following wind pressures.

| **PV Panel Location** | **Upward Pressure** | **Downward Pressure** |
|---|---|---|
| PV panels in corner zone | 111 psf | 26.5 psf |
| Panels in edge zone | 74 psf | 26.5 psf |
| Panels in interior zone | 45 psf | 26.5 psf |

(NOTE:. psf = pounds per square foot)

The widths of the edge and corner zones are as follows:

NCH – Casualty Physiotherapy Building – 1.5 metre (5 ft.)

SJGC - Conference Centre Building – 1 metre (3 ft)

# 4. STRUCTURAL MODIFICATIONS

***National Chest Hospital - Casualty /Physiotherapy Building***

Structural analysis carried out on the roof trusses of the Casualty /Physiotherapy Building indicates that following structural modifications will be necessary to the trusses for them to accommodate the PV panels under Category 4 hurricane winds.

The proposed modifications are illustrated on **Drawing 1819/04**

i) The 3.3m (11 ft.) long vertical king post at the mid-span of the trusses being only 76mm (3") thick is quite slender and has a low allowable compressive stress capacity which is exceeded under wind loads. The member thickness need to be increased by bolting to it two termite treated wooden members each of size 38 x 138 mm (1.5" x 5.5").

ii) The truss top chords are too small and are overstressed under wind loads. Their size need to be increased by bolting on two 38 mm x 240 mm x 4.8m long (1.5" x 9.5" x 16 ft.) wooden members,

iii) The bottom chords of the trusses need to be maintained in a braced condition. Currently the ceiling framing provides that bracing. Should there be any unbraced bottom chord members then wooden 89 x 89 mm (3.5" x 3.5") members are to be installed as bracing,

iv) The web members which join Joints 3 to Joints 4 are in tension under wind loads and are to have tension connectors fitted at Joints 4. The tension force to be resisted under wind load is 34.7 kN (7,800 lbs).

v) All joints of the truss and anchorage to the building at the truss bearing are to be checked for adequate connection capacity and improved where necessary. The estimated uplift force at each truss bearing due to wind only is 70.0 kN (15,700 lbs).

# 5. RECOMMENDATIONS

i) Solar PV panels can be mounted on the roof of the Casualty/Physiotherapy building at the National Chest Hospital but the panel framing is to be connected to the roof trusses **at their panel points (i.e. at the truss joints)**

ii) Some joints of the roof truss of the Casualty/Physiotherapy Building at the National Chest Hospital need to be strengthened

iii) The Henriques Ward Block at Sir John Golding Rehab Centre is not recommended for mounting solar PV panels on the roof.

Solar PV panels may however be mounted on self-supporting frames that cross clear of the building.

iv) Solar PV panels to be mounted over the roof of the Conference Centre Building at Sir John Golding Rehab Centre are to be mounted on self supporting frames anchored against uplift, at ground or to the metal side of the building. **Drawing 1819/25A** illustrates a possible arrangement for installing the framing.

Per …… SEALED

Hopeton Jones,

Registered Professional Engineer, Jamaica. #PE/01/0096