B.- INSTALLATIONS OF THE MAIN HOSPITAL OF SAINT VINCENT, W.I

B.1.- GENERAL DESCRIPTION

B.1.1.- LOCATION

The Kingstown General Hospital is located in the western extreme of the city, about 200 meters of the coastal line, within the urban zone In Figure B.1 its location is indicated and in Figure B.2 a site survey is presented; the dimensions, indication of the geographic North and separations between buildings are only approximated. On the West side it neighbours with the city's cemetery.

The area actually occupied by the health care installations has an approximate extension of 8.900 m^2, with a slope from the North-West towards the sea (see Figure B.1). The slope between the extremes of the lot, in the indicated direction, is of about 4 meters (see Photos 1 through 5).

Appart from the natural threats -wind and earthquakes- that are discussed in Section A of this Report, the area is also affected by rain (130 to 150 cm/year) with these values being 3 to 4 times greater in the central mountains, with maxima between June and December.

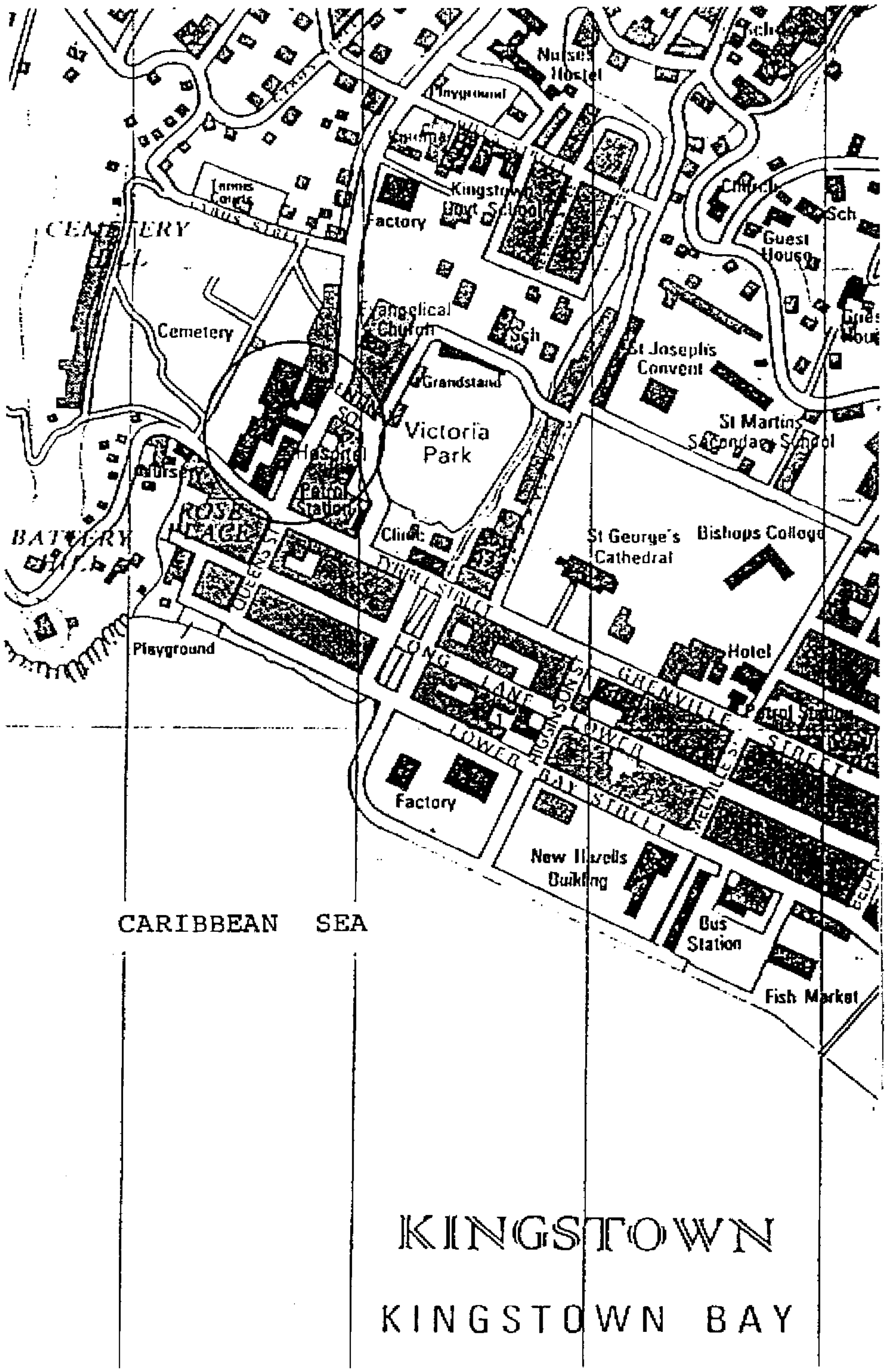


FIGURE B.1 LOCATION OF THE KINGSTOWN HOSPITAL, SAINT VINCENT

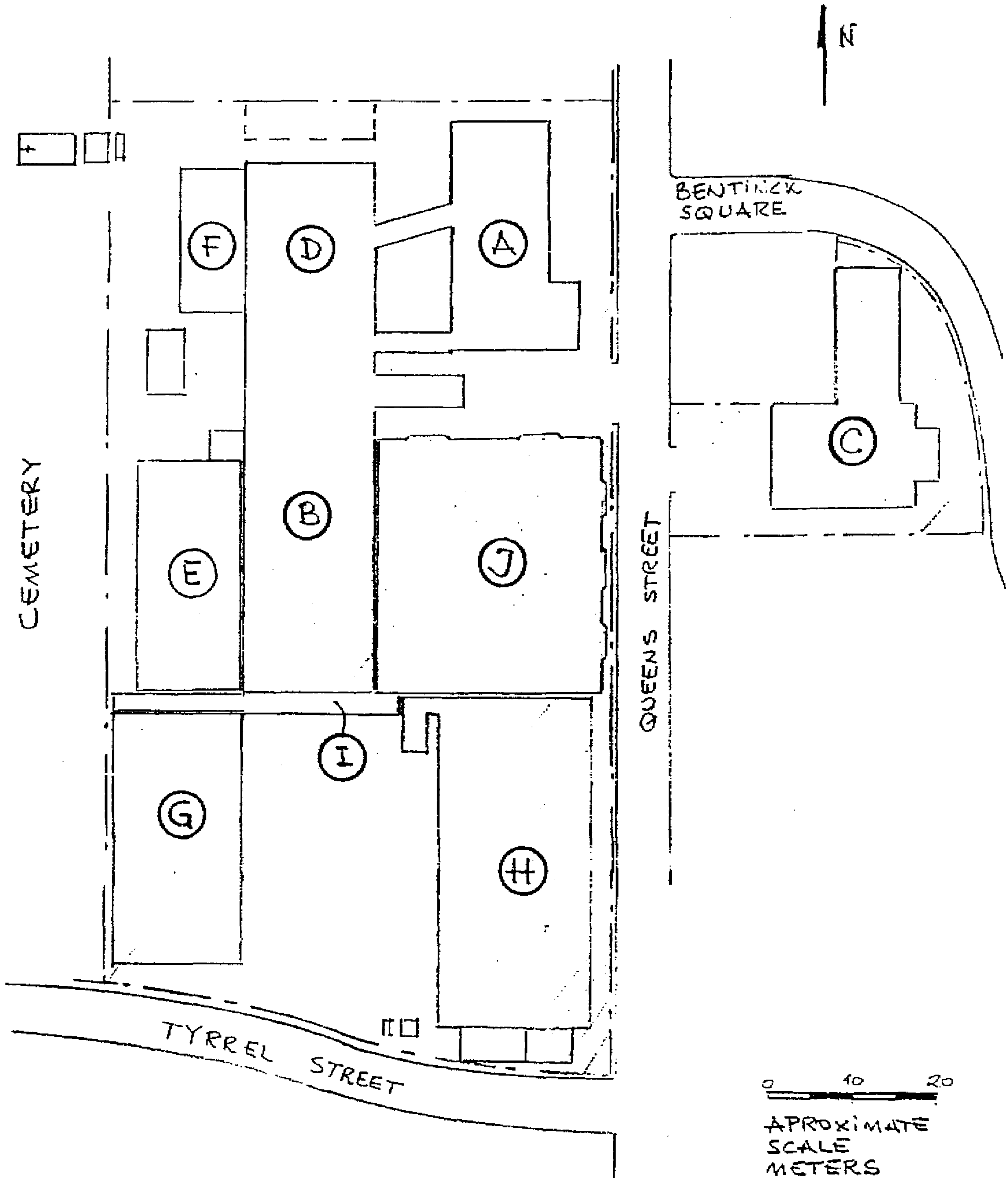


FIGURE B.2 LAYOUT OF THE HOSPITAL INSTALLATIONS (JULY 1996; SEE TABLE B.1)

B.1.2.- BRIEF HISTORY

The main building was built aruond 1898, with an auxiliary building for pharmacy and pathology, which was not concluded for years; it was finished in more recent times. In Table B.1 the inspected buildings that could represent the older parts are indicated. This inference is based on the type of construction: stone walls and /or masonry work of 50 to 60 cm at base level and between 40 to 50 cm at top level, with wooden floors.

For 1980-81 the two level paediatrics wing was finished and in 1984 a 3 story building was finished with capacity for 90 beds.

In 1991 there was the ceremonial opening of the two-level building for: surgery, sterilization and necessary equipment.

Around 1986 a Master Plan was made for the further development of this installation as a Hospitalarian Center, with a total of 11 stages of development and refurbishing, from which two have been done; the developmnet of a third stage has been announced for September 1996.

B.1.3.- CONFIGURATION

The installations of this hospital extend themselves in 3 levels mentioned here as: Level 0, Level 1, Level 2. These are connected through ramps and corridors covered in the different levels. Hence the use of elevatorts is not needed.

TABLE B1

IDENTIFICATION AND BRIEF DESCRIPTION OF THE BUILDINGS OF KINGSTOWN'S PRINCIPAL HOSPITAL (SEE FIGURE B.2)

IDENTIFICATION (CONSTRUCTION DATE)	LEVELS	APPROXIMATE AREA (M^2)	TYPE OF SERVICES
A (End of XIX century)	Level 1	900	Accidents & emergencies.
	Level 2		Clinical consulting-rooms and administration.
B (End of XIX century)	Level 1	1.100	Conference rooms, physical therapy, clinical histories wating room.
	Level 2		Recovery room and women hospitalization.
C (Several stages)	Level 1	700	Pharmacy, workshiops, consulting rooms and dentistry.
	Level 2		Main laboratory, blood bank, family planning and sterilization.
D (1950´s)	Level 1	700	Kitchen.
	Level 2		Women surgery.
E (1950´s)	Level 1	300	Radiology.
F (1950´s)	Level 1	100	Maintanince e cleaning.
G (1979-1981)	Level 0	1.000	Pediatrics.
	Level 1		Women hospitalization.

TABLE B1

IDENTIFICATION AND BRIEF DESCRIPTION OF THE BUILDINGS OF KINGSTOWN'S PRINCIPAL HOSPITAL (SEE FIGURE B.2)

IDENTIFICATION (CONSTRUCTION DATE)	LEVELS	APPROXIMATE AREA (M^2)	TYPE OF SERVICES
H (1982-1984)	Level 0	2.400	Men hospitalization.
	Level 1		Maternity B.
	Level 2		Men hospitalization.
I (1982-1984)	Level 0 to Level 2	200	Ramps and corridors monoframe.
J (1989-1991)	Level 1	1.500	Maternity A. Sterilization (CSSD) and Medical Director.
	Level 2		Surgery pabillions.
Other Installations	Level 0	--	Emergency generator, gas-oil tank, transformer.
	Level 1	--	Storage, crematorium, gas-oil tank, chapel, corridor between, building A and D.
	Level 2	--	Corridor between buildings A and D.

In this way, the surgery rooms could be considered to be at the same level as the hospitalization beds; the labour rooms at the same level as obstetrics.

In general terms, the external patients, the emergency services, clinics, dentistry, pharmacy and lab are located in easy access areas, essentially at ground level (Level 1).

Figures B.3, B.4 and B.5 describe the layout corresponding to each of the 3 levels mentioned above.

B.1.4.- INSTALLATION BUILDINGS AND TOTAL AREA

The studied hospitalarian installation has a total of 10 buildings, excluding minor buildings , which are identified in Figure B2 and Table B1. The areas that are given have been obtained from the survey made, which only represents approximate dimensions; hence it is possible that they differ from the real values. The total area obtained is equal to 8.900 m^2.

B.1.5.- ATTENTION CAPACITY

The hospital has a total of 204 beds, with an average occupation between 65% and 70%.

Because of being the only installation of specialized secundary attention in the whole island, the total of beds reffered to the actual population: 204/110.000 ~2/1.000 satisfies the average established requirements. Highly specialized requirements such as: radiotherapy, neurosurgery, etc. are refered to larger hospitals outside the island.

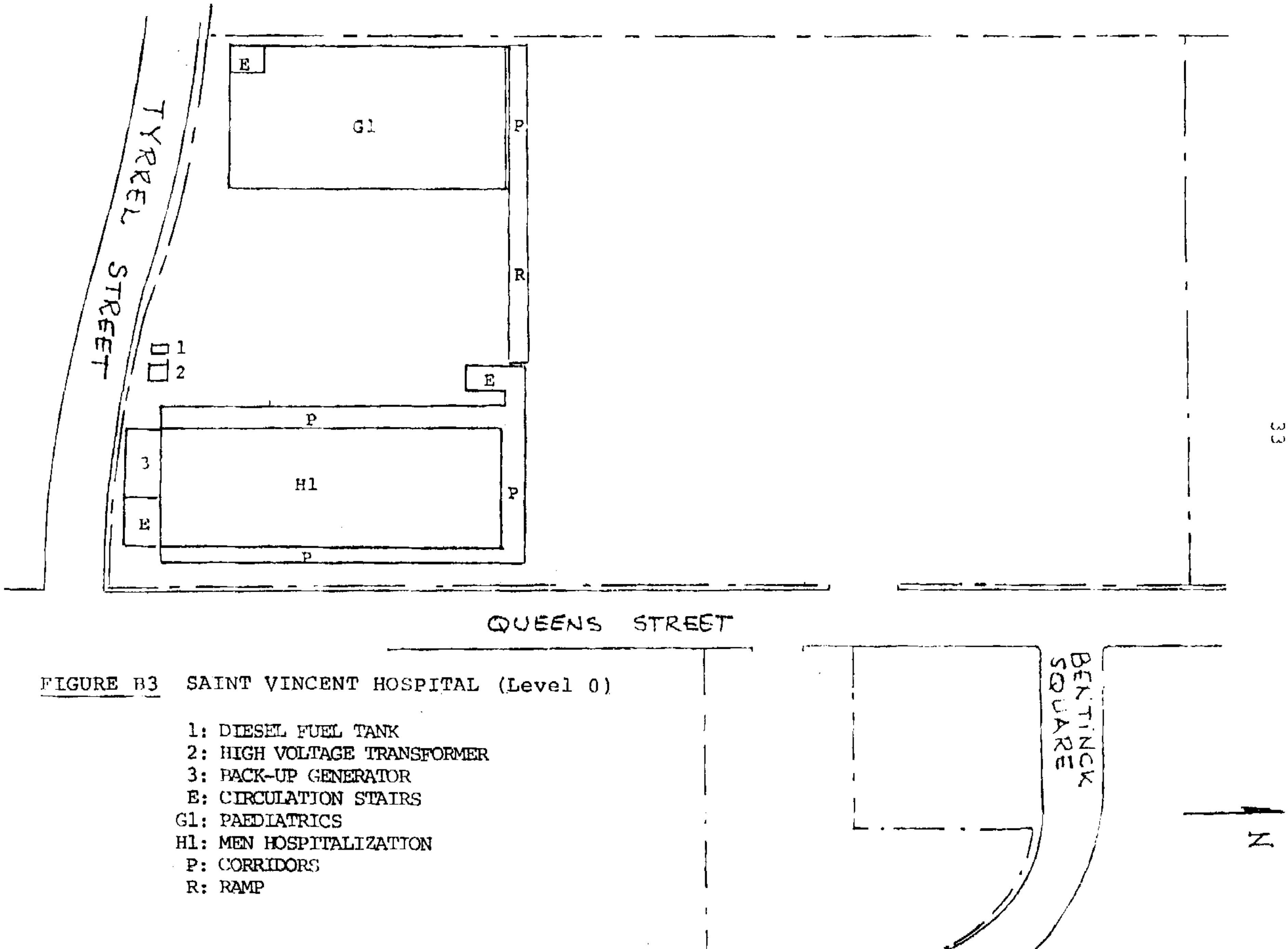


FIGURE B3 SAINT VINCENT HOSPITAL (Level 0)

1: DIESEL FUEL TANK
2: HIGH VOLTAGE TRANSFORMER
3: BACK-UP GENERATOR
E: CIRCULATION STAIRS
G1: PAEDIATRICS
H1: MEN HOSPITALIZATION
P: CORRIDORS
R: RAMP

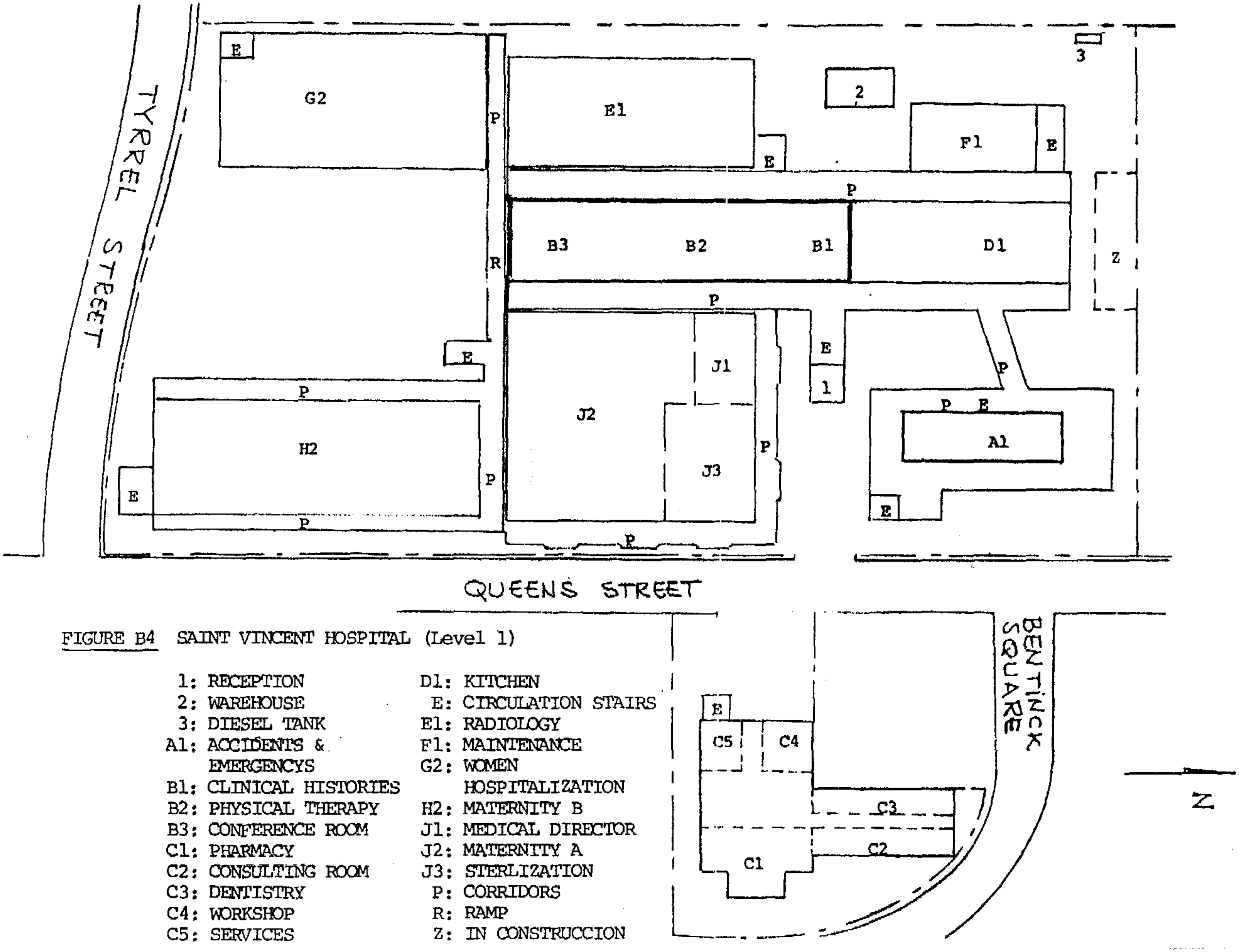


FIGURE B4 SAINT VINCENT HOSPITAL (Level 1)

1: RECEPTION
2: WAREHOUSE
3: DIESEL TANK
A1: ACCIDENTS & EMERGENCYS
B1: CLINICAL HISTORIES
B2: PHYSICAL THERAPY
B3: CONFERENCE ROOM
C1: PHARMACY
C2: CONSULTING ROOM
C3: DENTISTRY
C4: WORKSHOP
C5: SERVICES
D1: KITCHEN
E: CIRCULATION STAIRS
E1: RADIOLOGY
F1: MAINTENANCE
G2: WOMEN HOSPITALIZATION
H2: MATERNITY B
J1: MEDICAL DIRECTOR
J2: MATERNITY A
J3: STERLIZATION
P: CORRIDORS
R: RAMP
Z: IN CONSTRUCCION

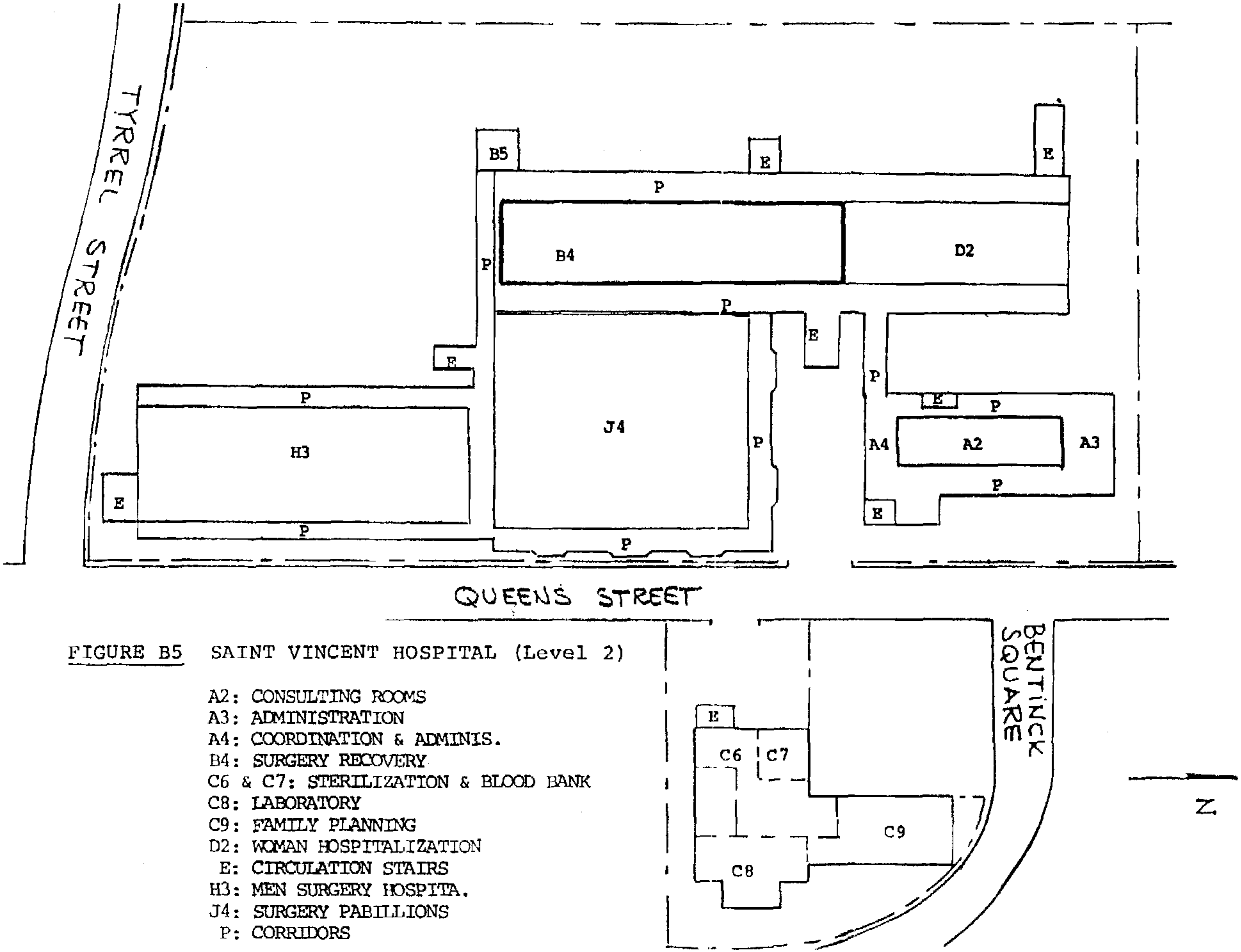


FIGURE B5 SAINT VINCENT HOSPITAL (Level 2)

A2: CONSULTING ROOMS
A3: ADMINISTRATION
A4: COORDINATION & ADMINIS.
B4: SURGERY RECOVERY
C6 & C7: STERILIZATION & BLOOD BANK
C8: LABORATORY
C9: FAMILY PLANNING
D2: WOMAN HOSPITALIZATION
E: CIRCULATION STAIRS
H3: MEN SURGERY HOSPITA.
J4: SURGERY PABILLIONS
P: CORRIDORS

B.2.- BUILDINGS A, B AND C

Because of being the oldest, these buildings are described and analyzed together.

B.2.1.- CONFIGURATION

Both Buildings A and B present a singularity which is their construction, almost centenary, with a rectangular horizontal projection with two levels, defined by stone walls and/or masonry-work of dimensions: 9 x 18 m in Building A and 9 x 38 m in Building B (see Figures B.4 and B.5), with sorrounding areas made of wooden structures and light roofs.

The detailed map made by TVA in April 1987 of the top floor and cross section of Building A is reproduced in Figure B.6.

B.2.2.- ROOFS AND CORRIDORS

The roof of these buildings are made of wood, covered with metallic sheets (Photos 1, 6, 7, 9, 14, and 15). The details of the roof support structures are not known due to the difficulty in the access for its detailed inspection. The corridors and peripheric areas of Building A are completely set up of wooden structures (Photos 6 to 10). Details of the roofs that cover such areas are given in Figure B.7 (Photos 25 and 26).

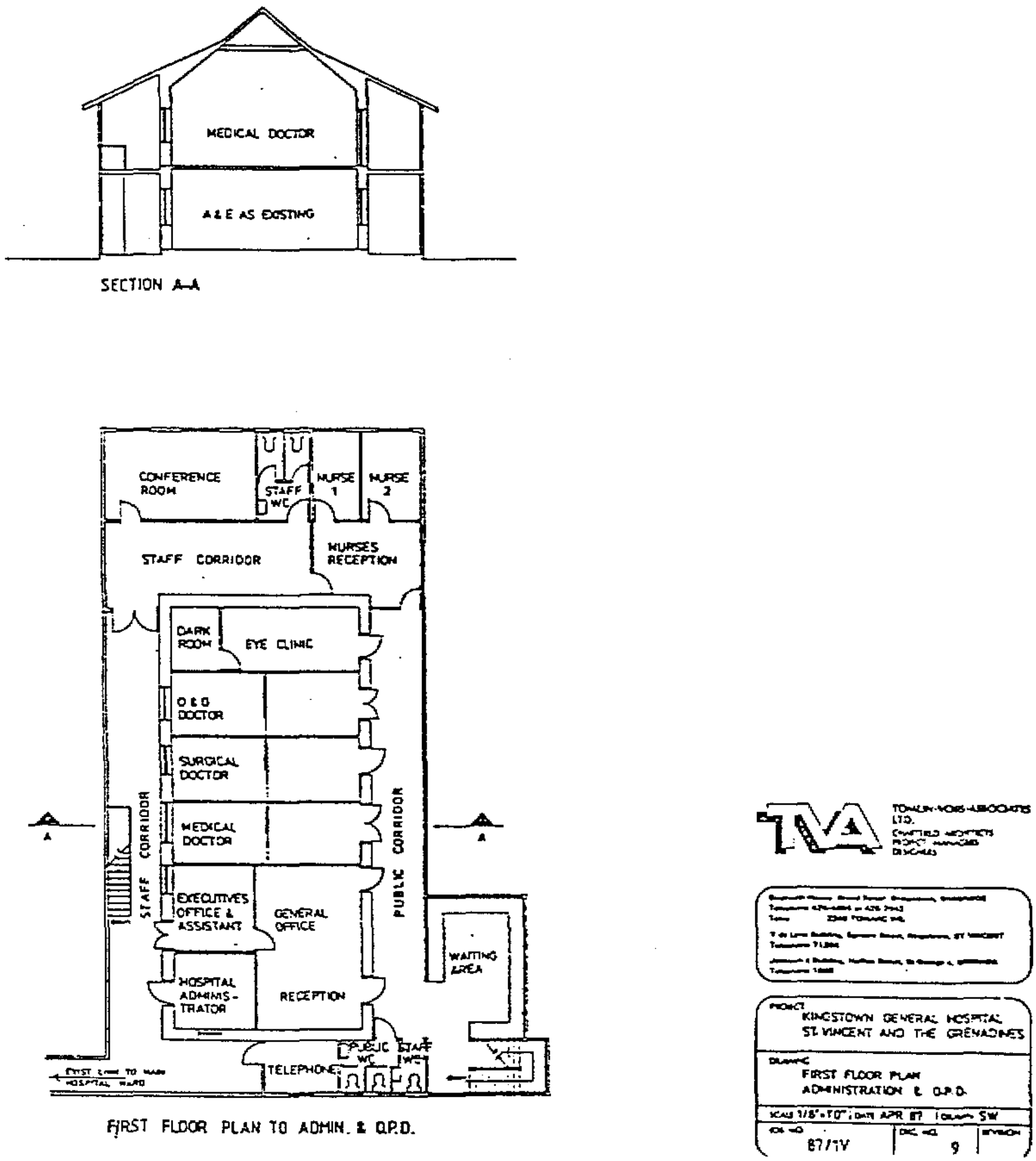


FIGURE B6 LAYOUT MADE BY TVA IN APRIL 1987, OF THE TOP FLOOR AND CROSS SECTION OF BUILDING A

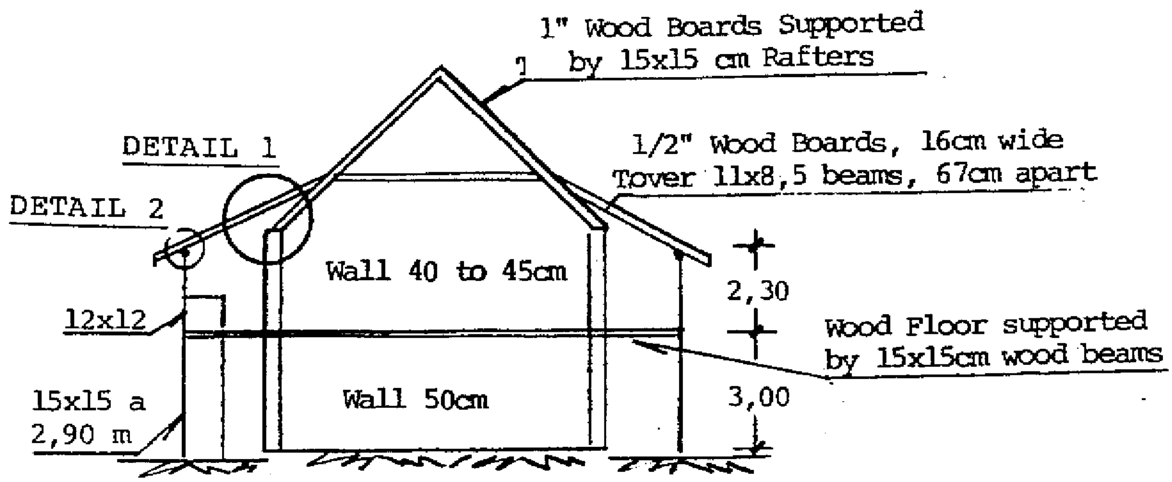
The banister elements, with diagonalized members, confer bracing in the frame´s longitudinal direction (12 x 12 cm columns) that support the corridors' roof (see Figure B.7).

The joints of the horizontal elements, with the columns that support the roof, deserve to be strenghtened to absorb the tensile forces transmited by wind suction (Photo 31).

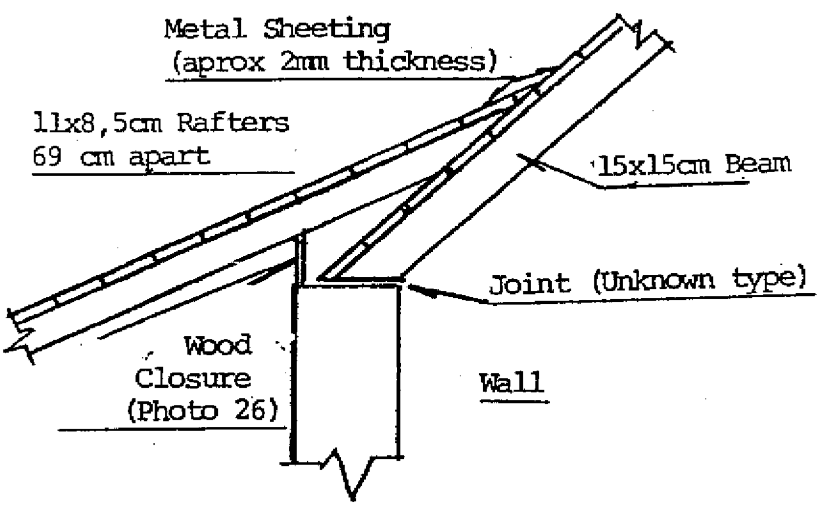
Parts of the roof's gable-end, in the Administration area, North face of Building A, is in bad shape and could be the beginning of a generalized flaw of that cover under intense winds (Photo 9). At the same time, the base of one of the wooden columns that are part of the roof support structure , East face of Building A (Photo 10), requires fixing.

The roofs of the corridors of Building B are a continuation of those of Building D (see Section B.3 and Figure B.10). This roof is supported by a wooden structure, with 14 x 14 cm columns separated 3,20 m from each other and with a height of 2,30 m; in the Western side, they are united by a 14 x 13 cm support beam, with a framing effect in the North-South direction, with 10 spans, transversely braced to the masoury wall by 30 x 23 cm beams in alternate spans (6 beams total).

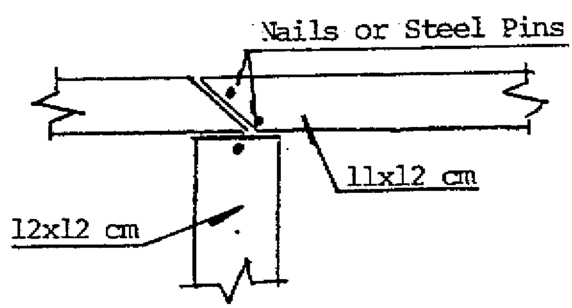
The configuration of the top floor corridors is continued in the corridor, at that same level, of the Southern side of Building B, bordering with Building I single frame with ramps.



BUILDING A TYPICAL CROSS-SECTION



DETAIL 1 (see Photo 25)



DETAIL 2 (see Photos 26 & 31)

Note: Steel sheeting is nailed to the wood roof by aligned nails similar to those shown in Photos 39 & 40, 25sm apart. They fall into line every 90 cm approximately. At gable-ends separation is halved

FIGURE B7 DETAILS OF THE ROOF ELEMENTS OF BUILDING A

The roof corresponding to the Eastern side corridor is similar to the already described Western side (Photos 27 and 28). It is convenient to emphasize here, that on top of the staircase roof which is back-to-back with that Eastern side of Building B-D, where there is a water tank, there is a leakage problem of undrained rain water (Photos 33 and 43), which is deteriorating through corrosion the reinforced concrete beam which serves as roof support (Photo 44).

The aerial corridor, that goes from Building A to Building B-D, level 2 (Photo 33), is 8 m long and 1 m wide with internal metallic members at roof level. This corridor is supported by four 6,5 x 14 cm columns, very slender, layed in the way illustrated Figure B.8. The support at Building A's facade (Photo 34) requires to be improved, for example with a metal corbel support.

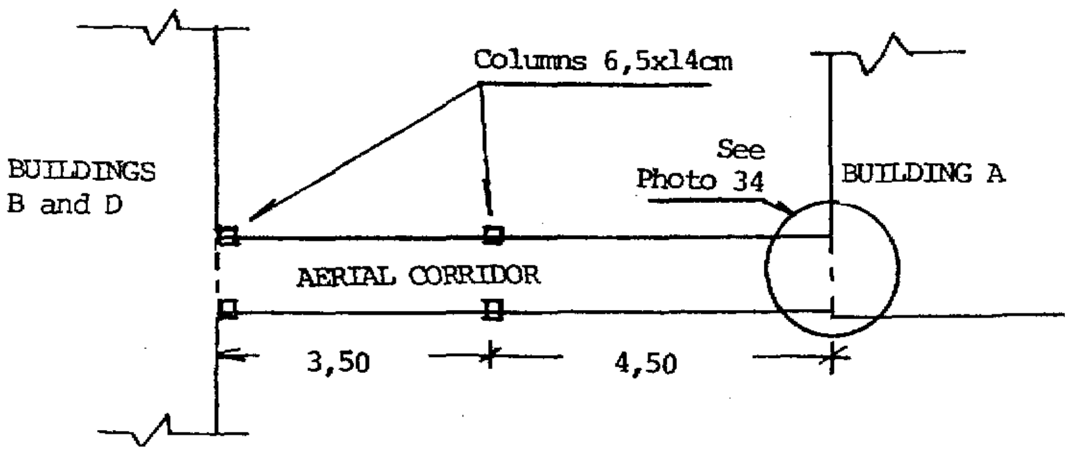


FIGURE B.8 LAYOUT OF THE AERIAL CORRIDOR BETWEEN BUILDINGS A AND B-D

B.2.3.- MASONRY WALLS

In the three described buildings masonry walls were identified, probably not reinforced, in good appearing conditions (without fissures or visible damages). Their thicknesses in Buildings A and B are: 50 to 60 cm at ground level and 40 to 50 cm in the top floor.

The bearing capacity to quakes of these walls, of unknown material, are substantially affected by openings. In Building A there are a total of 6 openings, predominantly windows of 1 to 1,20 m wide and 1,9 to 2,0 m high, and doors of 2,2 to 3,0 m high; these openings represent approximately 50% of the wall area in longitudinal direction.

In Building B, at top floor level, Western facade, in a total area of 15,5 x 3,90 = 60,5 m^2, there are 12 openings with an empty space area of 36,5 m^2, which represents 61% of the total area.

This aggravating circumstance in the vulnerability to seismic actions, is partially attenuated by the use of light roofs. Nontheless, the safety evaluation under earthquake type loading deserves a special study that goes beyond the scope of this Report.

B.2.4.- FLOORS

The floor-slabs are made of wood. In building B details of such can be observed, they being constituted by a wooden section shaped as a box, just as it is schematicly indicated in Figure B.9. This floor is directly supported on the masonry walls. It is possible that the floor-slab of Building A is similar to the recently described.

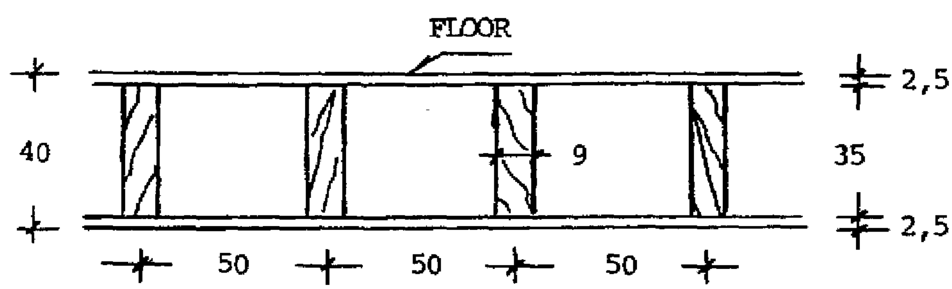


FIGURE B.9 CROOS-SECTION OF THE WOODEN SLAB

In Building C, the floor-slab of the area corresponding to the Main Laboratory, is wooden; underneath which, the Pharmacy is found. This slab does not seem to be in good conditions and for the reasons given later on, it deserves to be changed.

B.2.5.- EQUIPMENT

In the top floor of Building C important installations for the functioning of the hospital are found: laboratories, sterilization and blood bank, which have delicate equipment (analizers, reactives, controlled refrigerators, etc).

Taking into consideration the fire hazard and what has been said in Section B.2.4, it is advised to improve and/or reinforce all the floor-slab, for example placing a reinforced concrete slab. It is also advised to anchor to the walls those equipments susceptible to tipping over, that in case of breackage or spill could limit the operation of the services in Building C.

B.3.- BUILDING D

It is a two levels reinforced concrete building, with light roof, reinforced concrete slab and rectangular plan, placed back-to-back to the Northern face and giving continuity to Building B (see Figure B.10).

With an adequate structural configuration, the central span is about 8 m long, covered by beams in transverse direction with variable transition sections of about 60 cm, continuing on each side along the corridors; the slab rests on top of

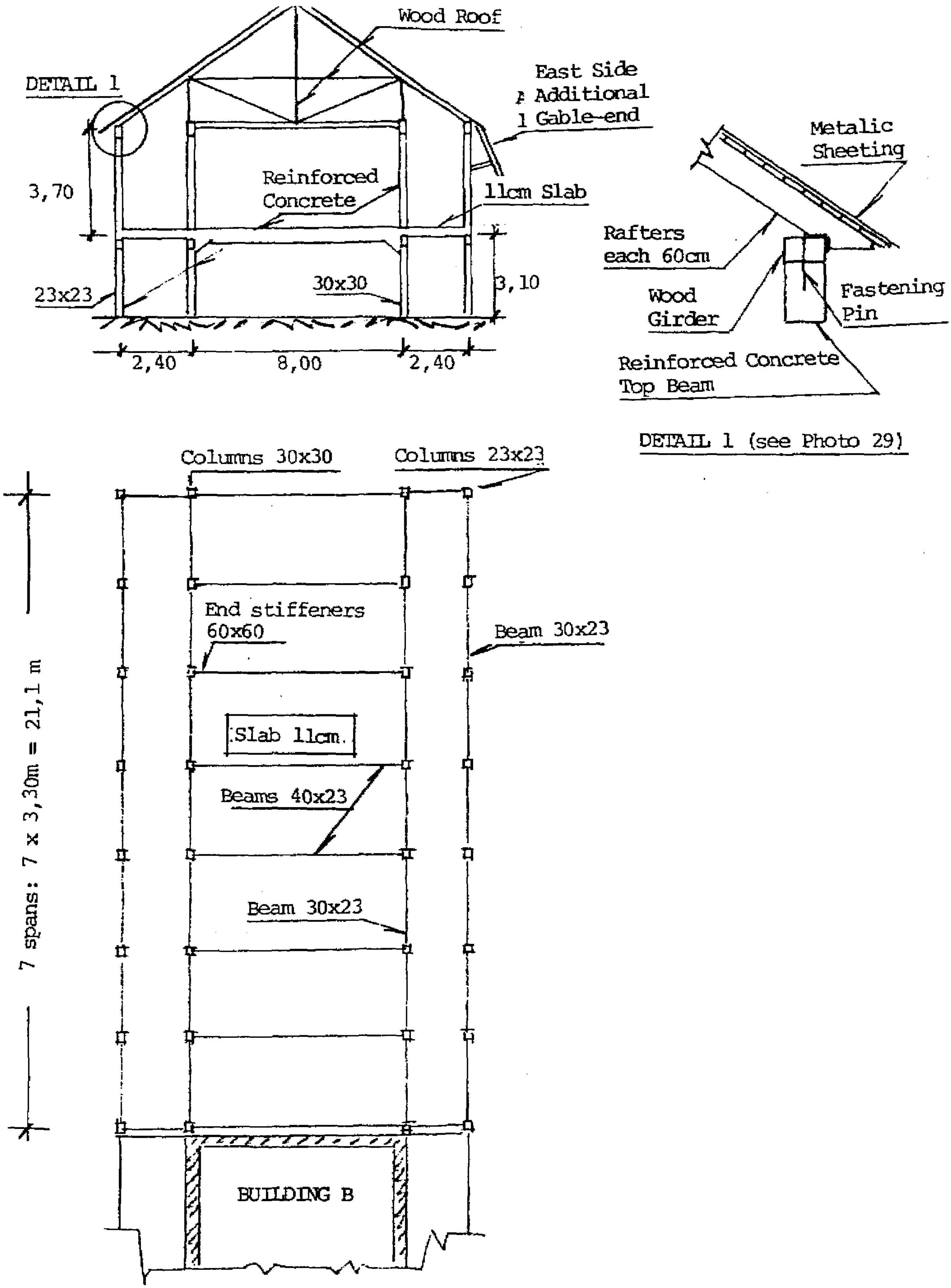


FIGURE B10 PLAN AND APPROXIMATED CROSS-SECTION OF BUILDING D the transverse beams and 30 x 23 cm longitudinal beams. The peripheric columns are of 23 x 23 cm and the internal 30 x 23 cm with the greatest side in the transverse direction.

The wooden roofing details were not inspected due to the presence of a hanging false roof placed more than 3 m high.

The connection bolt given in Detail 1 of Figure B.10 (Photo 29) could only be found every 2 to 2,5 m, with a diameter of about 3/4" (2,8 cm^2) For the foreseen suctions of 62,1 Kg/cm^2 (see Table C.1, Section C.2.2) the expected forces would reach of a maximum:

$$2,5 \times 62,1 \times 2,40 / (2 \times \cos 32) = 220 \text{ (kg)}$$

which are relatively small forces.

This bolts were not identified in the Eastern facade side, side in which there is and additional gabble-end to limit the rain water entrance to the corridor, according to what is indicated in the cross-section of Figure B.10.

B.4.- BUILDINGS E AND F

Both are rectangular buildings of only one level, with a reinforced concrete upper-slab. No particular problems were identified, except some humidity located towards the South-Western extreme of Building E (radiology) of unknown origin.

B.5.- BUILDINGS G AND H

B.5.1.- BEARING STRUCTURE

These buildings are of comparable structural configuration and were excecuted between the end of the 70s and beginning of the 80s: Building G has two levels (Photos 12, 16 and 17) and Building H has three levels (Photos 18 and 19), both with light wooden roofs covered with metallic sheets.

Due to the lack of stanctural logonts, it is not possible to classify the bearing system within some of the described in the actual Codes. During the inspection a reinforced concrete frame system that supports the slabs of that same material was identified. The hospitalization rooms are divided by partition wall elements that, in the upper levels, are about three meters, high.

Partition walls of greater height and slenderness are located towards the central zone of that level, in a parallell direction to the one of greatest dimension (North-South). In a perpendicular direction, in Building G, there are five resistant lines, clearly identified in Photo 16; in Building H there are six, since this building has one extra module than Building G.

B.5.2. SEISMIC ACTIONS

Because of the resisting elements, the partition walls and the total height, it is estimated that both buildings have periods that do not exceed 0,50 sec, with which, for the assumed soil conditions in the area, they would be left in the maximum zone of the spectrum (see Figure A.9). The value of K = 1,2 adopted for the determination of this spectrum implies limited ductilities

Assuming that, for example in Building H, each resistance line in the transverse direction has a 6 m tributary area, the shearing acting force is of about:

$$V = 0{,}125 \times Wt$$

$$Wt = (800 \times 2 \times 0{,}6) / 5 = 192 \text{ Ton}$$

$$V = 24 \text{ Ton / resistance line}$$

Assuming furthermore, that at ground level the shearing forces are mainly taken by the walls framed by the concrete structural members, and that the total length of those walls is 50% of the total building width, the average total stress would be of the order of:

$$\tau = 24000 / (900 \times 15) = 1{,}8 \text{ Kg/cm}^2$$

For cement mortars of average quality 125 Kg/cm^2, the allowable shearing stresses for unreinforced masonry in parallel direction to the horizontal joints, is approximately twice for the hollow units (stresses calculated over the net area) and three times if it is filled units. For partially reinforced masonry, the allowable stresses are about twice (AIS Code, 1984).

The obtained stresses, even considering increasing factors due to accidental torsional effects, are small enough and normal stresses due to gravity would be negligible, since gravity is essentially taken by the reinforced concrete structural elements.

In the longitudinal direction there is not enough information to provide a simplified evaluation. In that direction it is necessary to pay attention to the stability of the taller walls located towards the center of the floor area.

B.5.3.- WIND ACTION

In Section C.2.4 it is established that the wind lateral forces only reach a fraction of the total shear stresses due to earthquakes.

The deck of Building H was inspected (Photo 35), finding a separation between the rows of nails, not measurable because of access limitations, estimated in about 1,5 to 1,8 m and nails with separations of 15 to 20 cm. For wind suctions comparable to those given in Table C.1, Section C.2.2, of 62,1 Kg/cm^2, the following nail tension requirements are expected:

- for the smallest estimated area: 1,5 x 0,15 x 62,1 = 14 Kg
- for the greatest estimated area: 1,8 x 0,20 x 62,1 = 22 Kg

Both values are comparable with the resistance obtained in the pullout tests made (see Section C.1) for the predominant plank's thicknesses measured in the inspected roofs.

On the deck edges and top ridge sorrounding areas, for roofs with slopes under 30º, the negative pressures due to wind should be expected to double (see CUBIC, Figure A104.1). Therefore, in order to avoid the beginning of the covering sheet's tearing off, it is recommended to reduce the nail separation, inserting a second row of width equal to Z that should comply with the following conditions (Note 4 of Figure A104.1):

- Z > 1m
- Z > 0,04 x 18 = 0,72 m
- The smaller of the two following numbers:

  0,10 x 18 = 1,8 m

  0,40 x 12 = 4,8 m

In other words, at a width of 1,8 m measured from the edge of the gabble-end.

B.6.- BUILDING I

More than a building, structure I is composed of a reinforced concrete frame(also called monoframe) with five columns that connect, by means of ramps and horizontal sections, Buildings G, E, B, J and H. In Figure B.11 an approximate sketch of this structure is given, that typicaly has columns of 50 cm in the plan of the figure times a width of 35 to 37 cm. The top beam has a height of about 80 to

90 cm, providing rigidity and stability to the system in its own plan; the roof is made of wood covered with metallic sheets.

On the frame's perpendicular plan and at each side of the frame, a group of cantilever beams are found; they support the horizontal corridors in each level, as well as the ramps that allow displacement from one corridor to another. The stability normal to the frame is reached through the interaction with the neighbouring buildings and the wall placed at the lower level.

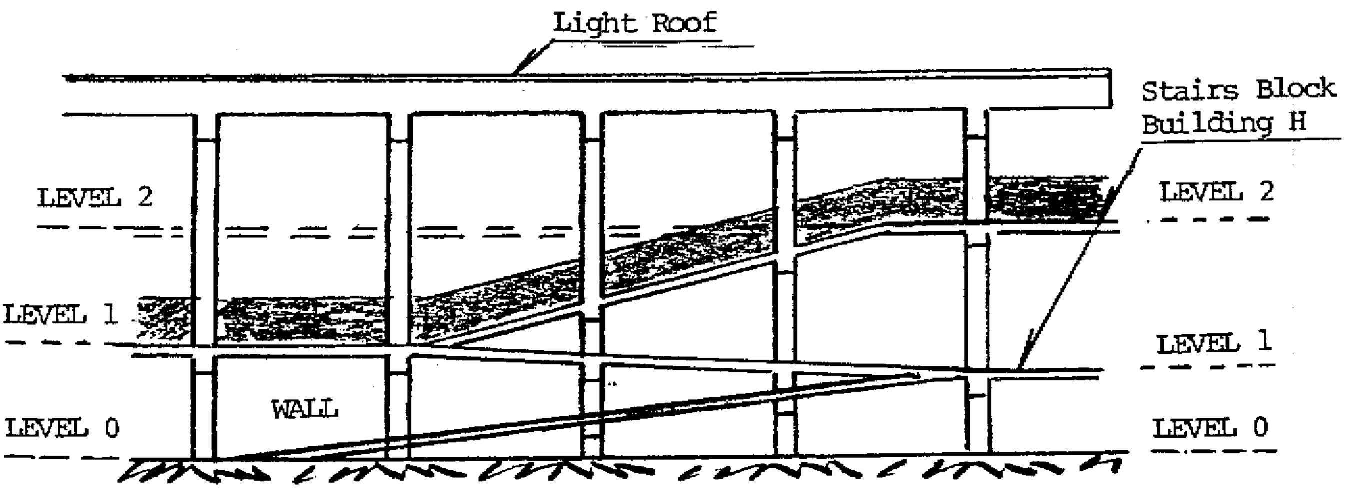


FIGURE B.11 SKETCH OF BUILDING I (REINFORCED CONCRETE MONOFRAME)

Such interaction, with visible joints of less than 1 cm of separation, surely will be a source of collision between the adjacent slabs with which minor local damages are expected; no specially vulnerable situations were found in this structure.

B.7.- BUILDING J

This is a two-level building, made of reinforced concrete, of rectangular shape (approximately 32 x 26 m), with 40 x 40 cm columns at ground level and 33 x 33 cm at the top level, separated 6,40 m in each direction. The 35 x 60 cm beams are build in to a solid reinforced concrete slab of about 12 to 14 cm wide (Photo 30). The peripherical beams are stronger.

Assuming a floor area of 832 m^2, and a weight of 1.000 Kg/m^2 for the slab including partition walls and facades, and 700 Kg/m^2 for the roof including the water tank, the building's total weight is of 1.414 tons.

This weight is distributed in the lower level, over 30 columns, assumed all equal to 40 x 40 cm, with which the mean column stress is equal to: (1.414)/(30 x 40 x 40) = 30 Kg/cm^2. In the upper level the average column stress is equal to: (832 x 0,7)/(30 x 33 x 33) = 18 Kg/cm^2.

The Eastern and Northern facades have large openings as it can be appreciated in Photos 2 and 22, which illuminate and ventilate the peripherical corridors. The absence of these elements in the Southern and Western facades tend to displace the center of rigidity towards the North-Eastern corner of the building. This effect is particularly worrying due to the fact that in its Southern and Western sides, this Building J is back-to-back to Buildings B and H; for example, in Photo 20 the contact zone between Buildings H and J is illustrated, and in Photo 21 the crack in the tyles of the floor in level two shows that joint.

Nontheless, the presence of interruptions in the facade walls brings about columns with restricted displacements. This is the case of the extreme South-Eastern column in level 1 (see the exterior views in Photos 20 and 22, and the interior view in Photo 23). This configuration, known as "short column", is vulnerable to seismic actions since its rigidity in actual conditions is substantially greater than that of the original design (say: if the free length of the column is reduced by 1/3, the rigidity is 27 times greater, therefore taking a much larger force than assumed at design level). In fact that column already shows some fissures in its upper part for unknown reasons (see Photo 24).

All in all, under the action of quakes of the expected intensity, it is probable that damages located in those types of elements occur, whether they are made of reinforced concrete or not.

In the interior of the corridor and in the Eastern side, there are glass windows of about 80 x 100 cm, solidly framed by wooden elements.

B.8.- SERVICES

B.8.1.- WATER

The water comes from the city's 4" pipes supply network. The water storage capacity of the hospital installations is of approximately 25.900 liters, distributed in tanks placed at roof level in the following places:

- Surgery building roof: metallic tank, of about 2 x 2 x 3 m (Photo 41) .... 12.000 liters
- Roof of the stairs complex of the hospitalization building (Photo 42): $2 \times \frac{\pi \times 1{,}8^2}{4} \times 2$ .... 10.000 liters
- Maintenance and cleaning building roof: 1,2 x 1,5 x 1,2 .... 2.200 liters
- Roof of the stairs complex adjacent to women hospitalization (Photo 43): .... 1.700 liters

It is estimated that this quantity of 25.900 liters of water covers the hospital needs for 24 hours.

If the actual disposition of emergency tanks has the advantage that it operates through gravity: (a) its capacity is limited; (b) its vulnerability to actions such as extreme winds or earthquakes is much greater than a subterranean tank. Hence, it is recommended to add, within the foreseen actions in the expansion plans, the construction of a subterranean tank of at least 50.000 liters.

B.8.2.- SEAWAGE

Served waters are placed in the local seawage system.

B.8.3.- ENERGY

The main supply of energy is controlled by a transformer located over a concrete base, sited towards the South-Eastern extreme of the installations It recieves high voltage power from the Saint Vincent Electricity Services Ltd. network, at 11 KV level. Its output is at 400/230 V level, 3 phases and 50 Hz (Photos 45, 47 and 48). The transformer's main body does not seem to be anchored (Photo 48).

According to the information collected at the site, the emergency generator has a capacity of 270 KVA and operates with diesel. This fuel is stored next to the transformer, sepparated by a fire-preventive wall (Photo 45). This back-up installation (Photo 51) is used relatively frequently to cover the local network's black-outs.

There is also a certain amount of energy, mainly for water heating purposes, generated by means of solar pannels.

B.8.4.- FIRE PREVENTIVE SYSTEM

In addition to the mechanical systems (manual), the existence of some smoke detectors that are part of the fire detection system were recorded. In the telephone operator cabine of the Hospital, there is a panel with lights that signals the location of the area in which an alarm signal is originated.

In each building or attention unit a hose that can be connected to hidrants has been placed. Manual extinguishers have also been identified.

This information was supplied by hospital personnel; it has not been annalized with the depth demanded by an installation in which an important percentage of the structures are made up of wood.

B.8.5.- EMERGENCY EXITS

Circulation and emergency exits are assured by means of 8 independent stair nuclei, with locations indicated by means of letter E in Figure B.4.

B.8.6.- GAS SUPPLY

There are two double systems for gas supply: one in the Surgery Building and Maternity A, next to the CSSD (sterilize area) (Building J) and the other one in the Paediatrics and Women Hospitalization Building (Building G). Each one of these systems is double, since part is for the supply of oxygen and another part for nitrogen oxide (anaesthesia).

Both systems are fed by two groups of cylinders: ones on use and others stored as back-up.

In general, many unsecured cylinders were detected (Photos 53, 54 and 55); others are in suitable containers (Photo 52).

B.8.7.- FUEL SUPPLY

Fuels are stored in two cylindrical tanks with horizontal axis (Photo 45, 46, 49 and 50). In both cases, their bases ought to be anchored to the support walls.