

## Chapter Nine

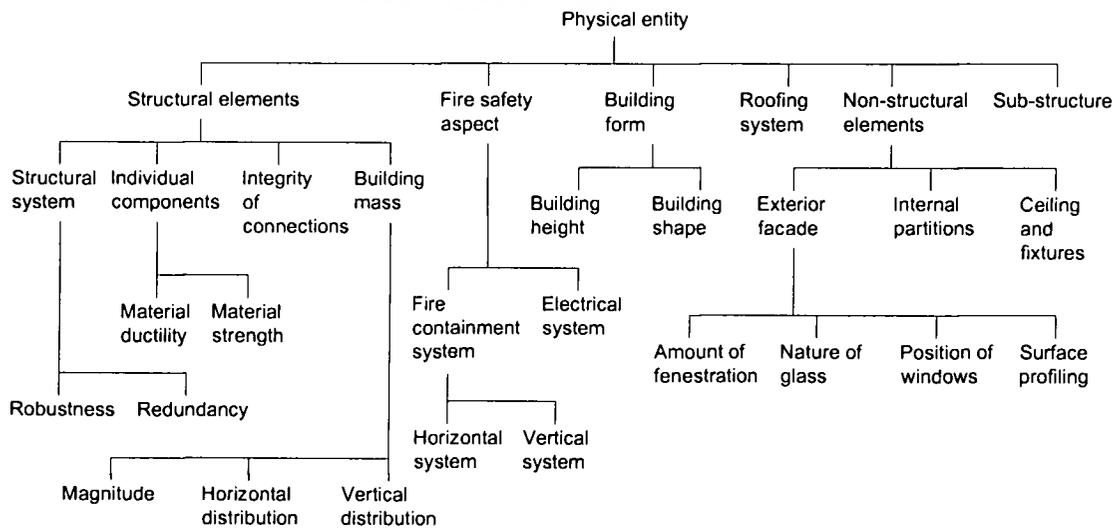
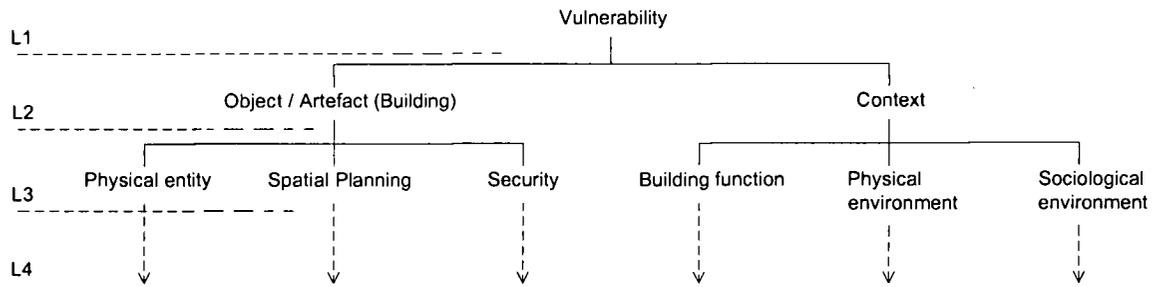
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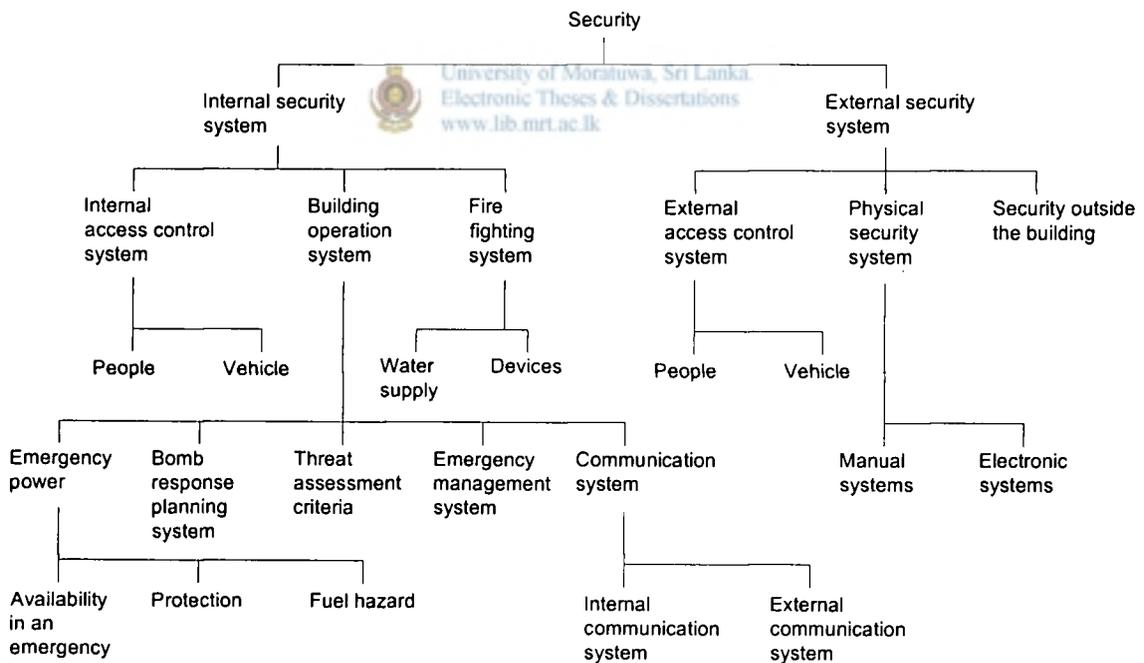
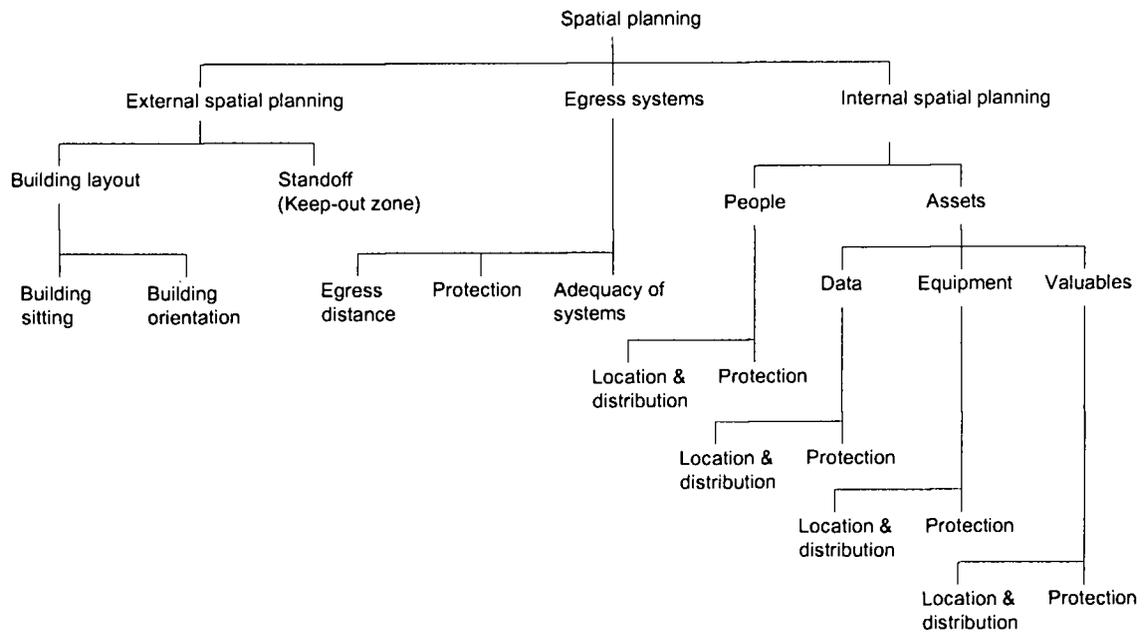
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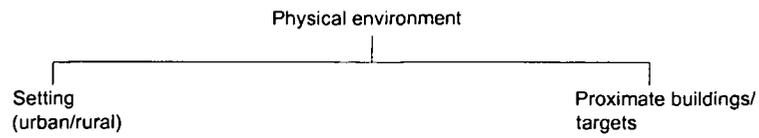
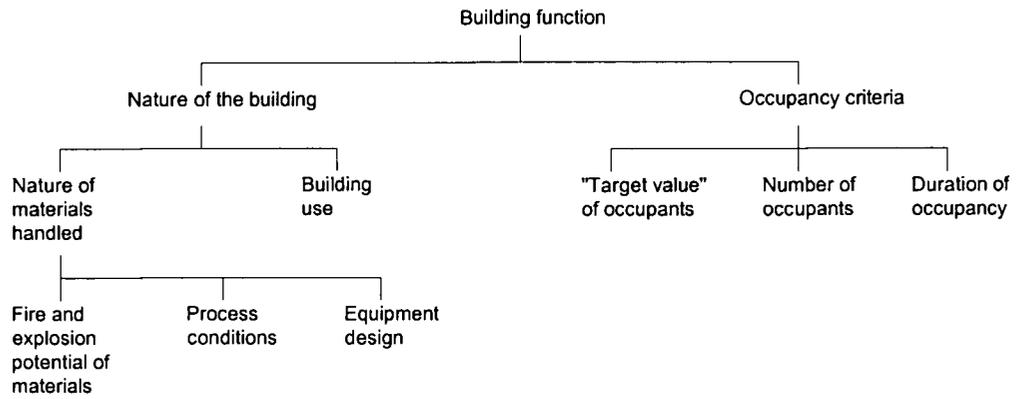
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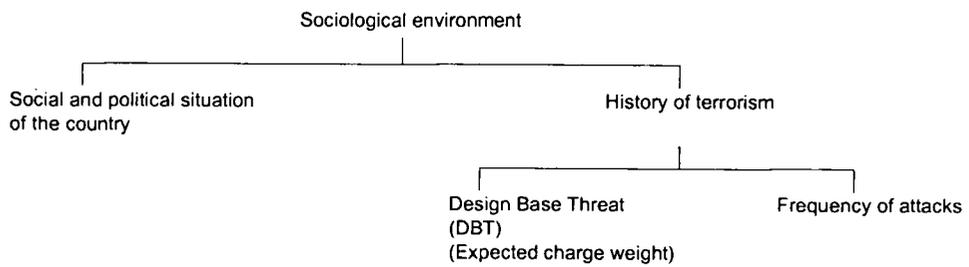
Detailed Hierarchical Model








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### Definition of Holons

#### L2: Object/ Artefact (Building)

##### L3: Physical entity

##### L4: Structural elements

##### L5: Structural system

##### L6: Robustness

- Evaluate, whether loads from all directions are well distributed to all the members of the Structure.

##### L6: Redundancy;

- Evaluate whether a local collapse prejudice the overall stability of the structure. (i.e. ability of the building to survive without collapse, except in the immediate locality of the explosion)
- Evaluate the structure for alternative load paths, which avoid progressive collapse.

##### L5: Individual components

##### L6: Material ductility;

- Evaluation of structural ductility of members. (i.e. whether they can undergo substantial bending without breaking)  
(ductile elements made of steel and r/f concrete can absorb lot of strain energy, while elements made of brittle materials such as glass, brick, timber and cast iron fail abruptly with little prior deformation. Flexible components such as long span beams and floors can absorb a great deal of the energy delivered by a blast load. On the other hand rigid, short-span lightweight elements are poor energy absorbers and fail catastrophically)

L6: Material strength and properties;

- Evaluate individual elements for their hardness, strength and toughness with relevance to their span.

L5: Integrity of connections;

- Evaluate the joints for their capability of resisting stress reversals.
- Evaluate the possibility of fire-induced connection failures.  
(Failure due to excessive heat generated)

L5: Building mass

L6: Magnitude;

- Evaluate the overall building weight in relation to the building height.

L6: Horizontal distribution;

- Evaluate the horizontal distribution of the building weight with respect to its structural system.



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L6: Vertical distribution;

- Evaluate the mass of lower levels with respect to overall mass of the building (buildings are more stable through the use of increased mass in the lower levels).

**L4: Fire safety aspect:**

L5: Fire containment system

L6: Horizontal systems;

- Evaluate the means of fire containment along one floor of the building.

L6: Vertical systems;

- Evaluate the means of fire containment between two floors of the building.

**L5: Electrical system;**

- Evaluate the degree of redundancy of the system.
- The system support adequate light to aid in evacuation, continuous supply to smoke exhaust fans and occupying elevators.
- Evaluate the probable damage to electrical conduits in case of structural failure and its contribution to fire or pose a threat to occupants, other systems and rescue personnel.

**L4: Building form:**

**L5: Building height;**

- Evaluate the natural period of vibration of the structure in relation to its height.  
(In general, a tall building will have low natural frequency and thus long response time in relation to the duration of the load)

**L5: Building shape;**



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- Evaluate the shape of the building for its level of blast confinement.
- Evaluate the shape of the building for large torsional effects against blast loading (typically, symmetrical buildings behave better when subjected to blast loading)

**L4: Roofing system:**

- Evaluate the weight of the roof against its structural system and span.
- Evaluation the capability of the roof to retain its upright walls or columns in contact against probable blast pressure.
- Evaluate the pitch of the roof for its contribution of focusing blast waves onto upper floor windows.
- Evaluate the interior ceiling system for its nature of fixing to the roof structure or horizontal cladding system (slab).

- Evaluate the nature of lighting and fixtures supported on the grid system or ceiling.

**L4: Non-structural elements:**

L5: Exterior façade

L6: Amount of fenestration;

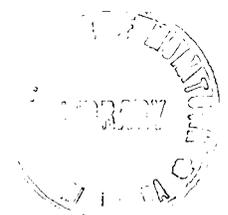
- Evaluate the solid/void ratio of the façade (structural/non-structural ratio) (Limiting the amount of fenestration will limit the blast effects)
- Presence of fragment entrapping meshes for fragment control in non-structural areas.

L6: Nature of glass;

- Capability of the glass to be retain in contact against predetermined blast pressure. (Assessment of the glass properties for their resistance against blast pressure) Note: Blast resistant glazing generally consists of laminated annealed glass or laminated toughened glass or, in double-glazed units, combination of toughened and laminated glass.

L6: Strength and position of windows;

- Strength of materials used for window frames.
- Robustness of the window assembly
- Position of windows from the finished floor level (FFL) of each floor. (Higher positions are preferable as it allows pressure above the head level of a man)
- Possibility of glass shards entering the central air conditioning system of the building



**L6: Surface profiling;**

- Evaluate the presence of deep reveals and deep, flat windowsills, which are accessible from ground level. (Which provide ideal concealment places for small devices)
- Evaluate the use of deep surface profiling, which can enhance last effects by virtue of the complex reflections produced and lead to greater level of damage than would be produced with a plane façade.

**L5: Internal partitions;**

- Evaluate the nature of fixing of cladding to the main structure (i.e. whether the cladding is securely fixed to the structure with easily accessible fixings)

**L5: Ceiling and fixtures;**

- Evaluate the nature of fixing of ceiling to the roof structure and conditions of fixing of light fittings to the ceiling or roof.

**L4: Sub-structure:**

- Evaluate the strength of foundations
- Evaluate the strength of connections between foundation and the structure.

**L3: Security**

**L4: Internal security system**

**L5: Internal access control system**

**L6: People;**

- Accessibility to utility services, storage facilities and fuel delivery systems.
- Accessibility to plant rooms.
- Accessibility to valued data storage areas.

Accessibility to high value occupants.

L6: Vehicle;

- Condition of basement parking or parking within the building.
- Loading operations under or within the building.
- Condition of public or private transport means being integrated to the building (eg: Light Rail Transit which run through the building).

L5: Building operation system

L6: Bomb response planning system;

- Evaluate the availability of pre-set team to manage an emergency event.
- Training the security personals and the employees for emergency events.
- Conscientious implementation of emergency exiting training programmes for building tenants.

L6: Threat assessment system;

- Periodic threat and vulnerability assessments by internal and/or external auditor, using assessments technique developed for civilian situations.
  - What kind of threat(s) that the building is subjected to?
  - Evaluation of the building for its vulnerability.

L6: Emergency management system;

- Availability of drawings, 3D models and computer based systems to handle an emergency event.

L6: Communication system

L7: Internal communication system;

- Availability of remote systems to communicate with security, emergency management personals and employees by the managers, in case of an emergency. (A communication cascade system for all the staff)

L7: External communication system;

- Availability of remote systems to communicate with fire brigade, national intelligence, defence and military departments in case of emergency.

L6: Emergency power

L7: Availability of power in case of an emergency;

- Availability of stand by power in case of an emergency. And continues supply.

L7: Protection;

- Protection given the stand-by power and distribution system.

L7: Fuel hazard;

- Condition of fuel storage.

L5: Fire fighting system



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L6: Water supply;

- Fire protection ratings that include the use of sprinklers in buildings require a reliable and redundant water supply. If water supply is interrupted, the assumed fire protection is generally reduced.
- Presence of adequate and sufficient vertical and horizontal distribution systems of water for fire fighting as specified by the fire safety codes.

L6: Devices;

- Presence of periodic checks for the appropriate performances of the fire protecting devices as specified by the fire safety codes.

**L4: External security system**

L5: External access control system

L6: People;

- Evaluating the system of handling the staff/employees and visitors (e.g. separate entrances, additional check)
- Personal identification system.

L6: Vehicle;

- Evaluation of parking adjacent to the building (on site or off site)
- Accessibility to the site (control over vehicles).

L5: Physical security system

L6: Manual systems;

- Availability of employees required for security operation system
- Hierarchy within the security system (availability of system(s) with grades of status, which relates to the responsibility)

L6: Electronic systems;

- Availability of electronic security systems, which are adequate and sufficient to handle the security operation system depending on the nature (function) of the building.

L6: Security outside the building;

- Evaluation of the site condition for hazardous material storage on site. (e.g. fuel storage, trash holding, pressure vessels and things which can contribute to fire and smoke generated in an explosion)
- Presence of architectural features that magnify (e.g. focus or increase) blast effects on site.
- Presence of "hard" landscaping, steps or mounds adjacent to the building.

- Presence of water bodies, mountains (site levels) or any other features that should be paid considerable attention.

### **L3: Spatial planning**

#### **L4: External spatial planning**

##### L5: Building layout

##### L6: Building siting;

- Analyse the location of the building on the site considering its position in relation to other buildings.  
(Nature of multiple reflections from other buildings/ nature of blast pressure focus by other buildings/ nature of threat by transferring fire or fall of other building segments in to the building in concern)

##### L6: Building orientation;

- Analyse the nature of threat possess by the building due to adjacent road network.
- Whether any feature adjacent to the building can overlook the building.

##### L5: Standoff (keep-out zone);

- Evaluate the distance between the bomb and the building.  
(As standoff distance increases, blast pressure drops significantly. Therefore it is important to evaluate standoff distance for a predetermined charge weight from probable locations of explosion)

#### **L4: Egress system**

##### L5: Egress distance;

- Evaluate the position of vertical exists (stair spacing and locations)
- Evaluate the position of horizontal exists (presence of areas compartmented by fire and smoke barriers, by which occupants can

continue to exit by stair or remain in the area of refuge as long as necessary).

L5: Protection;

- Evaluate the fire and smoke resistance of escape routes (vertical and horizontal)
- Condition of the containment (walls and partitions) of escape routes for their strength to resist to breach by flying debris.
- Presence of impact-resistant enclosure around egress paths.

L5: Adequacy of systems;

- Circulation system, including corridors, stairs, doors and ramps, provide adequate means for occupants to escape and emergency personal to enter the building.
- Evaluate whether the egress stairways are well marked and lighted.



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**L4: Internal spatial planning**

L5: People

L6: Location and distribution;

- Evaluate the location pattern of people, people density, people zoning, locating children and disabled people within the building.
- Evaluate the damage that can cause due to concentration of occupants in case of an emergency
- Evaluate the damage that can cause due to the 'operational criteria of people' within the organization.

L6: Protection;

- Evaluate the nature of work perform by the people (employees, students etc.) and their contribution to make harmful environment in a case of a blast event.

- Presence of safe areas (blast shelter areas) within closer proximity to occupants' work places.

L5: Assets

L6: Equipment

L7: Location and distribution;

- Evaluate the concentration of high value equipments, damage of which can cause considerable economic loss and long replacement procedure and time.
- Evaluate the location of heavy equipments in upper floors of the building, which can contribute to structural failure in case of a blast event. (Heavy equipments should be located in lower levels, preferably in the ground floor)

L7: Protection;

- Evaluate whether the critical equipments (which can contribute to a hazard) are well protected and minimize the damage that they can cause to operators or building users.
- Equipments with high economic value should be protected with additional protective measures depending on the case and need.

L6: Data

L7: Location and distribution;

- The valued data for the organization (manual or computerized) is safeguarded and the option for back-up facilities should be considered.
- Operational resilience could involve having duplicate critical system either located in another building away (at least 1 km) or, if it is large enough located at the opposite end of the building in concern.

L7: Protection;

- Evaluate the protection given to the data storage areas (some critical data cannot be duplicated and then blast effects should be minimized by locating

them in internal and relatively safe rooms that should, ideally offer good protection from fire and flying debris.

L6: Valuables

L7: Location and distribution;

- Evaluate the location(s) of valued assets of the organization within the building for their protection (Some organizations might have valuable assets such as cash, gold, jewellery etc. that have to be protected specially from blast induced fire).

L7: Protection;

- Evaluate the nature of containers of valuables, whether they can offer good resistance to fire and impact from external loads.

## **L2: Context**



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### **L3: Building function**

- Evaluate the function of the building in relation to its likelihood to become a target of terrorists (Military buildings, embassies, airports, railways, Large shopping centres are famous targets of terrorists)

### **L3: Physical environment**

L4: Setting;

- Evaluate where the building is situated (in an urban area or rural area), by which it possess a 'risk' of becoming a terrorist target (Buildings located in urban areas are mostly attracted by terrorists, but even some remote buildings might be targets for them depending on their function)

L4: Proximate buildings/ targets;

- Evaluate whether any other building or buildings, which possess high or moderate level of risk, surround the building in concern.

**L3: Sociological Environment**

L4: Social and political situation of the country:

- Evaluate the political stability of the country and the nature of internal and external conflicts.
- Evaluate the conflicts between different ethnic groups, racial groups and religious groups within and outside the country and their tendency and potential to make blast hazards within the country.

**L4: History of terrorism**

L5: Design base threat (expected charge weight);

- Evaluate the possible nature of threat possess by the building and possible charge weight expected, by analysing the case histories and the nature and potentials of the terrorists

L5: Frequency of attacks;

- Analysis the case histories to find out the frequency of terrorist attacks to make judgment about the risk possessed by the buildings of similar nature, function, located in the same area etc. to evaluate the risk attribute to the building in concern.



**Case Study Assessment**

**Structural system:**

Structural type	Reinforced concrete monolithic inner core with 12 columns around it
Robustness	High; dead load is well distributed over the structural load bearing members, but impose loads (equipment, furniture etc.) in some parts of the building are concentrated
Redundancy	High; damage to single or few columns would only leads to local collapse, but damage to the structural core sometimes may lead to total collapse

**Individual components**



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Structural materials	Reinforced concrete
Material ductility	High
Material strength	Tested for adequacy

**Integrity of connections**

Type of structural connections	Accordance with the structural specification
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**Building mass**

Average dead load	High
Average impose load	High
Building length (or diameter)	120' 00" dia.

## Fire safety aspect

Fire containment systems along one floor of the building

The structural core with fire resisting (one hour) doors, but there is a treat of fire spreading along the perimeter of the structural core

Fire containment systems between two floors of the building

The RC structural core is pressurised. One hour fire resisting doors prevent fire entering to the core and spreading to other floors (including 3 basements up to 32nd floor)

## Electrical system

Degree of redundancy



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High

Adequacy of light to aid evacuation

Adequate, but ceiling mounted fittings (because of the loose ceiling) are not reliable

Continuous supply to smoke exhaust fans

Redundant individual fans for each floor

Continuous supply to passenger elevators

Available

Stand-by power

Two generators with 1.2 MW are available

Damage that can cause to electrical conduits in case of structural failure and its contribution to fire

Main bus-bars are located within the structural core and horizontal

distribution is between slab and the ceiling

### **Building form**

Building height	435' 00" (above ground)
Building shape	Circular
Blast confinement capability	Within the core is high and outside the core is less

### **Roofing system**

Type of roof structure	Reinforced concrete slab
Roof span (avg,max,min)	120' 0" dia.
Roof covering	Reinforced concrete slab
Connection of the roof to the structure	Monolithic construction



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### **Exterior façade**

Amount of fenestration	24%
Nature of glass	Laminated safety glass
Sizes of glass	10mm thk. Approx.: 7'0" X 3'0" in size
Material(s) used for window frames	Aluminium sections
Position of windows above the finished floor level	6" (150mm)
Possibility of glass shards entering the central air conditioning system	Very less
Type of surface profiling	Flush finished Aluminium solid composite panels and glass. No projections or recesses, therefore multi-reflection is very less

## **Internal partitions**

Partition materials	Aluminium sections/ 10mm glass/ 9mm plaster board. Acoustical areas; 12mm glass wool
Use of glass	40-50% glass used as in-fill material of partitions. Vulnerable to produce shards and the positions are equivalent to seating height of occupants
Nature of fixing to the main structure	fairly good, fixing of in-fill panels to framework is weak

## **Ceiling and fixtures**

Ceiling type	Mineral fibre exposed grid (fire resistant) suspended ceiling Some areas plywood boards used (less amount)
Nature of connection to the main structure	Suspended
Type(s) of fixtures and fittings on the ceiling	Susceptible to collapse due to loose ceiling

## **Sub-structure**

Foundation type	Pile foundation
Number of levels in the basement	3 levels

### **Internal access control system - people**

Accessibility to utility services, storage facilities and fuel delivery systems	Maintenance staff can enter
Accessibility to plant rooms	Maintenance staff can enter
Accessibility to data storage areas	Office staff and maintenance staff can enter
Accessibility to high value occupants	With the permission

### **Internal access control system – vehicle**

Basement parking or parking within the building	3 basement levels parking (but limited to staff and identified
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Loading operations within the building	Very less
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### **Emergency power**

Availability of stand-by power	Two generators are available
Protection given to the power plants	Fairly good; located in the opposite directions to main access roads
Condition of the fuel storage	One underground storage (30000 litres) with catch pits and LP gas commercial cylinders approx. 16 Nos. handling externally

### **Bomb response planning system**

Presence of pre-set team to manage an emergency event

Two fire wardens are employed in each floor

Training given to the staff and security personals

First aid training to staff  
Annual fire evacuation drill

### **Threat assessment criteria**

Periodic threat assessments (by internal or external auditor)

No

### **Emergency management system**

Availability of drawings/ 3D models/ computer based systems to handle an emergency

Not practicing



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### **Communication system**

Internal communication system

Public address system; can be operated even without electricity

External communication system

Direct communication with Red Alert Security communication and Fire Brigade

### **External access control system**

*People:*

Personal identification system

Scanning system for other departments other than the bank

Separate entrance for staff/ employees and visitors

Not available

*Vehicles:*

Parking adjacent to the building

Yes, customer vehicles can be parked adjacent to the building

Control over vehicles entering to the site

Only physical security means are available. Electronic means are not available

**Physical security system**

*Manual systems*

Condition

Moderate condition

No: of employees employed in the operation

100 employees in the security



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Hierarchy within the system

Good

Electronic systems

Electronic control room  
CCTV security system

**Security outside the building**

Hazardous materials storage on site

Paints and lubricants  
(about 200 litres of paint and 20 litres of petrol)

Presence of architectural features that magnify the blast effect

Entrance lobby can confine the vehicle delivered bomb.  
No architectural features that may magnify the blast effect

Landscaping (hard/ soft)

Concrete blocks (curbs)  
6" - 8", customers parking area  
is about 5'-0" above the main  
road

Presence of mountains, water bodies or any other  
features that need due attention

No

### **Building layout**

#### *Building siting:*

Location of the building in relation to other buildings

Attack to adjacent buildings can  
cause vast damage.  
The gap between adjacent  
buildings and the building in  
concern is very less, therefore fire  
can easily transfer to the building  
in concern



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#### *Building orientation:*

Condition of the road network

Poor; if manual means of security  
is not present, it is critical

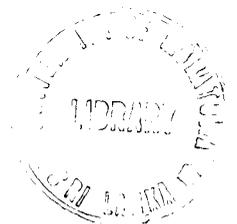
Building overlook from other features

Can be overlooked by tall  
buildings adjacent to the building  
in concern

### **Stand-off**

Distance between the probable blast and the building

15' 0" (critical)



## **Egress system**

### *Egress distance:*

Position of staircases

Two main staircase in the structural core and 2 other staircases from 3 basement levels to 4th floor

Areas compartment by smoke and fire

Smoke resistant lobby on each floor

### *Protection:*

Fire and smoke resistance of escape routes

Pressurised stairwell and fire resistant doors

Strength to resist breach by flying debris



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Good; escape routes located within the structural core

### *Adequacy of systems:*

Adequacy of circulation systems, staircases, corridors and ramps

Adequate, but total evacuation time is about 15 minutes, which is very high

Emergency entrance for emergency management people

External emergency access is available up to 8th floor from the ground level

## Internal spatial planning

### *People:*

Location and distribution;

Density, zoning, locating children and disabled, and high value occupants

Managers are occupying upper levels. Fire lifts are available for disables

Damage that can cause due to concentration of people

No: of occupants; 2100  
(Chance of concentration is there)

Damage that can cause due to operational criteria of people

Not considerable

Protection:

Nature of work perform by occupants

Office and banking functions

Presence of blast safer areas within close proximity

Structural core adjacent to the office area

### *Assets:*

Location and distribution of equipment:

Concentration of high value equipment

Moderate

Location of heavy equipment in upper floors

Water tanks at 31st and 33rd floors. Chillers at 17th floor.

Protection:

Protection given to the equipment which can contribute to hazards

Generator is located at the opposite side of two main access roads

Equipment with high economic value

Computers and electronic cash holding equipments

*Data:*

Distribution and location:

Duplicates, back-up for valued data

Available

Duplicate data available within the same building or some other location

Same building

Protection to data:

Protection given to data storage areas

Extra protection is given to stationary data stored at 13th floor

*Valuables:*

Location and distribution:



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Location of valued assets (cash, gold, jewellery etc.)

Located in central areas

Protection to valuables

Additional security and Tank Vaults are available

**Nature of materials handled**

Fire and explosion potential of materials

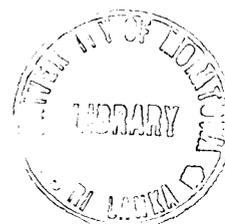
Fire threat to paper, electronic equipment is moderate

Process condition

Moderate

Equipment design

Average



**Occupancy criteria**

Target value of occupants

Less

Number of occupants

Approx. 2100

Duration of occupancy

Maximum 11-12 hours



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