DESIGN CONSIDERATIONS FOR FIRE PROTECTION SYSTEMS

IN INDUSTRIAL BUILDINGS

by

H.A.D.P. Mervyn Gunasekera

Introduction

The design of a fire protection system for any type of facility is not merely selecting a fire suppression and/or detection system available in the market. It depends on so many factors such as occupancy, construction materials, location, cost etc.

To design and install fire detection and suppression systems after completion of a project or during its construction stage is costly. Therefore, it is an essential requirement that the designer should give adequate consideration to the fire protection requirements at the planning and design stage of the project.

In this paper the author will briefly discuss some important factors which the designer should consider at the design stage of an industrial facility in fire protection planning.

Wherever applicable, guidelines used by the Colombo Municipal Council Fire Services (herein-after referred to as OMCF) in approving industrial facilities are also briefly discussed.

Responsibilities of the Designer

The designer's prime responsibility is to provide the client with the most economical structure that will suit the needs of the intended occupancy. A part of this responsibility is to explore methods of protecting lives and buildings from fire. He also owes it to his client to research the most practical and economical way of doing this.

The first important research work, the designer should do is to look for the applicable local fire regulations/codes. In Sri Lanka there is no fire legislation or any other approved fire code which can be used in designing fire protection systems. (A committee appointed by the Institute for Construction Training and Development is currently working on preparing a fire code and their work is scheduled to be completed before the end of 1987).

However, OMCF uses guidelines which are mainly based on the British Standards for reviewing and approving building projects. Therefore, the designer can solve most of problems if he can visit the local authority who approves plans, before the completion of the design and discuss the fire safety requirements applicable to the facility in question. These discussions not only help to expedite the drawing approval procedure but also help the designer to have some understanding of the options available to him when looking for an appropriate Fire Protection System.

Mr. H.A.D.P. Mervyn Gunasekera, BSc(Eng), MSc(Const. Mgt), CEng, MICE, MASCE, MIE(SL), COE is presently Deputy Director (Management Training), Institute for Construction Training and Development.

He graduated in Civil Engineering from the University of Ceylon in 1975 and obtained the MSc in Construction Management from the Loughborough University of Technology, U.K. in 1986.

He joined Walker & Greig Ltd. in 1975 and was assigned as Assistant Construction Engineer at the Padukka Satellite Earth Station Construction Site; assigned as Resident Agent for the Marine Drive Sewer Project, Republic of Maldives. Also held the posts of Project Engineer, Design and Estimating Engineer in the Firm.

He joined Ceylon Petroleum Corporation in 1978 as Civil Engineer and in 1979/1980, worked as Deputy Engineering Manager - Kolonnawa Oil Installation.

From 1980 to 1985, he worked as Senior Engineer of Altawil Maintenance and Operations Management in Saudi Arabia.

He is a Volunteer Officer attached to the Air Fields Construction Regiment of the Sri Lanka Air Force and worked as Officer-In-Charge of the Works Section - Katunayake Base in 1978/1979.
In general, the following are the some of the main items which the designer should consider when researching for the Proper Protection System:

- Type of Occupancy
- Building Construction
- Means of Egress
- Building Set-Backs and Fire Exposure
- Smoke Control
- Fire Detection
- Available Fire Extinguishing Systems
- Cost

Type of Occupancy

Occupancy is the purpose for which a building, or part thereof, is used or intended to be used. The type of occupancy is one of the most important factors, that the designer should consider in fire protection planning. In general, fire codes categorize buildings into specified groups depending on the activities inside the buildings, sizes of floor areas, severity of fire that might occur etc. Accordingly fire protection requirements will vary from group to group. When considering the type of occupancy, the designer should consider the following aspects:

- The number of people who will occupy the building, their activities within the building.
- Industrial process.
- Fire properties (eg. ignitability, flammability, spread of fire etc.) of raw materials, by products, finished products, packing materials etc.
- Size of building.
- If there is a mixed occupancy, area covered by each occupancy and their relative locations.

Building Construction

Building construction is generally of 4 types, or of combinations of these four types:

- Wood frame construction (all combustible).
- Ordinary masonry construction (walls are generally masonry, floors and roofs are combustible materials).
- Non-combustible (the walls and roofs are non-combustible).
- Fire resistant (the building walls and roofs will contain a fire for a period of 3 hours or more).

The selection of proper construction materials will:

- Reduce the fire hazards.
- Permit to use larger building areas for certain types of occupancies (most of the building codes permit larger building areas when the fire resistance of the construction is increased).

When selecting construction materials, the designer must satisfy fire resistance requirements as specified by the local authorities; for example, CMCFS requires two hours fire resistance construction for shops, factories, workshops and similar buildings. When a building is on fire it is very important for fire fighters to know its structural stability. The fire departments attack can be organized accordingly. Furthermore, the designer may have to consider the following items in details in fire protection planning:

- Fire walls
- Fire partitions
- Interior finishes

Fire Walls \(^2\) : In addition to the occupational requirements, sometimes fire codes demand the construction of fire walls to act as barriers to fire spread. In general, fire walls are self-supporting and should be designed so as to maintain structural integrity even in cases of complete collapse of the structure on either side of the wall.

Fire walls must be extended above the combustible roofs when these are erected next to each other.

As shown in the figure 1, some codes specify a parapet wall length of 600mm, but in general 450 mm parapet walls are considered standard. However, it must be noted that greater heights are used when the walls are over 16 m or 20 m in length. When both sides of fire walls are combustible, the spreading of fire can be stopped by extending the walls of the building or by construction a T-section at the end of the wall. It is not required to extend fire walls through fire resistive roofs.

Fire Partition : Fire partitions are constructed only upto the roof level and they are used to divide the floor areas.

Interior Finish : One of the main characteristics of determining the fire hazard of a building
that the designer must consider is the interior finishes of the building. The National Fire Protection Association (hereinafter referred to as NFPA) identifies the following characteristics of interior finishes relevant to the fire problems:

- Spread of fire
- Contribute - fuel to the fire
- Develop smoke and noxious gases when burning

Usually, in industrial buildings fire problems pertaining to interior finishes will include the lining and/or covering of ducts, utility shafts, acoustical insulation and protections against wear and abrasion.

As far as interior finishes are concerned, the designer shall take into consideration the following:

- Manufacturer's recommendations/Instructions
- Requirements of the fire code (NFPA life safety code provides invaluable guidelines in this regard).

Means of Egress

In any fire protection system, most important life safety consideration is the design of the means of egress. In other words, in case of fire, how occupants can be provided with safe exits before they are endangered by fire, smoke or panic.

When designing of egress the designer should consider factors such as the type of occupancy (residential, industrial, hospital etc.), occupancy load, number of exits and exit width and the travel distance.

In accordance with the OMQFS requirements, there shall be at least two openings remote from each other and leading to exits, from every room or enclosed space in which the total occupant load exceeds the maximum permissible occupant load for one door as listed in the table 1.

<table>
<thead>
<tr>
<th>Types of Occupancy</th>
<th>Maximum Occupant Load with one door</th>
</tr>
</thead>
<tbody>
<tr>
<td>High hazard</td>
<td>10</td>
</tr>
<tr>
<td>Godowns, storage buildings</td>
<td>50</td>
</tr>
<tr>
<td>Shops, Departmental stores and business premises</td>
<td>75</td>
</tr>
<tr>
<td>Factory buildings without high hazards</td>
<td>50</td>
</tr>
<tr>
<td>Educational Buildings</td>
<td>75</td>
</tr>
<tr>
<td>Hotels, Boarding houses, Hostels etc.</td>
<td>20</td>
</tr>
</tbody>
</table>

Table 1

Types of occupancy and related maximum occupant load with one door (OMQFS)
NOTE: Table 1 should be read in conjunction with other general fire safety requirements required by ONCF.

The travel distance is defined as the furthest point on a storey to an exit. The travel distance will be one of the main criteria to decide on locations and number of exits. It is interesting to study how fire codes arrive at values for travel distances. Research work done by the London Transport Executive shows that people may be discharged through a passage-way at the rate of 40 persons per minute per unit width (unit width was taken as 533 mm being the width across the shoulders of an average man). Further, their study shows that when considering this discharge rate with degree of crowding, sizes of passages, space, the speed of movement will be 12 - 18 m per minute. The acceptable evacuation time of a building is considered to be 24 minutes. Therefore, the speed of 12 - 18 m per minute represents travel distances of 30 m and 46 m. As per NFPA requirements, the travel distance for general industrial buildings, shall not exceed 30 m except where the building is completely protected by an automatic sprinkler system. For such buildings, travel distance can be increased to 46 m. Regardless of the size every high hazard building must have at least two separate and remote exits with a maximum of 24 m travel distance to an exit.

For industrial buildings, ONCF requires no person shall travel a distance more than 30 m to an exit from any point of the building.

Fig. 2: Principles of exit safety.
In addition to the above mentioned requirements, with regards to means of egress, the designer should consider the following:

- Exits must be unobstructed
- Width of exits (1m minimum)
- Clearly marked exit direction signs
- Illumination of the means of egress in emergency conditions
- Basement staircases must not be continuous to serve upper storey or vice-versa.
- Exit doors and doors providing access to exit shall open in the direction of exit travel.
- Protection of exit against fire and smoke as required by the code/regulation.
- To protect lives under panic, dark and smoky conditions. The maximum width of staircases shall not be more than four units of width, unless divided by handrails into sections of not less than two units of width (4) or more than four units of widths (unit width = $\frac{1}{4}$ m).

Figure (2) illustrates some of the principles of exit safety.

Building Set-Backs and Fire Exposure

Building codes specify a minimum distance from boundaries of the premises to external walls of the building due to the following:

- To avoid spread of fire by radiation via openings to combustible materials on the face of an adjacent building
- To provide adequate access facilities for the fire brigade in case of a fire.

In general, when the designer has to plan a building in a limited space he will confront a basic problem i.e. to satisfy the day lighting requirements for any habitable rooms by providing window openings on external walls while maintaining the minimum required distance from the boundary to reduce the radiation hazards.

As a guideline, OMFCS requires a minimum of 6 m from all boundaries to external walls for industrial construction with 2.4 m height of fire resistance boundary wall. However, this minimum distance depends on so many factors such as occupancies of the industrial facility and neighbouring facilities, height of the boundary wall, openings on external walls, fire resistance of the construction work etc. The fire department personnel of the OMFCS visit the site and decide on set-back distance by considering the above mentioned factors when there is a request for approval of drawings.

Furthermore, fire gaps are required to be maintained between buildings and storage areas within the premises to avoid spread of fire.

In relation to exposure to hazards, the designer has to consider not only spread of fire from/to adjoining buildings but also spreading fire from storey to storey. Fig. 3 illustrates the fire behaviour which the designer should consider in relation to vertical/horizontal separation of an external wall.

Traditionally, it was considered that if the windows in adjacent storeys were separated by at least 900 mm of fire resisting walls between the top of one window and the sill of the window above or if non-combustible fire resisting projection not less than 610 mm wide was provided at floor level, fire would be prevented from spreading from floor to floor via the windows. However, it must be noted, that this would not prevent ignition of flammable materials, such as curtains close to the windows of a room above.

Smoke Control

When designing a fire protection system for a building project, one difficulty is to find a method(s) to control the amount of smoke in the building in case of fire. Basically, a smoke control system has two aims:

- To keep smoky gases and flames away from the approaches to any fire, allowing it to be seen from a distance and to be fought more easily, more safely and more quickly.
- To protect the building's structural integrity by releasing heat from inside the building. (Note that the airflow necessary for ventilation allows the fire to continue growing unless appropriate action is taken by the fire fighting personnel).

The important factor to consider in designing a smoke control system is the geometry of the building in question because different geometries present different problems.
Multi Compartment Buildings: The simplest method which can be used in this type of building to control smoke is to use smoke doors in order to isolate lengths of corridor or stairwell, so that smoke entering one length does not affect its neighbours. One other method is pressurization. In this method, air is pumped in to the escape route (usually a stairwell) to maintain a pressure sufficient to oppose the buoyance of hot gases on the fire floor.

Large undivided volume buildings: Usually, large undivided volume buildings are industrial buildings and warehouses. In this type of buildings, designers generally use smoke control system called "Smoke Ventilation". The intention of this system is to allow the smoke to reach the ceiling/roof level leaving clean air near the floor to allow people to move freely. Fig. 4 shows the principles involved in this system and boundaries can be screened

---

Fig. 3: Fire behaviour and the external wall, vertical/horizontal separation.

---

Fig. 4: Principles of system needed to contain smoke in a well defined layer.
as shown. Smokey gases are removed from the reservoir at least as rapidly as they enter from below, either mechanically (using fans) or naturally.

Fire Detection

Early detection of a fire definitely reduces the fire-fighting effort required to extinguish the fire. Depending on the situation, the designer must have to consider designing of alarms and detector systems with or without automatic extinguishing systems. When appropriate, the designer can select an automatic detector system using one or a combination of the following detector types:

- Heat Detectors - Sensitivity to abnormally high temperatures.
- Smoke Detectors - Sensitivity to visible or invisible particles of combustion.
- Flame Detectors - Sensitivity to the infra-red ultraviolet or visible radiation produced by the fire.

Available Fire Protection Systems

The following sections will briefly discuss (with reference to the NFPA Standards) some of the most common fire protection systems employed in industrial facilities.

Portable Fire Extinguishers

At the start most fires are relatively small and could be easily extinguished in their incipient stage, provided the proper type of extinguishing agents in adequate quantities are readily available and can promptly be applied. Portable fire extinguishers are designed to fulfill this need.

To specify an extinguisher the designer needs to assess the likely nature of a fire at each location. Extinguishers must therefore, be specified according to the type, size and intensity of the fire that might be encountered at a particular location.

The NFPA extinguisher standards divides fires into the following four classes in order to show the proper extinguishers to be used:

Class A: Fires involving ordinary combustible materials, such as wood, cloth, paper, rubber and plastics.

Class B: Fires involving flammable liquids, oils, greases, oil base paints, lacquers and flammable gases.

Class C: Fires which involve energized electrical equipment where the electrical non-conductibility of the extinguishing media is of importance (when electrical equipment is de-energized extinguishers for Class A or B fires may be used safely).

Class D: Fires involving combustible metals, such as magnesium, titanium, zirconium, sodium, lithium and potassium.

Fire extinguishers are labelled with the letters A, B, C, or D indicating the classes of fire in which they should be used. In some cases fire extinguishers can be used on more than one class of fire. For example the A,B,C, or multi purpose dry powder extinguisher, is suitable for 3 classes of fire. However, it must always be remembered that a multi purpose extinguisher will be better on one type than on others. For instance, the best extinguishing agent for a class "A" fire is water, for although dry powder will work, it is not as effective as water since the powder has no cooling power but only cuts off the oxygen.

Distribution of Fire Extinguishers

One of the questions that is frequently asked is, how many extinguishers are needed and where should they be located? The answer is dependent upon the nature of the hazards and the general layout of the building.

The size and type of hazard determines how many extinguishers are needed.

In general fire extinguisher location should be selected so as to:

- provide uniform distribution of extinguishers throughout the building.
- provide easy accessibility.
- be relatively free from obstruction by stored goods and equipment.
- be close to the normal path of travel.
- be near entrance and exit doors.
- be free from potential physical damage.
- be readily visible.

The tables (2) and (3) are guides for determining the minimum number and rating of extinguishers for Class A and B fires.
Class C fires are usually either Class A or Class B fires involving energized electrical wiring. Extinguishing equipment for Class D fires should be located no more than 25 ft from Class D hazards.

### TABLE 2
Fire Extinguisher Size and Placement for Class A Hazards

<table>
<thead>
<tr>
<th>Basic Minimum Extinguisher Travel Distances for Area</th>
<th>Maximum Light Hazard Occupancy*</th>
<th>Ordinary Hazard Occupancy*</th>
<th>Extra Hazard Occupancy*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rating Specified</td>
<td>3,000 sq ft</td>
<td>4,500 sq ft</td>
<td>6,000 sq ft</td>
</tr>
<tr>
<td>1 A</td>
<td>75 ft</td>
<td>9,000 sq ft</td>
<td>11,250 sq ft</td>
</tr>
<tr>
<td>2 A</td>
<td>75 ft</td>
<td>11,250 sq ft*</td>
<td>11,250 sq ft*</td>
</tr>
<tr>
<td>3 A</td>
<td>75 ft</td>
<td>11,250 sq ft*</td>
<td>11,250 sq ft*</td>
</tr>
<tr>
<td>4 A</td>
<td>75 ft</td>
<td>11,250 sq ft*</td>
<td>11,250 sq ft*</td>
</tr>
<tr>
<td>6 A</td>
<td>75 ft</td>
<td>11,250 sq ft*</td>
<td>11,250 sq ft*</td>
</tr>
<tr>
<td>10 A</td>
<td>75 ft</td>
<td>11,250 sq ft*</td>
<td>11,250 sq ft*</td>
</tr>
</tbody>
</table>

*11,250 sq ft is considered a practical limit.
† Protection requirements may be fulfilled by several extinguishers of the minimum specified rating with the approval of the authority having jurisdiction.

### TABLE 3
Fire Extinguisher Size and Placement for Class B Hazard Excluding Protection of Deep Layer Flammable Liquid Tanks

**A. FOR EXTINGUISHERS LABELLED BETWEEN 1955 AND JUNE, 1969**

<table>
<thead>
<tr>
<th>Type of Hazard</th>
<th>Type of Extinguisher</th>
<th>Minimum Travel Distance to Extinguishers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>4 B</td>
<td>50 ft</td>
</tr>
<tr>
<td>Ordinary</td>
<td>8 B</td>
<td>50 ft</td>
</tr>
<tr>
<td>Extra</td>
<td>12 B</td>
<td>50 ft</td>
</tr>
</tbody>
</table>

**B. FOR EXTINGUISHERS LABELLED AFTER JUNE 1, 1969**

<table>
<thead>
<tr>
<th>Type of Hazard</th>
<th>Type of Extinguisher</th>
<th>Minimum Travel Distance to Extinguishers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>5 B</td>
<td>30 ft</td>
</tr>
<tr>
<td>Ordinary</td>
<td>10 B</td>
<td>30 ft</td>
</tr>
<tr>
<td>Extra</td>
<td>20 B</td>
<td>50 ft</td>
</tr>
</tbody>
</table>

Note.—Fire extinguisher ratings (ex. 1-A, 4-A) given in the tables (2, 3) are standard NFPA ratings which are based on tests carried out by the Underwriters Laboratories for the purpose of evaluating fire extinguisher performance.
Standpipe and Hose Systems

A standpipe and hose system is an arrangement of pipes and hose outlets providing a means for manual application of water to fires in buildings.

Types of Systems

Depending on the situation, the following standpipe systems are commonly used in industrial premises:

- Wet standpipe system with the supply valve open and water pressure maintained at all times. This is the most commonly used and desirable type of system.
- Standpipe system so arranged through the use of approved devices as to admit water to the system automatically by opening a hose valve.
- Standpipe system arranged to admit water to the system through manual operation of a remote control device located at each hose station.
- Dry standpipe system having no permanent water supply, but with connections and shut-off valves for Fire Department hose and equipment connection.

Water Supply for Standpipe System

The water supply for standpipe system depend on the size, number of hose streams and the required throw of these streams. Standpipes other than dry standpipes shall have a reliable water supply. Acceptable water supplies include the following:

- Municipal water system (if available), with adequate pressure.
- Automatic fire pumps.
- Manually controlled fire pumps with pressure tanks.
- Gravity tanks.
- Manually controlled fire pumps operated by remote control devices which are located at each fire hose station.

Sprinkler Systems

There are situations where fire cannot be reached with hose streams. In addition to that, fire extinguishers and hose streams have very little value unless a fire is discovered in its early stage. Although fire control can be achieved by improving building construction, the automatic sprinkler system is the system which can be reliably depended upon for earlier fire detection and subsequent complete extinguishing or at least prevention of spreading.

Sprinkler System Operation

The automatic sprinkler system is a system which is activated by heat from a fire and which will then discharge water over the fire area. In any sprinklered building, the most readily identifiable part of the system is the sprinkler head, which is the point where water is discharged onto the fire. Sprinkler heads are equipped with defectors, to provide a uniform discharge pattern. Water for the sprinkler system must be taken from a reliable source such as a city main, a gravity feed line or other storage device. The water passes through a sprinkler control valve and water flow alarm and then through piping which distributes it to the individual sprinkler head.

Classification of Occupancies

For the purpose of evaluating hazards, the following three main classifications are recognized by the NFPA Sprinkler Standard:

a. Light Hazard Occupancies

Occupancies where the quantity and/or combustibility of materials is low and where fires have a relatively low rate of heat release. Examples are education facilities, public buildings, offices (including Data Processing installations) and commercial facilities.

b. Ordinary Hazard Occupancies

Group 1: This group covers occupancies where combustibility is low, the quantity of combustibles is moderate, stock piles of combustibles do not exceed 2.4 m in height and potential fires have moderate rates of heat release (examples are canneries, laundries and electronic plants).

Group 2: Occupancies where the quantity and/or combustibility of the contents is moderate, stock piles do not exceed 3.7 m in height and potential fires have moderate rates of heat release (examples
are cereal mills, textiles plants, printing and publishing plants and shoe factories).

Group 3: Occupancies where the quantity and/or combustibility of the contents is high and potential fires have high rates of heat release. (examples are paper manufacturing and storage warehousing).

c. Extra Hazard Occupancies

Occupancies where the quantity and/or combustibility of materials is very high (examples are chemical processing or manufacturing explosives and pyrotechnics manufacturing, and woodworking with flammable finishing).

Types of Sprinkler System

The following are the types of sprinkler systems commonly used for fire protection:

- **Wet-pipe System**

  This is the most common type used to protect buildings. This system consists of automatic sprinklers which are attached to a piping system filled with water and pressurized at all times. When a fire occurs, sprinklers are individually activated by the heat, and water flows through these sprinklers immediately, covering the fire endangered area (sprinklers in non-affected areas remain inactive).

- **Dry-pipe System**

  The dry-pipe system is often installed in buildings where the surrounding temperature would cause the water in the pipe to freeze. In this system, automatic sprinklers are attached to a pipe system which contains air or nitrogen under pressure. When the sprinklers are activated by heat the pressure is reduced, the dry valve is opened, the water displaces the pressurizing medium and then flows through the activated sprinklers.

- **Pre-action System**

  This system is very similar to the dry-pipe system, but it may or may not be under pressure. When a fire occurs, heat sensors or detectors allow the water to flow into the piping system and it is discharged through automatic sprinklers opened by the heat of the fire.

- **Duluge System**

  A duluge system will be installed in areas that are subject to high fire hazard or where rapid spread of fire is possible. This system is very similar to the pre-action system except that all sprinklers are permanently open.

Designing of Sprinkler System

NFPA provides pipe schedules to designers to be used in the design of sprinkler systems. However, for large systems, hydraulically designed systems are generally far more economical since in most cases hydraulic designs allow the use of substantially smaller pipe diameters. For small application, systems sized according to the regular pipe schedule are more suitable.

Fire Department Connection

It is always recommended to install one or more fire department connections in the supply side of the sprinkler or standpipe system. The purpose of the fire department connection is to allow the fire department to connect their pumps and pump water into the building fire protection system. This provides a desirable auxiliary supply for maintaining the required system pressure.

Fire department connection size and specifications must be identical with local fire department hose connections.

Special Fire Protection Systems

There are buildings (for example: computer rooms, magnetic type-storage vaults, electronic equipment and control rooms, and special storage areas for art work and books) where water cannot be used as an extinguishing agent because of possible water damage to installed equipment and valuable stored items in those buildings. Usually designers recommend carbon dioxide and halogenated (for example Halon) extinguishing systems to protect such facilities.

Cost

When discussed the cost of fire protection systems, for most people fire is something
that only happens to others. Fire protection system is like everything else in a building, it must be shown to the client so that it will pay for itself. The following are some of the ways where expenditure of fire protection systems can be justified.

- Consideration of danger to life as result of fire.
- Time/materials/business losses as a result of fire.
- Demonstration of how cheaper construction can be used and areas can be larger if protected by automatic fire protection system.
- Depending on the type of occupancy, building construction, fire exposure and fire protection system installed, the insurance agencies allow discounts on fire premiums. For example, Sri Lanka insurance Corporation allows maximum of 30% on the fire premium of tea factories provided they satisfy the fire protection requirements required by the Corporation. It is recommended that the designer discuss the allowances/discounts which can be obtained on fire premium, with the officers of the insurance agency prior to the completion of the fire protection planning.

Acknowledgement

The author wishes to acknowledge the assistance rendered by Mr. K.M.I. de Silva (Chief Fire Officer, Colombo Municipal Council) in the preparation of this paper.

References

(10) "Building Regulations 1977" published by the Danish Ministry of Housing.