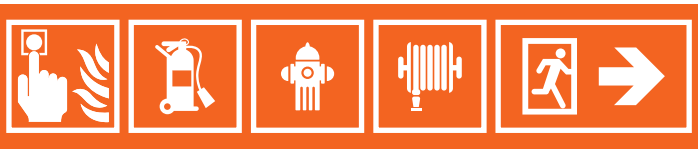
PROJECT ON PROMOTING BUILDING SAFETY FOR DISASTER RISK REDUCTION

BSPP

JICA

FIRE SAFETY



DESIGN GUIDEBOOK

Public Works Department
Bangladesh

FIRE SAFETY DESIGN GUIDEBOOK

PUBLIC WORKS DEPARTMENT

PREPARED UNDER

PROJECT ON PROMOTING BUILDING SAFETY FOR DISASTER RISK REDUCTION (BSPP)

A TECHNICAL COOPERATION PROJECT BETWEEN PWD AND JICA

2021

Published by:

Public Works Department

Purta Bhaban, Segunbagicha

Dhaka-1000

STRICTLY FOR OFFICIAL USE

First Edition
November 2021

The contents of this book are related to design and construction process generally undertaken by Public Works Department which have been described hereinafter in brief theoretical form with examples as guidelines. As such NO chapter, article, clause, sub-clause thereof, be referred to as VALID DOCUMENTS in the event of any arbitration, litigation, dispute, claim case, whatsoever secured, made or claimed by any person as the case may be under any circumstances. However, this may be used by other Govt. departments, private bodies and individuals also at their own discretion.

Utmost care has been taken to overcome printing and other mistakes. Even then there may always be chances of unintended mistakes.

Any mistakes and suggestions to update/ revise may please be addressed to:

The Chief Engineer, Public Works Department.

Price: Taka. 1000.00

Designed, Processed and Printed by:

Overprint
531/1, West Nakhalpara
Tejgaon, Dhaka-1215
Bangladesh
www.overprintbd.com

FOREWORD

Bangladesh is situated in one of the most tectonically active regions of the world where three tectonic plates, namely: the Indian plate, the Eurasian plate and the Burmese plate, met. Over the last two hundred and fifty years, Bangladesh has experienced eight major earthquakes of a magnitude over 7.0 on the Richter scale. Due to its proximity to the plate boundaries, active faults and impact of past earthquakes in and around Bangladesh, the probability of occurrence of strong earthquakes is considered high.

The risks of loss of life and damage to properties by an earthquake are almost entirely attributed to man-made structures. The process of rapid urbanization and expansion of several cities, especially Dhaka, Chattogram and Sylhet, during the last 30 years, with most of the buildings being poorly designed and constructed, has been a big concern.

The first edition of the Bangladesh National Building Code (BNBC) was published in 1993 and was enacted in 2006. PWD (Public Works Department) has been following the Code of the American Concrete Institute (ACI) to design reinforced concrete buildings. But its strict adherence to the latest codes, especially the seismic design provisions, have come into effect very recently. As a result, many existing buildings do not meet the seismic requirements of the current BNBC 2020. This necessitates retrofitting of the vulnerable buildings.

PWD has been facing difficulties in taking up projects to retrofit existing vulnerable public buildings due to a lack of technical know-how. To overcome the deficiencies, PWD had taken up two projects with technical cooperation from JICA titled, 1. “Project for Capacity Development on Natural Disaster Resistant Techniques of Construction and Retrofitting for Public Buildings in Bangladesh (CNCRP, 2013-2017)”, and 2. “Project on Promoting Building Safety for Disaster Risk Reduction (BSPP, 2017-2021)”. This has significantly enhanced the capacity of the engineers of PWD for seismic assessment and retrofitting of existing vulnerable buildings.

One of the important outputs of those two projects were the following eight manuals and guidebooks:

1. Manual for Seismic Evaluation of Existing Reinforced Concrete Buildings (First Edition: CNCRP, 2015. Second Edition: BSPP, 2021).
2. Manual for Seismic Retrofit Design of Existing Reinforced Concrete Buildings (First Edition: CNCRP, 2015. Second Edition: BSPP, 2021).
3. Manual for Retrofit Construction and Supervision of Reinforced Concrete Buildings (First Edition: CNCRP, 2015. Second Edition: BSPP, 2021).

4. Manual for Seismic Design of Reinforced Concrete Buildings (First Edition: CNCRP, 2015. Second Edition: BSPP, 2021).
5. Manual for Vulnerability Assessment and Damage Prediction of Reinforced Concrete Buildings against Non-Seismic Hazards (First Edition: CNCRP, 2015).
6. Fire Safety Design Guidebook (First Edition: BSPP, 2021).
7. Handbook for Architectural Design Work Considering Seismic and Other Issues (First Edition: BSPP, 2021).
8. Handbook of Geotechnical Engineering: Assessment of Bearing Capacity, Liquefaction Potential and Slope Stability (First Edition: BSPP, 2021).

It is evident from the above list that the manuals or guidebooks covered a range of technical issues and subjects. Apart from assessment and retrofitting of buildings, they also covered design of new buildings, construction & quality control, fire safety design, geotechnical issues for foundation design, and architectural design works taking into consideration seismic and other safety issues. All of these manuals/ guidebooks have been helpful to the engineers and architects in their design and construction work and making safe and disaster-resilient buildings, particularly against earthquakes and different natural and man-made hazards.

These manuals and guidebooks will not only help the engineers of PWD and architects of the Department of Architecture (DoA) but also the professionals of other organizations, including those in the private sector. These are going to be useful in designing and constructing new buildings, assessing and retrofitting existing vulnerable buildings, ensuring safety and resilience against disasters related to earthquakes and other hazards.

I deeply appreciate the members of the Editorial Advisory Board consisting of respected members from Japan and Bangladesh for their valuable contribution to the eight manuals prepared under CNCRP and BSPP. I also thank both Japanese and Bangladeshi team members of CNCRP and BSPP for their assistance in writing the manuals and guidebooks.

Finally, I want to thank the Government of Japan, JICA and the Government of Bangladesh for their whole-hearted support and cooperation throughout the project phases.

(Mohammad Shamim Akhter)
Chief Engineer, PWD
November, 2021

PREFACE

The building fire in Banani, Dhaka, in 2019 took away dozens of precious lives. In addition, incidents of fire occur in garment factories, almost regularly claiming many lives. However, if the buildings were designed with safety in mind against fire, the damage could be minimized, and many lives could have been saved. Bangladesh National Building Code (BNBC) describes the standards for various safety measures in design. Let us all be conscious about the need to conforming to the standards and make an increasing number of buildings safe against fire.

This guidebook illustrates with figures and tables the main fire safety standards of BNBC. We hope that our understanding of the BNBC codes will be deepened by unravelling its meanings and different stipulations.

This guidebook presents nine Chapters and an Appendix.

Chapter 1, gives the basic concept and the basic features of fire-safety design with particular notes on how to retrofit the existing buildings that are vulnerable to fire hazards;

Chapter 2 has the definition of the terms related to the fire safety design and the general requirements;

Chapter 3 focuses on the planning of stairways as a main means of egress. Stairway is an important evacuation route for the safe evacuation of many people at the time of emergency.

Chapter 4 illustrates a smoke-proof enclosure to prevent the spread of smoke and fire. The smoke proof enclosure or the compartment is the basis of fire safety design, without which the various fire extinguishing equipment will not work.

Chapter 5 focuses on the electrical cable, which is often the main source of fire and explains the notices to design.

Chapter 6 mentions the automatic sprinkler system. A system that automatically sprinkles water and extinguishes fires is effective for fire extinguishing activities and minimizes loss and damage.

Chapter 7 mentions the standpipe system. This system, with a higher fire extinguishing power than a fire extinguisher, has the potential to extinguish a fire that cannot be extinguished by a fire extinguisher.

Chapter 8 refers to a portable fire extinguisher that serves as the initial fire extinguishing tool. The initial activity is one of the important keys to effectively extinguish a fire. The proper placement of the portable fire extinguisher can become most beneficial in an emergency.

The last Chapter 9 describes the detector. Only the detectors can identify fires in places where the spaces are not constantly monitored by humans. In order to minimize loss and damage, it is essential to detect a fire by a detector and extinguish it before spreading.

The Appendix contains the checklists, the case studies and the design flow for fire safety design. The checklists are separated for architects and for equipment designers to provide a chance to check the main items of the fire safety design. The case studies represent the design examples with good and bad instances. Finally, the flowchart of the fire safety design gives a complete view of the total design.

We hope that a copy of this guidebook at the desk of a fire-safety designer will furnish her/him with all necessary references that is required. It is expected that this will give some valuable hints for an improved fire safety design for all concerned people.

Mr. Taku Shimada
Senior Fire Expert,
JICA Expert Team, BSPP

ACKNOWLEDGEMENT

Authors

Mr. Taku Shimada
Senior Fire Expert,
JICA Expert Team, BSPP

Md. Sayedul Islam
Senior Fire Expert,
Advisor to BSPP

Md. Ashraful Hoque
Additional Chief Engineer
PWD E/M P&D, Dhaka
Advisor to BSPP

Ms. Rafia Begum
Superintending Engineer (C.C)
PWD E/M P&D Circle, Dhaka
WT-6 Team Leader of BSPP

Mr. Biswajit Barua
Superintending Architect
Department of Architecture, Circle-05, Dhaka
WT-6 Deputy Team Leader of BSPP

Associate Authors

Ms. Rasmin Akter Jui
Architect
Project Architect, BSPP

Mr. Mohammad Omar Faruque
OGH Bangladesh, Dhaka
Contributor to BSPP

Ms. Joyeeta Biswas
Sub-divisional Engineer,
PWD (E/M) P&D Division-2, Dhaka
WT-6 Member of BSPP

Mr. Nahid Hasan Lizon
Assistant Engineer
PWD E/M P&D Division-1, Dhaka
WT-6 Member of BSPP

CONTENTS

Chapter 1. Introduction

1.1. Purpose

This guidebook is prepared for Architects, Civil Engineers and MEP Engineers.

BNBC (Bangladesh National Building Code), has dedicated a chapter (Part 4) titled “Fire Protection” containing detailed provisions for fire safety design and construction.

A recent fire (2019) in a high-rise building at the busy business district of Banani, Dhaka, caused as many as 25 deaths and 70 injured. The fire and smoke spread through the stairway to the upper floors, intensifying its fury and impact. It is believed that the cause of the high rate of fatality and damage was due mainly to this factor, i.e., the people lost sight of their evacuation route because the stairway was filled with smoke. The basic requirement of fire safety is to keep evacuation routes free from any obstruction, including fire smoke. If evacuation routes were kept functional by having smokeproof enclosures, it could have reduced the effect.

Figure 1. 1 Controlling the Banani fire (Courtesy of Mr. Mohammad Mintu Mian)

This Fire Safety Design Guidebook provides helpful information for adopting fire safety measures right from the design phase. This introductory guidebook deals mainly deals with the most essential aspects of the fire safety design provisions as delineated in BNBC 2020. For a detailed consultation, it is recommended to follow the guidelines of BNBC 2020.

1.2. Present Conditions and Issues

Fire accidents in the country are increasing from year to year. The change in the number of fire accidents per year is shown in Figure 1.2. The number is increasing and is expected to increase with economic development. Besides an increasing trend, it also indicates possible escalation with the rapid growth of the Bangladesh economy.

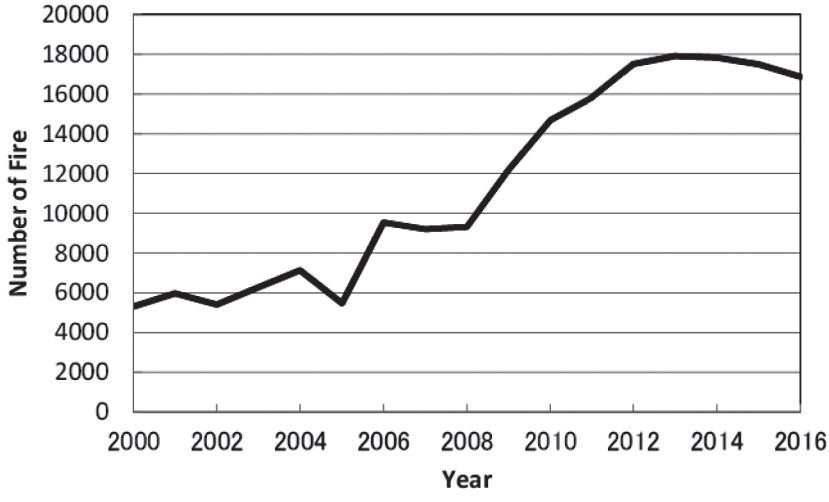


Figure 1. 2 Number of Fire Accidents (source Fire Service and Civil Defence Directorate)

The transition of cause of fire accidents per year is showed in Figure 1.3. The most common cause of fire accident is electrical disorder. Although the total number of fires has been decreasing slightly since 2013, the number of electrical disorders is increasing. The reason is guested to improper wiring connections due to an increase in the number of electrical appliances used and lack of maintenance

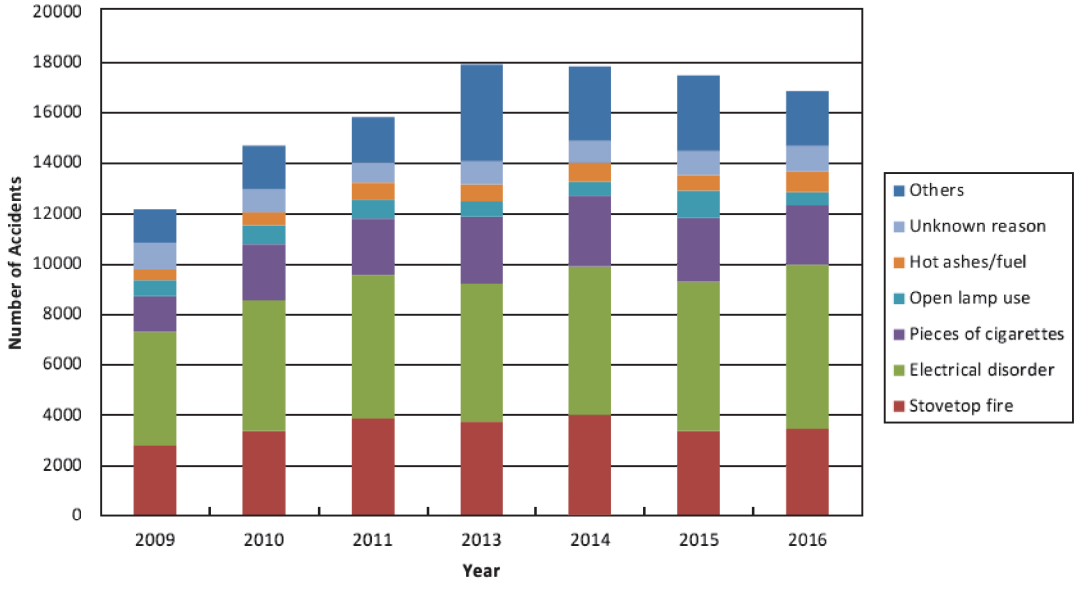


Figure 1. 3 Cause of Fire Accident per year (source Fire Service and Civil Defence Directorate)

The purpose of proper Fire Safety Design is the protection of life and property. This is essential for both new construction and renovation work. It is also a necessary approach for an architect, Civil Engineer and MEP Engineer.

1.3. Fire Safety Design Process

The purpose of fire safety design is to protect human lives and minimize property loss from fire. The fire safety design covers a wide range, from the arrangement of stairs to the installation of fire-extinguishing equipment and constructing fire-resistant structures.

Well-coordinated inputs from the architects, MEP engineers and civil engineers are a prerequisite for a successful fire safety design.

This section will describe the design processes and the roles of different actors.

The roles of engineers and architects in fire safety design are as follows:

- Stairways Design - Architects
- Smoke Proof Enclosure Design - Architect & Civil Engineers
- Electricals Design - MEP Engineers
- Standpipes & Sprinklers Design - MEP Engineers
- Fire Alarms Design - MEP Engineers

To remind the concerned professionals, the work of fire safety design must be carried out in compliance with BNBC stipulations.

The coordination between Architects and MEP Engineers is necessary to decide whether it is better to add separate stairways or install sprinklers, taking into account the budget and plan of the project.

Also, when designing smoke proof enclosures, these should be set up at convenient positions after taking into consideration the plan, installation of equipment, and the structural frame. Therefore, coordination among Architects, MEP Engineers and Civil Engineers are of utmost importance.

The process of Fire Safety Design is as follows:

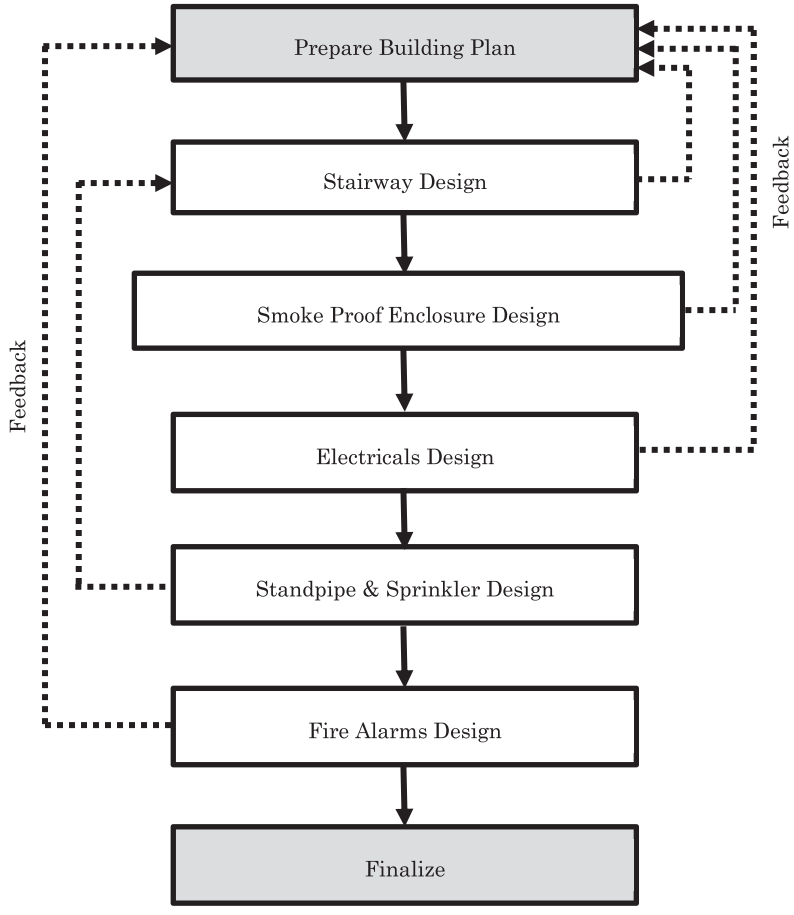


Figure 1. 4 Flowchart of Fire Safety Design Process

Basically, the iterative feedback system aims to eliminate any design inconsistencies and help proceed with the rational design. That is why it is emphasized that a Fire Safety Design should be done in a team. The Architect may play the role of a coordinator or deploy a Project Manager as the coordinator, who will ensure a smooth running of the project.

The higher or larger a building is, the more complicated the fire design is, requiring specialist advice from Fire Experts. As the Fire Experts cannot design everything, Architects, MEP Engineers, and Civil Engineers should jointly proceed with the design as per the advice of the Fire Experts. Figure 1.5 below suggests possible Coordination arrangements.

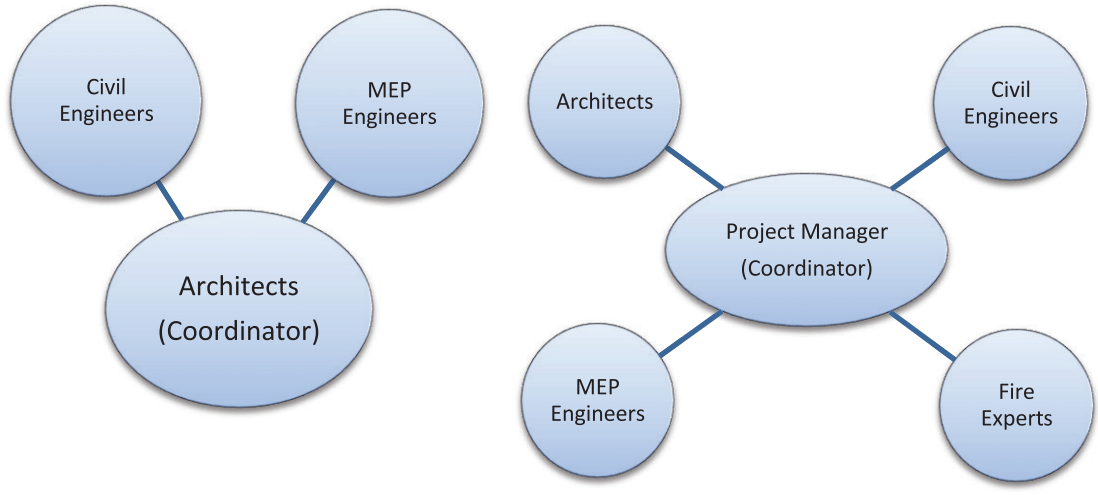


Figure 1.5 Role Network

Finally, the owner (of the building) should be informed about the Fire Safety Design and maintenance methods (Figure 1.6) after the building has been completed. Without proper maintenance, the system will not work when fires occur, and the Fire Safety Design will not make sense. When Design, Construction and Maintenance are executed in harmony, the building can be considered as a fire-safe building.

Figure 1. 6 Three Steps to Make a Building Fire Safe

1.4. Basic Concept of Fire Safety Design

1.4.1. Basic Concept

The basic concept of fire safety is comprised of: Fire Prevention, Fire Spread Prevention, Evacuation, Fire Extinguish, and Maintenance.

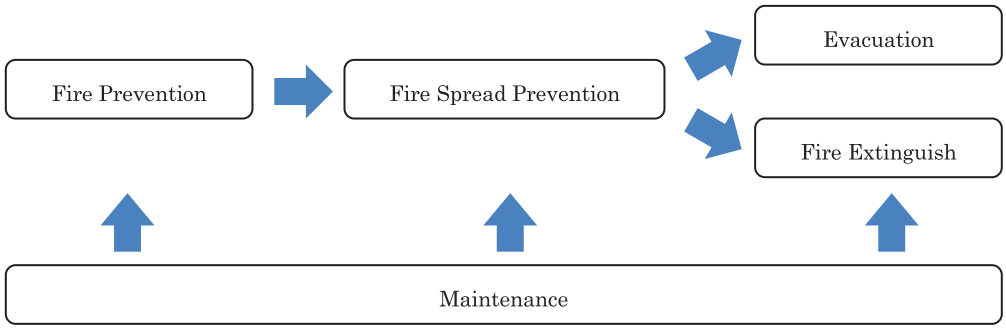


Figure 1. 7 Basic Concept of Fire Safety

Fire prevention means taking measures to prevent a fire from occurring. The main cause of fire in Dhaka are electricity (short-circuits) and fires from the kitchen. Electrical fires are caused by defective wiring and sparks from the distribution board and may burn the accumulated dust. These issues can be improved by protecting the electrical cables with non-combustible materials and by putting the distribution board in a casing to prevent dust from accumulating. In the kitchen, it can be improved by installing a gas leak detector and making the area around the gas range with non-combustible material. (*Ref* Chapter 5)

Fire spread prevention is to minimize fire damage and prevent smoke from entering evacuation routes such as stairways. Rooms with a high risk of fire and shafts for equipment piping can also cause fires to spread to other floors, so they can be improved by installing smoke proof enclosures. In addition, the prevention of smoke entering the stairways can be improved by installing smoke proof enclosures at stairways. (*Ref* Chapter 4)

Evacuation is an action to protect human lives. It is crucial to start evacuation early to the outside without confusion. Early evacuation can be improved by installing detectors and an alarm system. Confusion in evacuation is created mainly due to insufficient capacity of stairways and smoke entering the stairways. The capacity of the stairways can be improved by keeping enough width according to the number of evacuees and installing smoke proof enclosures at stairways. (*Ref* Chapters 3, 4 and 9)

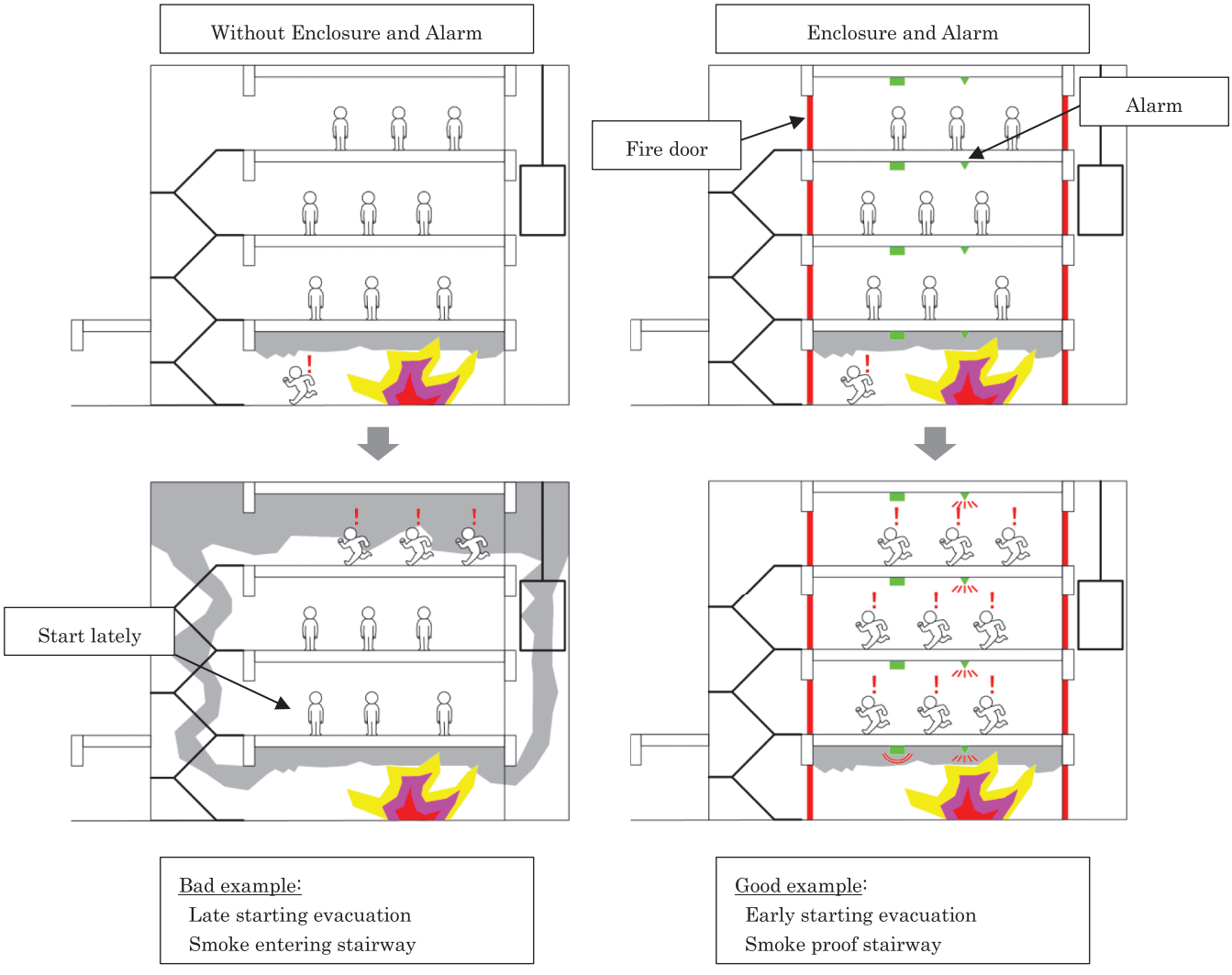


Figure 1. 8 Starting of Evacuation

Fire extinguishing is important to minimize fire damage. In addition to installing fire extinguisher, sprinklers, and standpipes; the proper functioning of the fire extinguishing equipment depends on practice and fire drills by the occupants. The equipment should be installed in easy-to-use positions and locations. (*Ref* Chapter 6, 7 and 8)

Maintenance is to clean the distribution board and electric cables, check the door closer of the fire door to see whether it is broken or not and check the detector and standpipe. Maintenance is the essential foundation to ensuring fire prevention, fire spread prevention, evacuation, and fire extinguishing. If the foundation is not solid, the system will not function effectively. (*Ref* Chapter 5)

For each measure, the concept of Fail-Safe and Fool-Proof is important. **Fail-Safe** is the idea that even if one measure fails, the second measure will make up for it. For example, prepare two stairways (two-way evacuation root) so that even if smoke entering one stairway, evacuees can escape through the other stairway. It is important to be prepared for failure. Also, preparation is

needed so that **Fool-Proof** does not fail. For example, if it is difficult to open the door of the stairways during the evacuation, the evacuation effort will fail. So, if a fire door is installed so that it opens in the evacuation direction, it will be easier to prevent failure.

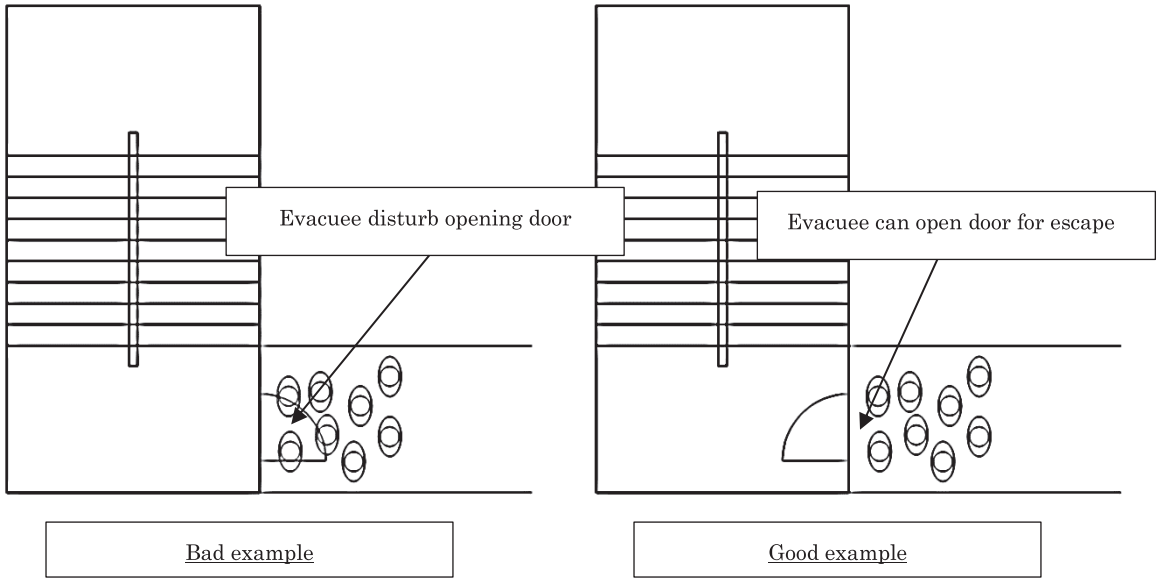


Figure 1. 9 Door Direction

The fire safety design should be conducted in a team. The team may consist of an Architect, an MEP engineer and a Civil engineer. Teamwork requires sharing of information between the members. One of the key information to be shared is about the smokeproof enclosure. From the lessons of the Banani fire, the smoke-proof enclosure was identified as the fundamental aspect of fire safety design. Information about the smokeproof enclosure should be shared in teamwork related to Architectural design, MEP design and Civil design.

Hence, it is recommended that a Smoke-Proof Enclosure Drawing is shared and discussed within the team. This drawing should clarify where to install the smokeproof enclosure and how to evacuate. By sharing the drawing, the possibility of any mistakes or design inconsistencies created by the team members can be reduced, and design quality improvement can be achieved.

1.4.2. Role of Smoke-Proof Enclosure Drawing

By developing drawings of the smokeproof enclosures, it is possible to prevent any defect during the design process by the Architects, MEP engineers and Civil engineers.

1.4.3. Description of Items in the Smoke-Proof Enclosure Drawing

The items to be described in the drawing are as follows.

- Smoke Proof Enclosures
- Fire Doors, Fire Shutters, Non-combustible Doors
- Safety Corridors
- Stairways
- Escape Directions

The safety corridor refers to a corridor that provides an escape route from the rooms to the stairs. If a fire occurs in this corridor, there will be no escape route, so there should be no combustible materials in the corridor. The corridor doors are recommended to be automatic close and made by non-combustible material.

1.4.4. Basic Principles of a Smoke-Proof Enclosure Drawing

Prepare a plan drawing. Draw smoke proof enclosures with a red line on it. Mark the F mark on the fire door, and N mark is a non-combustible door. The safety corridors should be painted in yellowish-green. The stairs should be painted in blue, escape direction should be a green line.

Thus, the smoke-proof enclosure drawing provides an exact safety idea for the design.

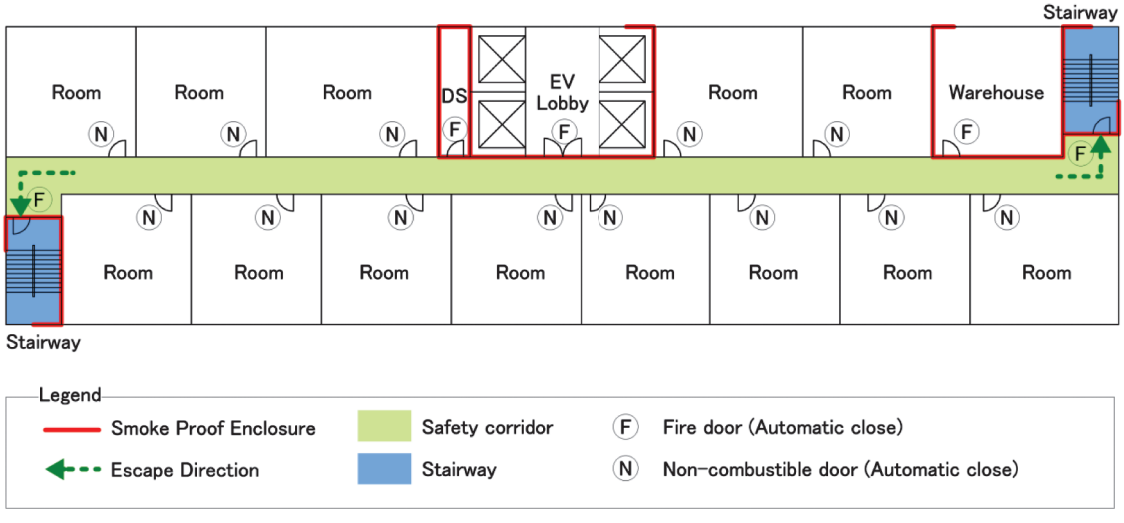


Figure 1. 10 Example of Smoke-Proof Enclosure Drawing

1.5. Proposal for Fire Safety Design of Retrofitting

When renovating existing buildings as adoption of some retrofitting measures is desirable following the BNBC stipulations for fire safety.

The table below proposes some of these steps as a priority when the renovation is carried out.

These steps are quite easy to adopt at the time of renovation and are highly effective.

Fire extinguishers and standpipes are highly important and effective, though; they are excluded from the table below as these are often already installed in existing buildings.

Table 1.1 First Priority Items for Fire Safety Design

Items	Reason
Two-way Evacuation	To facilitate two-way evacuation, the construction of two stairways is to be ensured. Even if smoke enters through one stairway, many lives can be saved by evacuating through the other. (Ref Chapter 3)
Smoke Proof Enclosure of Stairway	It is important to install a Smoke-Proof Enclosure at the stairways. Most of the stairways in Dhaka are partitioned by brick walls, which conform the firewall specifications. If a fire door is installed, the smoke-proof enclosure will be completed. Evacuation from a high-rise building on fire, can take an hour or more. Stairways that are safe from smoke are highly effective in saving lives. (Ref Chapter 4)
Smoke Proof Enclosure of Shaft	Shafts that connect multiple floors, e.g., shafts for electric cables. It is a possible path for smoke to travel and spreading of fire. Since the walls of the shaft are usually made of brick walls, the smoke-proof enclosure is often completed simply by closing the holes with sealant. (Ref Chapter 4)
Distribution Board Update	The distribution board should be overhauled once every 10 years or so. In Dhaka, this is hardly practiced, and some of them gather dust to increase the risk of fire. (Ref Chapter 5)
Automatic Alarm System	The components of an automatic fire alarm system include detectors, control panels, emergency bells, etc. Early detection of fire leads to the early extinguishing of it and starting an early evacuation process. Therefore, it is effective in minimizing property damage and protecting human lives. (Ref Chapter 9)

Chapter 2. General Requirements and Definition

2.1. Definitions

General

1.0. Authority: An organization, office responsible for enforcing the requirement of code(s) or standard(s), or for approving the equipment, material, and installation or procedure. It means here, the Bangladesh Building Regulatory Authority.

2.0. Barrier: A wall or a partition or a floor slab or a ceiling within a building which controls and limits the spread of smoke and fire.

2.1. Fire Barrier: A fire-resistant wall inside a building designed to restrict the spread of smoke and fire. Opening in this wall shall be fitted with fire protected doors or windows.

2.2. Smoke Barrier: A continuous separating element or assembly material designed and constructed to control the movement of smoke.

2.3. Thermal Barrier: A material that will limit the rise of the average temperature of the unexposed surface to not more than 121 °C after 15 minutes of fire exposure complying with the standard time-temperature curve of ASTM E119 Test Methods for Fire Tests of Building Construction and Materials.

3.0. Basement: Means a floor of a building more than 50 per cent of which is situated at a depth of 1 m or more below the crown of the main entry road.

4.0. Building: Means any permanent or semi-permanent structure which is constructed or erected for human habitation or for any other purpose and includes but not limited to the foundation, plinth, walls, floors, roofs, stairs, chimneys, fixed platform, verandah, balcony, cornice, projections, extensions, annexes etc. The term building will also include the sanitary, plumbing, electrical, HVAC, appurtenances and all other service installations of the building which are constructed or erected as an integral part of a building.

4.1. Existing Building: A building erected or officially authorized prior to the effective date of the adoption of this edition of the Code by the concerned authority or law.

4.2. High-Rise Building: Any building which is more than 10-storey or 33 m high from reference datum. Building appurtenances like overhead water tank, machine room, communication tower etc. will not be taken into account in determining the height.

5.0. Compartment:

5.1. Fire Compartment: A space within a building that is enclosed by fire barriers on all sides, including the top and the bottom, to limit the transfer of fire.

5.2. Smoke Compartment / Smoke Proof Enclosure: Any compartment or a room or a control area surrounded by barrier walls within a building structure that is protected from smoke penetration during a fire incident in the building shall be termed as smoke proof enclosure.

6.0. Fire Door: A door that provides a specific degree of fire and smoke protection to the opening where it is placed.

7.0. Exit: A means of egress that provides a protected way of travel separated by construction from all other spaces to a discharge area.

8.0. Horizontal Exit: Crossing a fire barrier of a building or connecting a building in the same level shall be treated as a horizontal exit.

9.0. Outside Stair: A stair with at least one side open to the outer air.

10.0. Panic Bar: A door-hatch arrangement provided with a bar that releases the hatch bolt upon application of force in the direction of egress travel.

11.0. Smoke Detector: A devise capable of sensing visible or invisible particles produced during combustion.

12.0. Travel :

12.1. Travel Distance: Straight line distance between the remotest point of a space of a floor and the exit access door placed thereof.

12.2. Travel Path: Length of a passage from the remotest point of space up to the exit access door placed thereof.

13.0. Tower: A tall, slim vertical structure.

Sprinkler System

14.0. Sprinkler System: The system consists of an array of pipe-works fitted with fusible solder or glass bulbs. This system shall become active at a predetermined temperature, and the required water shall be fed to the system from a source. In the event of fire or smoke, the system shall be automatically activated by sensing the temperature of the fire and discharge water to extinguish it. These devices also actuate an audible alarm automatically.

15.0. Fire Control: Minimizing the size of the fire and the rate of heat release from it by applying or discharging water on it and also pre-wet the nearby combustible (material) to prevent the spread of fire.

16.0. Fire Suppression: A mechanism of controlling the rate of heat-release and its reactivation by direct application of sufficient water or inert gas on fire through fire plume.

17.0. Hydraulic Calculation: A method of calculation in which pipe sizes are selected on a pressure loss basis to provide a prescribed water flow in gal/min/ft^2 or L/min/m^2 at desired pressure.

18.0. Noncombustible Material: A material, no part of which ignites or burns when it comes in contact with fire. Any material conforming to ASTM E136 shall be considered noncombustible.

19.0. Light Hazard Occupancy: occupancies or portion of occupancies where the quality or combustibility of the content is low and one from which a relatively low rate of heat release is expected.

20.0. Ordinary Hazard Occupancies (Group-I): Occupancies or portion of the occupancies where the combustibility is low; quantity of combustible is moderate; stockpiles of the content do not exceed 8 ft. (2.4m), and fire with a moderate rate of heat release is expected.

21.0. Ordinary Hazard Occupancies (Group-II): Occupancies or portion of other occupancies where the quantity and combustibility of content is moderate to high, stockpiles of content with a moderate rate of heat release do not exceed 12 ft. (3.66m) and a stockpile of contents with the high rate of heat release do not exceed 8 ft. (2.4m).

22.0. Extra hazard (Group-1): Occupancies or portion of other occupancies where quantity and combustibility of contents are very high and develops very rapidly spreading fire with no or little combustible or flammable liquid.

23.0. Extra hazard (Group-2): Occupancies or portion of other occupancies, where the quantity of combustibles are moderate to high and highly inflammable, causing rapidly developing and spreading fire and shielding of combustibles is extensive.

24.0. K-factor: It is the identification of sprinkler orifice size, including the discharge characteristics. The K-5.6(80) factor is the nominal value for general purpose application.

Standpipe System

25.0. Fire Department Connection: An inlet connection through which supplementary water can be supplied to automatic standpipe/sprinkler system from fire engine pump installed on a fire tanker at the required system demand.

26.0. Hose Connection: A combination of components or accessories used for the connection of a hose to a standpipe system which includes a hose or hydrant valve with a quick coupling type threaded outlet.

27.0. Construction Type:

27.1. Type-1 and Type-2 constructions: these are the types of construction in which all construction elements/members such as a wall, roof, floor etc. are of approved noncombustible or limited combustible materials.

27.2. Type-3 construction: This is the type of construction in which the exterior wall and structural elements are of approved noncombustible or limited combustible materials. This may also include interior structural components.

28.0. Exit Passageway: An exit way, which includes a hallway corridor or tunnel used as an exit component and separated from other parts of the building.

29.0. Hose Station: An assembly of hose cabinet provided with a hose rack or reel, hose, nozzle and hose connection.

30.0. Feed Main: A part of a standpipe system that supplies water to one or more standpipes.

31.0. Pressure:

31.1. Nozzle Pressure: Pressure required at the inlet of a nozzle that produces the required characteristic of water to be discharged.

31.2. Residual Pressure: The pressure acting on a point in the system with a flow being delivered.

31.3. Static Pressure: The pressure acting on a point in the standpipe system with no flow from this system.

32.0. Rated Capacity: The flow discharged from a device at a designated residual pressure.

Portable Fire Extinguisher

33.0. High-Pressure Cylinder: A cylinder or cartridge containing fire extinguishing gases at a pressure higher than 500 psi (3447 kpa.) at 70° F (21° C).

34.0. Low-Pressure Cylinder: A cylinder or cartridge containing a fire extinguishing agent at a pressure 500 psi (3447 kpa.) or lower at 70° F (21° C).

35.0. Portable Fire Extinguisher: A device containing an extinguishing agent that can be discharged at a high pressure for extinguishing or suppressing a fire that is carried by hand or wheel and operated manually.

36.0. Recharging: Refilling of extinguishing gas or agent at the required pressure for reuse.

37.0. Self-Expelling Fire Extinguisher: A fire extinguisher containing an agent (in a separate container) at sufficient vapour pressure at normal temperature and expels the extinguishing agent automatically when the temperature exceeds the rated limit.

38.0. Stored pressure Fire Extinguisher: A self-expelling fire extinguisher in which the extinguishing and expelling agent are stored in a single container that triggers itself in case of a rise of temperature by the fire.

39.0. Travel Distance: The actual walking distance from any point to the nearest fire extinguisher.

40.0. Water Mist Fire Extinguisher: A portable fire extinguisher containing distilled water under pressure and fitted with a nozzle to discharge the agent in the form of fine spray for extinguishing a fire.

41.0. Wheeled Fire Extinguisher: A portable fire extinguisher supported on a wheeled carriage for transportation to a fire to manually suppress the fire.

Detection System

42. Smooth Ceiling: A ceiling is considered a smooth ceiling where the beam projects less than 4 in. (100 mm) [applicable for the installation of heat detectors} or 8 in. (200 mm) [applicable for the installation of smoke detector] below the ceiling level.

43. Peak Ceiling: A ceiling having a slope on both sides with a ridge at the center is called a peak ceiling.

44. Shed Ceiling: A ceiling having a slope in one direction at a ratio of 1:8 to a horizontal level and a peak ridge at one side is treated as the shed ceiling.

2.2. General Requirement; Building Type and Construction

2.2.1. Occupancy Classification

All buildings shall be classified according to its application, uses and type of occupancy as stated below:

- Occupancy A: Residential
- Occupancy B: Educational Facilities
- Occupancy C: Institution for Care
- Occupancy D: Healthcare Facilities
- Occupancy E: Business
- Occupancy F: Mercantile
- Occupancy G: Industrial Buildings
- Occupancy H: Storage Buildings
- Occupancy I: Assembly
- Occupancy J: Hazardous Buildings
- Occupancy K: Garage
- Occupancy L: Utility
- Occupancy M: Miscellaneous

Each occupancy shall be subdivided according to the specific uses or applications for design development for particular types of buildings. These are as follows:

Table 2. 1 Summary of Occupancy Classification (source Table3.1.1 of Part 3 / BNBC2020)

Occupancy Type		Subdivision	Nature of Use or Occupancy
A	Residential	A1	Single-family dwelling
		A2	Two Families Dwelling
		A3	Flats and Apartments
		A4	Mess, Boarding Houses, Dormitories and Hostels
		A5	Hotels and Lodging Houses
B	Educational Facilities	B1	Educational facilities up to higher secondary levels
		B2	Facilities for training and above higher secondary education
		B3	Pre-school facilities
C	Institution for Care	C1	Institution for the care of children
		C2	Custodial institution for physically capable adults
		C3	Custodial institution for the incapable adults
		C4	Penal and mental institutions for children
		C5	Penal and mental institution for adults
D	Healthcare Facilities	D1	Normal medical facilities
		D2	Emergency medical facilities
E	Business	E1	Offices
		E2	Research and testing laboratories
		E3	Essential services
F	Mercantile	F1	Small shops and market
		F2	Large shops and market
		F3	Refuelling station
G	Industrial Buildings	G1	Low hazard industries
		G2	Moderate hazard industries
H	Storage Buildings	H1	Low fire risk storage
		H2	Moderate fire risk storage
I	Assembly	I1	Large assembly with fixed seats
		I2	Small assembly with fixed seats
		I3	Large assembly without fixed seats
		I4	Small assembly without fixed seats
		I5	Sports facilities
J	Hazardous Buildings	J1	Explosion hazard building
		J2	Chemical hazard building
		J3	Biological hazard building
		J4	Radiation hazard building
K	Garage	K1	Parking garage
		K2	Private garage
		K3	Repair garage
L	Utility	L	Utility
M	Miscellaneous	M1	Special structures
		M2	Fences, tanks and towers

2.2.2. Change of Occupancy

No change shall be allowed in the classification of occupancy or application of any building that would place it in a different class or in different sub divisions of the same class unless approved by the authority.

2.2.3. Mixed Occupancy

A building, when used for more than one occupancy or one purpose and each having a different occupancy class, shall be separated from other occupancies. It shall comply with the requirements of the code for the occupancy it falls in.

2.2.4. Occupancy Separation

A building accommodating different occupancies shall be separated horizontally or vertically or in any other form as to suit the requirement (e.g., provide complete separation.)

2.2.5. Type of Occupancy Separation

The classification of separation of occupancy shall be made as per the following resistance capacity.

a) Four-hour Fire Resistive: The four-hour fire-resistive separation wall or slab shall have no unprotected openings and thus provide fire resistance for at least four hours.
b) 3-Hour Fire Resistive: The three-hour fire-resistive separation wall or slab shall provide a fire resistance of not less than three hours. The total width of all openings in the separation wall of any one storey shall not exceed 25 Percent of the length of that wall in that storey, and no single opening shall have an area greater than 12 m^2. The openings shall be protected with fire-resistance assembly doors or windows, providing fire resistance for at least three hours.
c) Two Hour Fire Resistive: The two-hour fire-resistive separation shall have a fire-resistance rating of not less than two hours. All openings in such partitions shall be protected by a fire assembly door or window of a fire protection rating of at least one and one-half hours.
d) One hour Fire Resistance: The one-hour fire-resistive separation shall give at least one hour's fire protection. All openings in such separations shall be fitted with a fire protection assembly door or window capable of resisting fire for at least one-half hour.

2.2.6. Emergency Escape Option

Each room in the ground, 1st & 2nd floor shall be provided with at least one operable window or door for an emergency escape to an open exterior space. The clear opening size shall be a minimum 600x500 mm in height and width.

2.2.7. Shaft Separation

The vertical openings, including elevator shaft, vent shaft, and other openings, shall be separated with a partition having a fire-resistance rating of not less than 4-hours.

2.2.8. Protection of Horizontal Exit

The horizontal escape route shall be protected by at least 2-hours of fire-rated separation and shall be provided with a self-closing type door of the same fire-resistance rating.

2.2.9. Width

The width of the horizontal exit shall not be less than 1.0m.

2.2.10. Head Room

The clear head room of the horizontal exit shall not be less than 7 ft.-6in. (2285mm) and 6ft.-8in. (2030) where there is a projection from the ceiling above the finished floor level.

2.2.11. Type of Construction by Fire Rating

The construction is classified into two groups (as stated below) and some of the types are determined based on their resistance to fire. The detail is given at Section 4.3.1 of Chapter 4.

- GROUP I: Noncombustible subdivision
- GROUP II: Combustible subdivision

2.2.12. Recommended Types of Construction

2.2.12.1. New Buildings

Types of construction recommended for various buildings on the basis of fire safety area has been given in Table 3.2.1 of Part 3 / BNBC2020 (Fire Resistance Rating Requirements for Barrier Walls and Floor/Ceiling Assemblies between Separated Occupancies (hours)).

2.2.12.2. High Rise Building

A building having a height of more than 33 m (or 23 m as per NFPA) shall be constructed with non-combustible materials. Group II construction shall not be allowed for high rise buildings.

2.2.12.3. Exterior Walls

The fire-resistance rating of the exterior walls shall conform to the provision outlined in the following table.

Table 2. 2 Fire Resistance Ratings in Hours of Exterior Walls for Various Occupancy Groups (source Table 3.2.2 of Part 3 / BNBC2020)

Fire Separation Distance	Occupancy			
	A1, A2, K2, M2	A3, A4, A5, B, C, D, E1, F1, F2, G1, I	E2,, F3, F4, E3, G2, H1	H2, J
Up to 1.5m	1	2	3	4
Greater than 1.5m and up to 3m	N	1	2	3
Greater than 3m and up to 4.5m	N	N	1	2
Greater than 4.5m and up to 9m	N	N	N	1
Greater than 9m	N	N	N	N

N = No Requirement

2.2.12.4. Basement Floor

The basement floor of a building shall be enclosed with fire-resistive construction materials having a 1-hour fire rating. The doors shall also have a 1-hour fire protection rating.

2.2.12.5. Parking Area

The parking area shall be separated by 1-hour fire-resistive construction or protected with an automatic sprinkler system. The 'enclosed' parking areas shall be provided with CO_2, CO gas detection and removal system.

2.2.12.6. Storage Space

The enclosed spaces used for the storage of combustible materials shall be separated from other areas with 1-hour fire-resistive construction.

2.2.12.7. Generator Room

Rooms for generator set shall be provided with a separation quality of at least 2-hour fire-resistive construction, and the exhaust system shall be terminated to the exterior of the building at a safe location.

2.2.12.8. Transformer Room

Rooms used for housing oil-filled transformers for low rise buildings shall be separated from other occupancies by at least 2-hour fire-resistive construction.

Oil-filled transformers for high rise buildings shall be separated from other areas by 4-hour fire-rated construction and shall not be located above ground level, and shall be protected with a fire suppression system.

2.2.12.9. Boiler Room

The rooms meant for hosting boiler or other heat-generating devices shall be separated from other occupancies by a minimum 1-hour fire-rated construction.

2.2.12.10. Atrium

The atrium in a building shall be separated from the rest of the areas of the building by an automatically operable fire curtain having 2-hour fire-resistive ratings.

2.2.13. Prevention of Vertical Propagation of Fire

2.2.13.1. Internal Propagation

The inflow of fire, smoke, fumes and gas through the openings and voids in fire-resistive walls, floors, ceiling shall be prevented by sealing with approved materials having a fire-resistance rating of at least equal to that of floor and wall assembly.

2.2.13.2. External Propagation

The inflow of fire, smoke, fumes through the openings in the exterior walls in two consecutive floors located within 1.5m laterally shall be separated with a flame barrier having a fire-resistive rating of minimum ¾-hour and projecting at least 75 cm (30 in) from the external surface of the external wall.

2.3. General Requirement; Portable Fire Extinguisher

2.3.1. Housing

The Fire extinguisher housed in a cabinet shall not be locked unless it is believed to be used for malicious purposes. A means of emergency access shall be ensured when it is needed to be locked.

2.3.2. Maintenance

Portable fire extinguishers shall be maintained in a fully charged and operable condition and shall be installed in a designated place for use at any time.

2.3.3. Mounting Requirement

Wall-mounted type portable fire extinguishers shall be installed securely on approved type of hanger(s) or bracket(s) for easy take-out, in-cabinet or wall recess.

2.3.4. Operating Instruction

Operating instructions shall be printed on the front side of the extinguishers for easy visibility.

2.3.5. Protection

Adequate protection shall be provided for the fire extinguishers and protected from any physical damage, i.e., from impact, vibration, and environmental hazards.

2.3.6. Surrounding Ambient Condition

The extinguishers shall not be exposed to a temperature other than the rated temperature printed on the label or body.

2.4. General Requirement; Detection System

2.4.1. Power Supply

The fire alarm system shall have a provision of power supply from at least two independent and reliable sources, one primary and another secondary (stand by). Each source shall be of suitable rating and capacity for system operation. All power supply shall have sufficient capacity to operate the alarm signals for at least four continuous minutes.

2.4.1.1. Primary Power Supply

A reliable source of power shall be provided for the intended service. It may be a public supply source or an independent own generator facility.

2.4.1.2. Secondary Power Supply

The secondary power supply shall be provided from an auto-start engine-driven generator or storage battery, both having the capacity to supply power for four hours. The secondary supply shall provide power to the system within 30 seconds without loss of signals in the event of primary failure or dropping of rate voltage required for proper operation of the system.

2.4.1.3. Wiring

The wiring, cabling and installation accessories shall be as per the BNBC-2020, NFPA-70, IEE or BS codes and standards for communication circuitry. In the case of optical fibre cables, it shall be properly protected from mechanical damage.

2.4.2. Performance Requirement

For proper performance, the system components and accessories shall be so located that the condition of the location(s) do not exceed the following parameters for proper operation.

- 85% and 110% of the rated input voltage(s) of primary and secondary power supply.
- Ambient temperature of 32° F (0° C) for minimum duration of peak 3 hours.
- Relative Humidity of 85% ± 5% at a temperature of 86° F ± 3° F (30° C ± 2°C) for at least 24 hours.

Chapter 3. Means of Egress

3.1. Purpose

The stairs play an important role in evacuation. The stairs tend to be paths of smoke flow, so they must be carefully designed. When stairs are unusable, evacuation cannot be done. So, if one stair cannot be relied upon, we need to prepare multiple stairs so that evacuees can evacuate by another stair. Also, when a large number of people rush to a stair, it can trigger a secondary disaster caused by panic. Therefore, it is necessary to arrange a sufficient number of stairs.

This chapter will explain how to determine the width, number and position of stairs.

3.2. Definition

A means of egress is a continuous and unobstructed way of exit travel from any point in a building to a street, the roof of a building or a designated area of refuge.

3.2.1. Parts of Egress

A means of egress consists of three parts-

a) The exit access.
b) The exit.
c) The exit discharges.

3.2.1.1. The Exit Access

Exit access is the path from any location within a building to an exit. Elaborately, the portion of the means of escape that leads to the entrance of an exit and is included in the measure of travel distance to reach an exit shall be termed as exit access as shown below

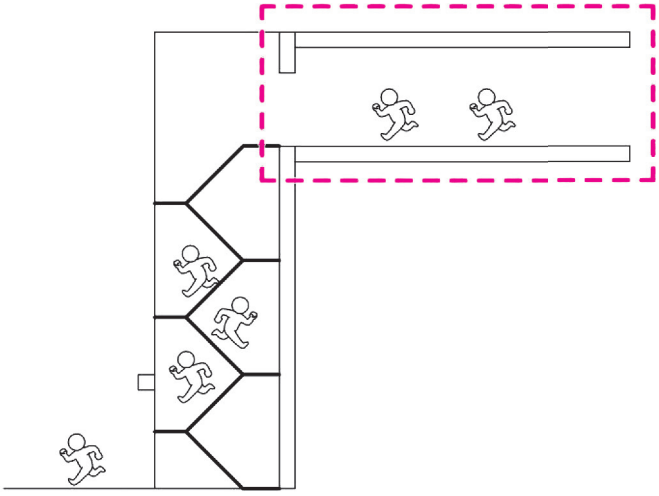


Figure 3. 1 Exit Access

3.2.1.2. The Exit

The exit itself shall be considered to be the means of escape which is protected from the area of incidence and provides a safe path to the exit discharge. An exit is typically a door leading to the outside or, in a multi-story building, an enclosed exit stairway.

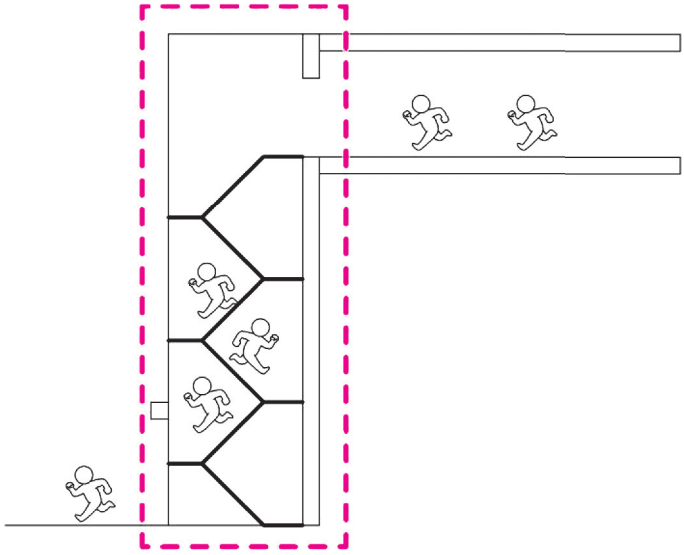


Figure 3. 2 Exit

3.2.1.3. The Exit Discharge

The exit discharge shall comprise any portion of the travel between the termination of exit and the exterior or the area of refuge as marked by the dots in figure 3.3.

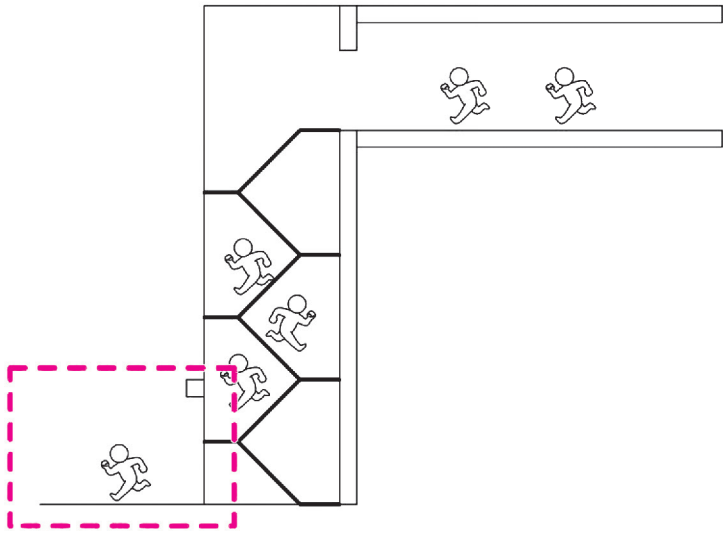


Figure 3. 3 Exit Discharge

3.2.2. Hazard Identification

The definition of Hazard is complex to describe. There are different types of hazards such as health hazard, fire hazard, etc. Generally, a fire hazard is a situation, condition or material that can cause a fire or related damage or the presence of fuel to increase the intensity of fire or explosion, which ultimately results in a threat to life or property. Hazard identification is the first step in starting the design of a passive or active fire and life safety plan.

Table 3. 1 Hazard Classification

Occupancy groups as per BNBC2020 *	Hazard Classification as per BNBC2020	Hazard Classification as per NFPA	Remarks
A1, A2, A3 E1	Light Hazard - I	Light Hazard	Please See NFPA13, NFPA14, NFPA101 for detail of Hazard Classification and Occupancy
A4, A5, B, C, D, E2, E3, I2, I4, F1	Light Hazard – II		
I1, I3, I5, F2, F3, G1	Ordinary Hazard – I	Ordinary Hazard Group 1 & 2	
G2, H1	Ordinary Hazard – II		
H2	Ordinary Hazard – III		
J	Extra Hazard	Extra Hazard Group 1 & 2	

*Table 4.4.1 of part 4 / BNBC2020

3.3. How to design Position, Width and Number of Stairs

3.3.1. Process

First, calculate the number of evacuees (= Occupant Load). The Occupant Load depends on the occupancy and area.

Next, calculate the width of the required stairs. The width depends on the Occupant Load, Occupancy and sprinkler.

Then, the number of stairs is calculated. This depends on the Occupant Load, Occupancy, number of stories and travel distance.

Finally, we need to decide on the stair positions. The positions depend on travel distance.

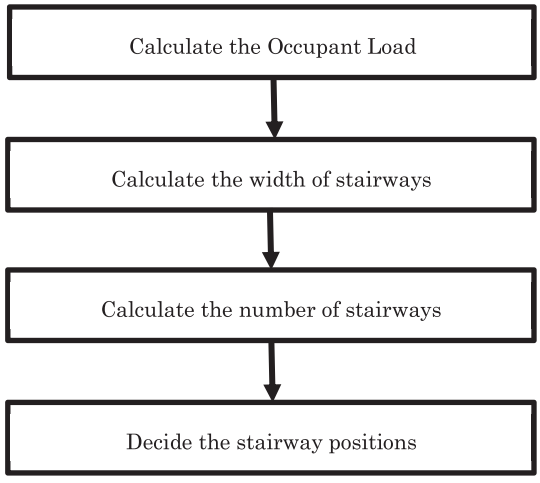


Figure 3. 4 Flow of Stairs Design

3.3.2. Occupant Load

The Occupant Load means the number of people. The design process must take into account the occupant load for which the component of means of egress is to be provided. This will consider the highest possible number of people computed as per the provisions of (a), (b) as stated below:

a) The actual number of occupants.
b) The load factor shall be computed following the structure provided in Table 3.2.

The number of occupants in any area shall be computed as per provisions of (a) or (b) as stated above and in all cases the higher value shall govern the design. The computation of occupant load shall be the summation of all the occupants of space and the evacuees of other spaces who are using the said space for waiting or passing through in case of emergency to gain access to a component of exit.

The Occupant Load Factor is shown in Table 3.2. The details of occupancy classification are described in Chapter 2, Part 3, BNBC2020.

3.3.2.1. Formula

Occupant Load = Area [m^2] / Occupant Load Factor [m^2 / Occupant]

Table 3. 2 Occupant Load Factor (source Table 4.3.1 of Part 4 / BNBC2020)

Occupancy			Unit of Floor Area in m^2 per Occupant*
A	Residential		18 gross
B	Educational	Class room	2 net
		Preschool	3.5 net
C	Institutional		12 gross
D	Health Care	In patient areas	15 gross
		Out-patient areas	10 gross
I	Assembly	With fixed seats	Number of seats designed
		With movable seats	0.93 net
		Standing space only	0.37 Net
		With table & chairs	1.5 Net
		Passengers hat can be unloaded simultaneously to a terminal or a platform	0.15 net
E	Business	Office Space	3 gross
F	Mercantile	Retail sales Area, Ground floor of basement	2.3 net
		All other floor	4.6 net
G	Industrial		10 gross
H	Storage		20 net
K	Garages and open parking structures		23 net
L	Utility		Actual occupant load
M	Miscellaneous Building		Actual occupant load

Note:

* Gross: Area including stairs, EV etc. Net: room area only. (See Fig.3.5)

3.3.2.2. Example

If the floor area of a Residential building is 1000 [m^2], the gross Occupant Load Factor is 18 [m^2 / occupant] from Table 3.2. The calculation is as follows.

Occupancy Load = Gross Area / Occupant Load Factor = 1000 / 18 = 56 [person]

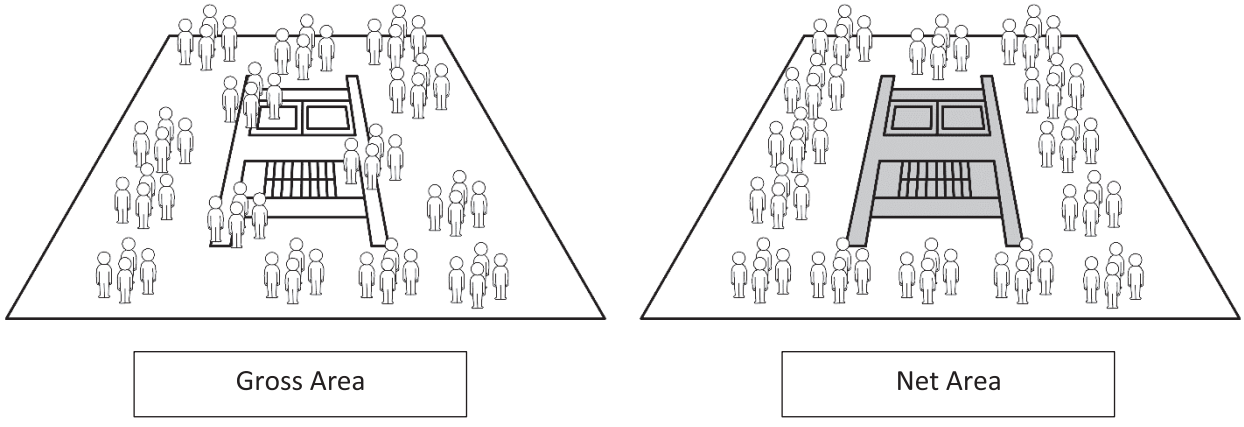


Figure 3. 5 Gross Area, Net Area

3.3.3. Width of Stair

The width of stairs per floor depends on the Occupant Load, occupancy and sprinkler.

The required width per occupant is shown in Table 3.3. However, minimum width is decided in Table 3.4.

3.3.3.1. Formula

Width by Table 3.3 = Occupant Load [person] x Required Width per Occupant [mm / person]

Width of stairs = Max [width by Table 3.3, width by Table 3.4]

Table 3. 3 Required Width per Occupant (source Table 4.3.2 of Part 4 / BNBC2020)

Occupancy				Buildings without Sprinkler System [mm per person]	Buildings thoroughly Sprinkled [mm per person]
				Stairways	Stairways
A	Residential	A1	Single family dwelling	8	5
		A2	Two Families Dwelling		
		A3	Flats and Apartments		
		A4	Mess, Boarding Houses, Dormitories and Hostels		
		A5	Hotels and Lodging Houses		
B	Educational Facilities	B1	Educational facilities up to higher secondary levels	8	5
		B2	Facilities for training and above higher secondary education		
		B3	Pre-school facilities		
C	Institution for Care	C1	Institution for care of children	8	5
		C2	Custodial institution for physically capable adults		
		C3	Custodial institution for the incapable adults	10	8
		C4	Penal and mental institutions for children		
		C5	Penal and mental institution for adults		
D	Healthcare Facilities	D1	Normal medical facilities	25	15
		D2	Emergency medical facilities		
E	Business	E1	Offices	8	5
		E2	Research and testing laboratories		
		E3	Essential services		
F	Mercantile	F1	Small shops and market	8	5
		F2	Large shops and market		
		F3	Refueling station	10	7
G	Industrial Buildings	G1	Low hazard industries	8	5
		G2	Moderate hazard industries		
H	Storage Buildings	H1	Low fire risk storage	8	5
		H2	Moderate fire risk storage		
I	Assembly	I1	Large assembly with fixed seats	10	7
		I2	Small assembly with fixed seats		
		I3	Large assembly without fixed seats		
		I4	Small assembly without fixed seats		
		I5	Sports facilities		
J	Hazardous Buildings	J1	Explosion hazard building	8	8
		J2	Chemical hazard building		
		J3	Biological hazard building		
		J4	Radiation hazard building		
K	Garage	K1	Parking garage	8	5
		K2	Private garage		
		K3	Repair garage		
L	Utility	L	Utility	8	5
M	Miscellaneous	M1	Special structures	8	5
		M2	Fences, tanks and towers		

Note: width of the components of egress shall be divided by value specified in this table to determine the maximum allowable occupant load served by them.

Table 3. 4 Width of fire exit stair (source Table 4.3.6 of Part 4 / BNBC2020)

Occupancy			Minimum Width of Each Stairway [mm]
A	Residential	A1, A2	As per Table 4.3.6 of Part 4 / BNBC2020
		A3, A4, A5	1120
B	Educational Institutions	Occupant load up to 130	1120
		Occupant load more than 130 but not more 250	2235
D	Hospital	Patient area	2235
		Staff area	1120
I	Assembly	I1, I2, I3, I4, I5	As per provisions of this Code.
All Others			As per provisions of this Code.

Note: The required number of stairways shall be determined by dividing the calculated total width of the stairways as per sections 3.5, 3.6 of Part 4 / BNBC2020 and Table 4.3.2 of Part 4 / BMBC2020 by applying minimum stair width as specified in this table and any fractions thereof shall be rounded up with the next higher integer. Unit width of stair and multiple even numbers shall be maintained as per provisions of this Code.

3.3.3.2. Example

As in the previous example, the floor area of the Residential unit is 1000 [m^2], without sprinkler and A3 (Apartment). The required width per occupant is 8 [mm/person] from Table 3.3. Based on the calculation result in (2), the calculation using 56 [persons] is as follows.

Width by Table 3.3 = Occupant Load x Required Width per Occupant = 56 x 8 = 448 [mm]

However, the minimum stair width is shown in Table 3.4. Here, when the apartment is 1120 [mm], then the required width of stairs is 1120 [mm].

Width of stairs = Max [Width by Table 3.3, Width by Table 3.4] = Max [448, 1120] = 1120[mm]

1120 [mm] is required for the total width of stairways per floor.

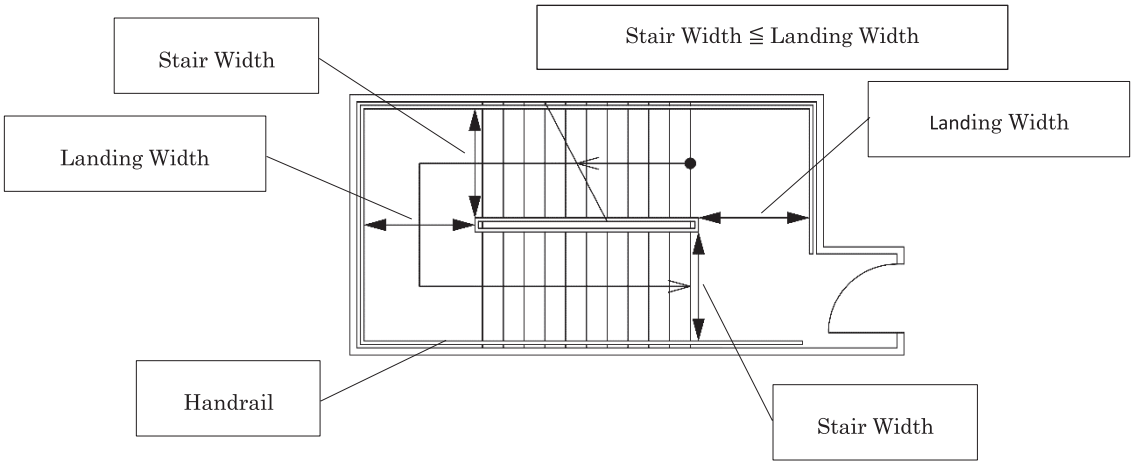


Figure 3. 6 Name of Stairway Parts

3.3.4. Number of Stairways

The number of stairways depends on the Occupant Load.

According to Table 3.5, two or more stairways are necessary. The checks are required in each floor. In a building with multiple uses, the number of stairways may differ from one floor to another.

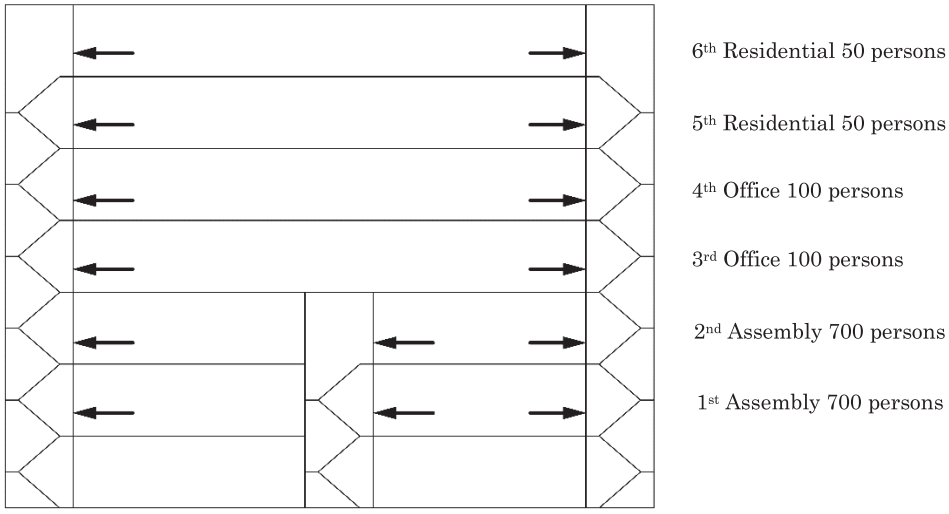


Figure 3. 7 Example of Number of Exits

Table 3. 5 Number of Exits (source Section 3.14.2 of Part 4 / BNBC2020)

Occupant load	Number of exits (Minimum)
Less than 50	1
50 to 500	2
501 to 1000	3
More than 1000	4

3.3.4.1. Example

As in the previous example, in the 1,000 [m^2] Residential unit, the Occupant Load is 56 [persons].

In this case, two stairways are needed as per Table 3.5.

3.3.5. Stairways Position

It is necessary to arrange the position of the stairs to meet the needs of the travel distance to the stairs shown in Table 3.6. The distance from any location to the nearest stairs shall be below the limit.

Table 3. 6 Determination of Exit and Access Requirements (source Table 4.3.8 of Part 4 / BNBC2020)

Occupancy Group / Classification		Maximum Travel Path [m]		Capacity Number of Occupancy per Unit Width of the Component [person]
		Unsprinklered	Full fire resistive or sprinklered	Stairs
A1, A2	Residential	N.R.	N.R.	N.R.
A3		45	60	30
A4, A5		45	60	30
B	Educational	45	60	60
C1, C2	Institutional	38	53	30
C3, C4, C5		38	53	15
D	Health	38	53	15
E	Business	60	90	60
F	Mercantile	45	60	60
G1	Industrial	60	120	60
G2		60	120	60
H1	Storage	30	53	45
H2		38	45	45
I	Assembly	45	60	60
J	High Hazard	15	45	30

Notes:

1. In Hazardous occupancy (occupancy J) Travel Path should be performance-based but shall not exceed 15240 mm.
2. N.R. = No requirement, (except as provided in Table 4.3.5b of Part 4 / BNBC2020)

3.3.5.1. Example

As in the previous example, for a residential unit of 1,000 [m^2] , there are two stairs so that we can satisfy the requirements of Table 3.6. Here, occupancy is A3, so 45 [m] is the upper limit.

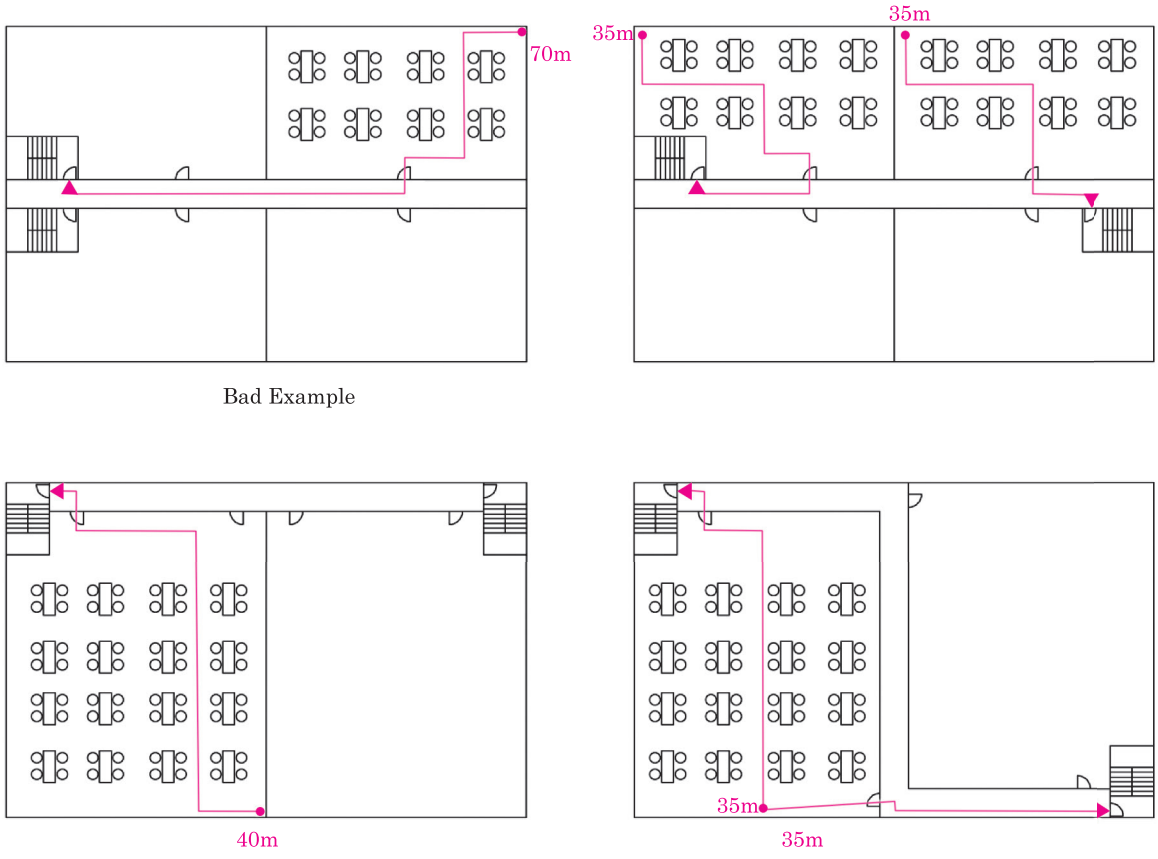


Figure 3. 8 Example of Travel Distance

3.4. Stairway Design Requirement

a) Headroom of stair shall not be less than 2030 mm measured vertically above the stair treads.
b) The surface of the stair treads shall be slip-resistant.
c) The tread depth of the stair shall not be less than 250 mm [as per BNBC] or 11 in. (280 mm) [according to NFPA].
d) The maximum height of risers shall be 230 mm [as per BNBC] or 7 in. (175 mm) [according to NFPA].
e) The minimum height of risers shall be 4 in. (100 mm) [according to NFPA].
f) The minimum clear width of the door or opening in means of egress shall not be less than 900 mm. But in case of door discharging from a stair, the clear width of the door shall not be less than two-thirds of the nominal width of the stair and the door shall swing in the direction of egress of travel.
g) The stair intended for use as means of egress shall be of permanently fixed construction.
h) The landings shall have at least the same width as that of the stair along the direction of travel.
i) The tread and landing shall be solid without perforation and shall be free from projection.
j) Variation of more than 3/16 in. (5 mm) in-depth and in rising with adjacent tread shall not be normally permitted.
k) Stair shall have handrails on both sides.

l) Minimum clear width between handrails shall be 560 mm.

m) Additional handrail shall be provided within 760 mm of all portion of egress stair in case the width of the stair exceeds 2210 mm as per BNBC or 6 ft. 3 in. (1905 mm) and according to NFPA.

n) The height of handrails shall not exceed 960 mm and shall not be less than 860 mm. from the tread surface.

o) The handrail shall be continuous and graspable all through the length.

p) Outside stair shall be arranged to restrict the accumulation of smoke and shall be open at least up to 50% on one side.

q) The stair shall be made enclosed from the highest point to the lowest point by a barrier having 2- hours fire resistant rating to make it smoke-proof.

r) Every fire stair shall discharge into a public way or into an open yard or court having direct access to a public way or into an exit passage way.

s) Where two accessible means of egress are required, the exits serving such means of egress shall be located at a distance from one another not less than one-half the length of the maximum overall diagonal dimension of the building or area to be served.

t) The fire stair shall not end up in the basement with no escape outlet. If it goes to the basement, there shall be a barrier like a 'cattle gate' on the ground floor to prevent the escaping occupants from getting into the basement.

u) Access to the fire stair shall not be through the kitchen, store room, rest room, closet, bedroom or similar spaces.

v) The fire escape stair shall extend to the roof in all cases where the roof provides a safe refuge Area.

w) Doors at fire stair shall be of side-hinged or pivoted swing type and shall swing in the direction of egress travel.

x) The door shall not project more than 7 in. (180 mm) into the required width of stair landing when it is fully open.

y) The stair shaft and vestibule (if there is any) shall be provided with an emergency power supply from either a standby generator or battery bank capable of supplying power for at least 60 minutes. The illumination level shall be at least 108 lux measured at the tread or waking surface.

z) Stair Pressurization: Enclosed fire stair shall be mechanically pressurized with a pressure difference across the separation walls, of not less than 0.025 in. of w.g. (12.5 pa) in sprinklered building and not less than 0.10 in. of w.g. (25 pa) in non-sprinklered building. Activation of this system shall be initiated by a smoke detector installed in the approved location. Please follow NFPA 92 for the proper design of positive pressure requirement at the staircase.

aa) If the enclosed staircase is windowless, mechanical ventilation shall be installed. If the vestibule is windowless, mechanical ventilation shall also be installed. In addition to ventilation, a positive pressure of 50 Pa shall be maintained in the vestibule. This positive pressure must be developed within 30 seconds of the incident of fire. When the staircase and the vestibule are windowless, emergency illumination shall be provided.

bb) An exit stairway shall not be built around a lift shaft unless both of them are located in a smoke proof enclosure.

cc) Exterior stairways used as fire stair shall not be considered as a component of means of egress, unless they lead directly to the ground or a refuge area, and are separated from the building, the interior of which is built by fire resistive assemblies or walls and are constructed by noncombustible materials. This should also be free from smoke accumulation.

3.5. Re-Entry / Refuge Area

Every door in a stair enclosure serving more than 5 stories shall be provided with a re-entry facility unless it meets the requirements.

Stair doors may be permitted to be locked from the stair (ingress) side that prevents re-entry to the floor provided that at least two floors allowing re-entry to access to another exit. Where there are not more than 4 stories intervening between the re-entry floors, re-entry is allowed on the top or next to the top level. Re-entry doors are identified as such on the stair side, and the locked doors shall be identified as to the nearest re-entry floors. When the discharge floor is determined, re-entry to the floor using the above requirements is not needed to be provided to return into the building on this level.

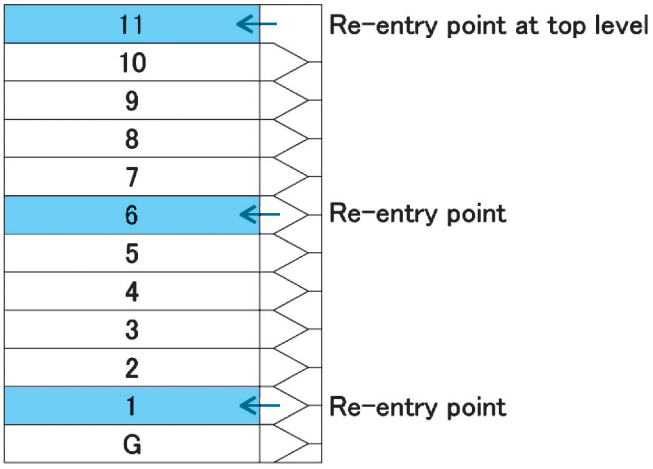


Figure 3. 9 Re-entry Point

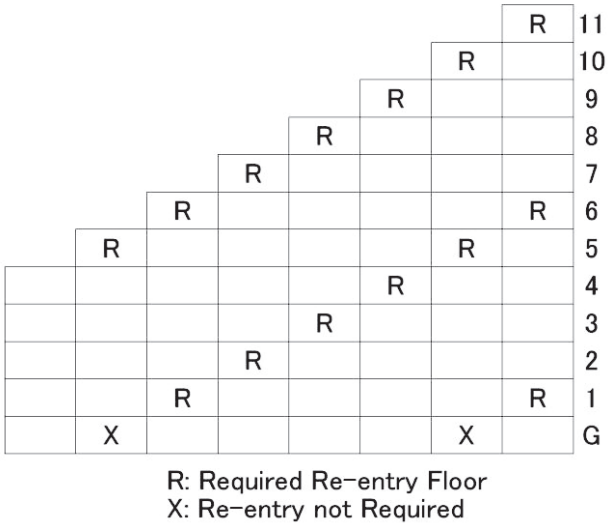


Figure 3. 10 Re-entry Floor

Except for the buildings with multi family dwelling, all other buildings shall incorporate the provision of refuge area on the external walls as cantilever projections or by any other suitable manner. The re-entry floor requires refuge area of not be less than $15m^2$ at the heights mentioned below.

Floors between 20 & 26m	One refuge area on the floor immediately above 20m
Floors above 26 m	One refuge area on the floor immediately above 26m then one refuge area per five floors above 26m

3.5.1. Corridors & Passageways

Direct route of access to the required exits shall be provided through continuous passageways, corridors or aisles, which are maintained free of obstructions.

3.5.1.1. Length & Width

The required minimum width of the corridors and passageways shall be determined on the basis of the occupant load, and it shall not be less than the following minimum.

a) 1.1 m that serves an occupant load of more than 50.
b) 0.9 m where an occupant load is 50 or less.
c) 2.4 m in Health Care building (Occupancy D) where the movement of beds is necessary.
d) 1.8 m in Educational building (Occupancy B), where the occupant load is more than 150.

The width of the exit corridors & passageways shall not be less than the aggregate of the required width of the doors leading from them towards the exterior.

3.5.1.2. Minimum Height

The minimum height clearance of the corridors and passageways shall not be less than 2.4 m.

All exit access corridors shall have a fire-resistance rating of 1 hour or more.

Door assemblies opening onto the exit access corridors shall be the fire doors having a fire-resistance rating of at least 20 minutes.

3.5.1.3. Dead End

A dead-end is an exit that looks like a passage that doesn't really open up to an exit. Occupants could get easily deceived by the dead-end if they are not appropriately arranged.

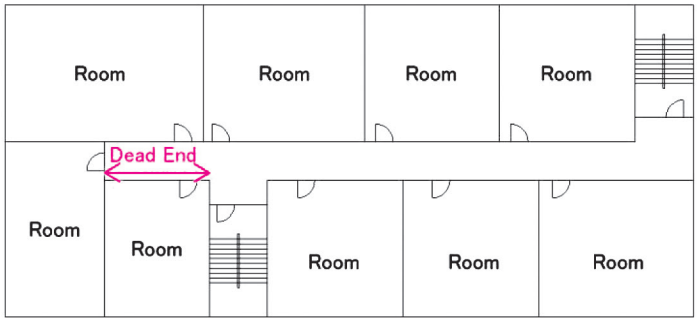


Figure 3. 11 Dead End

The length of a dead-end in which no exit door is available shall not exceed 10 m.

3.5.1.4. Doorways

According to both NFPA & BNBC, the exit doorway shall not open directly on a flight of stairs. The landing shall have a width not less than the width of the door.

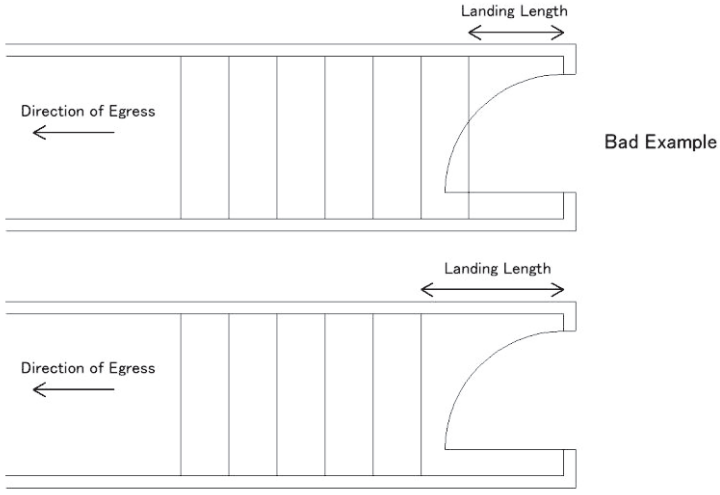


Figure 3. 12 Landing Length

The width of the doorway shall not be less than 1 m and the height not less than 2 m.

3.6. Exit sign and Illumination

The exit signs and illuminations are necessary for a smooth evacuation. The details of standards are described in Section 3.16 of Part 4 / BNBC2020. This has a detailed description of the subject.

3.6.1. Exit Sign

Exit signs need to be installed on the way of the escape route so that people can reach the ground by relying on exit signs during an evacuation process. Typical locations of the room exit, the staircase entrance, the staircase exit, and the corner of the corridor are to be easily found during an emergency. The signs should be installed in a way that the evacuees can find the exit sign if they look around 360 degrees from any place. This will help them find an escape route without any confusion.

3.6.2. Illumination

When a fire breaks out, there is a high possibility of a power outage. In a fire at night, if there is a power outage, it is not possible to find an escape route in the dark. Therefore, emergency illumination (lights) will be installed to illuminate the escape route. Since the facility is supposed to tackle the power outages, it should be connected to an emergency power supply.

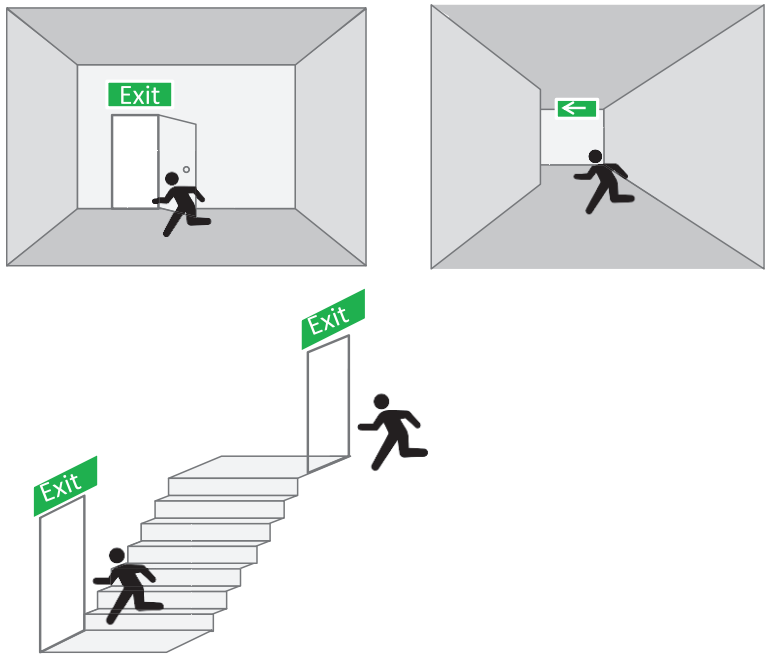


Figure 3. 13 Typical Location of Exit Signs

3.7. Symbols for General Use

This section provides uniform fire safety symbols to improve communication wherever signs and symbols are employed to provide fire safety information. The symbols for general use are given in Table 3.7, and the symbols for use by the fire service are shown in Table 3.8.

Table 3. 7 Symbols for General Use (source NFPA 170, 2009)

Symbol	Characteristics	Application	Example
Emergency Exit 	Square field Background green Door opening white Image in green	The identification and location of an emergency exit	The location of exit for use in a fire emergency
Emergency Exit Use of Arrows - Rectangular Field 	Painted version: Background colour white Arrows are red or black Backlit version: Doorway, arrows, and lettering in green or red	The identification and location of a route to an emergency exit	Progress to the right
	Painted version: Background colour white Arrows red or black Backlit version: Doorway, arrows, and lettering in green or red	The identification and location of a route to an emergency exit	Progress up and to the right
	Painted version: Background colour white Arrows red or black Backlit version: Doorway, arrows, and lettering in green or red	The identification and location of a route to an emergency exit	Progress down and to the right
	Painted version: Background colour white Arrows red or black Backlit version: Doorway, arrows, and lettering in green or red	The identification and location of a route to an emergency exit	Progress forward
	Painted version: Background colour white Arrows red or black Backlit version: Doorway, arrows, and lettering in green or red	The identification and location of a route to an emergency exit	Progress down
	Painted version: Background colour white Arrows red or black Backlit version: Doorway, arrows, and lettering in green or red	The identification and location of a route to an emergency exit	Progress to the left

Table 3.7 Continued

Symbol	Characteristics	Application	Example
	Painted version: Background colour white Arrows red or black Backlit version: Doorway, arrows, and lettering in green or red	The identification and location of a route to an emergency exit	Progress up and to the left
	Painted version: Background colour white Arrows red or black Backlit version: Doorway, arrows, and lettering in green or red	The identification and location of a route to an emergency exit	Progress down and to the left
Emergency Exit Route (Combination of Two Symbols) 	Square field Background green Door opening white Image in green For arrows: Square field Green arrow on white background or white arrow on green background	The identification and location of a route to be used in an emergency	The direction to a fire exit
Accessible Emergency Exit (Combination of Two Symbols) 	Square field Background green Door opening white Image in green International symbol of accessibility per ANSI A117.1, *Specifications for Making Buildings and Facilities Accessible to and Usable by Physically challenged People*	The identification of a route that leads to an emergency exit that is accessible to disabled users, as specified by ANSI A117.1, *Specifications for Making Buildings and Facilities Accessible to and Usable by Physically Challenged People*	The location of a route toward a fire exit that is accessible to disabled users

Table 3.7 Continued

Symbol	Characteristics	Application	Example
Accessible Emergency Exit Route (Combination of Three Symbols)   	Square field Background green Door opening white Image in green International symbol of accessibility per ANSI A117.1, *Specifications for Making Buildings and Facilities Accessible to and Usable by Physically challenged People* For arrows: Square field Green arrow on white background or white arrow on green background	The identification of a route that leads to an emergency exit that is accessible to people with disability.	The location of the route towards a fire exit that is accessible to the users who are physically challenged.
Not an Exit 	Square field Background white Door frame green Door opening white Image in black Red circle and diagonal slash	The identification of doors that do NOT lead to an exit	The location of an interior door such as one leading to a closet, an interior courtyard, or a basement
Use Stairs in Case of Fire 	Square field Red flame Black figure White background	An instruction to the user to use stairs (downward egress) in case of fire	The identification that stairs are to be used in case of fire
Use Stairs in Case of Fire 	Square field Red flame Black figure White background	An instruction to the user to use stairs (upward egress) in case of fire	The identification that stairs are to be used in case of fire

Table 3.7 Continued

Symbol	Characteristics	Application	Example
Do Not Use Elevator in Case of Fire 	Rectangular field Red flame Black figures White background Red circle and slash	An instruction to not use elevators in case of fire	Posted near elevator call button
No Smoking 	Circular field Red circle and slash Black image White background	The identification of areas in which smoking is prohibited	The identification of areas, such as those for flammable liquid storage, where smoking could lead to fire or explosion
No Campfires 	Circular field Red circle and slash Black image White background	The identification of areas where campfires are not permitted	The identification of areas, such as municipal parks, where campfires are not permitted.
Manual Station — Pull Station/Fire Alarm Box 	Rectangular field Red background White flame White hand White box White horn White wave	An instruction to actuate an alarm-initiating device in a fire emergency	Posted above a manually activated initiating device
No Cooking 	Square field White background Red flame Black pot and steam Red circle and slash	An instruction prohibiting cooking food in an area	Posted inside a guest room in a hotel or a student room in a college dormitory

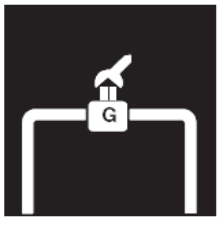
Table 3.7 Continued

Symbol	Characteristics	Application	Example
Area of Refuge 	Square field White background Red flame	The identification of an area of refuge	A designated area of refuge to be used in a fire emergency
Automated External Defibrillator (AED) 	Square field White background Red heart White bolt through the heart Black lettering	To identify the location of AEDs	Posted in airports and other places of assembly
Fire Extinguisher 	Square field Red background White symbol	For everyday use in workplaces and public areas; supplementary text and signs can be used to increase comprehension	Fire safety signage, manuals, and notices
Fire Hose or Standpipe 	Square field Red background White symbol	For everyday use in workplaces and public areas; supplementary text sign can be used to increase comprehension	Fire safety signage, manuals, and notices

Table 3. 8 Symbols for Use by the Fire Service (source NFPA 170, 2009)

Symbol	Characteristics	Application	Example
Fire Department Automatic Sprinkler Connection— Siamese 	Square field Red background White symbol	The identification of the location of a fire department for automatic sprinkler connection	The location of siamese automatic sprinkler connections on buildings The location of siamese freestanding automatic sprinkler connections
Fire Department Standpipe Connection 	Square field Red background White symbol	The identification and location of a fire department standpipe connection	The location of the standpipe connections on buildings and structures. The location of freestanding standpipe connections
Fire Hydrant (All Types) 	Square field Red background White symbol	The identification and location of a fire hydrant	The location of fire hydrants, wall hydrants, underground hydrants, or other fire-fighting water supply-sources
Automatic Sprinkler Control Valve 	Square field Red background White symbol	The identification and location of an automatic sprinkler control valve	The location of the control valves for automatic sprinkler systems. On doors of rooms containing control valves

Table 3.8 Continued

Symbol	Characteristics	Application	Example
Electric Panel or Electric Shutoff 	Square field Blue background White symbol	The identification and location of an electrical panel or other electric shutoff device	The location of electric panels or other electric control devices that can be located in basements or mechanical rooms
Gas Shutoff Valve 	Square field Red background White symbol Red letter G	The location of a gas shutoff valve	The location of gas shutoff valves On doors of rooms containing gas shutoff valves
Fire-Fighting Hose or Standpipe Outlet 	Square field Red background White symbol	The location of a fire-fighting hose or a standpipe outlet	The location of interior fire-fighting hose stations and standpipe outlets in buildings and structures The location on bridges or elevated highways
Fire Extinguisher 	Square field Red background White symbol	The location of a fire extinguisher	The location of fire extinguishers in buildings and exterior locations
Emergency Telephone 	Red background White phone	The identification and location of fire service or emergency telephone system	
No Fire Fighting 	Octagonal field White background Black truck Red prohibition symbol	To be posted on, near, or on the approach to buildings where fire fighting is not to occur	Explosives bunkers, frangible buildings, or contaminated buildings

Chapter 4. Smoke Proof Enclosure

4.1. Purpose

In order to protect human life and property from fire, it is necessary to prevent the spread of fire and smoke.

The main points are as follows:

a) To protect evacuation routes such as stairs and corridors.
b) To prevent the spread from rooms with many combustibles such as warehouses.
c) To prevent the spread to other floors.

The smoke enclosure is an effective means for fulfilling these purposes.

In BNBC2020, the requirements are described in Section 3.1.11 of Part 3 and Section 3.13 of Part 4.

In this chapter, the method of designing a smoke-proof enclosure will be described.

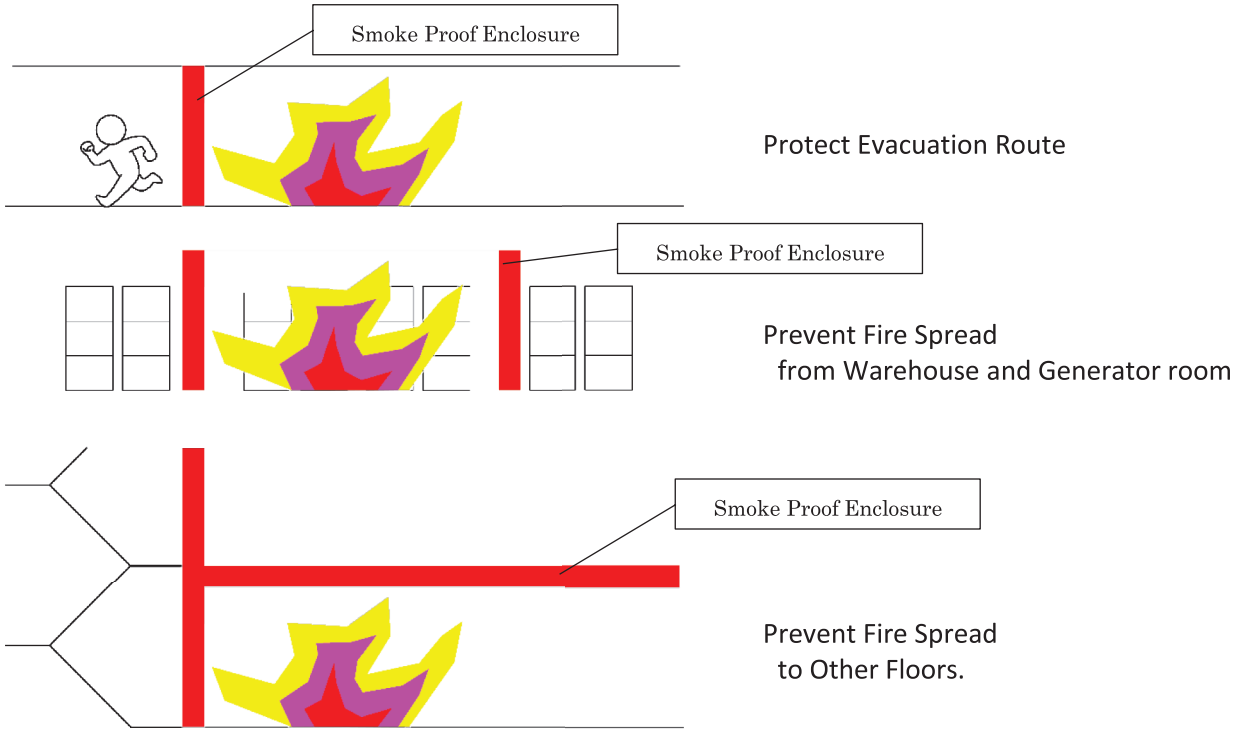


Figure 4. 1 The Purpose of Smoke Proof Enclosures

4.2. Where Smoke-Proof Enclosures are needed

The smoke enclosures are needed for staircases, evacuation routes from the stairs to the outside (Final escape route), warehouses, kitchens and shafts etc.

Table 4. 1 Places and Rooms that Require Smoke-Proof Enclosures

Purpose	Place and Room
Prevent vertical fire spread	Staircases (including not used for escape), EV Shafts, Equipment Shafts, Voids, Each Floor slab
Prevent horizontal fire spread	Warehouses, Kitchens, Generator Rooms, Final Escape Routes, Car Parking Rooms

If smoke penetrates into the stairs, people on the upper floors will lose the escape route. Therefore, stairs must be protected by a smoke enclosure. Similarly, the final escape routes must also be protected from the penetrations of fire and smoke.

It is difficult to extinguish the fire from warehouses and generator rooms as they are usually filled with a lot of combustibles resulting in a large amount of smoke when a fire occurs; Such fire tends to be large and furious. Therefore, it is necessary to suppress the spread of fire by a smoke enclosure.

The kitchen of restaurants is at a high risk of fire as the work is mainly dependent on it. Moreover, they are stocked with many combustible items, such as oil. So, a smoke enclosure is necessary to prevent the spread of fire and smoke.

Void, Equipment shafts and EV shafts tend to be diffusion routes for fire and smoke, and there is a risk of spreading fires to other floors. Therefore, a smoke enclosure is necessary to be installed.

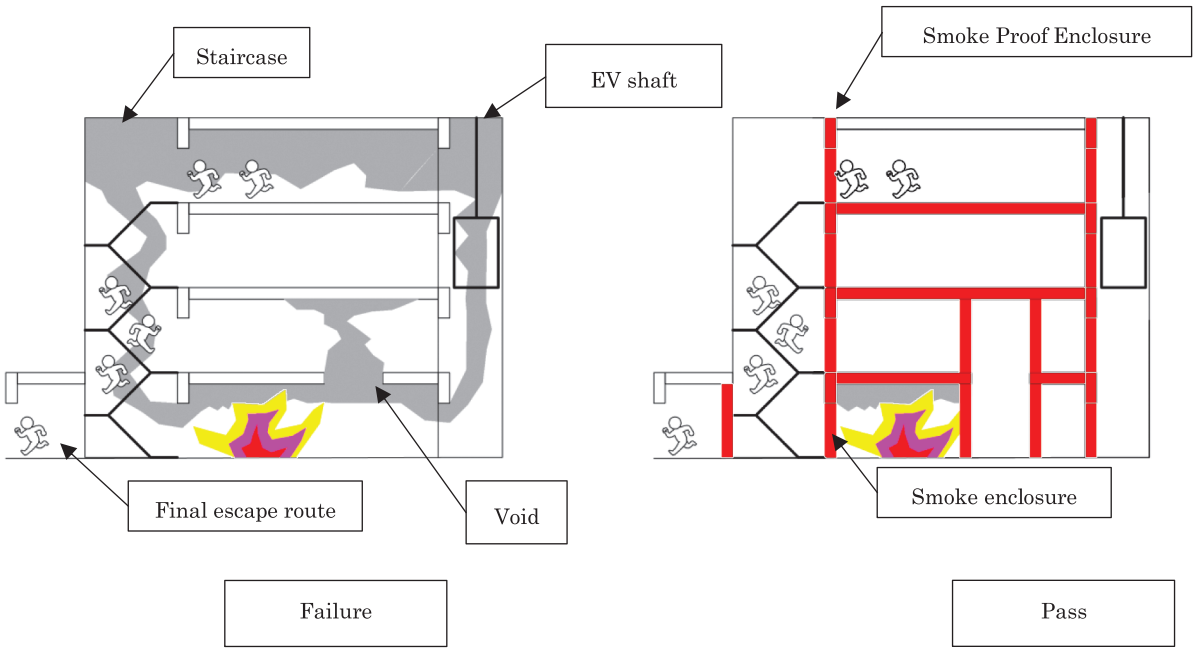


Figure 4. 2 Where Smoke Enclosures are Needed

4.3. Method of Smoke-Proof Enclosure

4.3.1. Floor, Wall, Door

The smokeproof enclosures are surrounded by floors and walls, and the openings such as doors, glass and penetrations of equipment are basically kept closed in case of fire. The basic configurations of the smokeproof enclosures are shown in Figure 4.3.

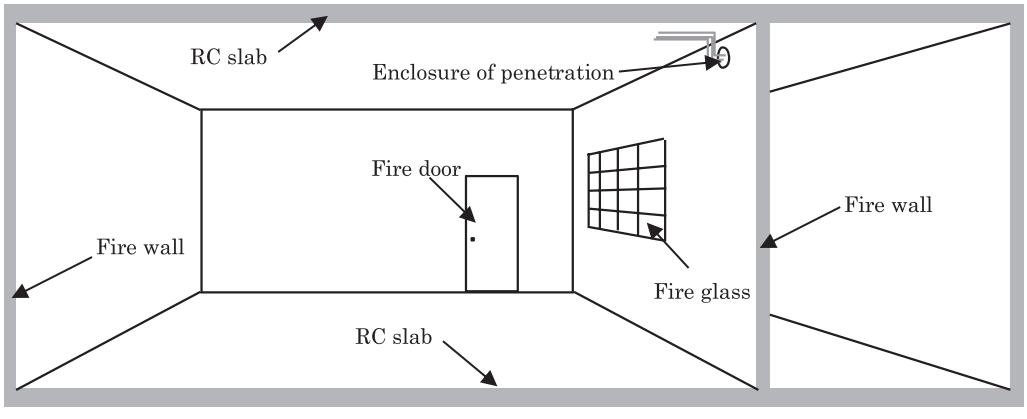


Figure 4. 3 Basic Composition of Smoke-Proof Enclosure

The elements of the smokeproof enclosures are required to meet the fire resistance rate. The required fire-resistance rate will vary by front road width plus front open space and Building height. The limitation is shown in Table 4.2.

This information is described in Section 1.9 of Part 3 / BNBC2020.

The types that appear in Table 4.2 are as follows,

GROUP I: Noncombustible, subdivision:

- Type I-A: 4-hour fire protected
- Type I-B: 3-hour fire protected
- Type I-C: 2-hour fire protected
- Type I-D: 1 hour fire protected
- Type I-E: Unprotected

GROUP II: Combustible subdivision:

- Type II-A: Heavy timber
- Type II-B: Protected wood joist
- Type II-C: Unprotected wood joist
- Type II-D: Protected wood frame
- Type II-E: Unprotected wood frame

This information and details are described in Chapter 3 of Part 3 / BNBC2020.

Table 4. 2 Height Limitations Based on Road Width, and Front Open Space (source Table 3.1.7 of Part 3 / BNBC2020)

2 × (Front Road Width Plus Front Open Space)	Maximum Permissible Height in Terms of Construction Classification							
	Group- I*						Group II*	
	Type I-A and Type I-B		Type I-C		Type I-D		Type II-A, II-B, II-D	
	No. of story	Height (m)	No. of story	Height (m)	No. of story	Height (m)	No. of story	Height (m)
Below 10.6 m	3	11	2	8	2	8	2	8
10.6m to below 13.6m	4	14	3	11	2	8	2	8
13.6m to below 16.6 m	5	17	4	14	3	11	3	11
16.6 m to below 19.6 m	6	20	4	14	3	11	3	11
19.6 m to below 22.6 m	7	23	4	14	3	11	3	11
22.6 m to below 25.6 m	8	26	4	14	3	11	3	11
25.6 m to below 28.6 m	9	29	4	14	3	11	3	11
28.6 m to below 31.6 m	10	32	4	14	3	11	3	11
31.6 m to below 34.6 m	11	36	4	14	3	11	3	11
34.6 m to below 37.6 m	12	39	4	14	3	11	3	11
37.6 m to below 40.6 m	13	42	4	14	3	11	3	11
40.6 m to below 43.6 m	14	45	4	14	3	11	3	11
43.6 m to below 46.6 m and so on in increments of 3m	15	48	4	14	3	11	3	11

Notes:

1. For plots with front road width not less than 23 m, residential and business and mercantile buildings of Type I-A and I-B construction shall have no height restriction subject to additional open space requirements.
2. The maximum permissible height for Type I-C construction is 4 stories or 14 m.
3. The maximum permissible height for Type I-D and I-E of Group I construction and all types of Group II construction is 3 story or 11 m

* For all Unprotected Construction Types I-E of Group I, Type II-C and Type II-E of Group II the maximum allowable story and height shall be one story and 8 m, respectively.

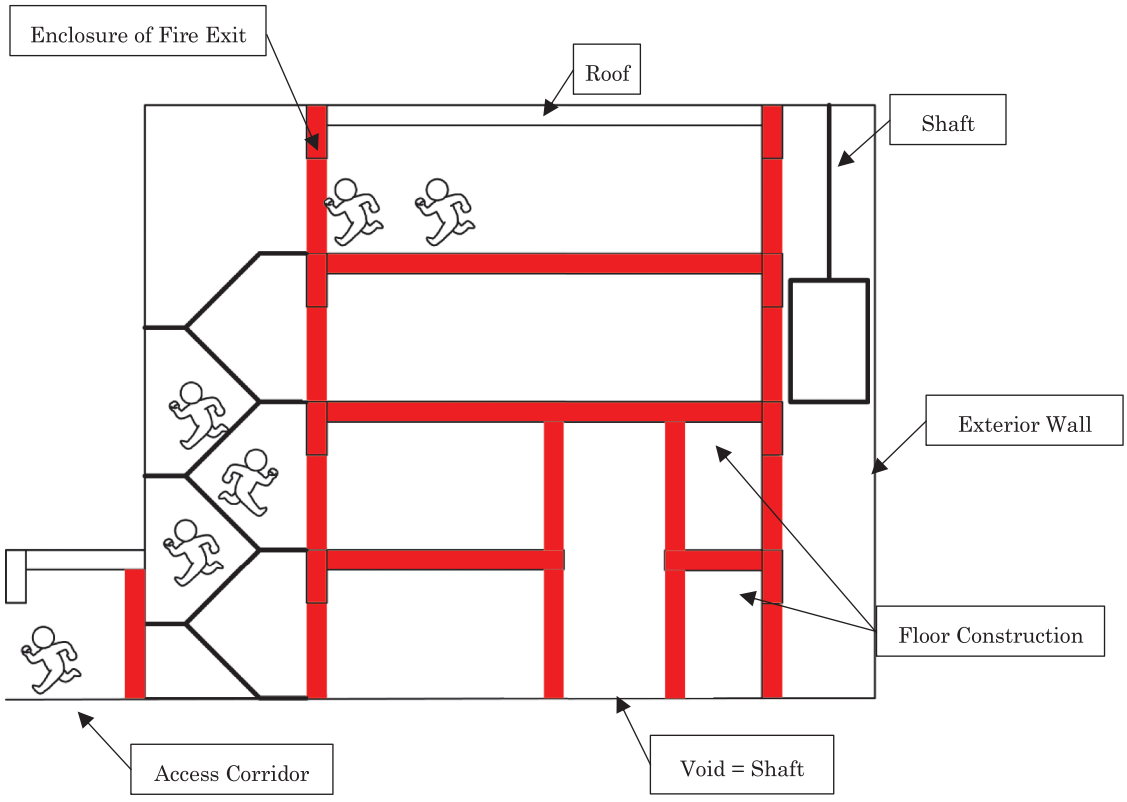


Figure 4. 4 Elements of Fire Resistance Rating

The fire-resistance rating of individual building construction components shall be determined by standard materials testing procedure as detailed below.

a) The fire-resistance ratings of building assemblies and structural elements shall be determined in accordance with ASCE 29 or ASTM E 119.
b) The construction materials which are classified as non-combustible shall be tested in accordance with ASTM E 136.
c) Flame resistance rating of all materials used for interior finish and trim shall be tested in accordance with ASTM E 84.
d) The fire door assemblies shall conform to the test requirements of ASTM E 152.
e) The fire windows and fire shutters shall meet the test requirements of ASTM E 163.
f) The fire-resistance rating of structural elements are provided in Table 4.3. For details, refer to ASCE 29.

This information is described in Section 1.5 of Part 4 / BNBC2020.

Table 4. 3 Fire Resistance of Structures (source Table 4.1.1 of Part 4 / BNBC2020)

Concrete Aggregate Type	Minimum Equivalent Thickness of Concrete Walls, Floors, and Roofs for Fire Resistance Rating				
	1 hr	1.5 hr	2 hr	3 hr	4 hr
	mm	mm	mm	mm	mm
Siliceous	89	109	127	157	178
Carbonate	81	102	117	145	168
Sand-light weight	69	84	97	117	137
Lightweight	64	79	91	112	130
Concrete Aggregate Type	Minimum Column Dimension for Fire Resistance Rating				
	1 hr	1.5 hr	2 hr	3 hr	4 hr
	mm	mm	mm	mm	mm
Siliceous	203	229	254	305	356
Carbonate	203	229	254	279	305
Sand-light weight	203	216	229	267	305

Clay Masonry Unit	Minimum Required Equivalent Thickness of Masonry for Fire Resistance Rating						
	0.5 hr	0.75 hr	1 hr	1.5 hr	2 hr	3 hr	4 hr
	mm	mm	mm	mm	mm	mm	mm
Brick of clay or shale, unfilled	43	51	58	72	86	109	127
Brick of clay or shale, grouted or filled with perlite, vermiculite, or expanded shale aggregate	58	67	76	94	112	140	168

The doors need to be fire doors. The components of the fire door are shown in Figure 4.5.

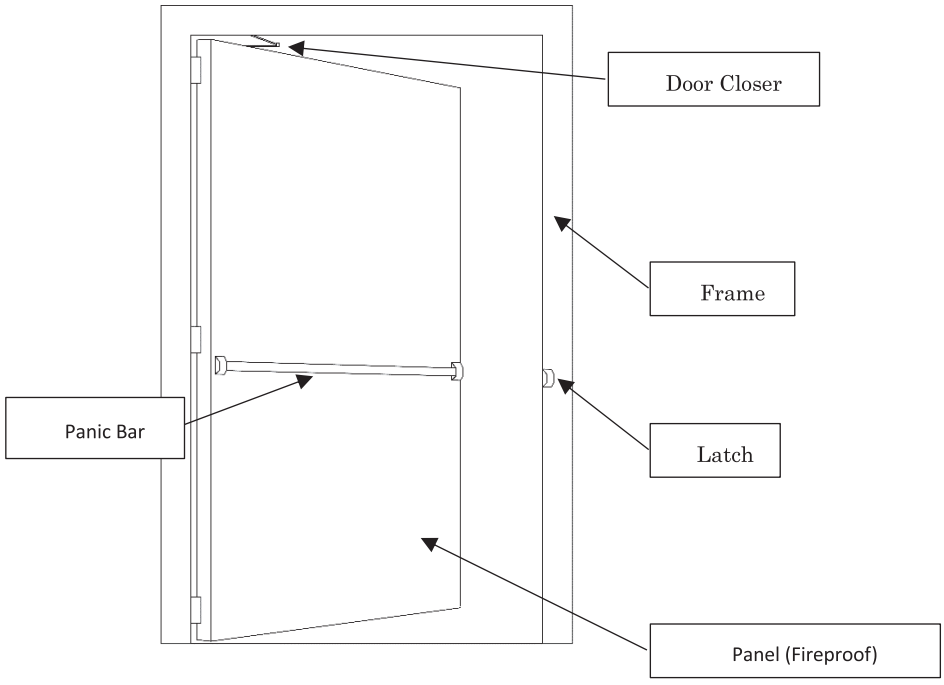


Figure 4. 5 Fire Door Components

4.3.2. Elevator (EV) shaft

In the smoke enclosures, not only the walls and floors but also the EV doors are the weak points. Even with steel doors, there are gaps, and the possibility of smoke inflow is high. Therefore, the smoke enclosure, including the EV lobby, is effective means of smoke control.

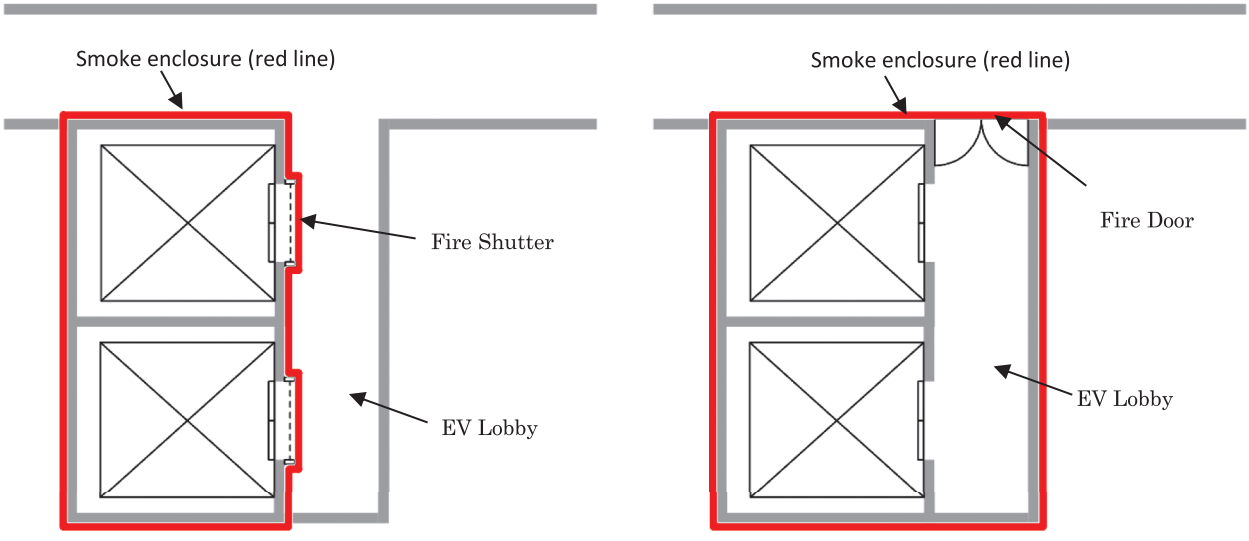


Figure 4. 6 Smoke Enclosure for EV

4.3.3. Criteria of Fire Elevator Shaft

a) Elevator(s) shall be allowed to be used as an alternative means of egress only from a tower under the following conditions.
b) The structure shall not mean to be used by the general public.
c) The elevator lobby area enclosed by fire compartment shall accommodate at least 50 per cent of occupants of the floor based on 0.28 m^2/person plus space for a wheelchair for every 50 persons or part thereof.
d) Barriers forming the elevator lobby, including the lobby door, shall be of fire-resistance rating of at least 1-hour.
e) The elevator lobby door(s) shall close by activation of a smoke detector or fire alarm system located outside the lobby near the door openings.
f) The elevator with all its support services, including a communication system, shall be supplied with both normal and emergency power, adequately giving protection to ensure 1-hour operation in the event of a fire.

4.3.4. Equipment penetration

The penetrations of equipment are both vertical and horizontal. When a piece of equipment crosses the smokeproof enclosures, if there are many gaps in the penetration, they become weak points, and the risk of fire spread increases. The purpose of the penetration enclosures is not to allow the spread of fire beyond the smokeproof enclosures.

In the air conditioning duct, a damper is provided in the penetration part to prevent the spread of fire. The damper closes by a signal from Fire Control Panel when an alarm occurs. The gap needs to be filled with fireproof sealants. The fireproof sealing materials are mortals or fireproof silicone sealants (see Figure 4.7)

Note: Fire dampers shall not be required or provided where the ducts or air transfer openings are part of an engineered smoke control system.

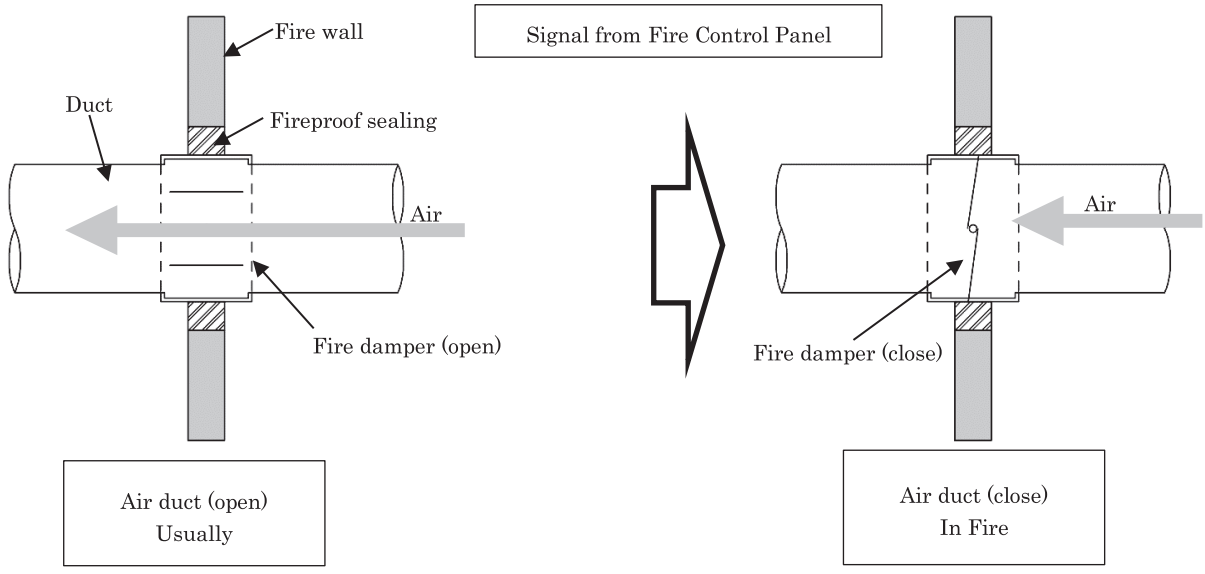


Figure 4. 7 Method of Air Duct Enclosure

If any gaps are created during plumbing and cables penetration work of the smoke enclosure, these must be filled with fireproof sealants. In addition, when plumbing is made of fireproof pipes, they need to be used near smoke enclosures. The fireproof pipes are made of steel or fireproof PVC. (See Figure 4.8)

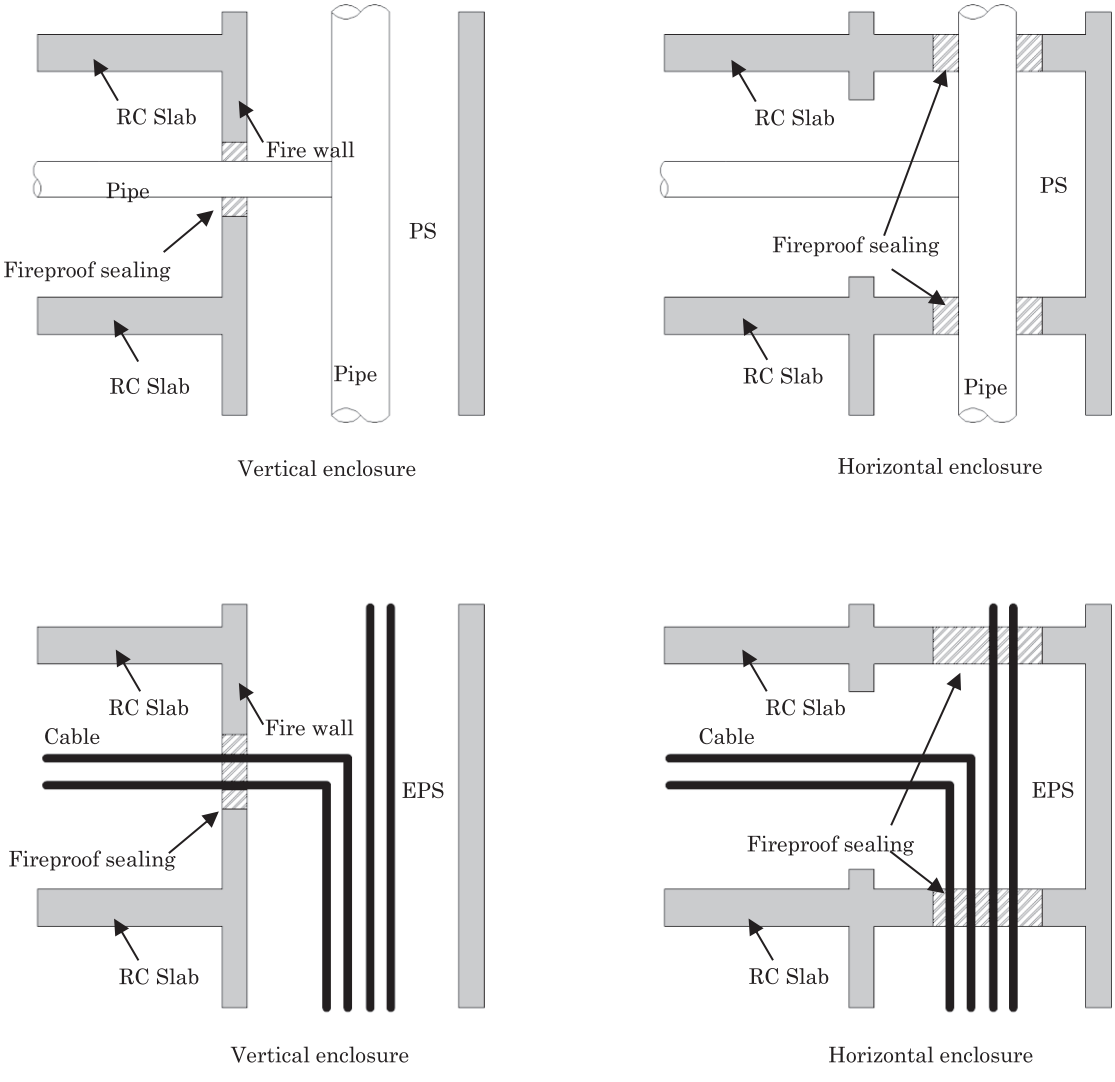


Figure 4. 8 Method of Plumbing and Cables Enclosure

4.4. Design Requirement for Smoke-Proof Enclosure

The construction of smoke enclosure shall be constructed by fire barriers to control the spread of fire and movement of smoke, shall comply the following features.

a) The doors used in horizontal exit separated by fire barrier shall be unlocked from the egress side unless permitted for special application. All fire doors in horizontal exits, protected by fire barrier, shall be self-closing or automatic closing type.
b) Each opening in the fire barriers shall be protected to control the spread of fire and smoke from one side to the other.
c) Windows or glazing in the smoke enclosure walls or fire barriers shall be of a fire-resistant wired glass of the required fire rating of at least 1-hour or equal to the rating of fire barrier and minimum thickness of 6 mm.

d) Fire stop systems or devices are required to restrict the spread of fire or smoke. These will have a fire-resistance rating of at least one hour but not less than the rating of the fire barrier that is protected.

e) Where the penetrating items use sleeves to pass through the walls, floor, ceiling, etc., the sleeves shall be securely fixed and the space between the item and the sleeve shall be filled with soft fire-resistant sealing material having a fire-resistance rating not less than that of a fire barrier.

Chapter 5. Electrical Cable

5.1. Purpose

More than 30% of fire accidents in Dhaka are caused by faulty electrical outlets and appliances. Improperly connected electrical cables increase resistance and generate heat. Defective electrical cables can cause sparks and shorts. In addition, if dust accumulates, the dust ignites and develops into a fire.

Careful attention from design to maintenance can prevent many electrical fires. The following points are to be noted at design, construction, and maintenance stages. This chapter is basically intended for architects as well as electrical engineers.

5.2. Considerations for Design, Construction and Maintenance

5.2.1. Design Stage

a) Distribution Board

- Clarification of indication
- Proper size of circuit breakers, bus-bar, earth terminal, etc.
- Bus Bar Trunking System (BBT) may be used for the higher load (more than 1000 Amp)
- Adequate Space in Distribution Board for accommodating control devices and accessories.
- Ventilation must be sufficient in and around DB cabinet.
- Spare capacity for future use
- Prevention of dust accumulation
- Proper layout plan for components and accessories
- All Distribution Board shall be positioned at eyesight level

b) Generator

- Indoor room
- Air conditioning in room / proper ventilation system
- Prevention of dust
- Fire compartment
- Layout plan
- Adequate free space for maintenance

In addition to these, regulations are described in Section 1.3.19.3 of Part 8 / BNBC2020.

5.2.2. Construction Stage

a) Conduct inspection
b) Display of device handling precautions
c) Display of periodic inspection method
d) Prior consultation with the structure
e) Checking the fire compartment layout
f) Confirmation of construction system as per electrical design

- Ensure proper cable size as well as the circuit breaker and its quality

- Double Insulated cable should be used for distribution line
- For underground cables, NYY or NYFG by is recommended with proper PVC pipe
- For Indoor Distribution line/wiring, FR Cable or BYM/NYY must be used with the required size ECC (BYA) through PVC pipe
- Electrical load greater than 10 A(single phase or three phase) must be supported by the circuit breaker
- Quality of Electrical fittings fixture must be ensured

Confirmation of System Earthing
Ensure Provision of Fire Lift
Ensure Dedicated Duct for Electrical Cables
Ensure Cable Connection with bus-bar with cable socket. Avoid loose connection.

5.2.3. Maintenance Stage

a) Periodic inspection

- Checking display for inspection methods.
- Checking the presence of any loose connection or any spark in the DB
- Checking ECC (Earth Continuity Conductor)
- Taking a reading of Line Current at peak time and ensuring the proper size of cables/control breakers
- Cleaning of dust

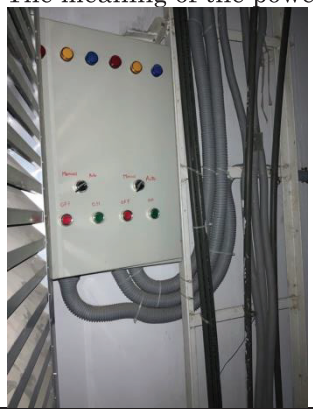
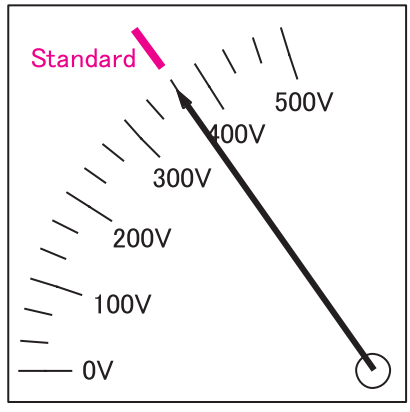
b) Checking and improving the status for error display
c) Conduct Drill

- Checking the escape route
- Checking the operational ability of extinguishing equipment (Portable extinguisher, Standpipe hose)

5.3. Examples of issue and solution

The table below shows examples of issue and solution that was observed during a survey of several buildings in Dhaka. These examples will be useful not only for new and retrofit designs but also for the maintenance of existing buildings.

No.	Issue	Solution
1	Dust accumulated in the EPS and power panel. 	Cleaning. Close the wiring intake at the top of the power panel.
2	The wiring is not protected. 	Install a protective tube (PF, Steel) to protect the wiring.
3	Wiring destination / device name is not described.	Put on the wiring destination / device name for ease of maintenance.
4	The meaning of the lamp display on the power panel is not described.	Put on the name of the lamp display. Visual inspection is possible by the display.

No.	Issue	Solution
5	The meaning of the power panel is not described. 	Put on the name of the power panel.
6	The detector in the smoking room has been removed.	Setting up a heat detector to the smoking room.
7	The power panel voltage is less than 400V.	Mark if there is no problem with the current-voltage. You can check whether a voltage drop has occurred. 
8	There is no emergency lighting with a built-in battery throughout the building.	Install emergency lighting with a built-in battery. If the generator cannot be operated due to fire or flood, lighting is necessary for evacuation.
9	There are openings in the outer wall of the transformer room, generator room, and EPS.	Close as much as possible to prevent rainwater and dust.
10	Fire drill is not done.	Regularly check about how to use firefighting equipment (Standpipe hose, Portable fire extinguishers, etc.), and make the actions more reliable in case of emergency.
11	The route through which the standpipe hose can be retracted is uncertain.	If there is a standpipe hose in the staircase, it is necessary to check its route.
12	There is an electric lock door on the evacuation route.	Display OFF on the electric lock button near the ceiling.

No.	Issue	Solution
13	The transformer room and generator room does are not have dedicated Smoke-Proof Enclosures. 	Compartment with fire prevention material (Fire door, Fire wall etc.).
14	The existing fire extinguishing equipment in the parking lot is water sprinkler system.	Bubble extinguishing equipment is suitable.

Chapter 6. Automatic Sprinkler System

6.1. Purpose

Initial firefighting is important to minimize fire damage. In this case, an automatic sprinkler system is a highly effective means of extinguishing a fire.

Automatic sprinkler systems should be installed in high rise buildings (23 m or higher as per NFPA 13, NFPA 101). In addition, this system should be installed in multipurpose and sleeping facilities. Because the people in these buildings must face difficulties to notice fire immediately and to escape from the Buildings.

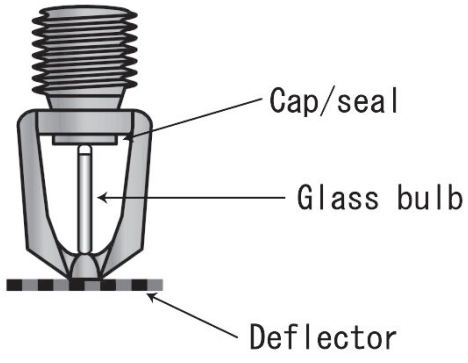


Figure 6. 1 Sprinkler Head

6.2. What is Sprinkler System

A Sprinkler System is

a) An integrated piping system filled with pressurized water or air and connected to a suitable water supply source and pump system.
b) The distribution piping network runs overhead at ceiling level throughout the space to be protected.
c) Sprinkler heads of proper type and rating are connected to a piping network.
d) The heat generated due to fire triggers the quartzoid bulb of the nearest sprinkler to collapse/break when it attains its rated temperature.
e) Water is then discharged onto the fire from the sprinkler(s) in the form of a spray.
f) The discharge of water is stopped by shutting off the pump manually when the fire is extinguished.
g) Once activated, the head(s) shall be replaced by a new one(s).

Temperature Ratings (Frangible Bulb)

Ordinary temperature-rated sprinklers shall be used throughout the buildings.

Exception No.1: Where maximum ceiling temperatures exceed 100°F (38°C), sprinklers with temperature ratings in accordance with the maximum ceiling temperatures of the following table as per NFPA 13-2019 Edition shall be used.

Table 6. 1 Temperature Rating, Classifications, and Color Codings

Maximum Ceiling Temperature		Temperature Rating		Temperature Classification	Color Code	Glass Bulb Colors
° F	° C	° F	° C			
100	38	135-170	57-77	Ordinary	Uncolored or black	Orange or red
150	66	175-225	79-107	Intermediate	White	Yellow or green
225	107	250-300	121-149	High	Blue	Blue
300	149	325-375	163-191	Extra high	Red	Purple
375	191	400-475	204-246	Very extra high	Green	Black
475	246	500-575	260-302	Ultra high	Orange	Black
625	329	650	343	Ultra high	Orange	Black

6.2.1. System Component and Hardware

The following components and hardware are required for a complete self-operating Sprinkler system.

a) A Water supply source.

- A City water supply source (dedicated to fire protection only).
- Water storage tank.

b) Water supply and/or pressure boosting pumps.

- Centrifugal/ vertical turbine pump.
- Diesel engine operated standby pump.
- Jockey pump.

c) Water distributing piping network.

d) Water flow control valves.

- Alarm Check Valve (for wet pipe system)
- Dry Pipe Valve (for dry pipe system).
- Deluge Valve (for pre-action and deluge system)

e) Water motor gong/alarm.

f) Electric alarm.

g) Water flow alarm switch.

h) Pressure switch.

i) Valves: Gate valve, Check valve, Drain valve, Test valve.

j) Fire department connection.

k) Air compressor (for dry pipe system).

l) Dry pipe accelerator (for dry pipe system).

6.2.2. Water Storage Tank

In case of unavailability of city water supply system for fire protection, provision for an in-house water storage tank within the building premises should be ensured. The water storage tank shall be constructed on the ground level to have a positive suction pressure. Still, in case of unavailability of space for a ground tank, an underground water tank may also be provided with the provision to ensure priming.

6.2.2.1. Capacity of Storage Tank

The tank shall have a capacity to store enough water to meet the peak demand for fire protection supply for an expected duration of the operation—the total capacity to be calculated from Table 6.5.

6.2.2.2. Location of Storage Tank

The groundwater tank shall be placed at a location accessible to a fire engine. In case of an underground storage tank, due to unavailability of space on the ground, the same shall be located within the building and be easily accessible to fire department personnel.

6.2.3. Fire Pump

The fire pumps commonly used for fire protection systems are of centrifugal or of multi-stage vertical turbine pumps. The duty pump shall be operated by electric power, and the standby one shall be driven by a diesel engine. All electric motor driven pumps shall be supplied with both normal and emergency power with properly protected fire resistant cables.

The fire pumps shall be so selected that these shall be able to supply required flow at required pressure at the hydraulically most remote discharge point.

In the case of an underground water storage tank, a vertical turbine pump is commonly recommended. For the service or a centrifugal pump with a syphon tank is also recommended to ensure constant priming. The pump shall be so selected that it is able to supply water at 150% of rated capacity at 65% of the maximum rated head.

6.2.4. Pump Room

An enclosure meant for installation or accommodation of pumps and shall be located at a readily accessible position within the premises or inside the building and shall be of non-combustible construction. The pump room shall be preferably located as close as possible to the fire water tank when constructed on the ground and not more than a distance of the actual suction head for lift suction needed in case of the underground reservoir.

6.3. Type of Sprinkler System

- Wet pipe --------- by far the most common,
- Dry-pipe --------- where water freezing is possible,
- Deluge ---------- for high hazard applications,
- Pre-Action ------- where there is a possibility of accidental breakage of the sprinkler-head and water discharge.

Table 6. 2 Type and Where of Sprinkler

Sprinkler Type		Where to Install
1	Wet Pipe System	Occupancies with temperature 95 ° C > X > 0 ° C
2	Dry Pipe System	Occupancies with risk of temperature X < 0 ° C and X > 95 ° C
3	Deluge Systems	Occupancies with rapid fire spread
4	Pre-Action Pipe Systems	In occupancies where water damage is not accepted by accidental activation

6.3.1. Wet Pipe Sprinkler System

A system fitted with an automatic sprinkler head is connected with a piping network containing water released under pressure and connected to a water supply source and suitable pump(s).

Water discharges immediately from the sprinkler head(s) opened by the heat generated from a fire to suppress or control the fire.

Water will continue to flow until the pump is shut off manually.

The open sprinkler head(s) is/are replaced to reset the system.

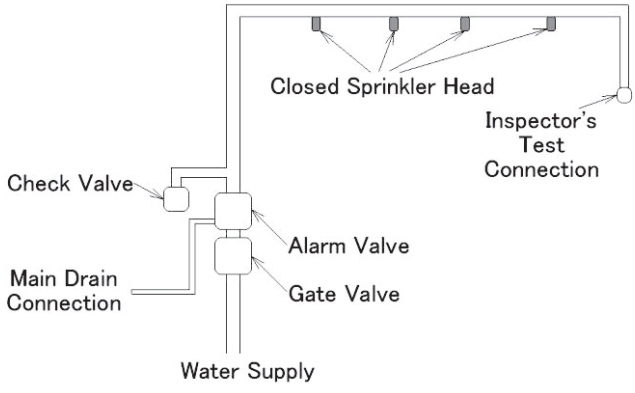


Figure 6. 2 Component of Sprinkler System

6.3.2. Pre-Action Pipe Sprinkler System

- A system furnished automatic sprinkler connected to a piping network containing air or inert gas that may or may not be under pressure.
- The system is integrated with a supplementary fire detection system installed in the same area as the sprinkler.
- Actuation of the fire detection system opens a valve that allows water to flow into the piping network and discharges from the sprinkler that is open.
- This system is designed to counteract the operational delay in a dry pipe system.
- This system is applied to eliminate the risk of water damage caused by accidental breakage of sprinkler head or piping.

The detectors shall be electric fixed temperature type with a rating less than that of a sprinkler.

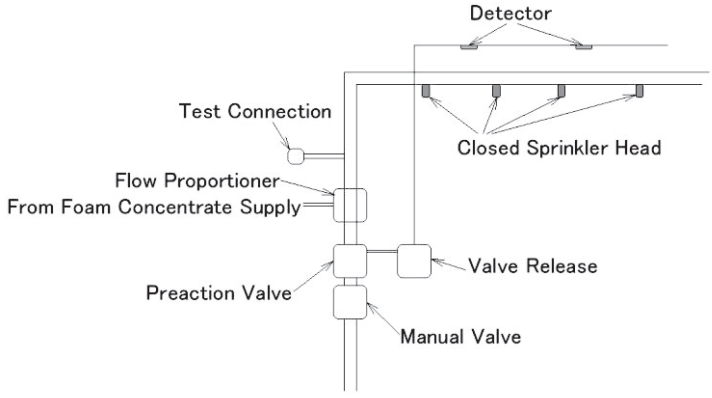


Figure 6. 3 Pre-Action System

6.3.3. Dry Pipe System

- It is a system fitted with an automatic sprinkler connected to a piping system containing air or inert gas under pressure.
- The release of air/gas (due to the opening of the sprinkler head by heat) permits the water pressure to open a valve called a dry pipe valve.
- The water then flows into the system and discharges through the open sprinkler onto the fire.

6.3.4. Deluge System

- A system furnished with open sprinklers fitted to an empty piping network connected to a water supply source through a valve called deluge valve that is opened by actuation of a fire detection system installed in the same area as sprinklers.
- As the valve opens, water flows into the piping network and discharges from the open sprinklers or spray nozzles onto the fire to extinguish or control the same.
- The purpose of the deluge system is to deliver maximum water in a minimum time.
- This system is suitable for extra hazard occupancies where there is a risk of flushing the fire ahead of the operation of a conventional sprinkler.

6.4. Consideration for Sprinkler System Design

The design of a sprinkler system shall be undertaken through an analysis and considerations of the anticipated hazard class and characteristics of fire inside the space to be protected with a sprinkler for its type, arrangement, flow rate, etc.

a) Occupancy Classification

- Light Hazard
- Ordinary Hazard
- Extra Hazard
- Storage

b) Sprinkler Type
c) Protection Area by Each Sprinkler
d) Spacing Between the Sprinklers
e) Temperature Rating of Sprinkler

Maximum coverage by a sprinkler system under a riser or a combined system riser is shown in Table 6.3.

Table 6. 3 Maximum Coverage by a Sprinkler System under a Riser

Hazard Type		Maximum Coverage
Light Hazard (Building or portion that has low quantities of flammable/combustible contents.)		52,000 ft² (4,831 m²)
Ordinary Hazard (Combustibility is low. Quantities of materials is moderate to high; stockpiles do not exceed 12 feet.)		52,000 ft² (4,831 m²)
Extra Hazard (Quantity and combustibility of materials is very high, dusts, lint present. Moderate to substantial amounts of flammable liquids are present.)	Pipe schedule	25,000 ft² (2,323 m²)
	Hydraulically calculated	40,000 ft² (3,716 m²)
Storage (High-piled storage (as defined NFPA) and storage covered by other NFPA standards.)		40,000 ft² (3,716 m²)

6.5. Design of Sprinkler System

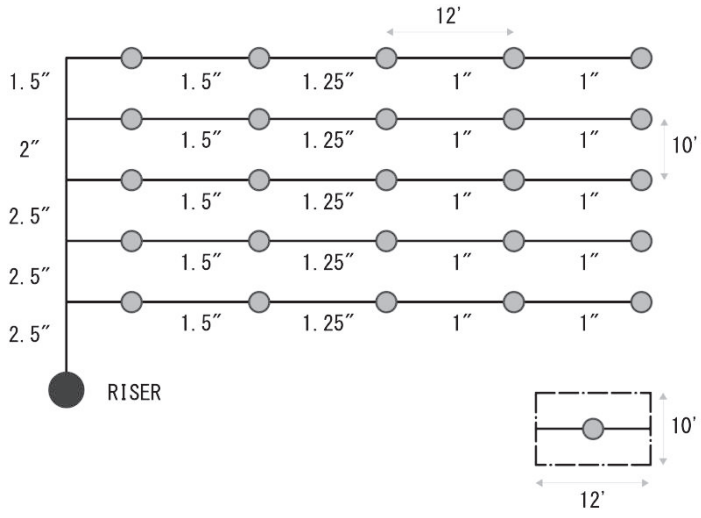


Figure 6. 4 Pipe Size of Sprinkler

6.5.1. Method of Approach to Design Development

- Identification of Riser Location
- Identification of the farthest end from the riser
- Minimum and maximum distances for sprinkler heads and branch lines
- Confirm, each head is not required to cover more square footage than its max coverage (See Table 6.6)
- Distance between sprinkler heads X Distance between branch lines may not exceed the maximum coverage per head (See Table 6.6)
- Determine pipe size considering hazard (See Table 6.7)

6.5.2. Design Requirement

6.5.2.1. Water temperature

- Maximum: The maximum temperature of water flowing through the sprinkler system shall not be more than 120° F (49° C) in any case.
- Minimum: Proper measures shall be taken to ensure that the minimum temperature of the water for any sprinkler system shall not be below 40°F (4° C).

6.5.2.2. Water Flow Requirement for Pipe Schedule Method

The minimum water supply requirements for different hazard class occupancies: Protected by a sprinkler system with pipes sized by Pipe Schedule Method is given Table 6.4.

6.5.2.3. Residual Pressure Requirement

The residual pressure required at the most remote sprinkler head located at the highest elevation for an area of 5000 ft^2 (465 m^2) or less is given in Table 6.4.

The residual pressure shall be minimum 50 psi (3.4 bar) at the most remote sprinkler head at the highest elevation for a space having an area of more than 5000 ft^2 (465 m^2).

Table 6. 4 Water Supply and Residual Pressure Requirement for Sprinkler System Designed by Pipe Schedule Method. (source NFPA-13)

Occupancy Classification	Minimum Residual Pressure Required		Flow Rate At Base of Riser Including Hose Stream Allowance		Duration of Flow (Minutes)
	Psi	Bar	gpm	L/min.	
Light Hazard	15	1.0	500-750	1893-2834	30 - 60
Ordinary Hazard	20	1.4	800-1500	3218-5678	60 – 90

6.5.2.4. Hydraulic Calculation for Water Demand

The water demand for sprinkler system shall be determined by the designer at his /her own judgment based on the density area method as per NFPA 13.

Table 6. 5 Fire Protection Flow Requirements (source Table 4.4.1 of Part 4 / BNBC2020)

Building type (Occupancy group)	Sprinkler System [litre/min.]	Standpipe and Hose System [litre/min.]	Duration for Building Heights [min.]		
			Up to 51m	51m to 102m	Above 102 m
Light hazard- I (A1, A2, A3, E1)	1000	1000	30	38	45
Light hazard- II (A4, A5, B, C, D, E2, E3, I2, I4, F1)	1900	1900	50	62	75
Ordinary Hazard- I (I1, I3, I5, F2, F3, G1)	2650	1900	75	95	112
Ordinary Hazard- II (G2, H1)	3200	1900	75	95	112
Ordinary Hazard- III (H2)	4800	1900	75	95	112
Extra Hazard (J)	Pressure and flow requirement for this group shall be determined by Fire Department but shall not be less than required value for Ordinary hazard-III.				

6.5.2.5. Protection Area Coverage by a Single Sprinkler Head

The protection area of coverage per sprinkler (As) shall be calculated by the following Equation:

As= SXL

where S = Distance between the sprinklers along the branch line and

L = Distance between the branch lines.

Table 6. 6 Protected Ceiling Area for a Sprinkler Head (source Table 4.4.7 of Part 4 /BNBC2020)

Building Type	Light Hazard		Ordinary Hazard		Extra Hazard	
	Protected area	Spacing (Max)	Protected area	Spacing (Max)	Protected area	Spacing (Max)
	ft² (m²)	ft (m)	ft² (m²)	ft (m)	ft² (m²)	ft (m)
Roof or Floor on Trusses, Girders or Beam With High Piling***	200 (18.6)	15 (4.6)	130 (12.1)	15 (4.6)	100 (9.3)	12 (3.7)
Open wood Joists With high piling***	225 (20.9)	15 (4.6)	130 (12.1)	15 (4.6)	100 (9.3)	12 (3.7)
Other type of construction With High Piling***	168 (15.6)	15 (4.6)	130 (12.1)	15 (4.6)	100 (9.3)	12 (3.7)

* Maximum distance in m between sprinklers and between lines of piping.

** The definitions of these terms are given in Table 6.5.

*** Storage facilities which permit closely piled materials over 4.5m or materials on rack over 3.6m.

Table 6. 7 Size of Water Supply Steel Pipe to Sprinklers (source Table 4.4.5 of Part 4 / BNBC2020)

Pipe Size mm (inch) nominal	No. of Sprinkler for Light Hazard*	No. of Sprinkler for ordinary Hazard*	No. of Sprinkler for Ordinary Extra Hazard*
25 (1)	2	2	1
32 (1¼)	3	3	2
38 (1½)	5	5	5
50 (2)	10	10	8
63 (2½)	30	20	15
75 (3)	60	40	27
88 (3½)	100	65	40
100 (4)	NL**	100	55
125 (5)	-	160	90
150 (6)	-	275	150
200 (8)	-	400***	225***

* Definition of these terms are given in Table 6.5.

** No limit.

*** One sprinkler system riser or combined system riser shall serve the floor area not more than 4850 m^2 for light and ordinary hazardous occupancy and 2325 m^2 for extra hazardous occupancy

Table 6. 8 Size of Water Supply Copper Pipe to Sprinklers (source Table 4.4.6 of Part 4 / BNBC2020)

Pipe Size mm (inch) nominal	No. of Sprinkler Connection for Light Hazard*	No. of Sprinkler Connection Ordinary Hazard*	No. of Sprinkler Connection Ordinary Extra Hazard*
25 (1)	2	2	1
32 (1¼)	3	3	2
38 (1½)	5	5	5
50 (2)	12	12	8
63 (2½)	40	25	20
75 (3)	65	45	30
88 (3½)	115	75	45
100 (4)	NL**	115	65
125 (5)	-	180	100
150 (6)	-	300	170
200 (8)	-	***	***

* Definition of these terms is given in Table 6.5

** No limit.

*** One sprinkler system riser or combined system riser shall serve the floor area not more than 4850 m^2 for light and ordinary hazard occupancy and 2325 m^2 for extra hazard occupancy

6.5.2.6. Installation Requirement

a) Minimum Distance from Walls.

- Sprinklers shall be located at a minimum of 4 in. (102 mm) from a wall.

b) Minimum Distance between Sprinklers.

- Sprinklers shall be spaced not less than 6 ft. (1.8 m) on the center.
- Exception: in-rack sprinklers shall be permitted to be placed less than 6 ft. (1.8m) on the centre.

c) Maximum Distance between Sprinklers.

- The distance from sprinklers to walls shall not exceed one-half of the allowable distance between sprinklers.

The distance from the wall to the sprinkler shall be measured perpendicular to the wall.

Where walls are angled or irregular, the maximum horizontal distance between a sprinkler and any point of floor area protected by that sprinkler shall not exceed 0.75 times the allowable distance permitted between sprinklers, provided the maximum perpendicular distance is not exceeded.

6.5.2.7. Fire Department Connection

Fire department connection shall be located on the street side of the building and shall be free from any obstruction from a nearby object, including building itself, fences, etc., for quick connection of hose line(s) to the inlet(s) by fire department personnel.

Fire department connection shall be installed not less than 18 in. (460 mm) or more than 48 in. (1200 mm) above the level of the adjoining ground, sidewalk or grade surface.

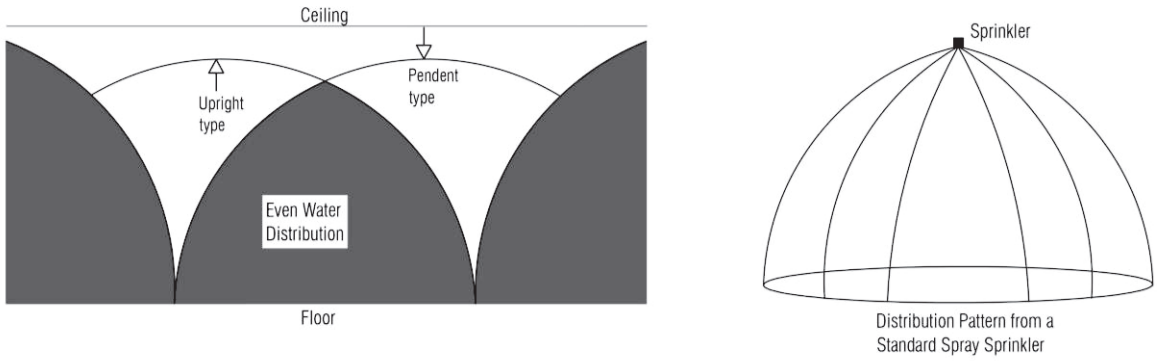


Figure 6. 5 Sprinkler Head Coverage Range

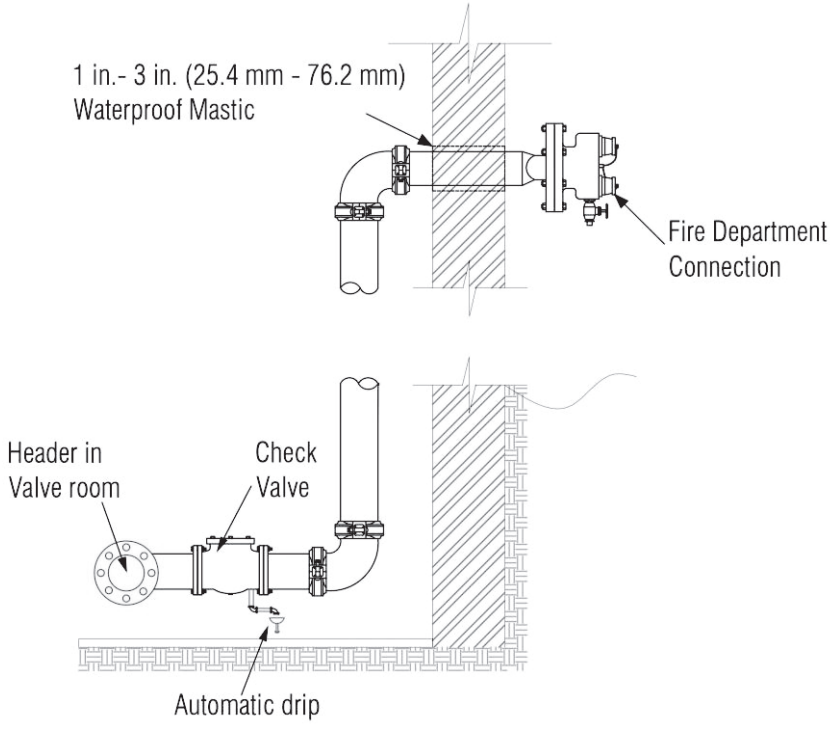


Figure 6. 6 Typical Fire Department Connection for wet Standpipes

6.5.2.8. Location of Sprinkler Head below the ceiling or above the false ceiling

The architect shall consult with a Fire safety expert before the finalization of false ceiling arrangement.

Pendent sprinkler arrangement needs extra space above the false ceiling to ensure return bend arrangement as per the picture

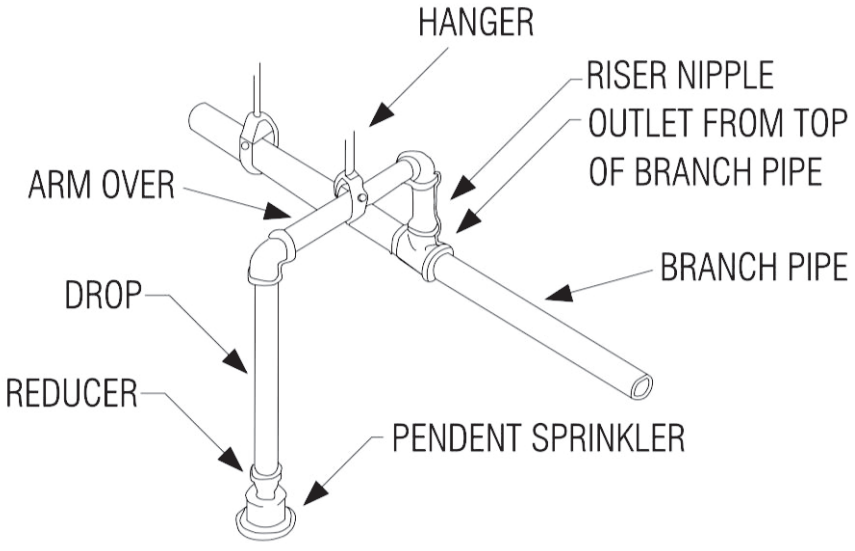


Figure 6. 7 Component of Sprinkler

If there is space limitation, then a flexible sprinkler arrangement can be installed instead of a return bend arrangement.

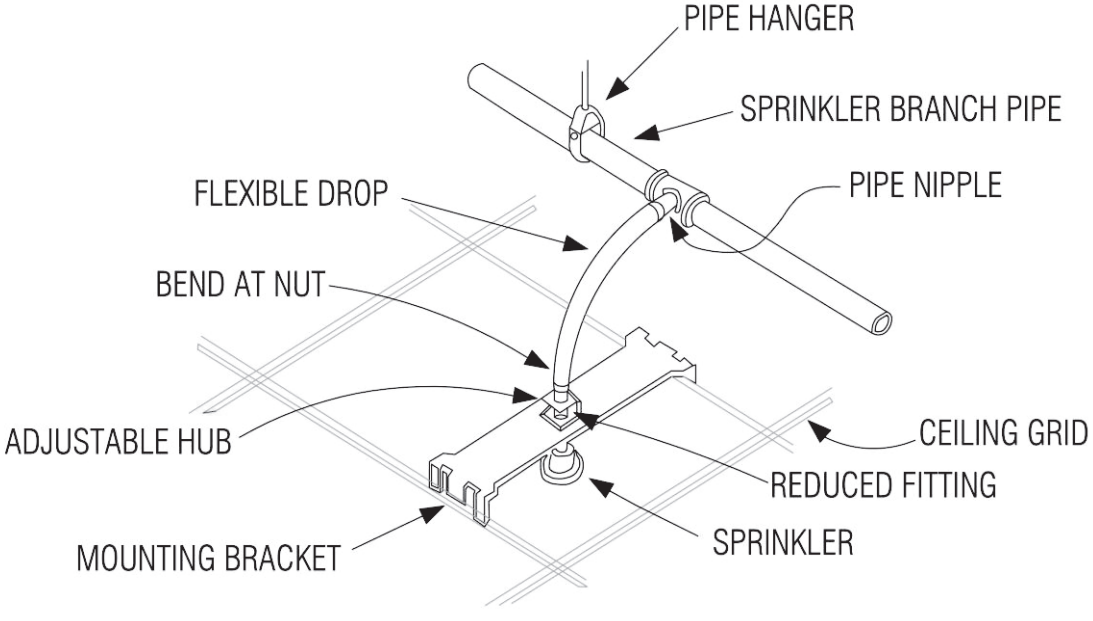


Figure 6. 8 Component of Sprinkler Flexible Drop

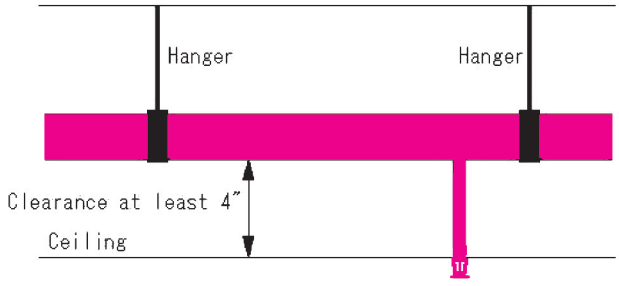


Figure 6. 9 Pendent Sprinkler Arrangement

Special Arrangement of Zone Control valve:

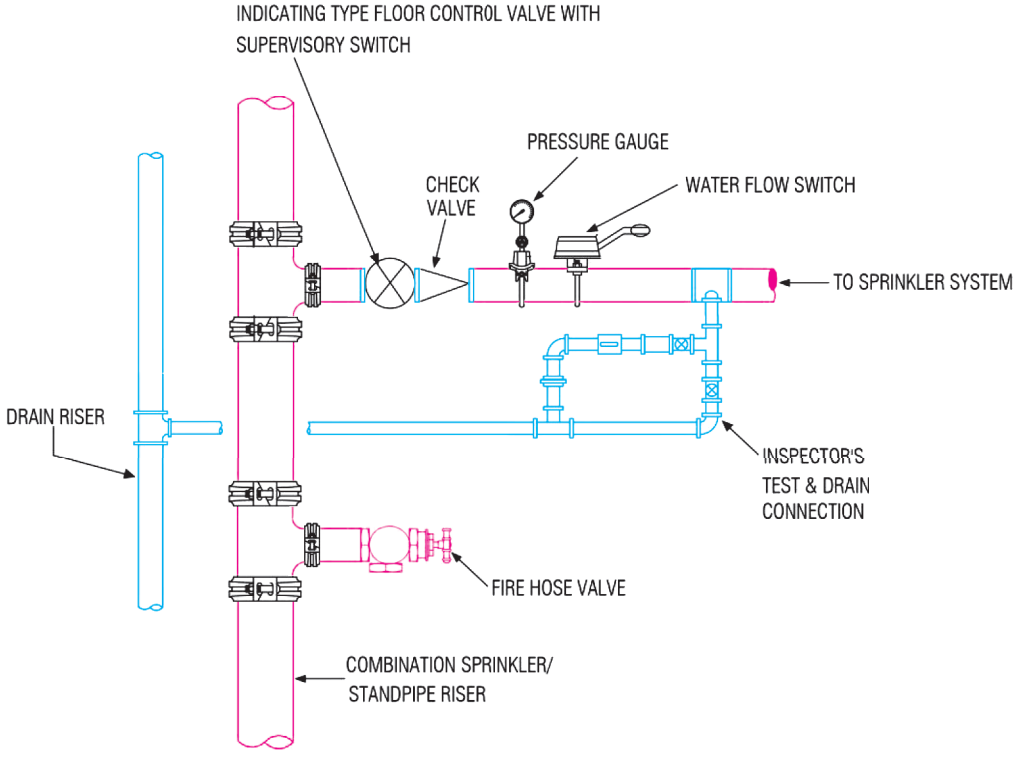


Figure 6. 10 Acceptable Piping Arrangement for Combined Sprinkler System

Chapter 7. Standpipe System

7.1. What is Standpipe System

A standpipe system is a fire safety system that is designed to provide rapid access to water in the event a fire breaks out.

Standpipes are installed as stand-alone systems which act like building specific fire hydrants, providing fire protection that will be readily available to firefighters.

7.1.1. Automatic Standpipe System

A standpipe that supplies water instantly with the operation of a hydrant valve, connected to a hose, from a water source capable of supplying the demand all the time required by the system.

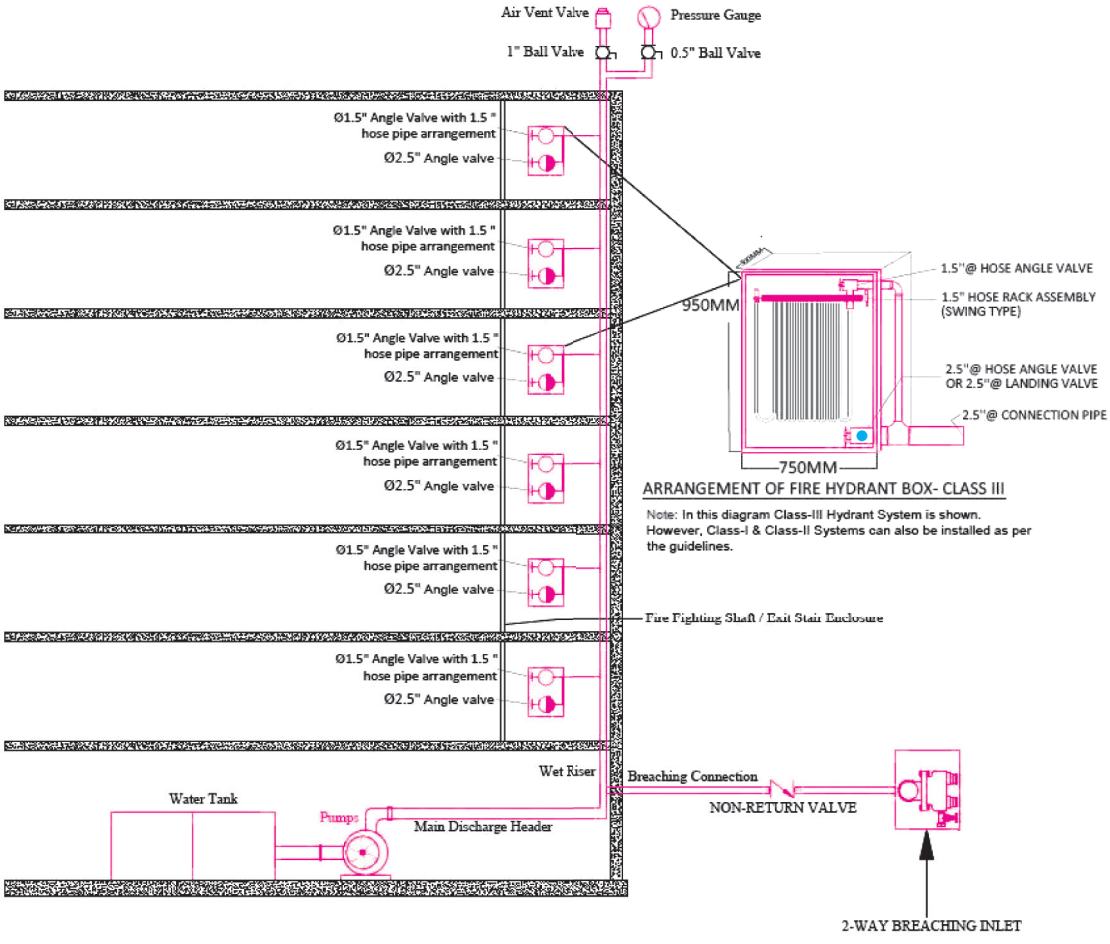


Figure 7. 1 Standpipe System Schematic Diagram

7.2. System Components and Hardware

7.2.1. Water Supply Source

City Supply: the most common water supply source for fire protection is dedicated city supply.

7.2.2. Water Storage Tank

In case of the absence of city supply, a water storage tank shall be provided within the premises or building for firefighting purposes. The capacity of the water storage tank depends on the flow rate requirement and the duration to fight against fire for a particular hazard like Light Hazard, Ordinary Hazard or Extra Hazard. (See Table 6.5)

7.2.3. Water supply and/or Booster Pump

The purpose of the fire pump is to supply enough water under pressure to the hose nozzle(s) through standpipe(s). The pumps generally used for fire protection systems shall be either single or multi-stage centrifugal or multi-stage vertical turbine type. The selection of pump(s) depend(s) on the volume and total head required to fight the anticipated fire.

7.2.4. Pipes

The pipes to be used in the standpipe system shall meet or exceed the standard recommended by NFPA, BS or any other acceptable standard for fire protection.

7.2.5. Hose Station

It is a closet, commonly constructed of an 18-gauge steel sheet, to house all the accessories required for a hose station. The cabinet shall have a size to accommodate hydrant valve(s), hose with nozzle, pressure reducing valve etc., and so designed to facilitate easy operation of the accessories at the time of the fire. The cabinet shall be painted with bright colours for easy identification.

7.2.5.1. Hose

A hose that is to be used by the building occupant shall be of 1 ½ in (40 mm) diameter and 100 ft. (30.0 m) long collapsible type for ready use. The hose is made of woven twill fabric with an internal linin of synthetic rubber. A hose less than 40 mm dia. shall be of non-collapsible type.

7.2.5.2. Hose rack and Cradle

The hose cabinet shall be furnished with a hose rack of adequate size to store a hose of 100 ft. (30 m) length in folded and suspended manner. The rack shall be swing type so as to facilitate easy stretch out of the hose at the time of a fire.

7.2.5.3. Nozzle

Nozzle(s) that is/are fitted at the outlet of the hose(s) is/are made of various kinds of metal or metal alloys or non-metal materials and are common of two types: - (a) Fixed and (b) Adjustable.

7.2.6. Fire Department Connection

Fire department connections are provided for fire department personnel to supply water from the fire engine or any other sources into the system. These are provided with 2 to 4 nos. of 2 ½ in. (65 mm) dia. quick coupling type inlet fittings.

7.2.7. Water Motor Gong/Alarm

A device to give the audio alarm as soon as an automatic or semi-automatic standpipe/sprinkler system is activated.

7.3. Types of Standpipe System

7.3.1. Automatic Dry

An automatic standpipe system is normally filled with pressurized air or nitrogen gas and fitted with a dry pipe valve which allows water to flow into the system upon opening a hose valve.

7.3.2. Automatic Wet

An automatic wet system is filled with water under pressure and capable of supplying the system demand upon opening of the hose valve.

7.3.3. Semi-Automatic Dry

A standpipe system connected to a water supply source is capable of supplying the system demand, and fitted with a deluge valve for activation from a remote-control device located at an easily noticeable place.

7.3.4. Manual Dry

A manual dry is a dry standpipe system that does not have a permanent water supply source connected to the system. Water is supplied into the system from the fire department engine (or the like) through the fire department connection.

7.3.5. Manual Wet

A standpipe system is normally filled with water and connected to a water supply source and pump(s) for first aid fighting of the fire. But this system exclusively relies on water supply from a fire engine through fire department connection to meet the system demand.

7.3.6. Limitation of Application of Manual Standpipe System

- A manual standpipe system cannot be used in high rise buildings.
- A manual standpipe system cannot be used in Class – II and Class – III systems.

7.3.7. Limitation of Application of Dry Standpipe System

- Dry standpipe system cannot be used in Class – II and Class – III systems.
- A dry standpipe system shall not be used where the pipe is subject to danger of freezing.

7.3.8. Classes of Standpipe Systems

7.3.8.1. Class – I System

- A Class – I standpipe system is provided with 2 ½ in. (65mm) dia. hose connection to supply water and intended for use by the fire department personnel or those trained in handling heavy fire stream.
- The flow rate and residual pressure required for the system are 250 us gpm (945 L/min.) and 100 psi (6.9 Bar), respectively at the hydraulically most remote hose.

Figure 7. 2 Class I System

7.3.8.2. Class - II System

A Class II standpipe system is provided with: -

- 1 ½ in. (38.1mm) hose connection to supply water for use primarily by the (trained) building occupants or by the fire department personnel during initial response.
- Exception: A minimum 1-in. (25.4-mm) hose pipe or hose reel shall be permitted to be used for hose stations in light hazard occupancies, where it is inspected and listed for this service and where it is approved by the authority having jurisdiction.

Figure 7. 3 Class II System

7.3.8.3. Class - III System

A Class III standpipe system is provided with: -

- One 1 ½ in. (40 mm) hose station to supply water for use by (trained) building occupants and
- One 2 ½ in. (63.5-mm) hose connections to supply a larger volume of water for use by fire department personnel or those trained in handling heavy fire streams.

Figure 7. 4 Class III System

7.3.8.4. Exception

A minimum 1-in. (25.4-mm) hose or hose pipe shall be permitted to be used for hose stations in light hazard occupancies where it is investigated and listed for this service and where it is approved by the authority having jurisdiction. (Source NFPA 14)

7.4. Installation Requirement for Hose Stations

7.4.1. Criteria of Location of installation

The hose stations shall be installed at a location that is unobstructed, readily noticeable and accessible by the people and shall be fixed at a height not less than 3 ft. (0.9 m) and not more than 5 ft. (1.5 m) above floor level measured from the floor to centre of the hose valve.

7.4.2. Locations of Hose Stations

7.4.2.1. Class – I System

a) A hose station shall be provided at each main floor landing of exit stair(s).
b) On each side of the wall, adjacent to the exit opening of a horizontal escape route.
c) Travel distance for hose stations shall not be more than 200 ft. (60 m) from any point (on the floor) for sprinklered building.

d) Travel distance for hose stations shall not be more than 130 ft. (40 m) from any point (on the floor) for a non-sprinklered building.
e) Hose station shall be provided in each exit passageway according to recommended travel distance.
f) A hose station shall be provided at the highest landing of the stairway where it can access the roof.
g) No hose station shall be required where the ratio of the slope of the roof is 1:3 or more.
h) Hose station shall be installed at the intermediate landing of the highest floor where permitted by the local authority.
i) A fire hose station is allowed to be installed at the intermediate landing.

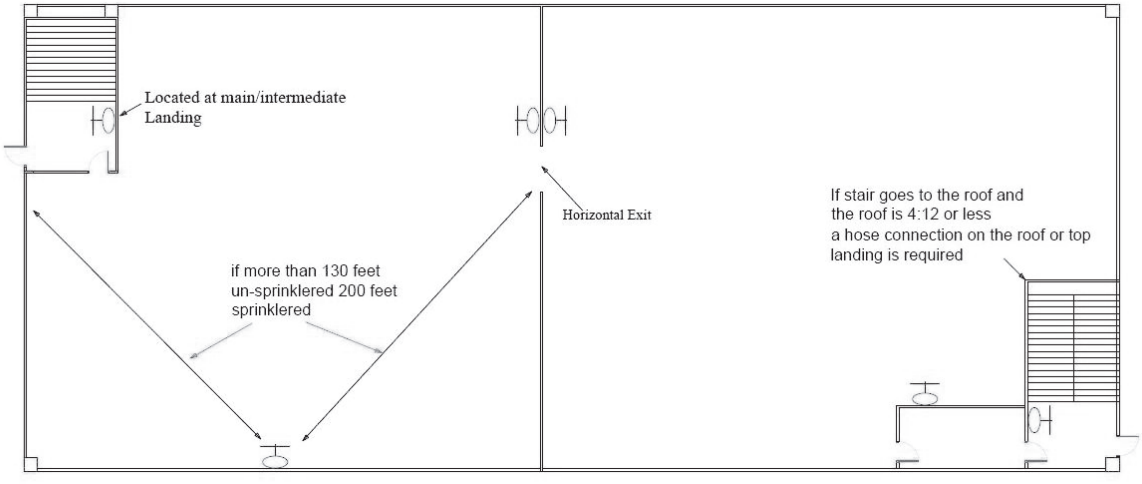


Figure 7. 5 Location of Class I and III

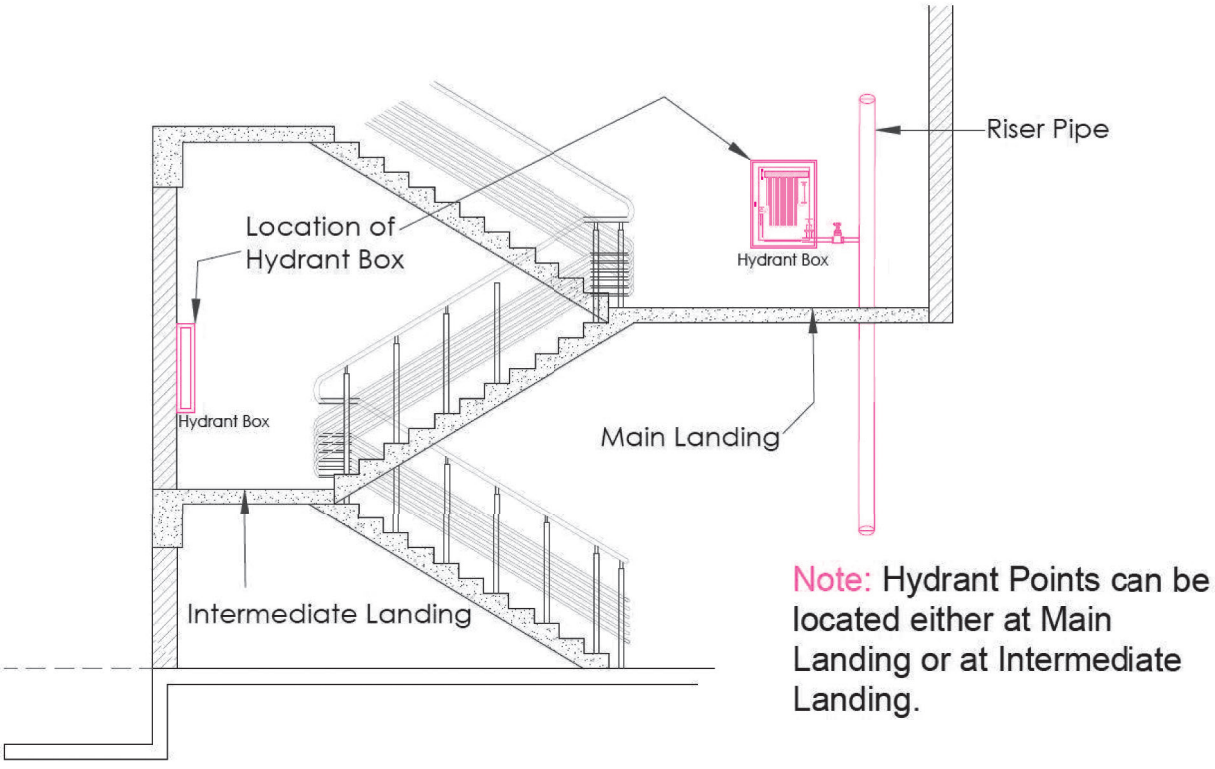


Figure 7. 6 Class I Standpipe Hose Station Location

Horizontal Exit

- The horizontal exit must have a minimum 2-hours fire-resistance rating, and the openings must be rated at least for 1-1/2-hours.
- Providing standpipe hose outlets on both sides of the horizontal exit gives firefighters a refuge while fighting a fire on the opposite side of the fire barrier.

Figure 7. 7 Horizontal Exit and Standpipe Hose Outlet

7.4.2.2. Class - II System

Class – II system is intended for use by the occupants of the building. It shall be located in position(s) that shall be accessible without exposing the user to the danger from the fire, and for this reason, these are usually installed along the escape route.

Hose station shall be so located that all portions of each floor are within 130 ft. (40 m) of the hose station where the hose dia. is 1 ½ in. (40 mm) and within 120 ft.

(36.6 m) for hose diameter less than 1 ½ in.

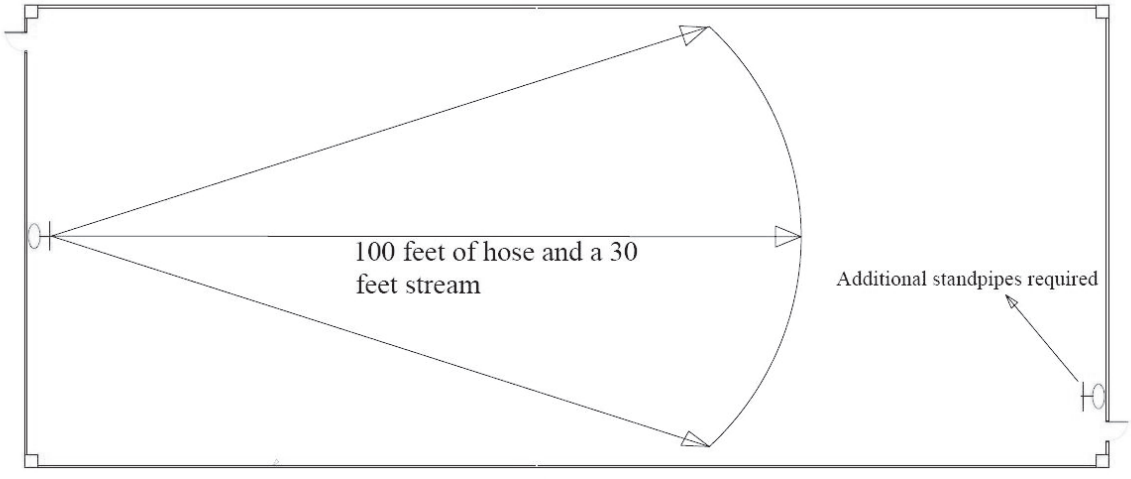


Figure 7. 8 Hose Station Class II Location

7.4.2.3. Class – III System

Class – III system shall be provided with hose stations at locations as required by Class – I and Class – II system.

7.4.3. Design Requirement for Standpipe System

7.4.3.1. Design criteria

The basic factors that are to be taken into consideration prior to design development includes:

- Clarification on the intended use of the building.
- Character (i.e., plan layout) of the building.
- Type of construction, i.e., construction material, story, etc.
- Accessibility to the building (to a fire engine).

The selection of type and class of a system for a particular building depends on the above criteria.

a) Standpipe system piping

- shall not pass-through hazardous areas
- shall be located so that it is protected from any mechanical and fire damage.

b) Standpipes and lateral piping supplied by standpipes shall be located

- in enclosed exit stairways
- or shall be protected by a degree of fire resistance equal to that required for enclosed exit stairways in the building in which they are located.

7.4.3.2. Number of Standpipes

The number of standpipe requirements depends on the character of the building, travel distance, coverage area of the hose. However, separate standpipes shall be provided in exit passageways. The number of Standpipes shall be determined as per BNBC.

7.4.3.3. Residual Pressure

The standpipe shall be capable of supplying system demand at minimum residual Pressure of 100 psi (6.9 Bar) and 65 psi (4.5 Bar) at the outlet of hydraulically most remote 2 ½ in. (65mm) and 1 ½ in.(40mm) dia. hose respectively.

7.4.3.4. Flow Rate

a) Hose Outlet

- The flow rate at the outlet of the hydraulically most remote hose of Class – I and Class – II shall be 250 us gpm (945 L/min) and 100 us gpm (379 L/min.) respectively.

Table 7. 1 Flow Rate & Residual Pressure

Description	Type of Class		
	Class - I	Class - II	Class - III
Maximum Flow Rate for Remote Riser (gpm)	500	100	500
Minimum Residual Pressure at the Hydraulically Most Remote Hose Connection (psi)	100	65	100

b) Class – I & III System

- Class – III system shall be provided with hose stations at locations as required by Class – I and Class – III system.
- The maximum flow rate shall be 1000 gpm (3785 L/min) for buildings that are sprinkled throughout, in accordance with NFPA 13.
- The maximum flow rate shall be 1250 gpm (4731 L/min) for buildings that are not sprinklered throughout, in accordance with NFPA 13.
- The minimum flow rate (as per NFPA 14) for the most remote standpipe shall be 500 gpm (1893 L/min) through the most remote2 ½ in. (65 mm) outlet.
- The minimum flow rate (as per NFPA 14) for additional standpipes shall be 250 gpm (946 L/min) per standpipe for a building with a floor area not exceeding 80,000 ft2 (7432 m2) per floor.
- But for a building with a floor area exceeding 80,000 ft2 (7432 m2) per floor, the minimum flow rate (as per NFPA 14) for additional standpipe shall be 500 gpm (1893 L/min) for 2nd standpipe and 250 gpm (946 L/min) for 3rd standpipe in case of additional flow requirement for an non-sprinklered building.

In high rise buildings, the standpipe system may be automatic or semiautomatic.

The maximum pressure at any point in the system shall not exceed 350 psi (24.1 Bar).

The maximum pressure at the outlet of 2 ½ in. (65 mm) dia. hose is limited to 175 psi (12.1 Bar). A pressure regulating device shall be provided where the pressure exceeds the limit and shall be installed within 7.5 ft (2.3 m) from the floor.

In the case of a combined system (standpipe and sprinkler), the diameter of the standpipe shall be a minimum of 6 in. (150 mm).

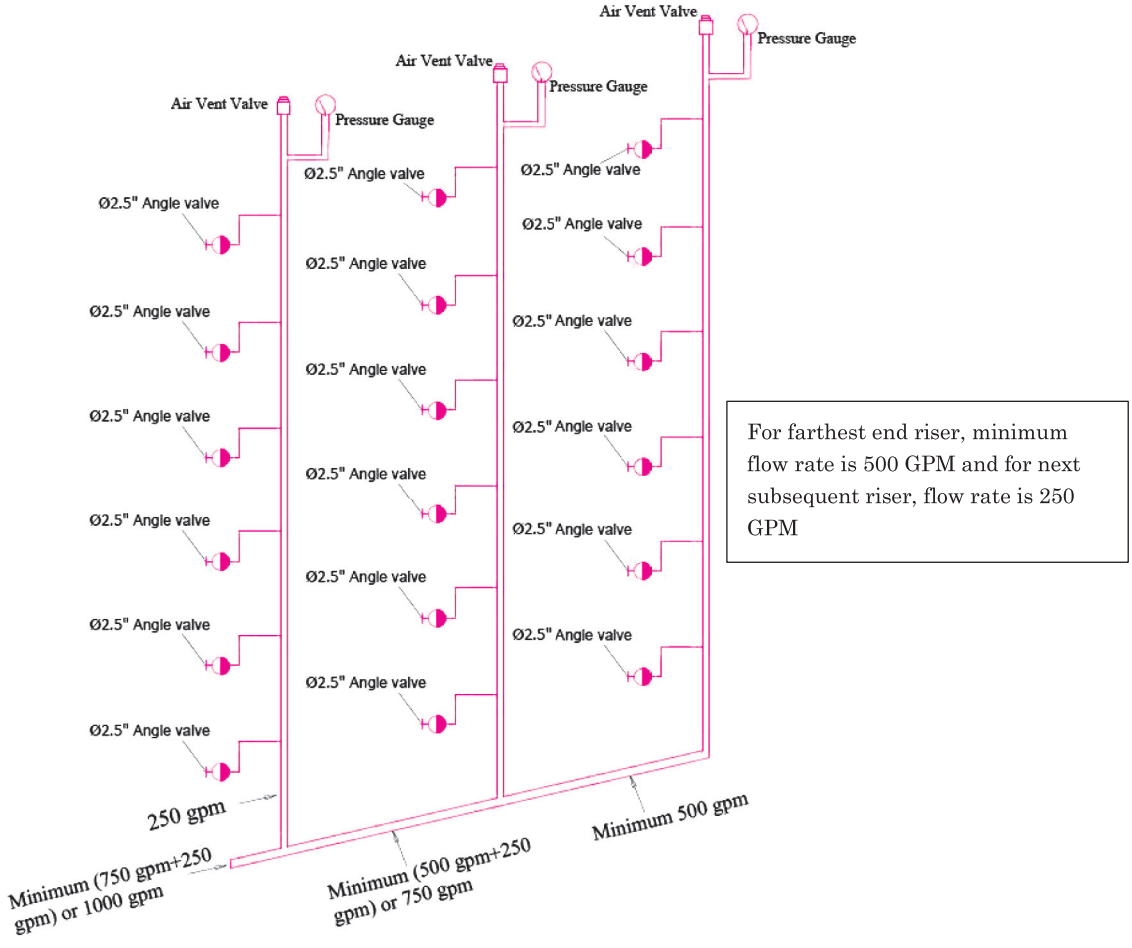


Figure 7. 9 Location of Class I and III Minimum Flow Rate

Class II

- The Minimum flow rate for the farthest end standpipe from the pump shall be 100 gpm.
- Additional flow shall not be required where more than one hose connection is required.

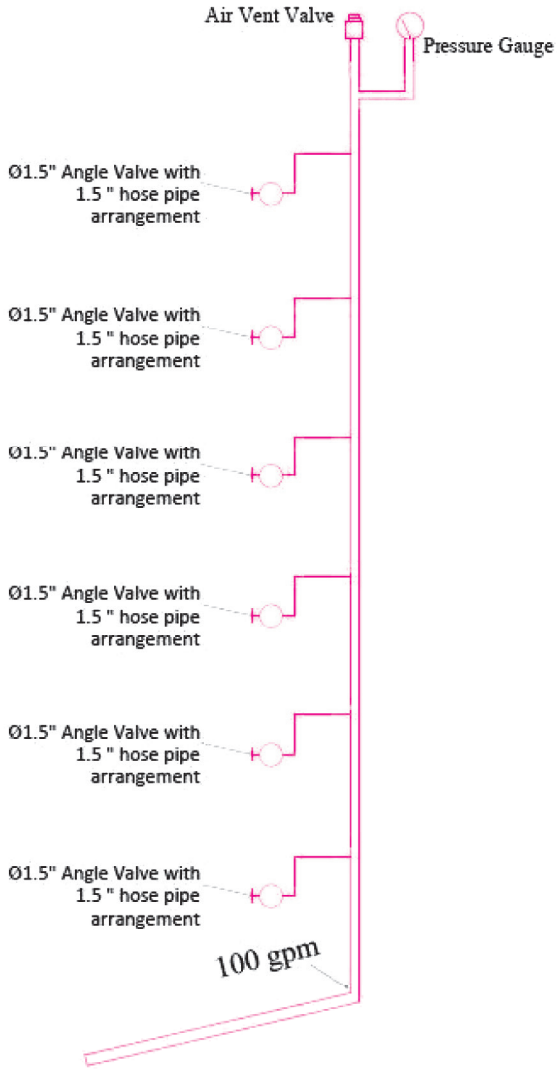


Figure 7. 10 Class II Minimum Flow Rate

7.5. Hydraulic Calculation Procedure

Required pressure at hydraulically most remote hose connection from the pump

Total Required Pressure

= Friction Loss + Elevation Pressure + Residual Pressure

= Suction head +Friction loss +Elevation Pressure +Residual

Pressure (where the pump needs a suction lift or negative suction).

7.5.1. Friction Loss

Pipe friction losses shall be determined based on the Hazen-Williams formula, as follows:

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}}$$

Where: p = frictional Resistance in psi per foot of pipe

Q = flow in gpm

C = friction loss coefficient

d = actual internal diameter of pipe in inches

Friction Loss = pL

Where: p = frictional resistance in psi per foot of pipe

L = expressed pipe length

7.5.2. Elevation Pressure

$P_E = h\rho g = 0.433h$

Where: P_E = elevation pressure

h = height up to which water has lift [ft.]

ρ = density of the liquid

g = gravitational acceleration (ρg = 0.433)

7.5.3. Residual Pressure

Table 7. 2 Minimum Residual Pressure

Description	Type of Class		
	Class - I	Class - II	Class - III
Minimum Residual Pressure at the Hydraulically Most Remote Hose Connection at psi	100	65	100

Table 7. 3 Equivalent Pipe Length Chart (source NFPA 14)

Fittings and Valves	Fitting and Valves Expressed in Equivalent Feet of Pipe [in.]													
	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4	5	6	8	10	12
45-degree elbow	1	1	1	2	2	3	3	3	4	5	7	9	11	13
90-degree standard elbow	2	2	3	4	5	6	7	8	10	12	14	18	22	27
90-degree long turn elbow	1	2	2	2	3	4	5	5	6	8	9	13	16	18
Tee or cross (flow turned 90-degree)	3	5	6	8	10	12	15	17	20	25	30	35	50	60
Butterfly valve	-	-	-	-	6	7	10	-	12	9	10	12	19	21
Gate valve	-	-	-	-	1	1	1	1	2	2	3	4	5	6
Swing check*	-	5	7	9	11	14	16	19	22	27	32	45	55	65
Glove valve	-	-	-	46	-	70	-	-	-	-	-	-	-	-
Angle valve	-	-	-	20	-	31	-	-	-	-	-	-	-	-

For SI units: 1 in. = 25.4mm.
*Due to the variations in design of swing check valves, the pipe equivalents indicated in this table are considered to be average.

Table 7. 4 Hazen-Williams C Value (source NFPA 14)

Pipe or Tube	C Value
Unlined cast or ductile iron	100
Black steel (dry systems, including pre-action)	100
Black steel (wet systems, including deluge)	120
Galvanized (all)	120
Plastic (listed - all)	150
Cement-lined cast or ductile iron	140
Copper tube or stainless steel	150

Table 7. 5 Adjustment Factors for C Values (source NFPA 14)

Value of C	100	130	140	150
Multiplying factor	0.713	1.16	1.33	1.51

7.5.4. Example

7.5.4.1. Condition as follows

- Class I Hydrant system
- Height, size and length are showed in Figure 7.11.
- Pipe is black steel (wet system)

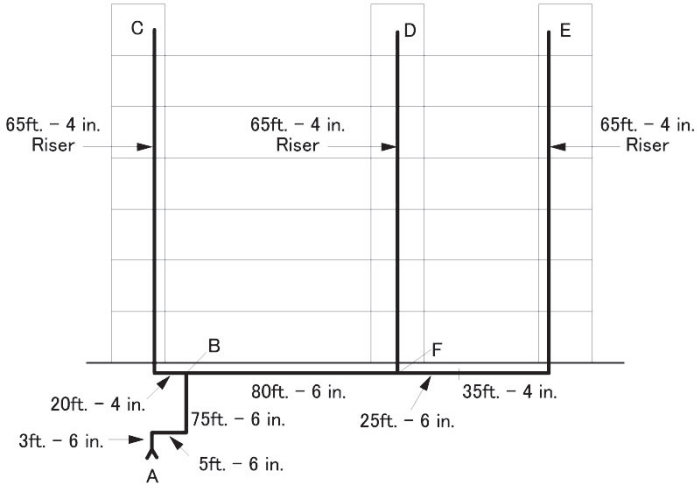


Figure 7. 11 Example of Hydraulic

7.5.4.2. Friction Loss

The maximum friction loss should be worked out first. Here, the farthest riser E has the maximum friction loss in this plan. The minimum flow rate for the farthest end riser from the pump shall be 500 [gpm].

Flow rate for riser E = 500 [gpm]…(a)

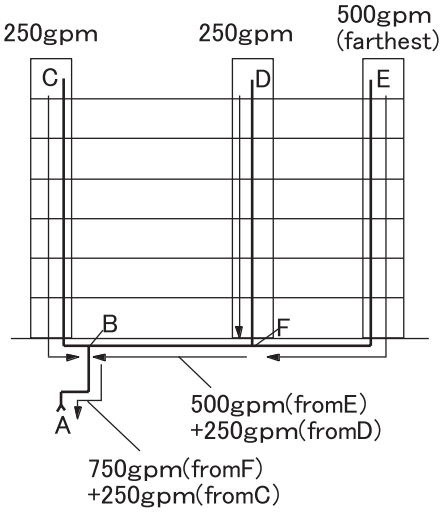
The minimum flow rate for additional risers shall be 250 [gpm].

Flow rate for riser C = 250 [gpm]…(b)

Flow rate for riser D = 250 [gpm]…(c)

Flow rate from F to B = from E + from D = (a) + (c) = 750 [gpm] …(d)

Flow rate from B to A = from F + from C = (d) + (b) = 1000 [gpm] …(e)



From E to F

C value of black steel (wet system) is 120. (see Table 5.10)

Q = (a) = 500 [gpm], C value = 120, d = 4 [inch]

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}} = \frac{4.52 \times 500^{1.85}}{120^{1.85} \times 4^{4.87}} = 0.074[psi/ft.] \quad \ldots(f)$$

Q = (a) = 500 [gpm], C value =120, d= 6 inch

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}} = \frac{4.52 \times 500^{1.85}}{120^{1.85} \times 6^{4.87}} = 0.010[psi/ft.] \quad \ldots(g)$$

Friction loss of elbow and tee are replaced with straight pipe length.

Elbow length: 90 degree standard elbow @ 4 in. = 10 [ft.](see Table 5.9) ...(h)

Tee length: Tee @ 6 in. = 30 [ft.](see Table 5.9) ...(i)

Pipe 4 in. L = Lnegth of pipe 4 inch + 1 Elbow = (65 [ft.] + 35 [ft.]) + (h) = 100 + 10 = 110 [ft.] ...(j)

Pipe 4 in. pL = (f) × (j) = 0.074 × 110 = 8.1 [psi] …(k)

Pipe 6 in. L = Length of pipe 6 in. + 1 Tee = 25 [ft.] + (i) = 25 + 30 = 55 [ft.] ...(l)

Pipe 6 in. pL = (g) × (l) = 0.010 × 55 = 0.55 [psi] …(m)

From F to B

Q = (d) = 750 [gpm], C value = 120, d= 6 inch

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}} = \frac{4.52 \times 750^{1.85}}{120^{1.85} \times 6^{4.87}} = 0.022[psi/ft.] \quad \ldots(n)$$

L = Length of pipe + 1 Tee = 80 [ft.] + (i) = 80 + 30 = 110 [ft.] ...(o)

pL = (n) × (o) = 0.022 × 110 = 2.4 [psi] …(p)

From B to A

Q = (e) = 1000 [gpm], C value = 120, d= 6 in.

$$p = \frac{4.52Q^{1.85}}{C^{1.85}d^{4.87}} = \frac{4.52 \times 1000^{1.85}}{120^{1.85} \times 6^{4.87}} = 0.037[psi/ft.] \quad \ldots(q)$$

Elbow length: 90 degree standard elbow @ 6 in. = 14 [ft.](see Table 5.9) ...(r)

L = Length of pipe + 2 Elbow = (75 [ft.] + 5 [ft.] + 3 [ft.]) + (r) × 2 = 83 + 14 × 2 = 111 [ft.] ...(s)

pL = (q) × (s) = 0.037 × 111 = 4.1 [psi] …(t)

Total friction loss = (k) + (m) +(p) +(t) = 8.1 + 0.55 + 2.4 +4.1 = 15 [psi] …(u)

7.5.4.3. Elevation Pressure

Highest position of pipe end should be calculated. In this example, highest position is 65 [ft.].

Elevation Pressure = 0.433h = 0.433 [psi/ft.] × 65 [ft.] = 28 [psi] ...(v)

7.5.4.4. Residual Pressure

100 [psi] (see Table5.8) …(w)

7.5.4.5. Total Calculation

System demand gpm = (e) = 1000 [gpm]

System demand psi = Friction Loss + Elevation Pressure + Residual Pressure = (u) + (v) + (w) = 15 + 28 + 100 = 143 [psi]

7.6. Typical Diagram for Fire Protection

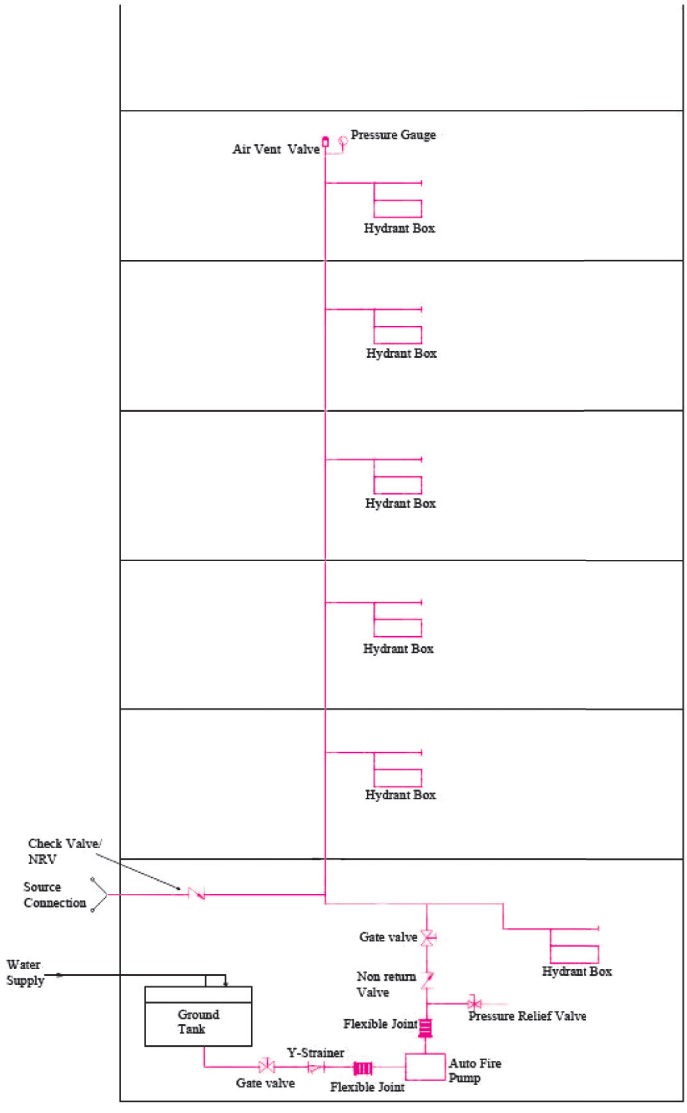


Figure 7. 12 Typical Diagram for Fire Protection with Ground Tank and Automatic Fire Pump

The pump shall be housed in a readily accessible position in a building of non-combustible construction. The pump shall be adequately protected against any mechanical damage.

There shall be a provision for a secondary fire pump that can be operated by a dedicated generator or by an alternate power supply source with an adequate control system and in compliance with safety operation during fire.

The quality of the pump assembly shall comply with the specification of the International Association of Fire. From these generators and alternative power supply sources, power cannot be utilized for regular use other than (i) fire lift, (ii) stretcher lift (iii) emergency light (iv) alarm system.

After installation of the hydrant system, a flow test shall be conducted to verify the capacity of the discharge system, such as what the installation can fulfil (the minimum capacity of flow and time) as specified in Table 6.5 This system shall be periodically inspected, maintained and tested in accordance with NFPA 25.

A wet riser is a vertical pipe of not less than 100 mm internal diameter, kept permanently charged with water. This can be used immediately from any floor of the building at which a hydrant or landing valve is provided.

If the same reservoir is used for firefighting, domestic and other purposes, then the arrangement is to be made so that sufficient water as per requirement for firefighting need to be always maintained. Then the remaining water can be used for domestic or other purposes.

Table 7. 6 Size of Vale & Accessories for Pump as per Flow Capacity

NFPA Minimum Piping Sizes (Normal) in inches						
Item \ Flow in gpm	250	500	750	1000	1250	1500
Suction size	3 1/2	5	6	8	8	8
Discharge size	3	5	6	6	8	8
Main relief valve	2	3	4	4	6	6
Main Relief Valve Discharge	2×2 1/2	5	6	8	8	8
Waste cone	2×2 1/2	3×4	4×6	4×8	6×8	6×8
Hose valve header	3	4	6	6	8	8
Hose valve quantity	1	2	3	4	6	6
Flow meter	3	5	5	6	6	8

7.7. Location of Pump Room & Reservoir

It is highly recommended as per NFPA 20, that a Pump House with Reservoir should be located at least 50 feet away from the building if space permits.

However, if it is not possible to place the pump house with a reservoir at 50 feet from the building, then at least try to place the pump house with a reservoir outside of the building.

If space is not available outside of the building, then locate the pump house with the reservoir at a safe place so that during an emergency, trained personnel can enter into the pump house and can work safely.

Locate reservoir & pump house for firefighting at the ground floor instead of the basement of the building.

Distance between pump house and reservoir shall not be more than 1 feet.

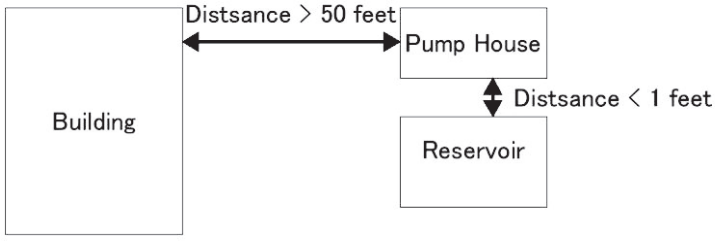


Figure 7. 13 Plan View of Pump House, Reservoir Location and Building

7.8. Pump Room Size

The size of the pump house should be at least 20’ x 18’.

The clear height of the pump house should be kept at least 12 feet. (Excluding Beam Height)

This is applicable for fire pumps only.

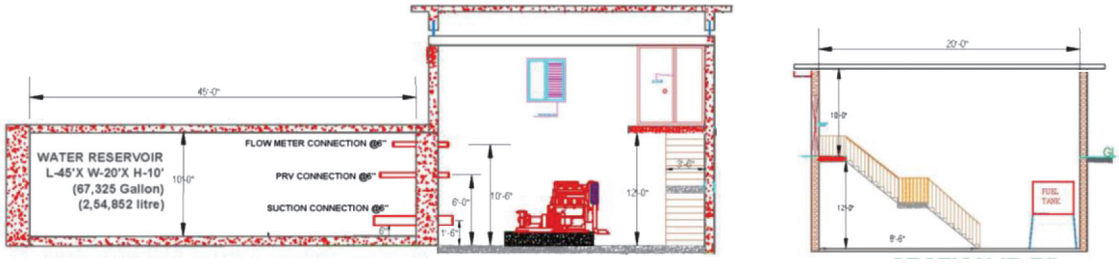


Figure 7. 14 Typical Pump House

7.9. Ventilation of Pump Room

Ventilation for the pump room is essential. Before finalization of design, consultation with HVAC Engineer is necessary to ensure desired ventilation as per pump capacity or recommendation of pump manufacturer. The same is also necessary for all other equipment installed in the pump room.

The height of the pump room should be considered in such a way that the discharge pipe (System line), and exhaust pipe of the engine driven pump can be taken outside of the room without creating any obstruction in the means of egress components.

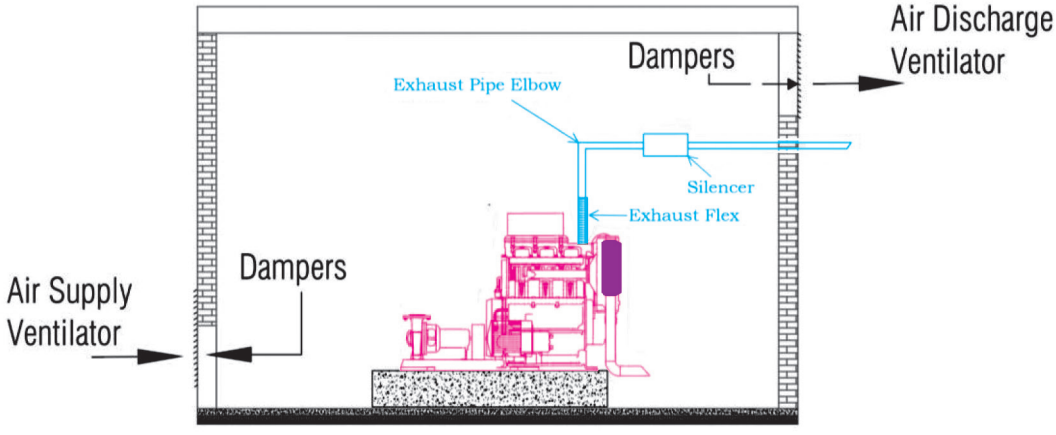


Figure 7. 15 Ventilation of Pump Room

7.10 Difference Between Positive Suction & Negative Suction

In the positive suction, the pump with the driver is installed either at the lowest level of the reservoir or under the reservoir's lowest level.

In this arrangement, the pump does not need to use energy to draw water from the reservoir. Water flows into the pump from the reservoir due to the gravitational force, making it always available.

As per NFPA 20, a positive suction arrangement shall be ensured.

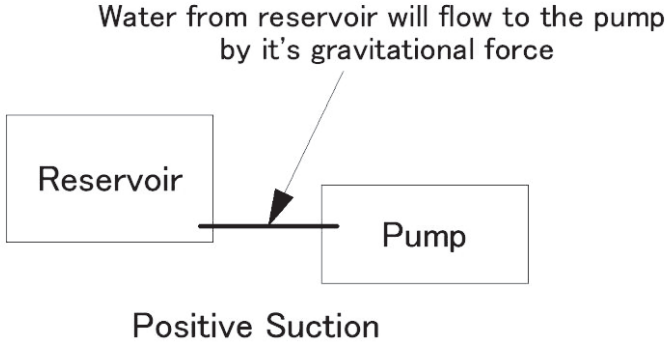


Figure 7. 16 Positive Suction

In case of the negative suction, the pump with the driver is installed at the upper level of the reservoir.

Water may not be available due to the non-functionality of the check valve or the foot valve at the end of the suction pipe.

In this case the pump needs to give extra energy during suction and is not recommended by NFPA 20.

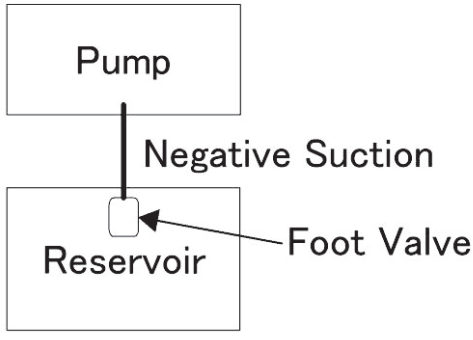


Figure 7. 17 Negative Suction

Chapter 8 Portable Fire Extinguisher

8.1 Classification of Fire Extinguisher

Portable fire extinguishers are categorized into different classes depending on the different type of fires and are rated for their relative effectiveness in extinguishing the different classes of fires hazards. The classification of fires is as follows:

- Class 'A' Fire: Fire in ordinary combustible materials i.e., wood, cloth, paper, rubber, plastic, etc.
- Class 'B' Fire: Fire flammable liquids such as combustible liquid, petroleum, oil paints, solvent lacquers, alcohol, flammable gases, etc.
- Class 'C' Fire: Fire caused by energized electrical appliances or equipment,
- Class 'D' Fire: Fire in combustible metals, e.g., potassium, magnesium, sodium, titanium, etc.
- Class 'K' Fire: Fire in cooking appliances that include combustible cooking oil or fats.

8.2 Selection Criteria of Fire Extinguishers

The Selection of the most suitable extinguisher for a particular situation is determined by careful analysis of the following factors.

a) Nature of combustible or flammable materials.
b) Anticipated size, intensity and the rate at which the fire spreads.
c) Effectiveness of the extinguishing agent on fire.
d) Ability of the personnel or (trained or untrained) occupants to operate the extinguisher.
e) Environmental conditions that suit the requirement for the fire extinguisher installation.
f) Potential adverse effect from the suppressing agent and the combustible material.
g) Safety concern on operation and health.

8.3 Selection of Extinguisher

The selection of the fire extinguisher for a particular type of hazard depends on critical analysis of the above criteria, the advantages and disadvantages of the available types of fire extinguishers.

8.3.1 Water Type Fire Extinguisher

It is filled with stored pressurized water as an extinguishing agent. The most common size is 2 ½ gallon (9.5 litter) capacity. It is suitable for extinguishing a fire of Class 'A'.

8.3.2 AFFF or FFFP Fire Extinguisher

AFFF (aqueous film-forming foam) and FFFP (film-forming fluoroprotein foam) are applicable to extinguish both Class 'A' and Class 'B' fires. They prevent the regeneration of Class 'B' flammable liquid fire by floating and suppressing the liquid surface.

8.3.3 CO_2 Fire Extinguisher

CO_2 Fire Extinguishers are suitable for Class 'B' and Class 'C' fires. This type of extinguisher is not recommended for outdoor or indoor use. This is because, in areas where strong air current prevails, the air carries away the CO_2 gas preventing the fire to be extinguished effectively. The advantage of this extinguisher is that the agent does not leave any residue.

8.3.4 Halogenated Gas Extinguisher

Chapter 8. The extinguishing agent of this type of extinguisher is either Halon 1211 or 1301. They are similar to CO_2 and are suitable for cold weather since they leave no residue. This extinguisher is suitable for Class 'A', Class 'B' and Class 'C' fires. Windy conditions and strong air current make it difficult to extinguish the fire since the agent disperses rapidly.

8.4 Installation Requirement

8.4.1 Location of Installation

c) Portable fire extinguishers should be located where they are readily visible, accessible and available for use in the event of a fire. They should be located along the path of travel, escape route or exit way.
d) Fire extinguishers should not be obstructed or obscured from view. A means should be provided to indicate the location of the extinguishers if they are obscured from view.
e) The extinguishers should not be positioned at a location where there would be a chance of engulfment of the operator by the fire.
f) Wheeled fire extinguishers shall be kept at a designated location that is readily noticeable, accessible, available and unobstructed from view.

8.4.2 Height of Installation

Portable fire extinguishers having gross weight not more than 40 lbs. (18 kg) should be installed so that top of the extinguisher is not more 5 ft. (1.5 m) above the floor. The top of extinguishers having gross weight more than40 lbs. (18 kg) should not be more than 3 ½ ft. (1.07 m) from the floor. There shall be a minimum 4 in. (100 mm) clear space between the bottom of the extinguisher and the floor.

8.4.3 Orientation

The fire extinguishers should be so installed that the operating instruction printed on the body is easily visible from the front.

8.4.4 Travel Distance

The maximum travel distance to the extinguisher for Class "A" fire should not be more than 75 ft. (23 m) and for Class 'B' fire should be less than 50 ft. (15.25m) as per NFPA 10.

Extinguisher Selection as per NFPA 10.

The extinguisher is selected on the basis of fire rating.

8.5 Rating of Portable Fire Extinguishers

8.5.1 Class A Rating

To achieve a Class “A” rating, the extinguisher must be capable of putting out the wood crib, wood panel and excelsior (shredded paper) tests. Ratings are based on the size of the material that can be repeatedly extinguished.

Table 8. 1To Achieve Class A Rating

Rating	Wood Crib (inches)	Wood Panel (Feet)	Excelsior (lbs)
1-A	20 x 20 x 20	8 x 8	6
2-A	25 x 26 x 26	10 x 10	12
3-A	30 x 30 x 30	12 x 12	18
4-A	33 x 30 x 30	14 x 14	24
6-A	38 x 38 x 38	17 x 17	36
10-A	48 x 48 x 48	17 x 17	36

8.5.2 Class B Rating

To achieve a class “B” rating, the extinguisher must be repeatedly put out a flaming liquid fire. Ratings are based on the size of the fire.

Table 8. 2 To Achieve Class B Rating

Rating	Pan Size (sq ft.)	Gallons of Heptane
1-B	2.5	3.25
2-B	5.0	6.25
5-B	12.5	15.5
10-B	25.0	31.0
20-B	50.0	65.0
30-B	75.0	95.0
40-B	100.0	125.0

Table 8. 3 Fire Extinguisher Size and Placement for Class A Hazards (source NFPA10)

	Light (Low) Hazard Occupancy	Ordinary (Moderate) Hazard Occupancy	Extra (High) Hazard Occupancy
Minimum rated single extinguisher	2-A	2-A	4-A
Maximum floor area per unit of A	3000 ft^2	1500 ft^2	1000 ft^2
Maximum floor area for extinguisher	11,250 ft^2	11,250 ft^2	11,250 ft^2
Maximum travel distance to extinguisher	75 ft	75 ft	75 ft

For SI units: 1ft = 0.305m; 1ft^2 = 0.0929m^2

Table 8. 4 Fire Extinguisher Size and Placement for Class B Hazards (source NFPA10)

Type of Hazard	Basic Minimum Extinguisher Rating	Maximum Travel Distance to Extinguishers	
		(ft)	(m)
Light (low)	5-B	30	9.15
	10-B	50	15.25
Ordinary (moderate)	10-B	30	9.15
	20-B	50	15.25
Extra (high)	40-B	30	9.15
	80-B	50	15.25

Notes:

1. The specified rating does not imply that fires of the magnitudes indicated by these ratings will occur, but rather they are provided to give the operations more time and agent to handle difficult spill fires that could occur.
2. For fires involving water-soluble flammable liquids, NFPA10
3. For specific hazard applications, see NFPA10

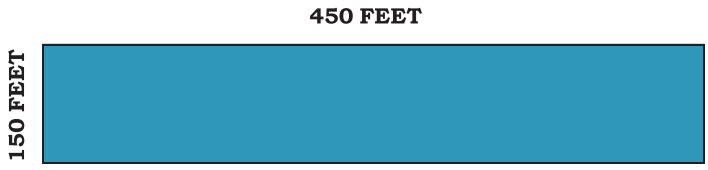
Table 8. 5 Maximum Area to Be Protected per Extinguisher (Ft^2) (source NFPA10)

Class A Rating Shown on Extinguisher	Light (Low) Hazard Occupancy	Ordinary (Moderate) Hazard Occupancy	Extra (High) Hazard Occupancy
1A	-	-	-
2A	6000	3000	-
3A	9000	4500	-
4A	11,250	6000	4000
6A	11,250	9000	6000
10A	11,250	11,250	10,000
20A	11,250	11,250	11,250
30A	11,250	11,250	11,250
40A	11,250	11,250	11,250

For SI unit: 1ft^2= 0.0929m^2

Note: 11,250ft^2 is considered a practical limit.

8.6 Example



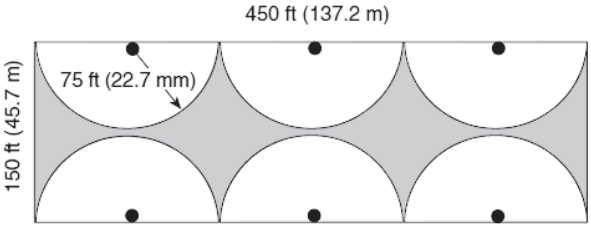
Area: 150’ x 450’ = 67500 sqft

Select 4A, light hazard.

A number of extinguishers need as per Table 8.3:

67500/11250 = 6 nos. (4A Rating fire extinguisher)

Place the extinguisher (4A rating) as per the below picture.



Area coverage & travel distance requirement failed to meet as per above arrangement.

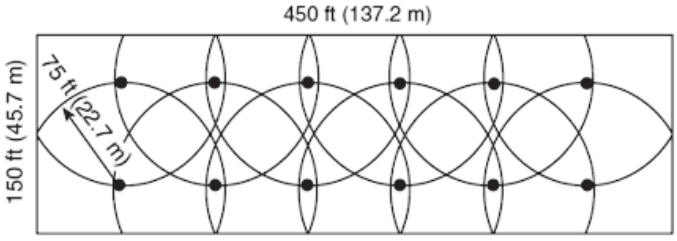
New Consideration

Area: 150’ x 450’ = 67500 sft

Select: 2A, LIGHT HAZARD.

Number of Extinguisher Need:

67500/6000 = 11.25 or 12 nos. 2A RATING FIRE EXTINGUISHER



Area coverage & travel distance requirement meet as per above arrangement.

Chapter 9 Automatic Fire Detection and Alarm System

9.1 Purpose

Early detection and announcement of the fires are important to ensure safe evacuation. For this reason, a precautionary alarm system is needed. It is easy to install in existing buildings as well as the ones that are under construction.

A fire alarm system has a number of devices working together to detect and warn people through visual and audio appliances when smoke, fire, carbon monoxide or other emergencies are present. An integrated system combines all detection, notification and auxiliary functions in a single system.

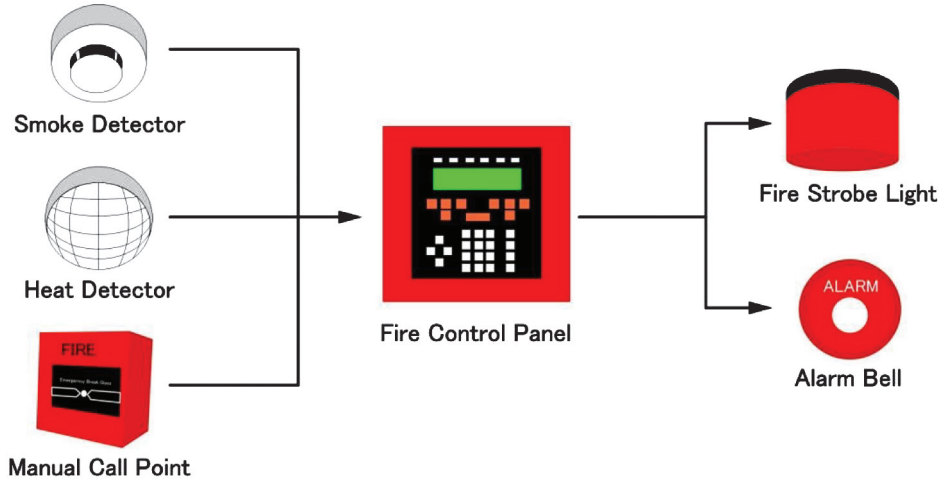


Figure 9. 1Components of Fire Detection and Alarm System

9.1.1 System Components

- Initiating Device: Manual Call point, Smoke Detector, Beam Detector, Heat Detector, etc.
    - Automatic: Sensors to receive environmental status and send signal to Control Unit for audio/visual indication.
    - Manual: Manually activated device to send a signal to Control Unit for audio/visual indication.
- Notification Device: Sounder/Hooter, Strobe, Alarm Bell.

9.2 Installation and Required Location of Initiating Devices

9.2.1 Monitoring Area

- All rooms
- Halls
- Storage Areas
- Basements
- Attics
- Lifts
- Spaces above Suspended Ceilings and below Raised Floors.
- Other Subdivisions and Accessible Spaces
- Inside of All Closets, Elevator Shafts, Enclosed Stairways, Dumbwaiter Shafts, and Chutes.
- Area below Galleries.

9.2.2 Partial Monitoring Area

All common areas or workspaces

- Corridors
- Lobbies
- Storage Rooms
- Equipment Rooms
- Other Vacant or Empty Rooms.

9.2.3 Special Monitoring Area

Areas are selected according to the codes, standards, laws or authority having jurisdiction.

9.3 Types of Detectors

The following types of detectors are commonly used for the detection of fire in any space.

- Heat Detector
- Smoke Detector
- Air Sample Detector
- Flame Detector

9.3.1 Heat Detector

It senses the abnormal temperature, due to generation of heat caused by a fire inside a space.

9.3.1.1 Types of Heat Detector

- Fixed Temperature Detector: This is a type of heat detector which will respond when its operating element becomes heated to a pre-set level.
- Rate of Rise Detector: The detector that activates when it senses the temperature rising at a rate exceeding the preselected rate.

9.3.2 Smoke Detector

A smoke detector should detect abnormal quantity of smoke that may be caused by a fire in a building.

9.3.2.1 Types of Smoke Detector

- Photoelectric Light Scattering Detector: The detector is installed with the photosensitive sensor in a way so that a major part of the light does not fall on the sensor. When smoke gets into the light path, the rays of light falls on the sensor through reflection/refraction, causing an alarm as soon as the amount of falling rays meet the pre-set criteria.
- Photoelectric light Obscured Detector (or Beam Detector): This is a line type detector comprising of a beam transmitter and a photosensitive sensor (receiver). A major portion of light emission is allowed to fall on it. When the light is obscured by the smoke it causes a reduction of light reaching the sensor to a pre-set level thus activating the alarm.
- Flame detector: A device to detect a flame caused by fire and suitable for operation in daylight or ambient lighting environment.
- Gas Detectors: Gas detectors are intended to detect one or more gases produced by the burning of substances.
- Air sampling detector

9.4. Design and Installation Requirement

9.4.1. General Installation Criteria

- The location and spacing of detectors should be selected after a detailed analysis and engineering assessment based on the shape, surface, height of the ceiling, configuration of contents, burning characteristic of combustible with space, ventilation and ambient environment.
- Detectors should be installed at a location where they are not subject to mechanical damage.
- Detectors should be suspended independently of their attachment to the conductors of the circuit.
- Detectors should not be fixed into the mounting surface unless made for recessed installation.
- Detectors should be installed at an accessible location for routine maintenance.
- Detectors should not be required for the protection of inaccessible space unless it contains combustible materials. In case the space contains combustible materials should be provided with detectors and made accessible.
- The standard coverage area of a smoke detector is 900 ft^2 (83.6 m^2) for 6.0 to 7.5 air change. The area of coverage reduces with the increase of air change.
- The recommended linear spacing of the heat detector reduces with the height of the space to be protected.

Table 9. 1 Heat Detector Spacing Reduction Based on Ceiling Height (source NFPA 72)

Ceiling Height Above		Up to and Including		Multiply Listed Spacing by
ft	m	ft	m	
0	0	10	3.05	1.00
10	3.05	12	3.66	0.91
12	3.66	14	4.27	0.84
14	4.27	16	4.88	0.77
16	4.88	18	5.49	0.71
18	5.49	20	6.10	0.64
20	6.10	22	6.71	0.58
22	6.71	24	7.32	0.52
24	7.32	26	7.93	0.46
26	7.93	28	8.54	0.40
28	8.54	30	9.14	0.34

In case of beam(s) dropping down more than 18 in. (460 mm) below the ceiling and more than 8 ft. (2.4 m) apart, each area formed by the beams should be treated as separate area.

9.4.2. Locations of Installation of Heat Detectors

9.4.2.1. Spot type heat detectors shall be located

a) On the ceiling, not less than 4 in. (100 mm) from the sidewall and on the sidewalls between 4 in. and 12 in. (100 mm and 300 mm) from the ceiling to top of the detector.
b) Line type detectors should be installed on the ceiling or on the sidewall at a location not exceeding 20 in. (500 mm) from the ceiling.

9.4.2.2. Spacing of Heat detectors

a) Smooth Ceiling: The distance between the detectors should not be more than recommended spacing i.e. 50 ft. (9.1 m) but for better performance, it is recommended to set the spacing between detectors 0.7 times of the rated spacing.
b) Irregular Area: The distance between the detectors may be permitted to exceed the rated spacing subject to the condition that the maximum distance from a detector to the remotest point on the sidewall or corner is not more than 0.7 times the rated spacing
c) Solid Joist Construction: The distance between heat detectors measured at right angle to the solid joist shall not exceed 50% of the spacing of a smooth ceiling.
d) Beam Construction: Where the beams project more than 4 in. (100 mm) below the ceiling, the spacing of spot type heat detectors from the right angle to the beam run should not exceed two-thirds spacing of smooth ceiling. Where the beams project more than 18 in. (460 mm) below the ceiling and are more than 8 ft (2.4 m) on the centre, each bay formed by the beams shall be treated as a separate area.
e) Peak Ceiling: Installation of the detector should begin with spacing and location at or within 3 ft. (0.9 m) of the peak of the ceiling. The spacing and quantity of additional detectors, if required, should be as per horizontal projection of smooth ceiling.
f) Shed Ceiling: The shed ceiling should be provided with a row of detectors located within 3 ft. (0.9 m) of the high side of the ceiling measured horizontally. The additional detectors, if required, should be installed in the remaining are based on horizontal projection of the ceiling.

9.4.3. Locations of Installation of Smoke Detectors

9.4.3.1. Spot type smoke detectors shall be located

o) On the ceiling not less than 4 in. (100 mm) from the sidewall and on the sidewalls between 4 in. and 12 in. (100 mm and 300 mm) from the ceiling to the top of the detector.

p) Line type detectors shall be installed on the ceiling or on the sidewall at a location not exceeding 20 in. (500 mm) from the ceiling.

q) The detectors installed inside the raised floor or similar space shall be installed in either pendent or side-wise position to minimize the accumulation of dust on the sensor.

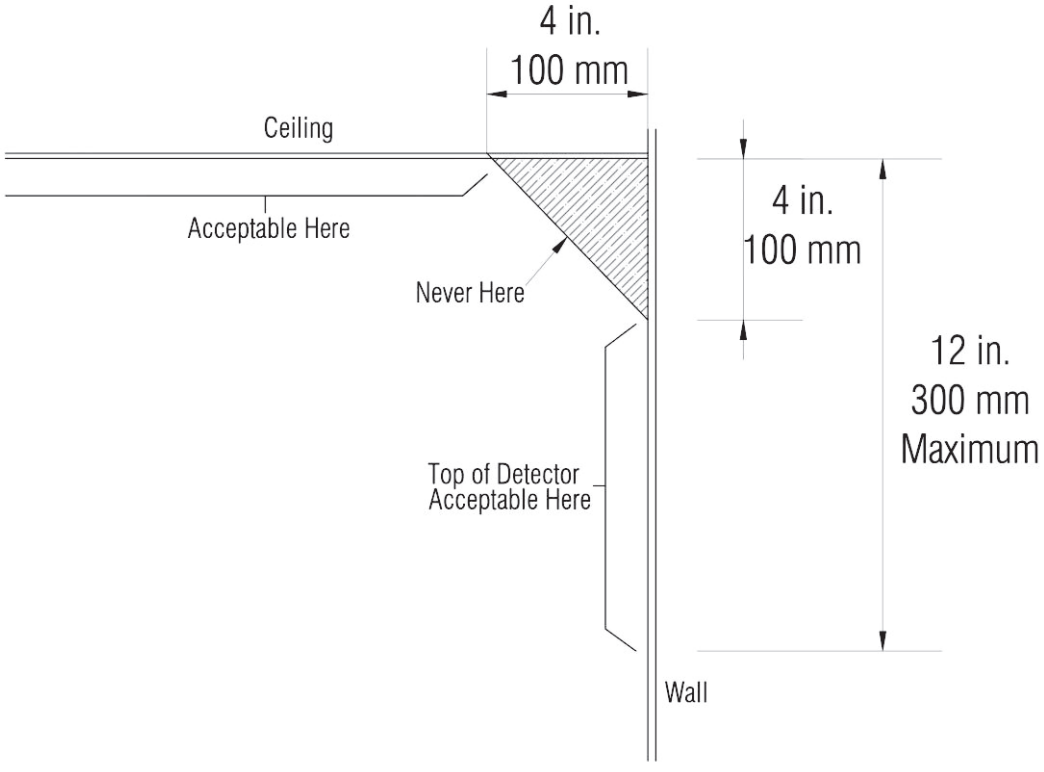


Figure 9. 2Example of Proper Mounting for Detectors

9.4.3.2. Spacing of Smoke Detector

a) Smooth Ceiling: On smooth ceilings, spacing of 30 ft. (9.1 m) should be followed as a guideline. Other spacing should be permitted to be used depending on ceiling height, different conditions, or response requirements. All points on the ceiling should have a detector within a distance equal to 0.7 times the selected spacing for better coverage.

b) Solid Joist Construction: The spacing of spot type detectors installed perpendicular to the solid joist should be $^{2}/_{3}$ of the spacing recommended for smooth ceiling when the joist depth becomes more than 8 in. (200 mm).

c) Beam Construction: The spacing of spot type smoke detectors from the right angle to the beam should be reduced to two-thirds spacing recommended for the smooth ceiling. If the beams are less than 12 in. (300mm) in-depth and less than 8 ft. apart, spot type detectors should be allowed to be installed on the bottom of the beam.

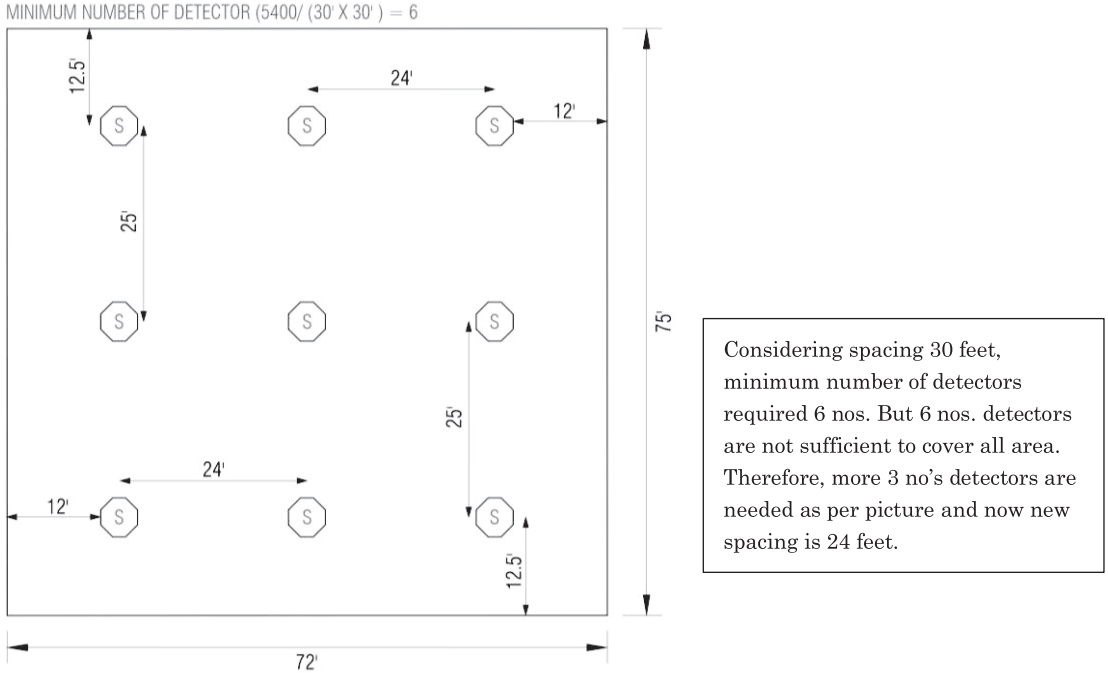
d) Peak Ceiling: Installation of the detector should begin with spacing and location at or within 3 ft. (0.9 m) of the peak of the ceiling. The spacing and quantity of additional detectors, if required, shall be as per horizontal projection of smooth ceiling.

e) Shed Ceiling: The shed ceiling should be provided with a row of detectors located within ft. (0.9 m) of the high side of the ceiling measured horizontally. The additional detectors, if required, should be installed in the remaining are based on horizontal projection of the ceiling.

f) Partitions: The spacing of the spot type smoke detectors should be the same as the spacing recommended for a smooth ceiling where the partition extends vertically up to 18 in. (460 mm) from the ceiling, where the opening between the ceiling and top of the partition is less than 18 in. (460 mm) the spacing of the detectors should be reduced by applying the engineers own assessment after considering the effect of the smoke travel.

g) Staircase: In the staircase, at least one detector should be installed on the ceiling of each floor.

Example



Considering spacing 30 feet, minimum number of detectors required 6 nos. But 6 nos. detectors are not sufficient to cover all area. Therefore, more 3 no's detectors are needed as per picture and now new spacing is 24 feet.

Figure 9. 3 Example of Detectors Spacing

9.5. Design Consideration for Beam Pocket

9.5.1. General Installation Criteria

Beams are defined as squared metal or timber extending 4 in. (10 cm) or more down from the ceiling and spaced more than 3 ft. (1 m) apart.

Beams less than 8 in. (20 cm) depth are considered flat ceilings.

Detectors can be mounted on the bottom of the beams, which are less than 12 in. (30.4 cm) in-depth and less than 8 ft. (2.4 m) on centre.

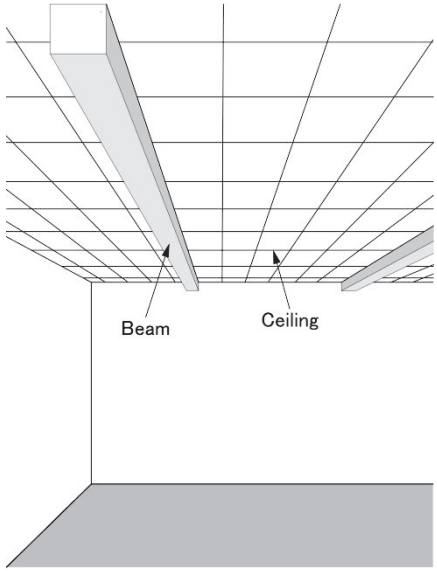


Figure 9. 4 Beam & Ceiling

9.5.2. Location of Installation of the Detector

Smoke/Heat detectors should be mounted on the ceiling or on the bottom of beam as per the following condition

D/H > 0.1 and W/H > 0.4 then mount the detector on the ceiling
D/H < 0.1 or W/H < 0.4 then mount the detector on the bottom of the beam

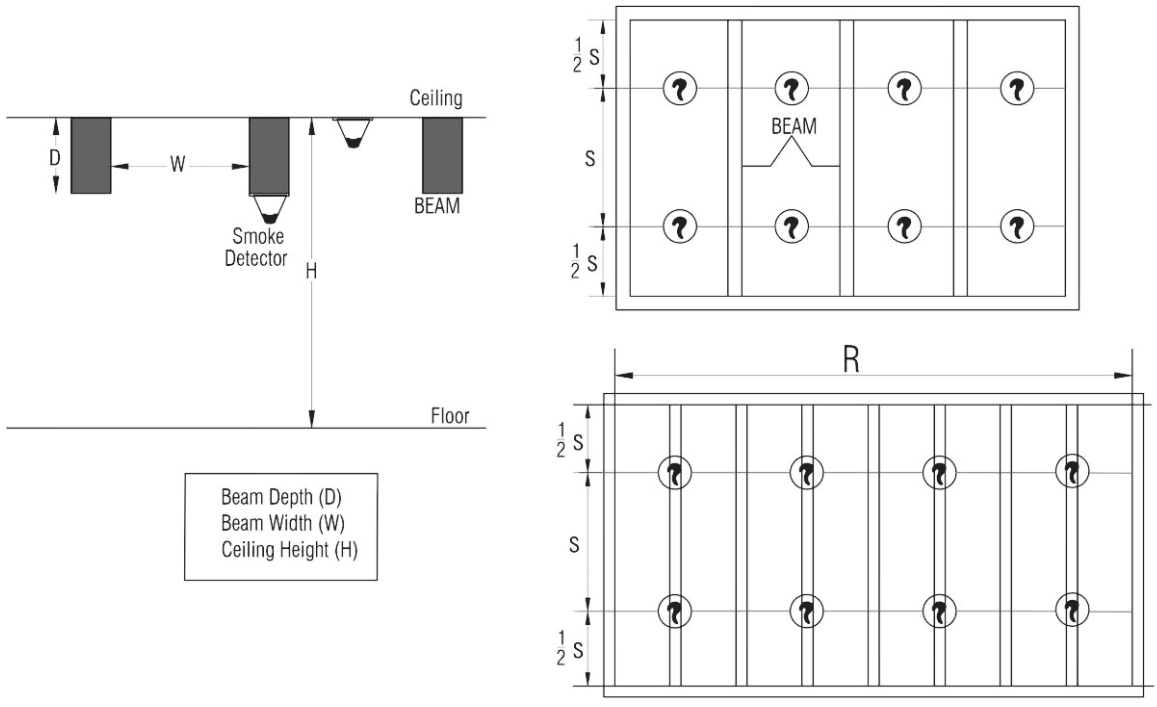


Figure 9. 5 Location of Mounting the Detectors

9.5.3. Location of Detectors for Shed / Peaked Type Ceiling

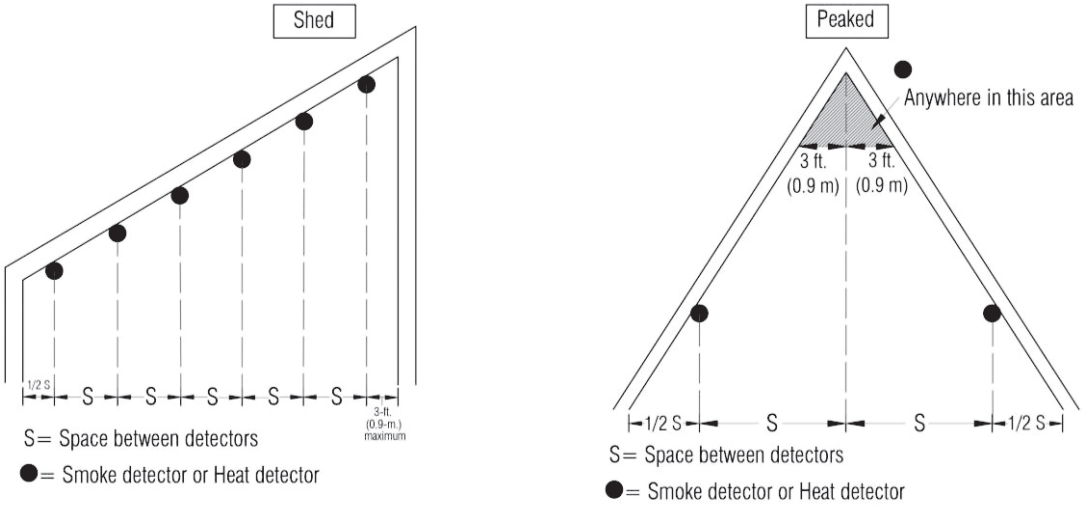


Figure 9. 6 Detector Position on Shed and Peaked Roof

9.5.4. Design Consideration for Raised Floor and Suspended Ceilings

- Spaces beneath raised floors and above-suspended ceilings should be treated as separate rooms for to create spaces between smoke detectors
- Detectors installed beneath raised floors or above-suspended ceilings, or both should not be used together to provide detection inside the room.

r)

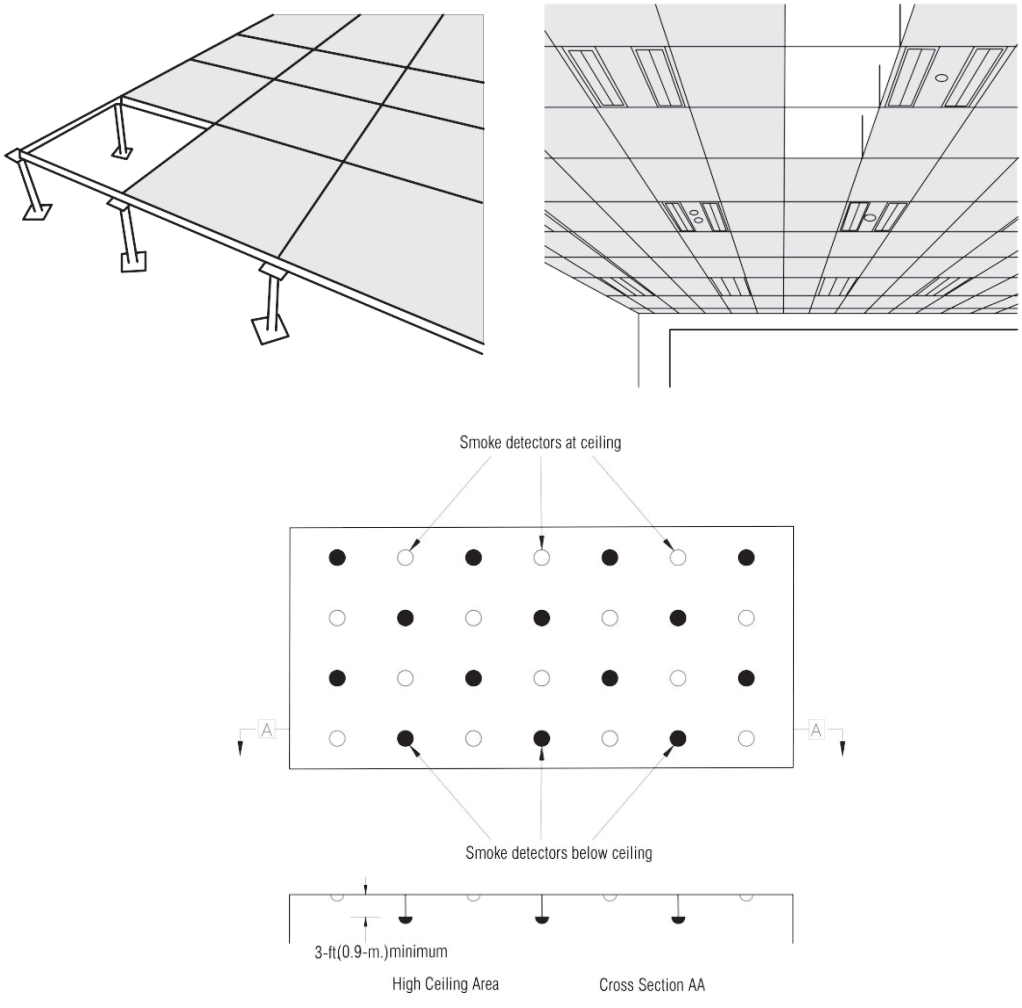


Figure 9. 7 Smoke Detector Position

9.5.5. High Air Movement Areas

The spacing of smoke detectors depends on air change per hour caused by air movement inside the space from both ventilation and re-circulating air and should be as per the following table.

Detectors must not be located directly in the airstream of supply registers.

Table 9. 2Spacing and Distance of Detector in High Air Movement room

Minimum per Air Change	Air Changes per Hour	Spacing per Detector	
		ft.^{2}	m^2
1	60	125	11.61
2	30	250	23.23
3	20	375	34.84
4	15	500	46.45
5	12	625	58.06
6	10	750	69.68
7	8.6	875	81.29
8	7.5	900	83.61
9	6.7	900	83.61
10	6	900	83.61

Smoke detector spacing shall be in accordance with the above Table.

Exception: Air-sampling or projected beam smoke detectors should be installed in accordance with the manufacturer's documented instructions.

NB: For Heat Detector, spacing applies the similar rule mentioned above and shall consider spacing 50 feet maximum.

9.6 Condition for Evaluating the Location & Spacing of Beam Detector

Figure 9. 8 Component of Beam Detector

When Ceiling Height is more than 30 feet, Beam Detector is suitable to detect smoke.

- Comprises a transmitter and receiver in a single enclosure
- Installed between 19 inches and 24 inches below the ceiling.
- The transmitter emits an invisible infrared (IR) light beam that is reflected via a prism mounted directly opposite and with a clear line of sight.
- The reflected infrared light is detected by the receiver and it is analyzed. Smoke in the beam path will reduce the received infrared light proportionally to the density of the smoke.
- The detector analyzes this attenuation or obscuration of light and acts accordingly. Detectors are typically mounted within ±30 feet (9.14 m) of a potential fire source.

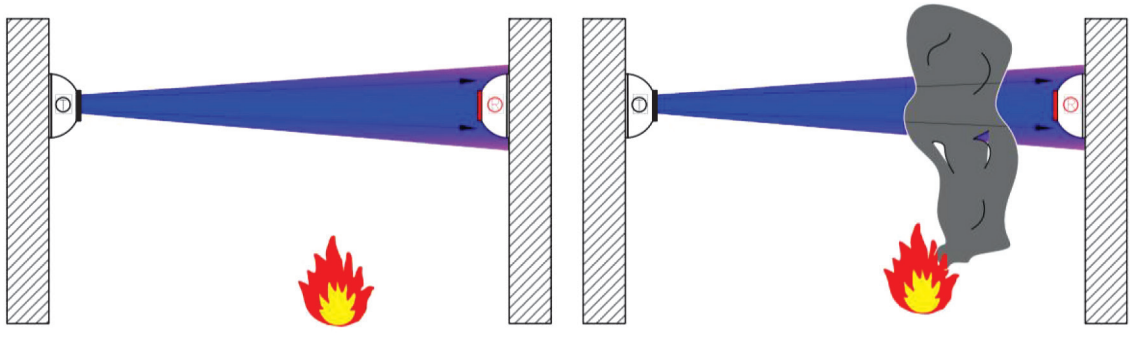
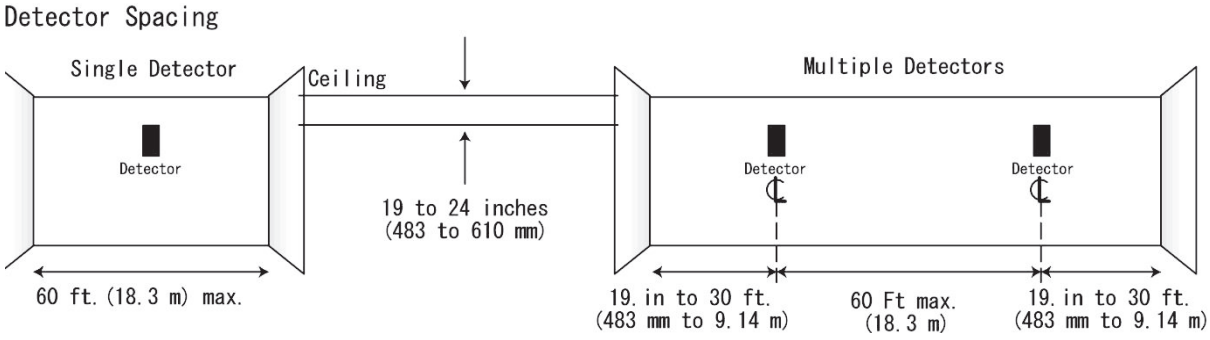


Figure 9. 9 Working process of Beam Detector (Courtesy/Collected from Edward Fire Alarm system)

- Beam Smoke Detector works on the principle of light obscuration. The photosensitive element of the Beam Smoke Detector detects IR light produced by the Transmitter in a normal condition.
- When the IR beam is obscured by smoke, the received signal drops accordingly.



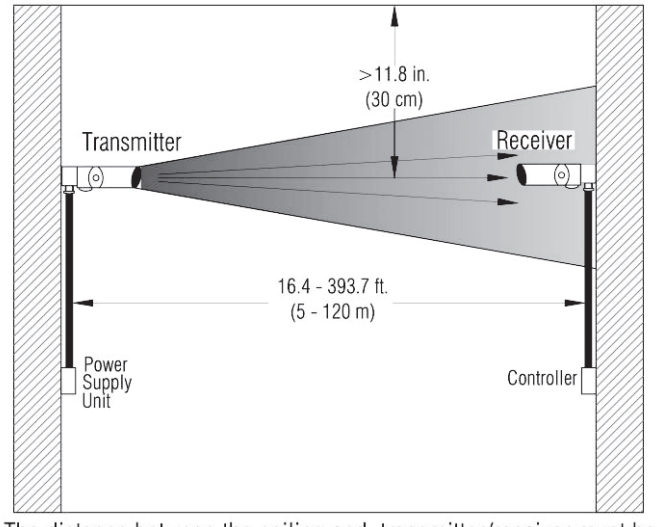
(Note: As per manufacturer, may vary)

Figure 9. 10Spacing of Beam Detector (Courtesy/ Collected from Edward Fire Alarm system)

9.6.1 Location of Installation

The beam detector shall be installed between 19 in. (480 mm) and 24in. (600 mm) Below the ceiling.

The beam length shall not exceed 60 ft. or the maximum permitted by the equipment listing.



(Note: As per a manufacturer, may vary)

Figure 9. 11 Distance between Ceiling and Receiver (Courtesy/ Collected from Edward Fire Alarm system)

9.6.2 Installation Criteria

- It should be mounted on stable surfaces to prevent false or erratic operation due to movement.
- The beam should be designed so that small angular movements of the light source or receiver do not obstruct any operation due to smoke and do not cause any false alarms.
- The light path of projected beam-type detectors should be kept clear of opaque obstacles at all times.

9.7 Design Consideration: Manually Actuated Alarm Initiating Device

Manual fire alarm boxes should be used only for fire alarm initiating.

The purpose behind it is to ensure that the occupants of the building or premises are aware of any fire hazard arising.

9.7.1 Recommended Location of Installation

Manual call points should be installed at locations where the alarms are clearly visible and accessible and installed along the escape route, such as:

- Exits.
- Corridor
- Staircase
- Lift lobby
- Entrance Hall
- Hose Cabinet
- Hazardous Areas

At an interval of a maximum 100 ft. (30 m).

9.7.2 Manually Actuated Alarm Initiating Device

9.7.2.1 Locations of Installation

Manual fire alarm boxes should be located:

- Throughout the protected area so that they are unobstructed and accessible.
- Within 5ft. (1.5m) of the exit doorway opening at each exit on each floor.
- On both sides of group openings over 40ft. (12.2m) in width.
- Within 5ft. (1.5m) of each side of the opening.
- Additional manual fire alarm boxes shall be provided so that the travel distance to the nearest fire alarm box will not be in excess of 200ft. (61m) measured horizontally on the same floor.
- The operable part of each manual fire alarm box shall be not less than $3^{1/2}$ft (1.1 m) and not more than $4^{1/2}$ ft (1.37 m) above floor level.
- In case of obstruction to visibility by a fire door, change of elevation or any other obstruction, then it shall be treated as a separate space or corridor, and hence additional call box(s) shall be provided.

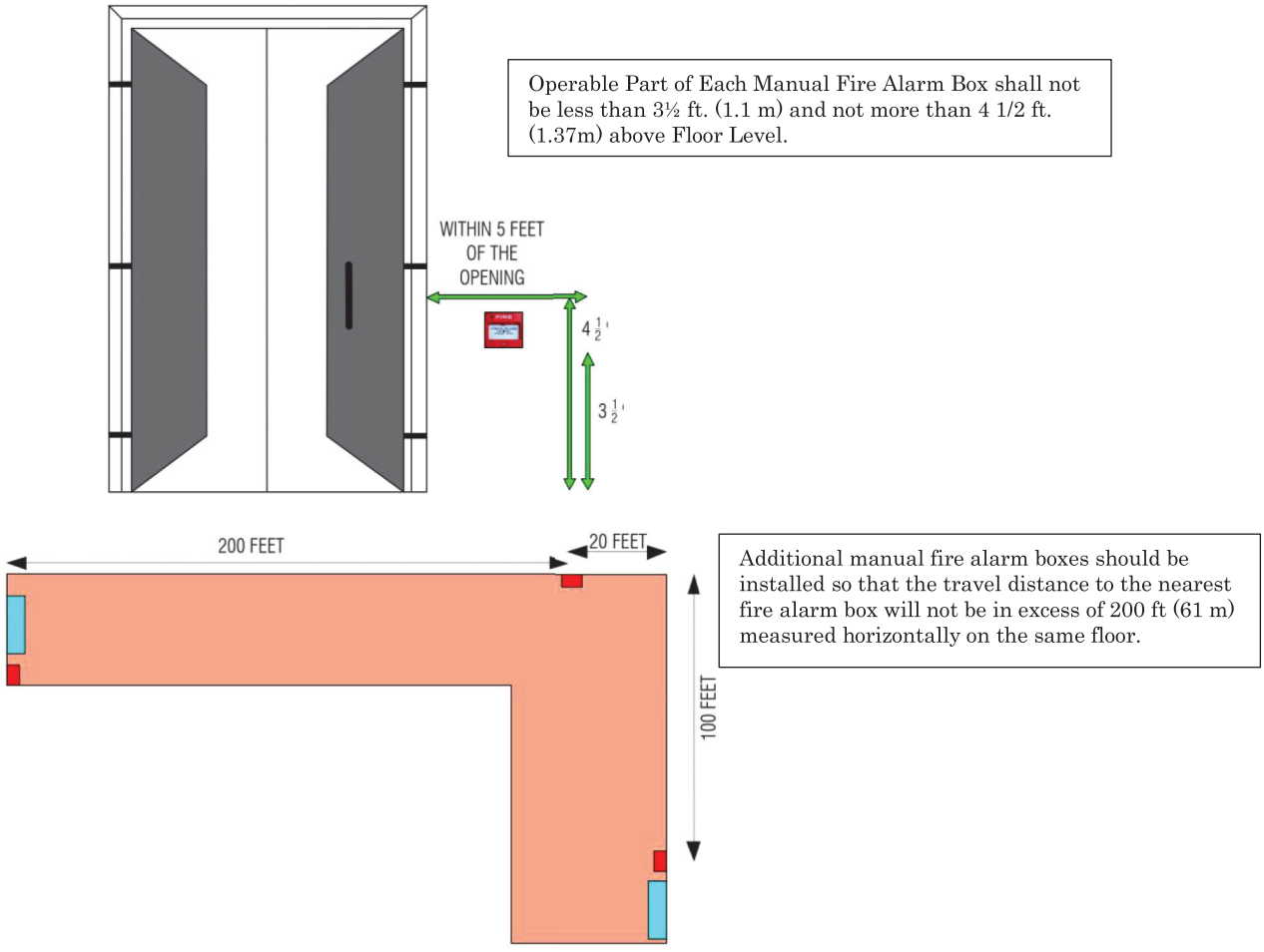


Figure 9. 12 Location of Manual Fire Alarm Box

9.8 Design Consideration: Notification Appliances

9.8.1 Public Mode of Application

Audible and Visible signaling is intended for the inhabitants of the area protected by the fire alarm system.

In public places such as shopping malls or banks, etc., the fire alarm is intended to alert all occupants and convey the need for them to evacuate.

9.8.2 Required Sound Level of Alarm Devices (Public Mode)

- Minimum Sound level: 75dBAat10ft(3m)
- Maximum Sound Level: 120dBA
- At least 15 dBA above the average ambient sound level or 5 dBA above the maximum sound level having a duration of at least 60 seconds, whichever is greater, measured 5 ft. (1.5 m) above the floor in the occupiable area.

Audible and Visible signaling is intended only for people directly concerned with the implementation and direction of emergency actions in the area protected by the fire alarm system.

In prison or hospital, the system may be designed to notify only the trained personnel. They will then initiate emergency procedures, including assisting occupants who might not otherwise be able to evacuate or relocate themselves.

9.8.3 Required Sound Level of Alarm Devices (Private Mode)

- Minimum Sound level:45dBAat10ft(3m)
- Maximum Sound level: 120dBA.
- At least 10 dBA above the average ambient sound level or 5 dBA above the maximum sound level having a duration of at least 60 seconds,
- Whichever is greater, measured 5 ft. (1.5 m) above the floor in the occupiable area.

9.8.4 Design Consideration: Notification Appliances (Audible)

If ceiling heights allow, wall-mounted appliances shall have their tops above the finished floors.

- At heights of not less than 90in. (2.30m) and
- At heights of not less than 6in. (152mm) below the finished ceilings.

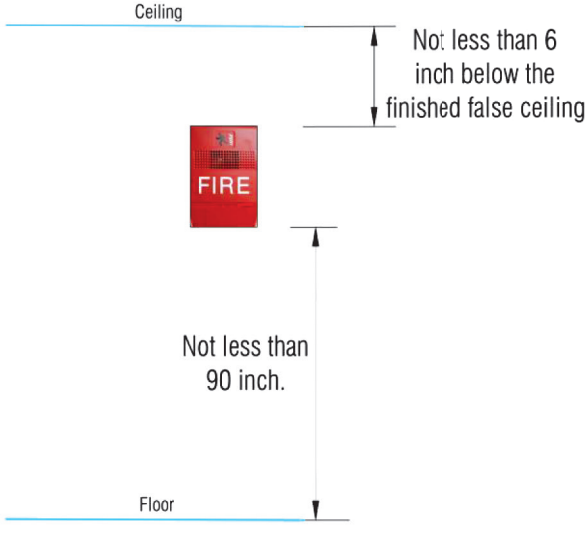


Figure 9. 13 Height of Audible Notification Appliance

9.8.5 Design Consideration: Notification Appliances (Visual)

An average ambient sound level greater than 105 dBA shall require the use of a visible notification appliance(s).

Visible notification appliances should be installed in accordance with Table 9.3 and 9.4, using one of the following:

Single visible notification appliance.

Two visible notification appliances are located on opposite walls.

More than two appliances in any field of view spaced a minimum of 55 ft. (16.76 m) from each other in rooms 80 ft. × 80 ft. (24.4 m × 24.4 m) or greater.

Wall-mounted appliances must be mounted in a way so that the entire optical unit is neither less than 80 in. (2.03 m) nor greater than 96 in. (2.43 m) above the finished floor.

Table 9. 3 Spacing of Notification Appliances (Ceiling Mounted Visible Appliances) (source NFPA 72)

Maximum Room Size		Maximum Ceiling Height		Minimum Required Light Output (Effective Intensity); One Light (cd)
ft.	m	ft.	m	
20 × 20	6.1 × 6.1	10	3.05	15
30 × 30	9.14 × 9.14	10	3.05	30
40 × 40	12.2 × 12.2	10	3.05	60
50 × 50	15.2 × 15.2	10	3.05	95
20 × 20	6.1 × 6.1	20	6.1	30
30 × 30	9.14 × 9.14	20	6.1	45
40 × 40	12.2 × 12.2	20	6.1	80
50 × 50	15.2 × 15.2	20	6.1	115
20 × 20	6.1 × 6.1	30	9.14	55
30 × 30	9.14 × 9.14	30	9.14	75
40 × 40	12.2 × 12.2	30	9.14	115
50 × 50	15.2 × 15.2	30	9.14	150

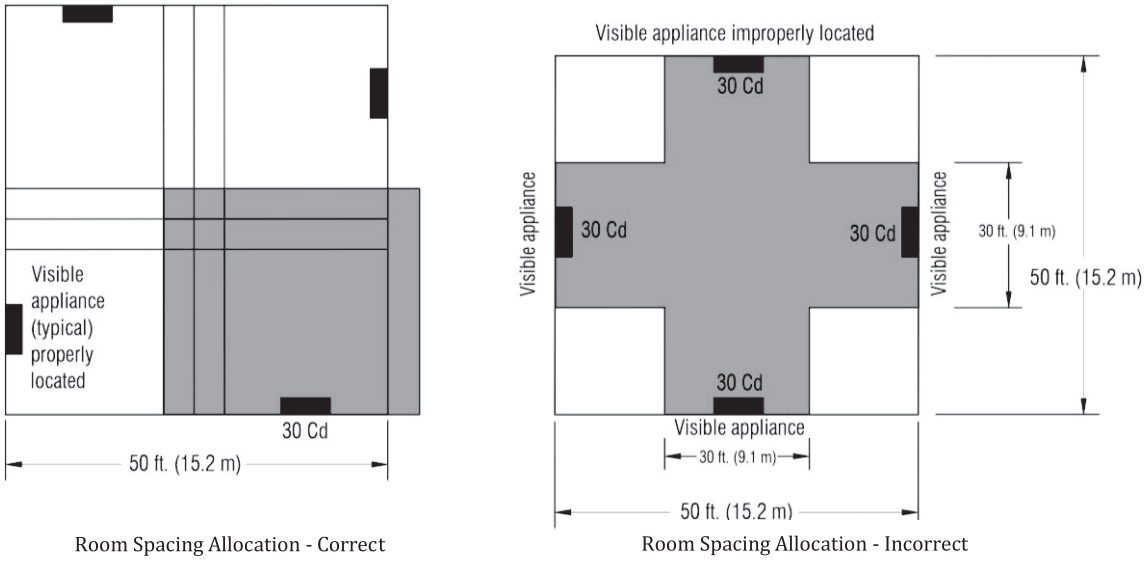


Figure 9. 14 Room Spacing Allocation

Table 9. 4 Spacing of Notification Appliances (Wall Mounted Visible Appliances) (source NFPA 72)

Maximum Room Size		Minimum Required Light Output (Effective Intensity); (cd)		
ft.	m	One Light Per Room	Two Lights Per Rooms;(Located on Opposite Wall)	Four Lights Per Room; (One Light Per a wall)
20×20	6.1 × 6.1	15	NA	NA
30 × 30	9.14 × 9.14	30	15	NA
40 × 40	12.2 × 12.2	60	30	15
50 × 50	15.2 × 15.2	95	60	30
60 × 60	18.3 × 18.3	135	95	30
70 × 70	21.3 × 21.3	185	95	60
80 × 80	24.4 × 24.4	240	135	60
90 × 90	27.4 × 27.4	305	185	95
100× 100	30.5 × 30.5	375	240	95
110 × 110	33.5 × 33.5	455	240	135
120 × 120	36.6 × 36.6	540	305	135
130 × 130	39.6 × 39.6	635	375	185

Wall-mounted appliances shall be installed in a way so that the entire optical unit is neither less than 80 in. (2.03 m) nor greater than 96 in. (2.43 m) above the finished floor.

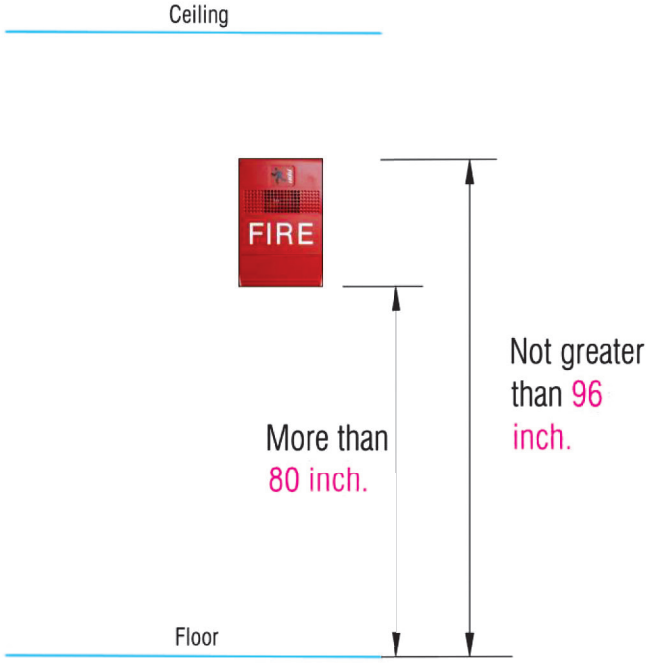
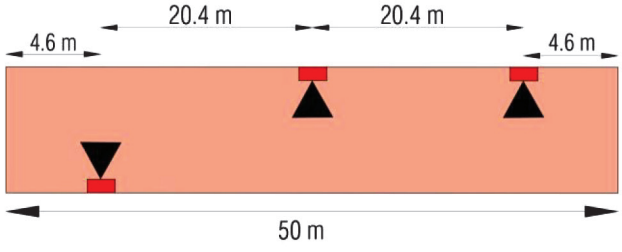


Figure 9. 15 Height of Visible Notification Appliance

9.8.5.1 Corridor

- Should not be located more than 15 ft. (4.6 m) from the end of the corridor.
- The separation will not be greater than 100 ft. (30.4 m) between appliances.
- They should be spaced in a minimum of 55 ft. (16.76 m) from each other where there are more than two visible notifications



Corridor Lenght (m) 6m less in width	Minimum Number of 15 Candela Strobe
0-9	1
Oct-40	2
41-70	3
71-100	4
101-130	5
131-160	6

s)

Figure 9. 16 Position of Visible Notification Appliance

For corridors greater than 20 ft. (6.1 m) wide, Table 9.3 & 9.4 shall apply. In case of a corridor application, the visible appliances must be rated at a minimum of 15 cd.

Visible notification appliances shall be installed in accordance with Table 9.3 and 9.4 using one of the following:

a) A single visible notification appliance.

b) Two visible notification appliances are located on opposite walls.

c) More than two appliances in any field of view are spaced in a minimum of 55 ft. (16.76 m) from each other in rooms 80 ft. × 80 ft. (24.4 m × 24.4 m) or greater.

Appendix 1. Check List for Architect

No.	ITEMS	REFERENCE [Fire Safety Design Guidebook]	REMARKS
General Feature			
1	Flow of Fire Safety Design Process	Figure1.4; Chapter 1	
2	Occupancy Classification	Table 2.1; Chapter 2	
3	Hazard Classification	Table 3.1; Chapter 3	
4	Occupancy Separation	Sec 2.2.4.; Chapter 2	
5	Emergency Escape Option	Sec 2.2.6.; Chapter 2	
6	Shaft Separation	Sec 2.2.7.; Chapter 2	
7	Protection of Horizontal Exit	Sec 2.2.8.; Chapter 2	
8	Type of Construction by Fire Rating	Sec 2.2.11.; Chapter 2	
9	Recommended Types of Construction	Sec 2.2.12.; Chapter 2	
10	Fire Separation Distance	Table 2.2; Chapter 2	
11	Prevention of Vertical Propagation of Fire	Sec 2.2.13; Chapter 2	
Means of Egress			
12	Parts of Egress	Sec 3.2.1.; Chapter 3	
13	The Exit Access	Sec 3.2.1.1.; Chapter 3	
14	The Exit	Sec 3.2.1.2.; Chapter 3	
15	The Exit Discharge	Sec 3.2.1.3.; Chapter 3	
Stair			
16	Flow of Stairs Design	Figure 3.4; Chapter 3	
17	Occupant Load	Sec 3.3.2. &Table 3.2; Chapter 3	
18	Width of Stair	Sec 3.3.3., Table 3.3& 3.4; Chapter 3	
19	Number of Stairways	Sec 3.3.4.; Chapter 3	
20	Stairways Position	Sec 3.3.5.; Chapter 3	
21	Stairway Design Requirement	Sec 3.4; Chapter 3	

No.	ITEMS	REFERENCE [Fire Safety Design Guidebook]	REMARKS
22	Re-Entry/ Refuge Area	Sec 3.5; Chapter 3	
Smoke Proof Enclosure			
23	Where Smoke Proof Enclosures are needed	Sec 4.2; Chapter 4	
24	Floor, Wall, Door	Sec 4.3.1.; Chapter 4	
25	EV Shaft	Sec 4.3.2.; Chapter 4	
26	Criteria of Fire Elevator Shaft	Sec 4.3.3.; Chapter 4	
27	Equipment penetration	Sec 4.3.4.; Chapter 4	
28	Design Requirement for Smoke Proof Enclosure	Sec 4.4.; Chapter 4	
Corridor			
29	Safety Corridor	Sec 1.4.3; Chapter 1	

Appendix 2. Check List for MEP Engineer

No.	ITEMS	REFERENCE [Fire Safety Design Guidebook]	REMARKS
Electrical Cable			
1	Distribution Board	Sec 5.2.1. a); Chapter 5	
2	Generator	Sec 5.2.1. b); Chapter 5	
3	Construction Stage	Sec 5.2.2.; Chapter 5	
4	Periodic Inspection	Sec 5.2.3. a); Chapter 5	
5	Conduct Drill	Sec 5.2.3. c); Chapter 5	
Sprinkler System			
6	Component of Sprinkler Head	Figure 6.1; Chapter 6	
7	Temperature Rating, Classifications, and Color Coding	Table 6.1; Chapter 6	
8	System Component and Hardware	Sec 6.2.1.; Chapter 6	
9	Water Storage Tank	Sec 6.2.2.; Chapter 6	
10	Location of Storage Tank	Sec 6.2.2.2.; Chapter 6	
11	Fire pump & Pump Room	Sec 6.2.3. & 6.2.4.; Chapter 6	
12	Type of Sprinkler System	Sec 6.3; Chapter 6	
13	Sprinkler Installation type & where to install	Table 6.2; Chapter 6	
14	Consideration for Sprinkler System Design	Sec 6.4; Chapter 6	
15	Maximum area coverage by a Sprinkler System under a Riser	Table 6.3; Chapter 6	
16	Pipe Size of Sprinkler	Figure 6.4; Chapter 6	
17	Fire protection flow requirements	Table 6.5; Chapter 6	
18	Protection Area Coverage by a Single Sprinkler Head	Sec 6.5.2.5.; Chapter 6	
19	Ceiling Area for a Sprinkler	Table 6.6; Chapter 6	

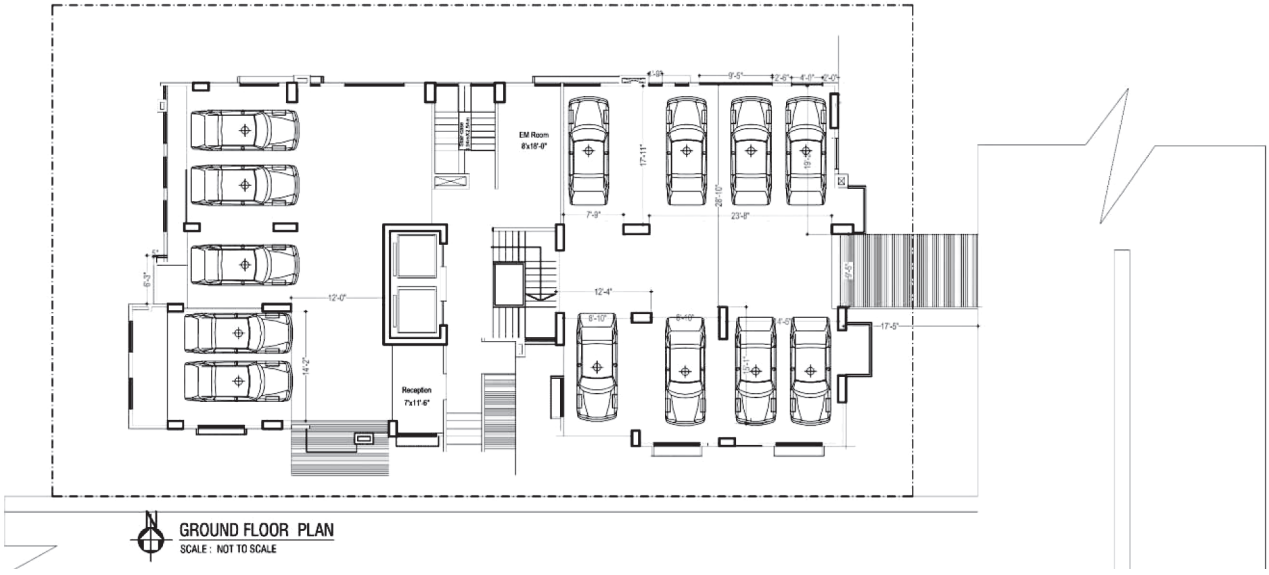
No.	ITEMS	REFERENCE [Fire Safety Design Guidebook]	REMARKS
20	Size of Water Supply Steel Pipe to Sprinklers	Table 6.7; Chapter 6	
21	Size of Water Supply copper Pipe to Sprinklers	Table 6.8; Chapter 6	
22	Minimum Distance from Walls	Sec 6.5.2.6. a); Chapter 6	
23	Minimum Distance Between Sprinklers	Sec 6.5.2.6. b); Chapter 6	
24	Maximum Distance Between Sprinklers	Sec 6.5.2.6. c); Chapter 6	
25	Fire Department Connection	Sec 6.5.2.7.; Chapter 6	
26	Sprinkler Head Coverage Range	Figure 6.5; Chapter 6	
Standpipe System			
27	Automatic Standpipe System	Sec 7.1.1.; Chapter 7	
28	Hose Station	Sec 7.2.5.; Chapter 7	
29	Types of Standpipe System	Sec 7.3; Chapter 7	
30	Locations of Hose Stations	Sec 7.4.2.; Chapter 7	
31	Design Requirement for Standpipe System	Sec 7.4.3.; Chapter 7	
32	Typical Diagram for Fire Protection with Ground Tank and Automatic Fire Pump	Sec 7.6. & Figure 7.12; Chapter 7	
33	Size of Vale & Accessories for Pump as per Flow Capacity	Table 7.6; Chapter 7	
34	Location of Pump room & Reservoir	Sec 7.7; Chapter 7	
Portable Fire Extinguisher			
35	Classification of Fire Extinguisher	Sec 8.1; Chapter 8	
36	Selection Criteria of Fire Extinguishers	Sec 8.2; Chapter 8	
37	Selection of extinguisher	Sec 8.3; Chapter 8	
38	Location & Height of Installation	Sec 8.4.1 & sec 8.4.2; Chapter 8	
39	Travel Distance	Sec 8.4.4; Chapter 8	
40	Maximum Area to Be Protected per Extinguisher (Ft^2)	Table 8.5; Chapter 8	

No.	ITEMS	REFERENCE [Fire Safety Design Guidebook]	REMARKS
Automatic Fire Detecting and Alarm System			
41	Components of Fire Alarm System	Figure 9.1.; Chapter 9	
42	Location of Initiating Devices	Sec 9.2.; Chapter 9	
43	Types of Detectors	Sec 9.3.; Chapter 9	
44	General Installation Criteria	Sec 9.4.1.; Chapter 9	
45	Locations of Installation Heat Detectors	Sec 9.4.2.; Chapter 9	
46	Locations of Installation Smoke Detectors	Sec 9.4.3.; Chapter 9	
47	Design Consideration for Beam Pocket	Sec 9.5; Chapter 9	
48	Evaluating the Location & Spacing of Beam Detector	Sec 9.6; Chapter 9	
49	Design Consideration: Manually Actuated Alarm Initiating Device	Sec 9.7; Chapter 9	
50	Location of Installation	Sec 9.7.1.; Chapter 9	
51	Notification Appliances	Sec 9.8.; Chapter 9	
52	Height of Visible Notification Appliance	Figure 9.15; Chapter 9	
53	Position of Visible Notification Appliance	Figure 9.16; Chapter 9	

Appendix 3. Case Study for Architect

Example: 01 Residential

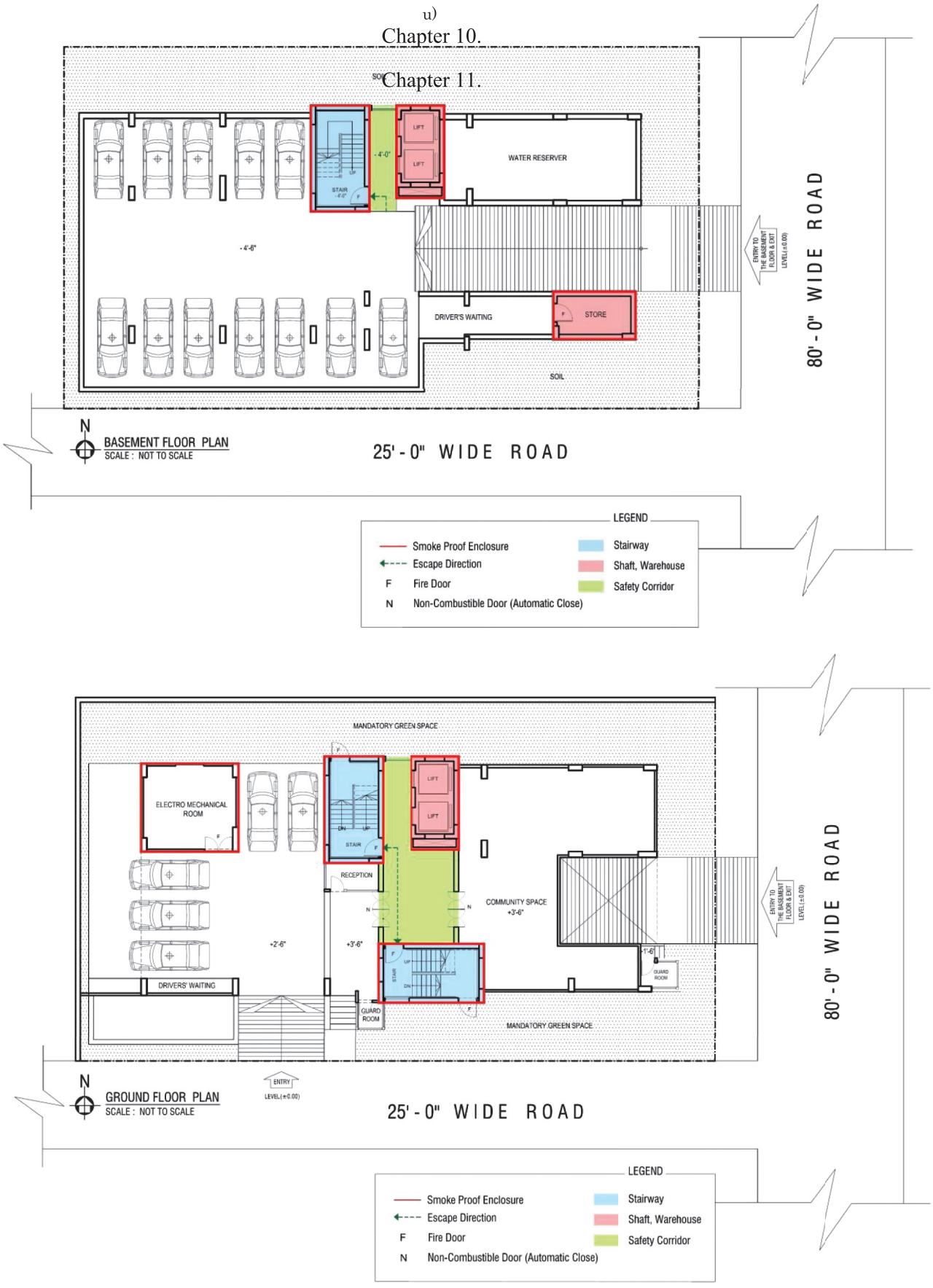
Bad example:

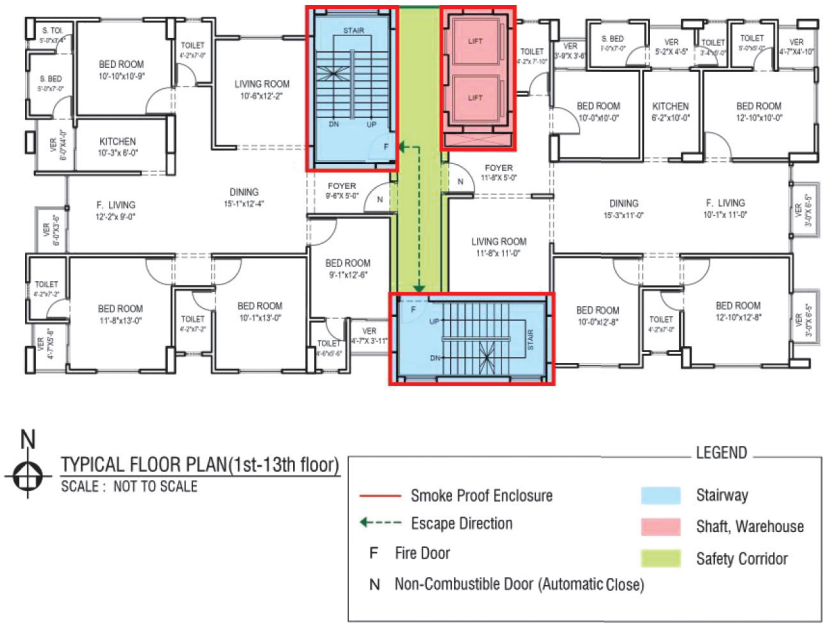


Notes:

a) Two stairs are designed on each floor; however, these two staircases are inadequate in case of an emergency evacuation from the building in case of a fire hazard. According to "DMNIB 2008", there must be two additional fire escape routes dedicated for emergency evacuations.
b) The stairs are not smoke protected. Therefore, they are not suitable to be used as a fire escape.
c) If the appropriate smoke control measures are not put in place inside the corridor, then it is not suitable. People's lives would be at risk and it would not be safe, Therefore, the corridor should be well equipped.
d) Smoke proof enclosure such as a fire door has not been properly indicated in the plan for all the locations that are necessary such as corridors, stairs, and lifts.
e) Fire doors are missing from the existing layout plan. This means that the fire/smoke protection is inadequate.
f) When a fire breaks out, the stair (in front of the lifts) will act as a chimney.
g) In case of an emergency evacuation, the exit protocol on the ground floor layout has not been properly implemented.

Good example:





Notes:

a) In the revised layout plan, the indicated two staircases are to be used as fire exit stairs.

b) The stairs are suitable for fire/smoke protection and has sufficient width to be used as a fire escape.

c) When it comes to controlling the smoke that arises from any kind of fires the corridor is well equipped for people to escape through the fire door/non-combustible door.

d) The smokeproof enclosure has been mentioned properly in all the required locations of the corridor, stairs, and lifts.

e) Fire doors have been provided on the exit stairs.

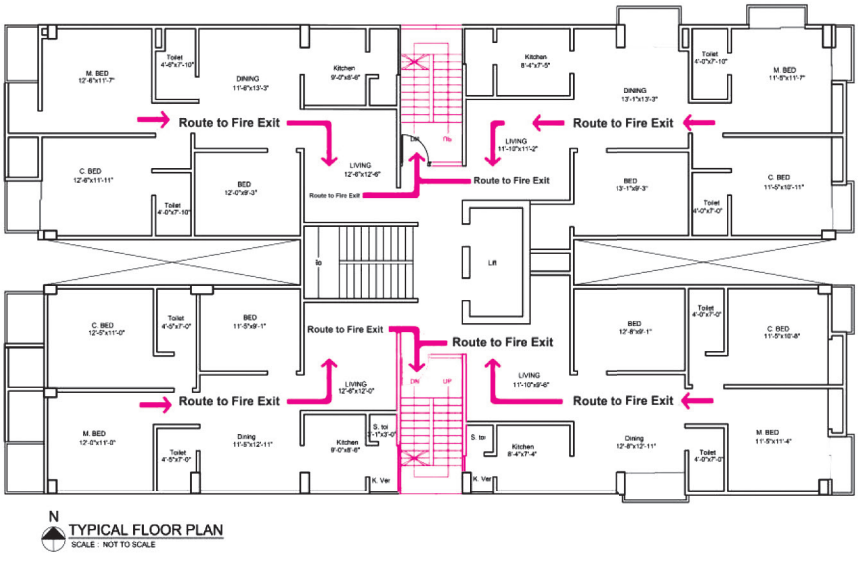
f) At the time of any fire hazard, the stairs will not be used as a chimney to disperse the smoke.

g) The exit protocols in the ground floor layout plan ensure that the proper evacuation protocols are followed.

Example: 02 Residential

Bad example:

v)



Notes:

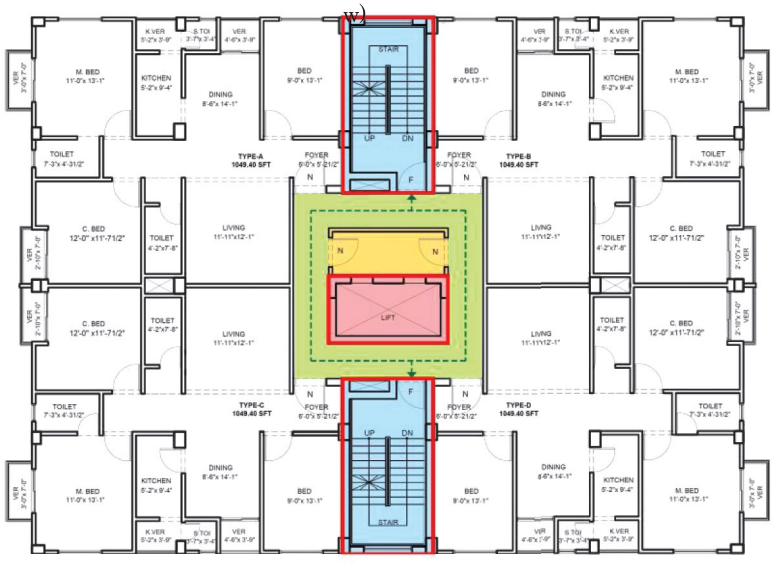
a) Among the three stairs, two stairs are intended to be used as emergency fire exit stairs. According to the rules, a minimum of two stairs is required for the fire exit. Therefore, without the protection of the smokeproof enclosure, the extra staircase in front of the lift would lead to a disastrous situation if any fire hazard arises.

b) The safety corridor (exit access) is not properly indicated in case of controlling the smoke from the fire, making it highly dangerous, risky, unsafe and completely unsuitable for use in case of a fire emergency.

c) The smokeproof enclosure has not been properly mentioned in the necessary locations such as corridors, stairs and lifts.

d) In case of a fire emergency, the stair in front of the lift poses a great threat to people's lives since the smoke has no other way to disperse.

Good example: Option 01

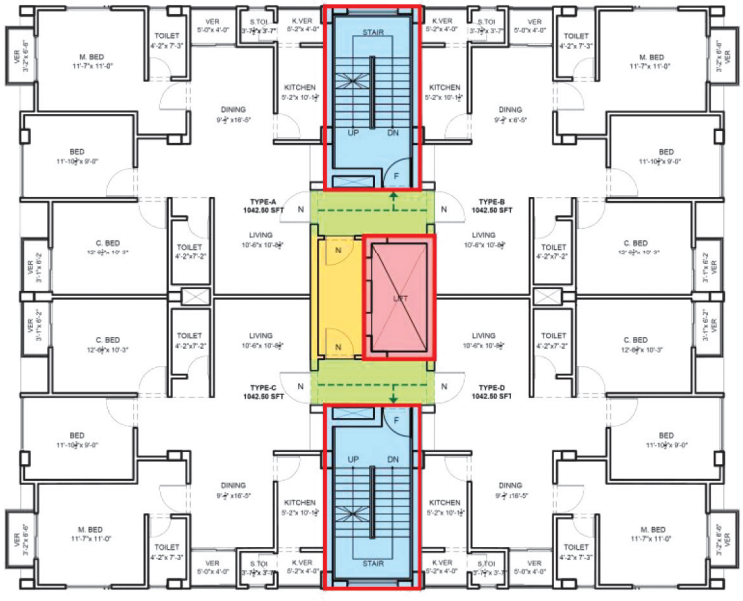


TYPICAL FLOOR PLAN (1st to 11th floor)
SCALE : NOT TO SCALE

LEGEND

Smoke Proof Enclosure	Stairway
Escape Direction	Shaft, Warehouse
F Fire Door	Safety Corridor
N Non-Combustible Door (Automatic Close)	Vestibule

Good example: Option02



TYPICAL FLOOR PLAN (1st to 11th floor)
SCALE : NOT TO SCALE

LEGEND

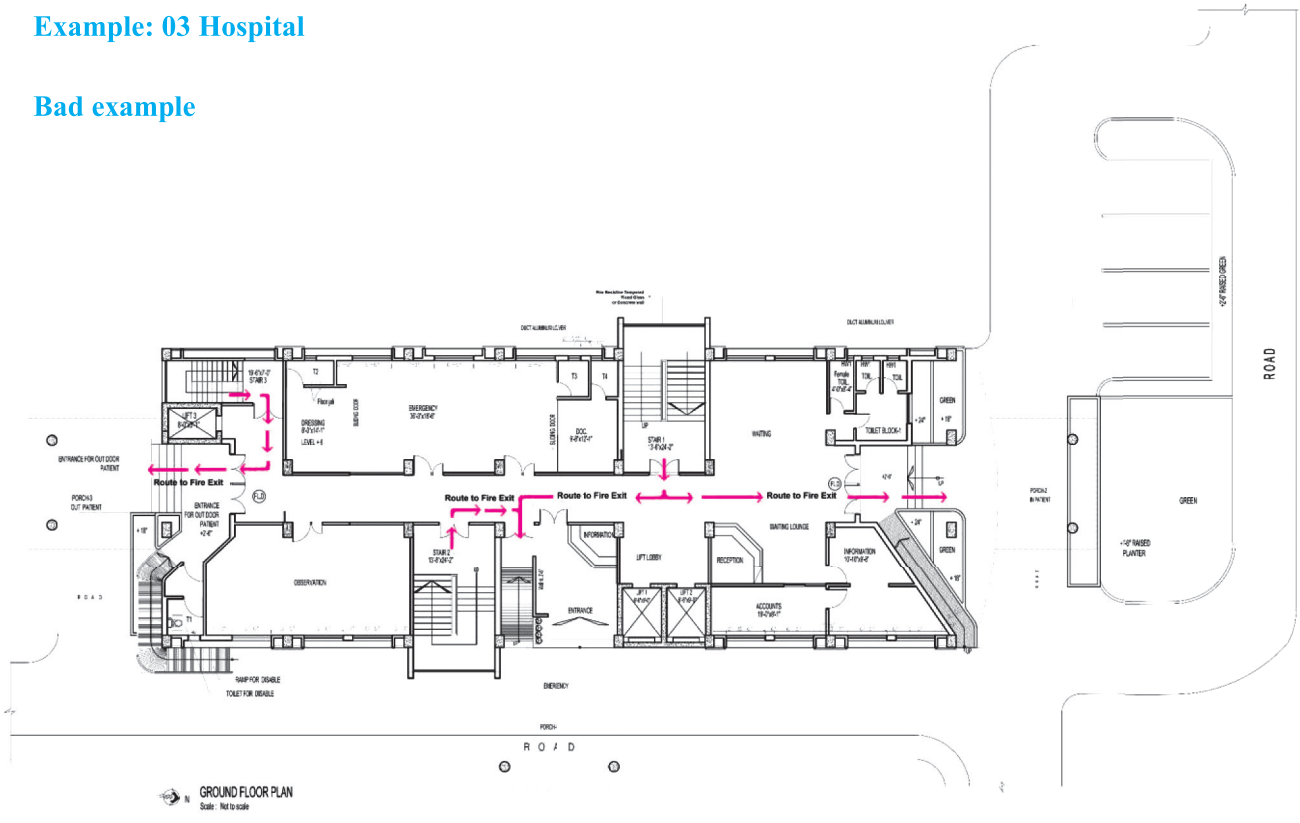
Smoke Proof Enclosure	Stairway
Escape Direction	Shaft, Warehouse
F Fire Door	Safety Corridor
N Non-Combustible Door (Automatic Close)	Vestibule

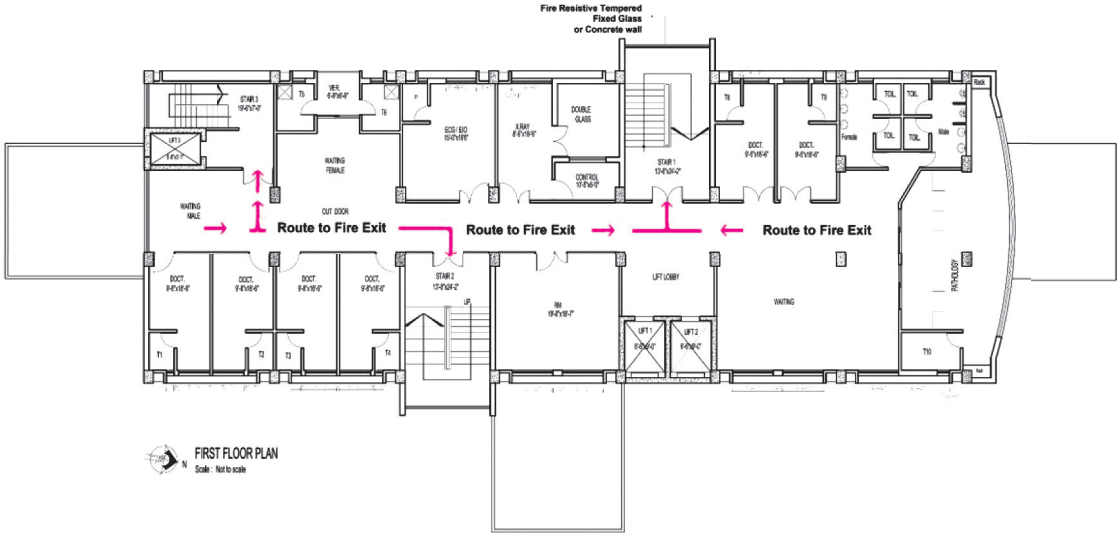
Notes:

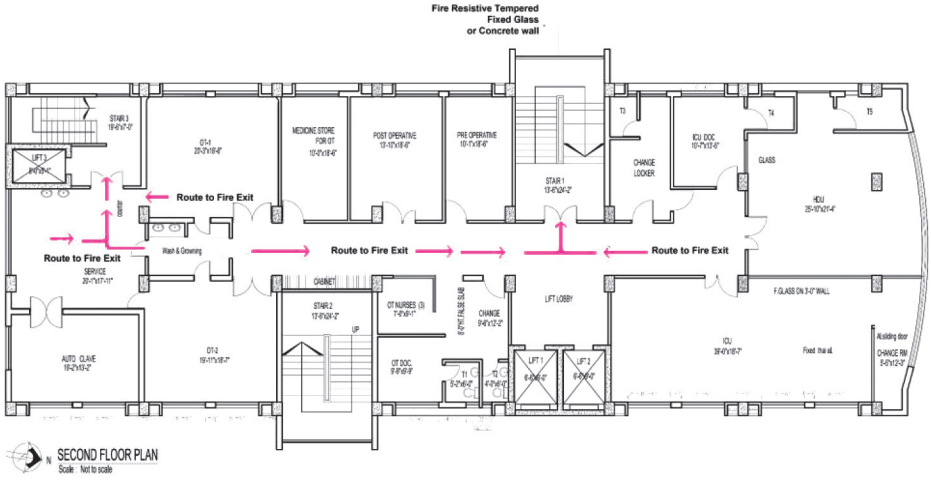
a) In the revised plans of both option 01 and option 02, two stairs are mentioned as fire exit stairs and they are protected by smokeproof enclosure, such as fire doors, etc.
b) EV shafts (lift) are also protected by smokeproof enclosures.
c) The stairs and safety corridor (exit access) have been secured properly by fire doors and smoke-proof enclosure for fire escaping. If at the time of a fire incidence, even if one exit stair becomes unusable, then the other exit staircase can be used easily.
d) Smoke-proof enclosure has been mentioned in all appropriate locations of corridors, stairs, and lifts.
e) The stairs will no longer act as a chimney if a fire breaks out.

Example: 03 Hospital

Bad example







Notes:

a) A proper exit protocol has not been appropriately defined for emergency evacuation on the ground floor layout plan.

b) Among the three fire exit stairways, the width of all the exit stairways is less than 2m (by AutoCAD drawing), where, according to "DMINB 2008" a minimum of two stairs are required, and the minimum unobstructed width of each stair is supposed to be 2m for this hospital.

c) In the exit stairs, handrails are missing (identified by AutoCAD drawing) where, according to the rules, they are essential for this hospital.

d) Smoke-proof enclosures have not been defined properly in all the necessary pathways such as corridors, stairs and lifts.

e) Safety corridor (exit access) has not been protected properly by fire doors etc.

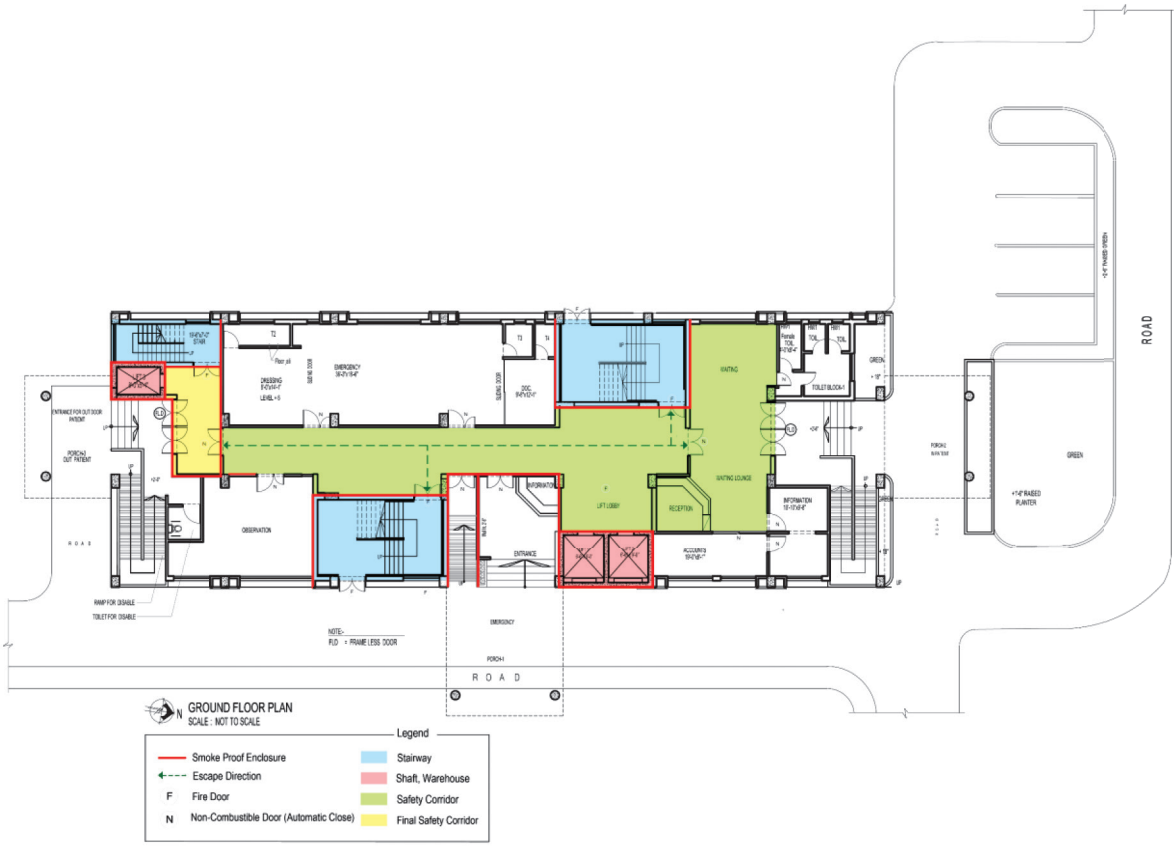
Good example: Option: 01

N SECOND FLOOR PLAN
SCALE : NOT TO SCALE

Legend

Smoke Proof Enclosure	Stairway
Escape Direction	Shaft, Warehouse
F Fire Door	Safety Corridor
N Non-Combustible Door (Automatic Close)	Final Safety Corridor

Good example: Option: 02



Notes:

a) The approach of exit evacuation from the fire has been properly mentioned on the revised ground floor layout plans in both Options 01 and 02.

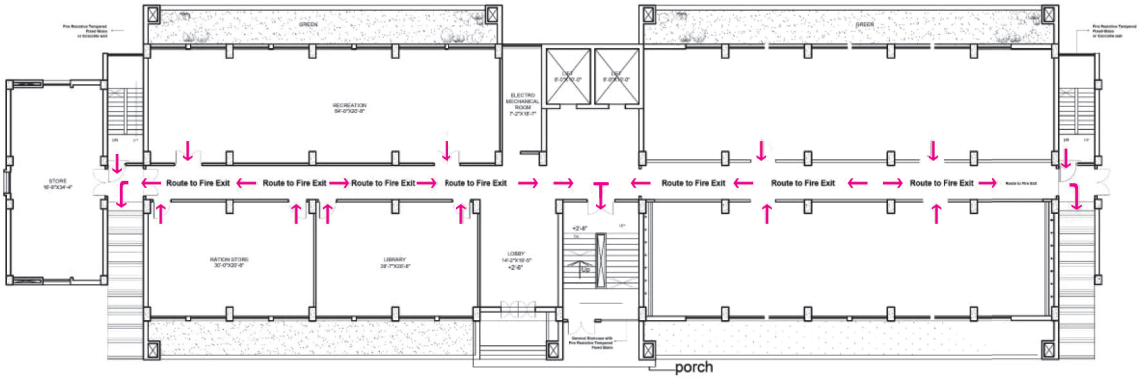
b) In the revised plan, the width of two exit stairways has been done by providing the minimum unobstructed required width of 2m for the hospital by the rules.

c) Smoke-proof enclosure has been defined properly in all the required locations of corridors, stairs, and lift.

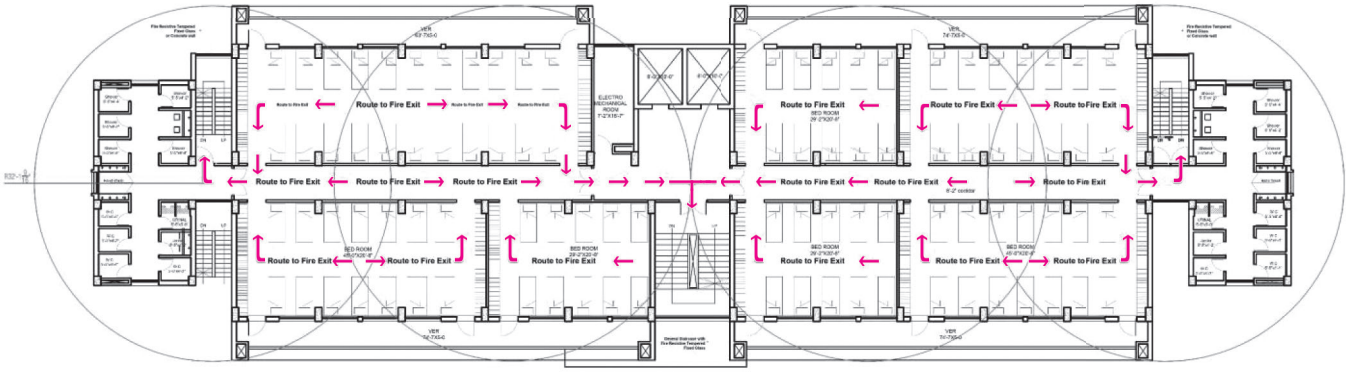
d) Safety corridor (exit access) has been protected properly by fire doors etc.

Example: 04 Hostel

Bad example



GROUND FLOOR PLAN
SCALE : NOT TO SCALE



1ST TO 9TH FLOOR PLAN
SCALE : NOT TO SCALE

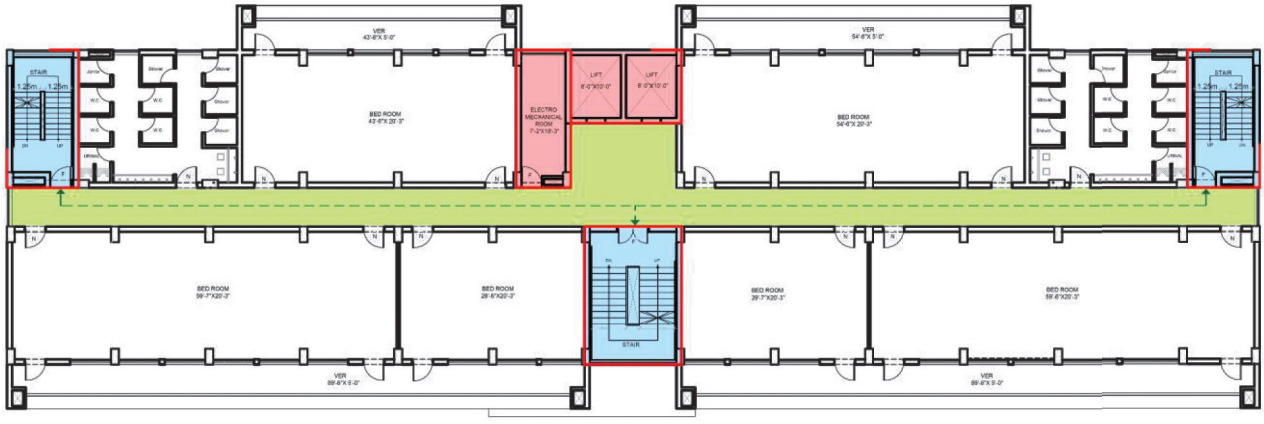
Notes:

a) The exit stairs located at the ends of the last two stairs of the building are not in a suitable position for evacuation from the fire.

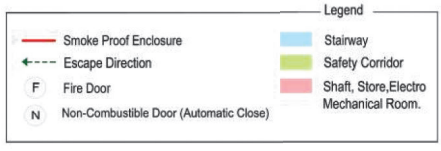
b) The width of the exit stairs at the last two ends of the building are less than what is required by the safety standards (measured by AutoCAD drawing), where, according to “Sec 58 (Gha) (1); Chapter-5; DMINB 2008”, the minimum unobstructed width of the stairs is actually supposed to be 1.25m for the Hostel.

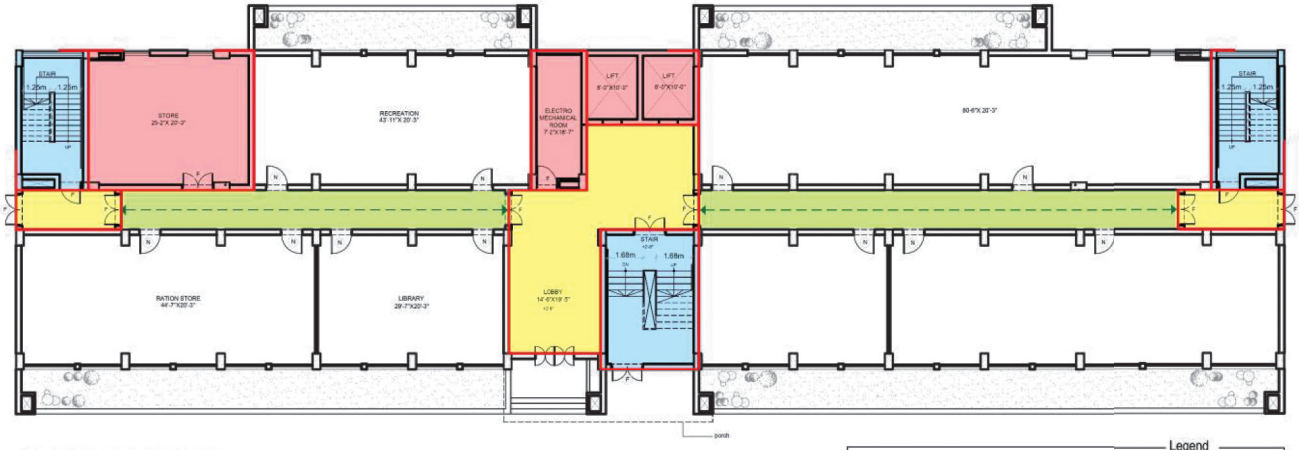
c) According to “Sec 12.04; Appendix-1; DMINB 2008”, The two exit stairs located at the two ends of the building has not been connected properly with the open space making it unsafe and dangerous for people to escape in case of a fire.

Good example:Option01

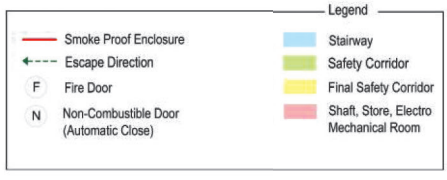


TYPICAL FLOOR PLAN (1st to 11th floor)
SCALE : NOT TO SCALE

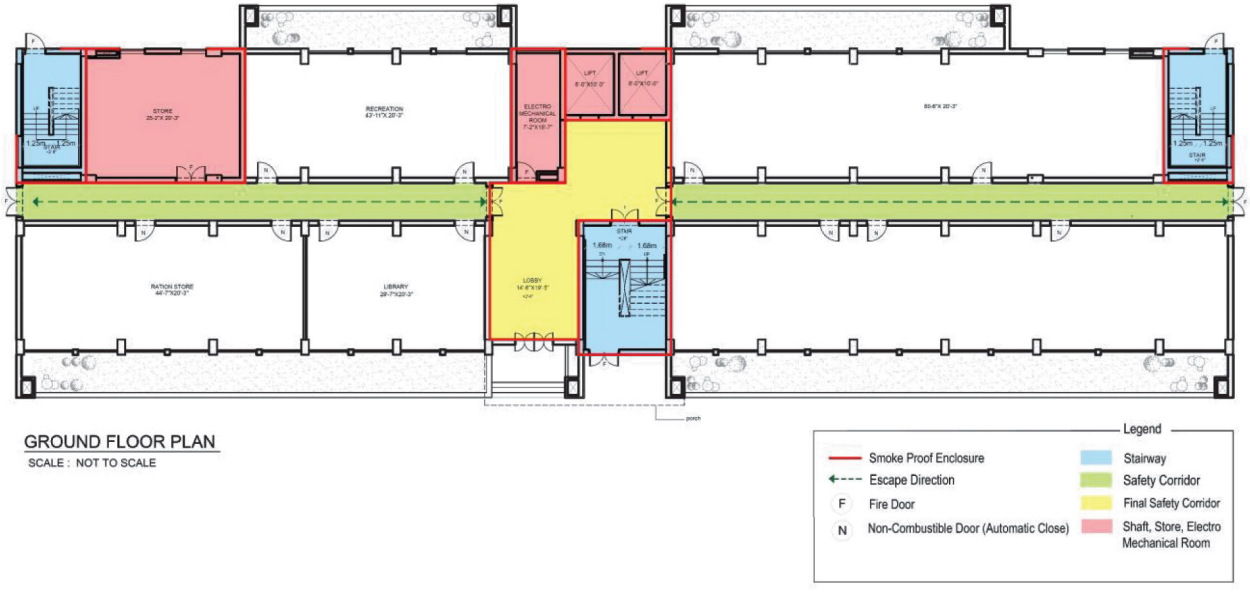




GROUND FLOOR PLAN
SCALE : NOT TO SCALE



Good example:Option 02



Notes:

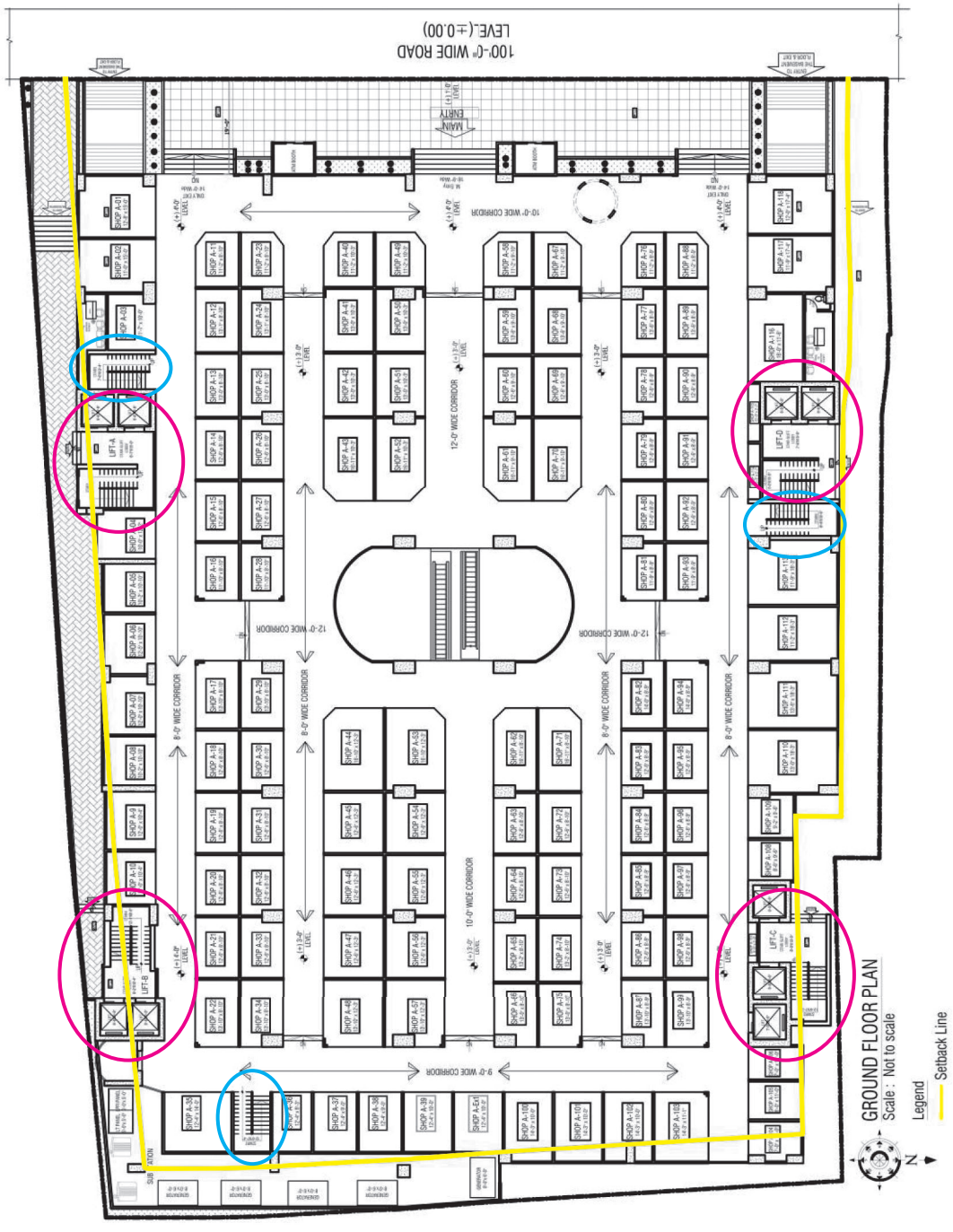
a. In the revised plan, the exit stairs at the last two ends of the building are in a suitable position for evacuation from the fire.

b. The width of the exit stairs at the last two ends of the building have been adjusted according to the required measurements of 1.25m, which is the minimum unobstructed width of the stairs for a hostel, according to “Chapter-5; 58 (Gha) (1); DMINB 2008”.

c. According to “Sec 12.04; Appendix-1; DMINB 2008”, the exit route of the stairs' at the last two ends of the building, in both option 01 and option 02, has been connected with the open space properly.

Example: 05 Multistoried Building

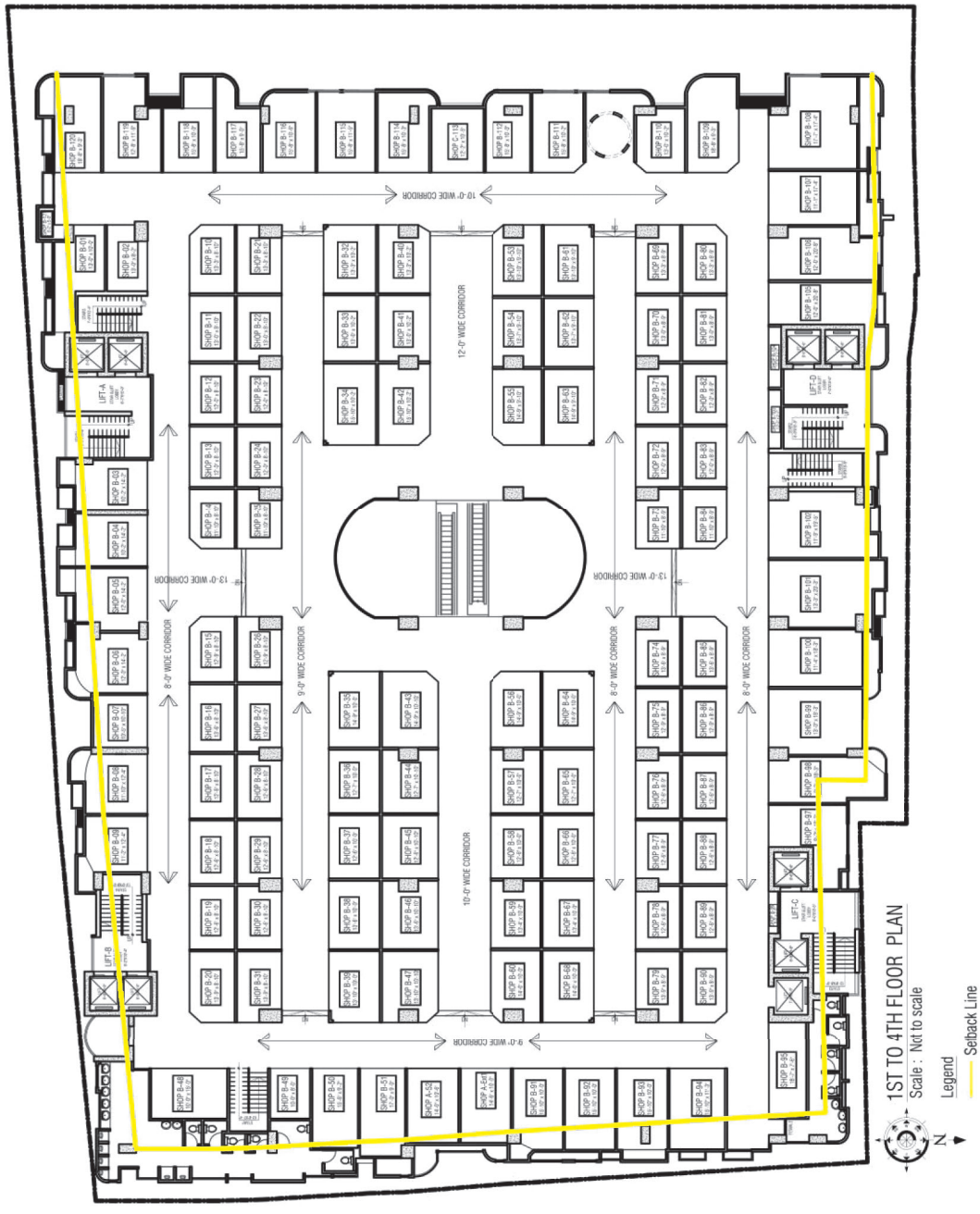
Bad example



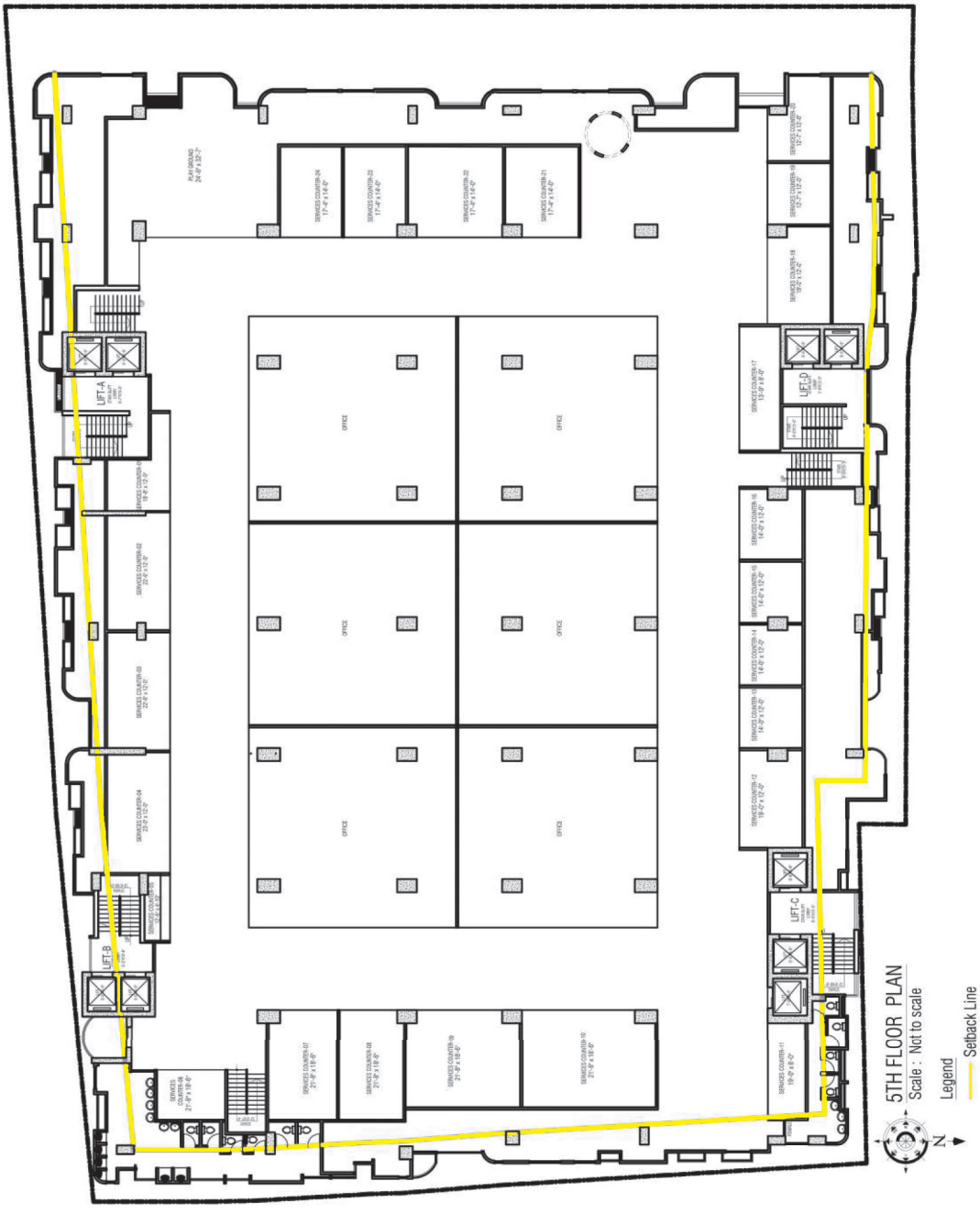
Legend

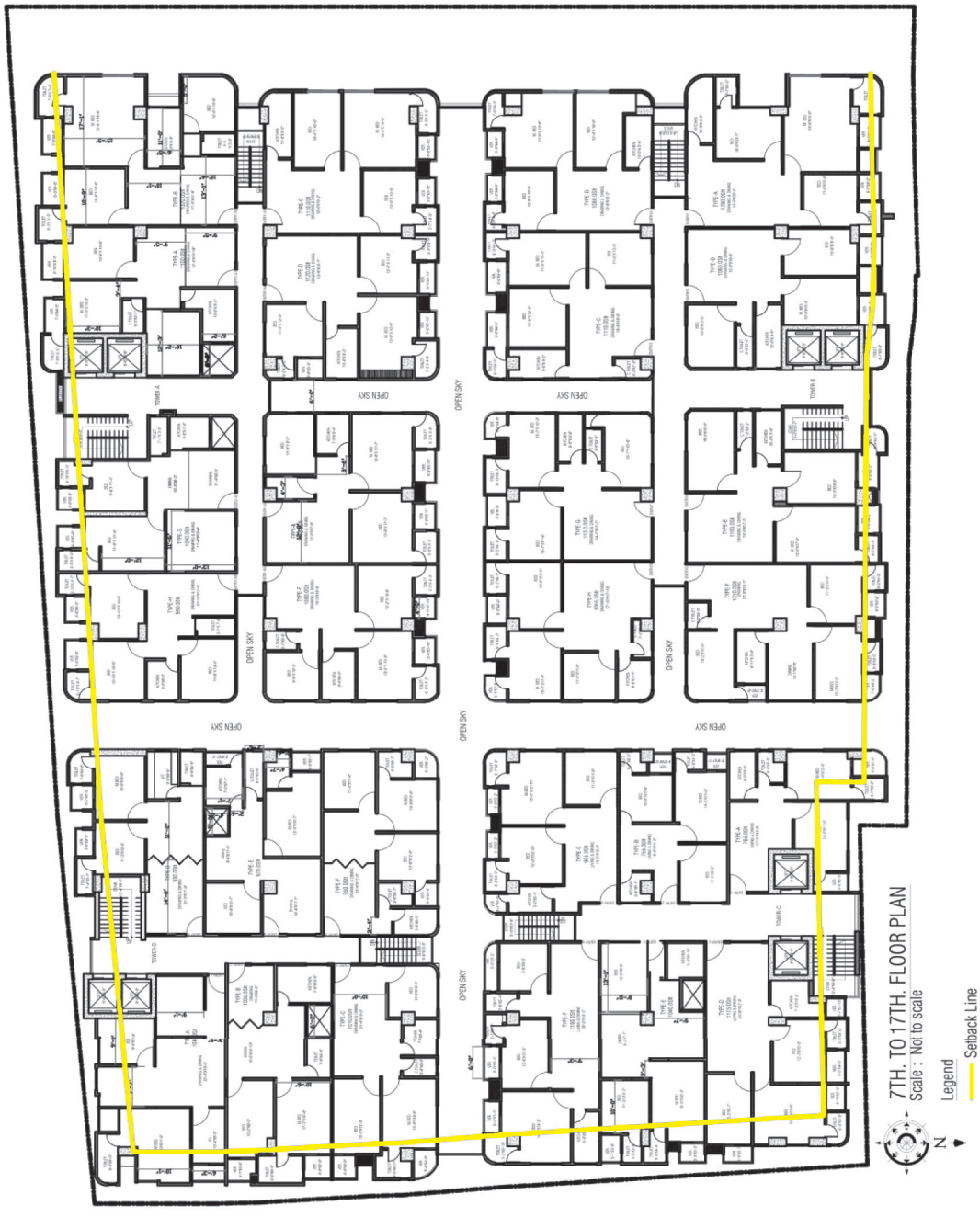
Stairs for Shopping & Office Area

Stairs for Residential Area


1ST TO 4TH FLOOR PLAN
Scale : Not to scale
Legend
Setback Line
N
12'-0" WIDE CORRIDOR
10'-0" WIDE CORRIDOR
9'-0" WIDE CORRIDOR
8'-0" WIDE CORRIDOR
13'-0" WIDE CORRIDOR

Appendix 3. Case Study for Architect




7TH. TO 17TH. FLOOR PLAN
Scale : Not to scale
Legend
Setback Line
N
OPEN SKY
TOWER A
TOWER B
TOWER C
TOWER D

Notes:

a) In the existing layout plan, the setback does not follow the rule properly.

b) Considering the travel distance (distance from any point of the floor area to the exit) of office spaces (5th floor) and shopping areas (GF - 4th floor) requires four stairs, however as we can see in the existing layout only three stairs are in place (blue circles).

c) There are inadequate exit routes for the office space (5th floor) and shopping areas (GF to 4th floor). On the other hand, the exit route for residential areas (7 - 17th floor) has not been properly mentioned on the ground floor layout plan.

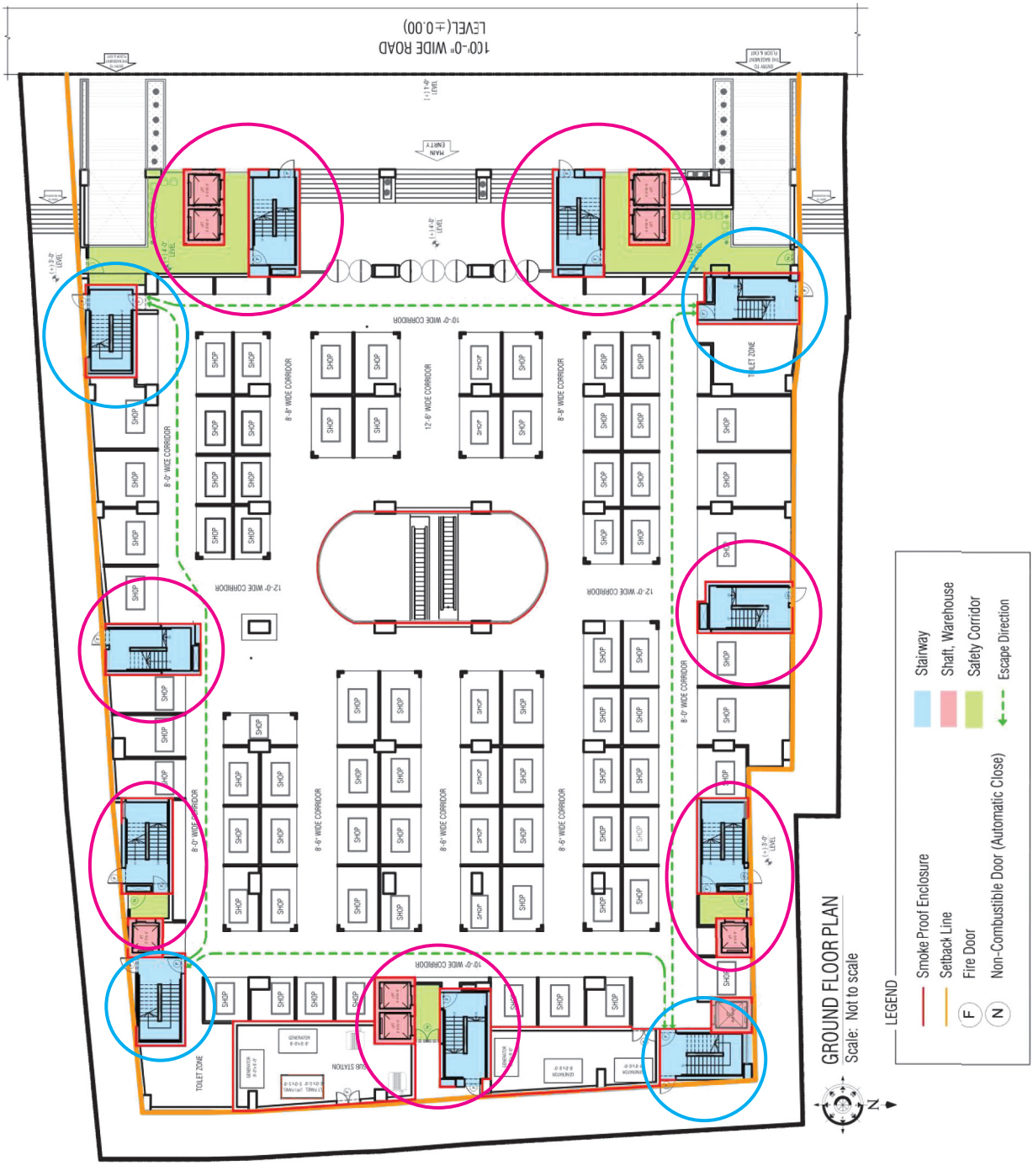
d) According to the layout, the proper width of the exit paths (from the exit stairs up to the road) for the occupancy of the “residential part (7 - 17th floors)” is insufficient in the existing ground floor layout plan. And the exit paths for the occupancy of "shopping and office spaces (GF - 5th floor)" are not sufficiently protected for escape in case a fire breaks out..

e) The fire door is missing in all the exit stairs.

f) Considering the fire smoke control, the stairs and the corridors are not suitable for evacuation from the fire at all.

g) In the residential floor areas (7-17th floors), exit stairs are not in the appropriate position (because, if a fire breaks out at any end of the corridor, the stairs at the other end cannot be used for fire escape).

Good example



Legend

- Stairs for Shopping & Office Area
- Stairs for Residential Area


1ST TO 4TH FLOOR PLAN
Scale: Not to scale
LEGEND
Stairway
Shaft, Warehouse
Safety Corridor
Escape Direction
Smoke Proof Enclosure
Setback Line
Fire Door
Non-Combustible Door (Automatic Close)
F
N
SHOP
STORE
TOILET ZONE
12'-0" WIDE CORRIDOR
10'-0" WIDE CORRIDOR
8'-0" WIDE CORRIDOR
8'-6" WIDE CORRIDOR
8'-8" WIDE CORRIDOR
17'-6" WIDE CORRIDOR


5TH FLOOR PLAN
Scale: Not to scale
LEGEND
Stairway
Shaft, Warehouse
Safety Corridor
Escape Direction
Smoke Proof Enclosure
Setback Line
Fire Door
Non-Combustible Door (Automatic Close)
F
N
TOILET ZONE
TOILET ZONE
OFFICE
SERVICES COUNTER
N


6TH FLOOR PLAN
Scale: Not to scale
N
LEGEND
Smoke Proof Enclosure
Setback Line
Fire Door
Non-Combustible Door (Automatic Close)
Stairway
Shaft, Warehouse
Safety Corridor
F
N


8TH- 11TH, 13TH- 16TH FLOOR PLAN
Scale: Not to scale
N
LEGEND
Smoke Proof Enclosure
Setback Line
F Fire Door
N Non-Combustible Door (Automatic Close)
Stairway
Shaft, Warehouse
Safety Corridor
Escape Direction


OPEN SKY
OPEN SKY
OPEN SKY
OPEN SKY
7TH,12TH & 17TH FLOOR PLAN
Scale: Not to scale
N
LEGEND
Smoke Proof Enclosure
Setback Line
F Fire Door
N Non-Combustible Door (Automatic Close)
Stairway
Shaft, Warehouse
Safety Corridor
Escape Direction

Notes:

a) In the revised layout plan, the setback follows the guideline properly.

b) Considering the travel distance (distance from any point of the floor area to the exit) of office spaces (5th floor) and shopping areas (GF - 4th floor), the revised layout plan has fulfilled the required number (four) of stairs (blue circles).

c) Exit routes for the occupancy from all areas (shopping, office spaces, and residential) has been sufficiently installed and properly mentioned in the revised ground floor layout plan.

d) According to the rules, the proper width of the exit paths (from the exit stairs up to the road) has also been properly indicated in the revised ground floor layout plan.

e) The fire doors have been highlighted properly in all exit stairs.

f) Considering fire smoke control, stairs and corridors are now suitable for fire escape in the revised plan.

g) In the residential floor area of the revised layout plan (7-17st floors), exit stairs are placed in the appropriate position (because, if a fire breaks out at any end of the corridor, the stairs at the other end can be used for fire escape).

h) In the revised layout plan of the residential floor area (7 - 17st floors), a connecting bridge has been introduced as a safety corridor after every fifth floor from the top (7th, 12th and 17th). As a result, when a fire breaks out in any block of the residential area, it will become easier for the occupants to evacuate from one block to another block through this connecting corridor.

Appendix 4. Example for MEP Engineer

Basic Consideration of Fire Safety& It's Equipment During Design Phase

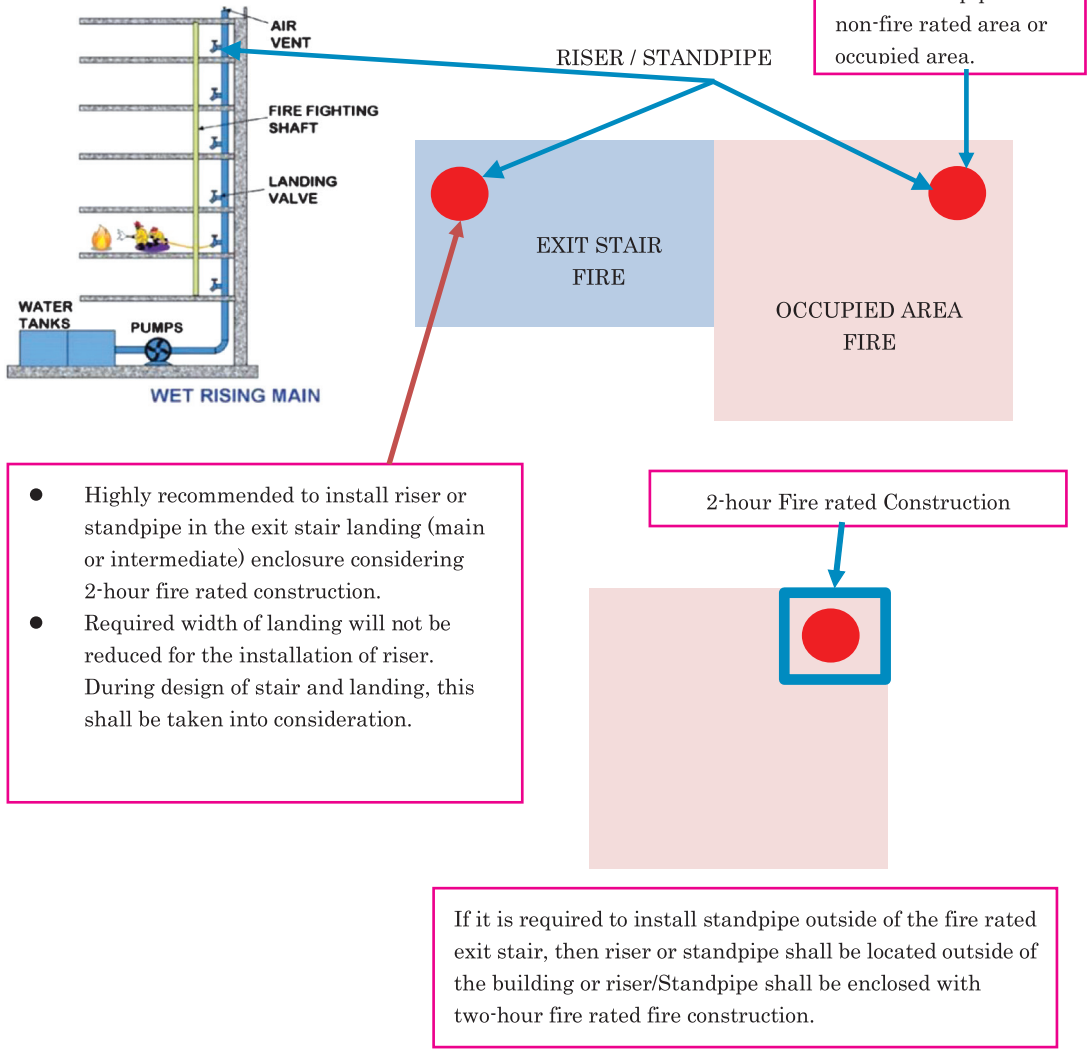
Location of Riser or Standpipe

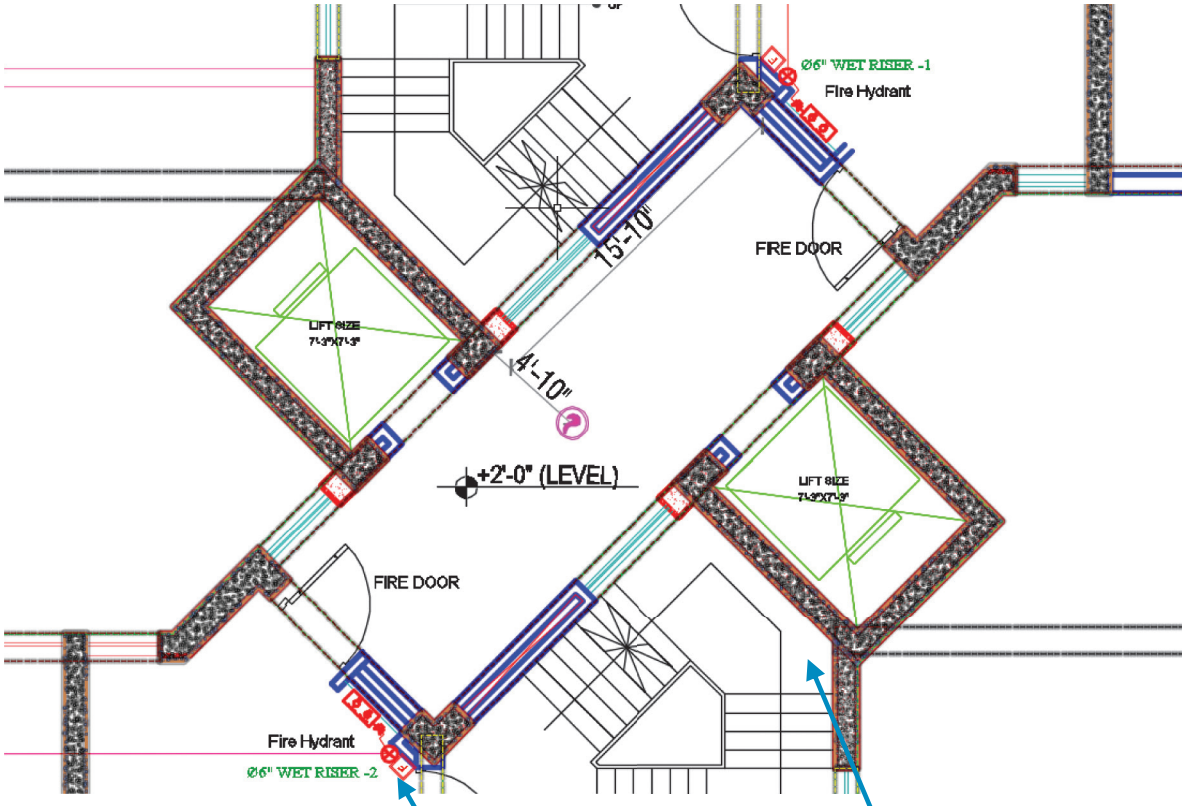
a) Standpipe system piping:

- Should not pass-through hazardous areas
- It should be located so that it is protected from mechanical and fire damage.

b) Standpipes and lateral piping supplied by standpipes should be located:

- In enclosed exit stairways or
- It should be protected by a certain degree of fire resistance equal to that required for enclosed exit stairways in the building in which they are located.

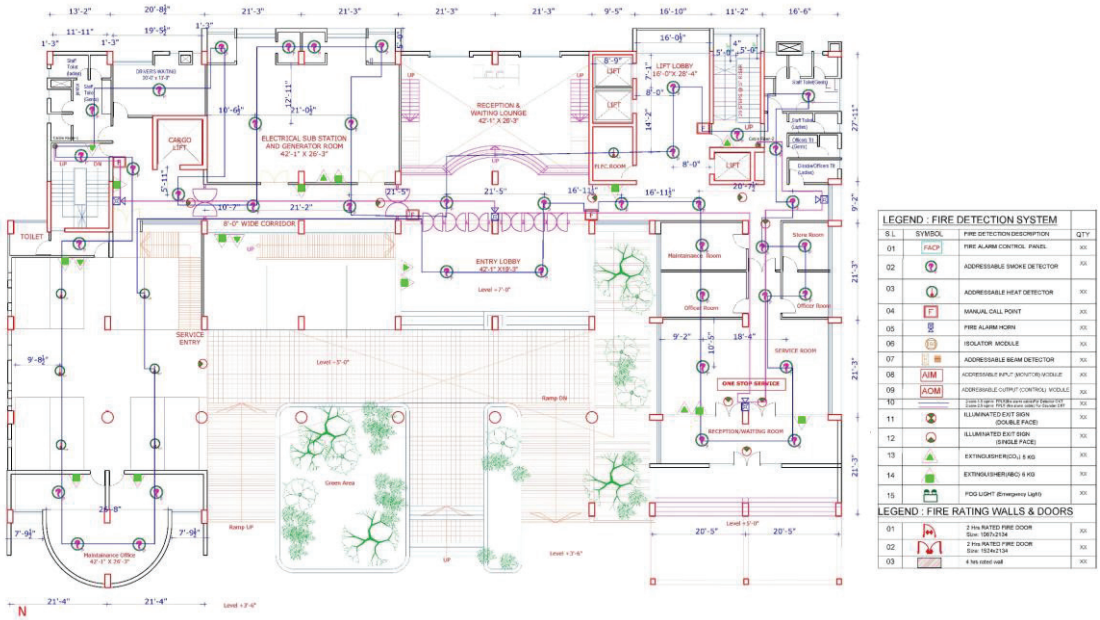


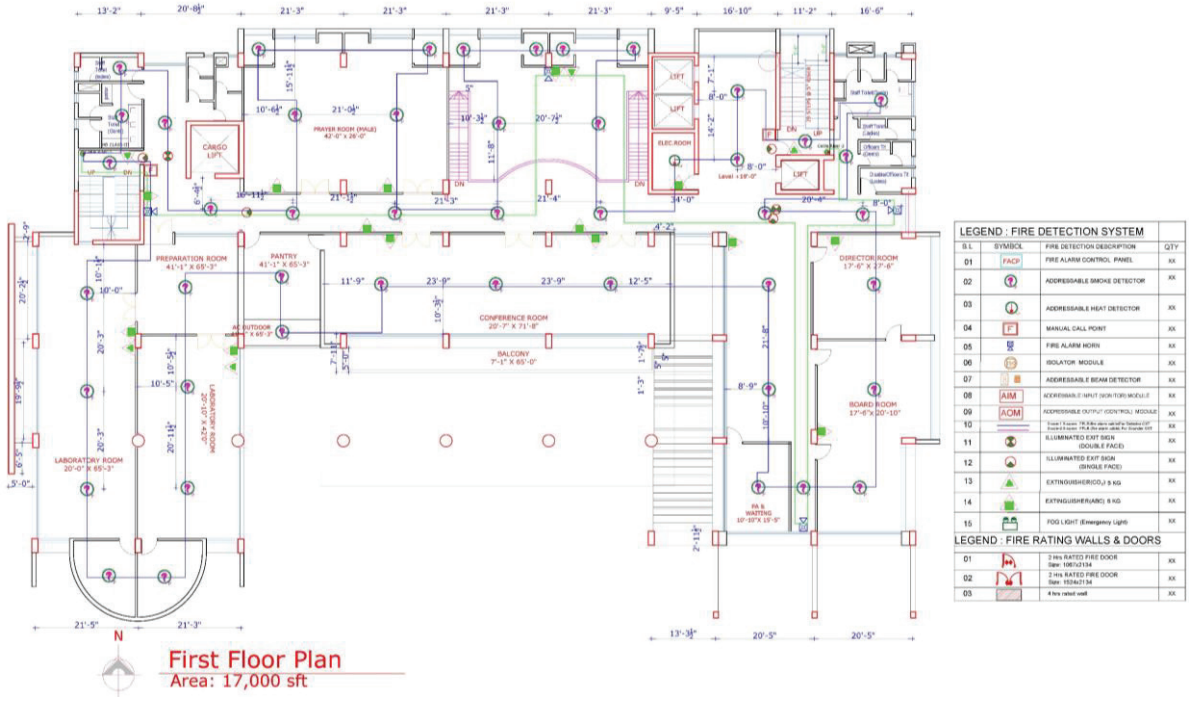


Provision is given to install fire hydrant box and riser inside the lobby which is actually wrong.

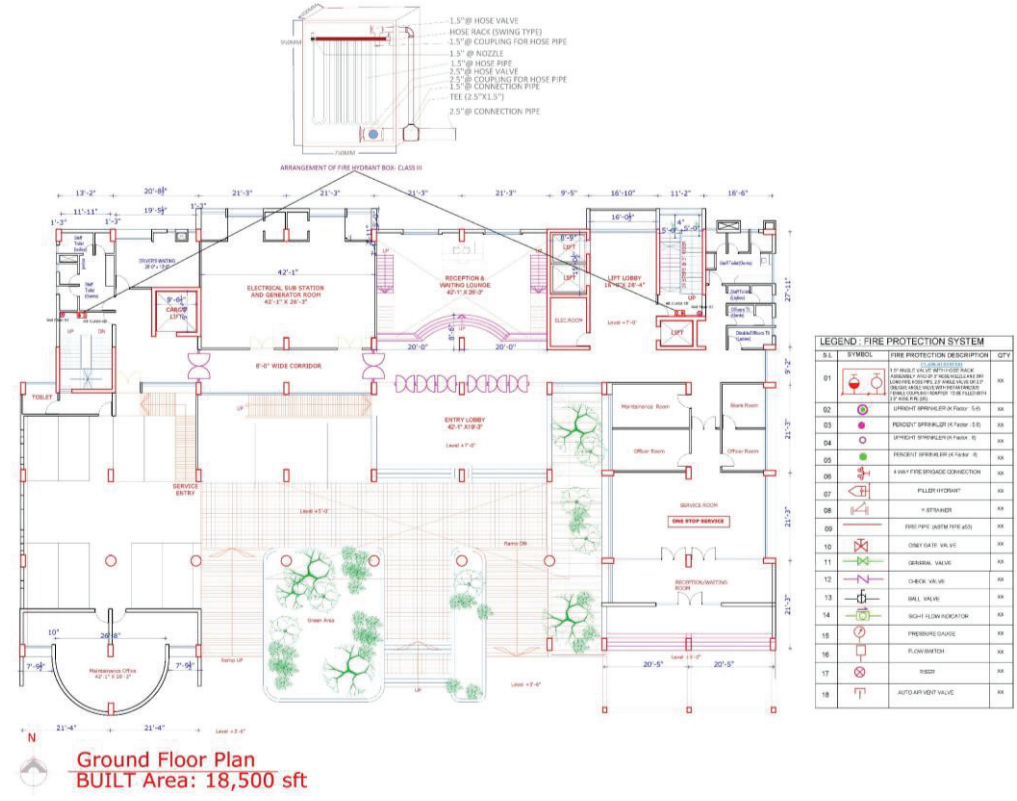
Riser/Standpipe and hydrant point is not inside of the fire rated exit stair.

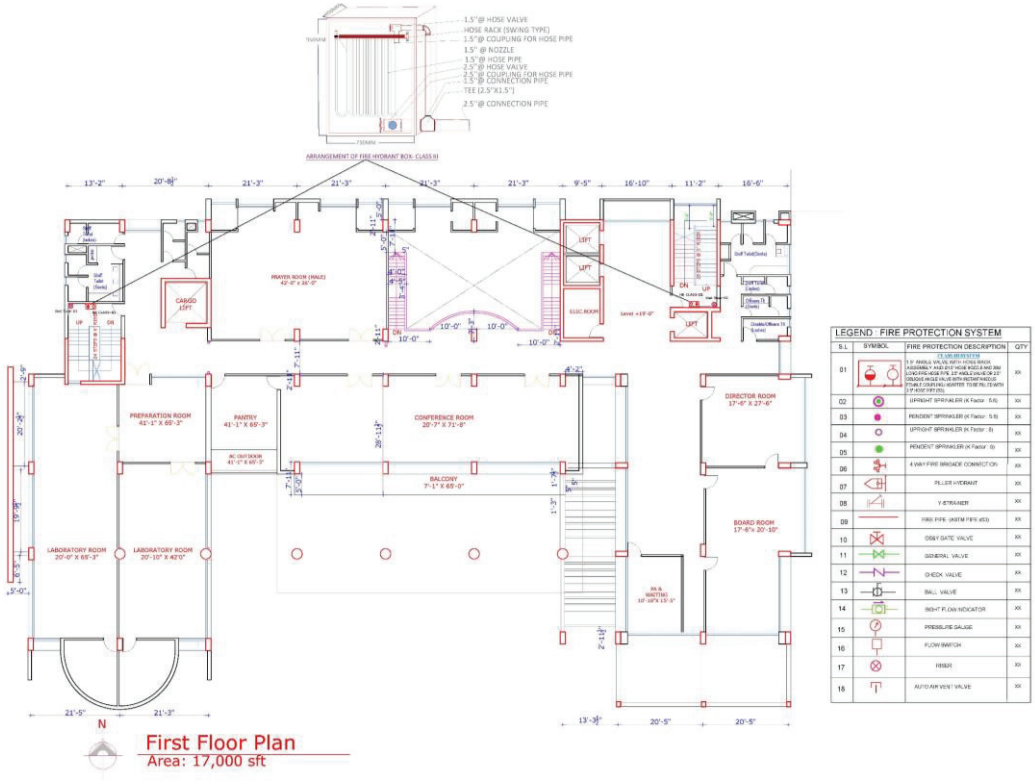
Example of Detection



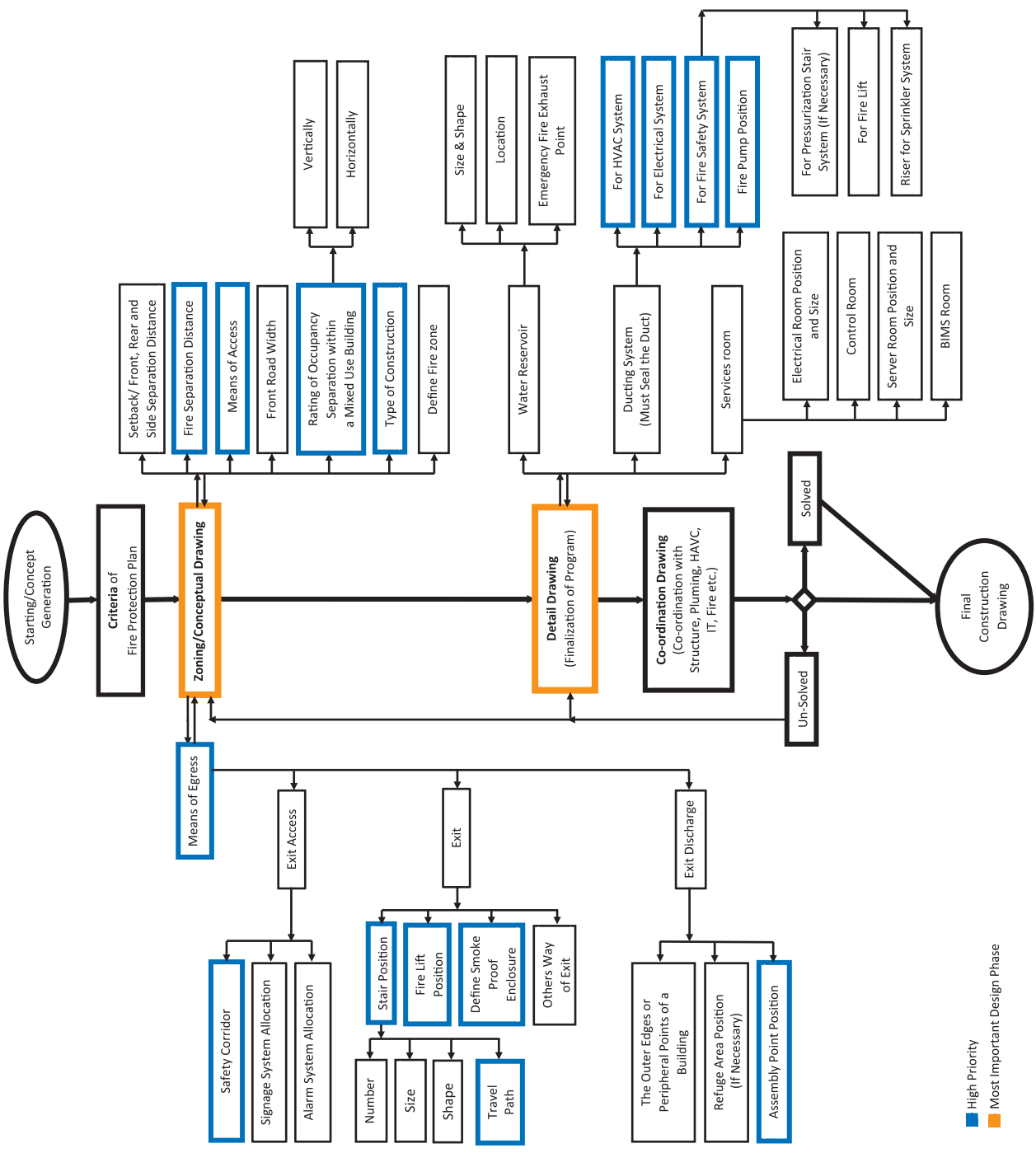


Example of Hydrant





Appendix 5. Fire Safety Design Flow



Fire Protection Plan: Sec 5.1.6, Chapter 5, Part 4, Vol-1, BNBC 2020

Means of Egress: Sec 3.2, Chapter 3, Part 4, Vol-1, BNBC 2020

Exit Access: Sec2.8.1.1(c), Chapter 2, Part 8, Vol-3, BNBC 2020

Stair Position: Sec 3.10, Chapter 3, Part 4, Vol-1, BNBC 2020

Fire Lift: Sec 2.11, Chapter 2, Part 4, Vol-1, BNBC 2020

Assembly Point Position: Appendix A-10, Part 4, Vol-1, BNBC 2020

Travel Path: Sec 3.15, Chapter 3, Part 4, Vol-1, BNBC 2020

Signage System: D-26, D-27, Appendix D, Part 3 and Sec-3.16, chapter 3, Part 4 of Vol-1, BNBC 2020

Smoke Proof Enclosure: Sec 3.13, Chapter 3, Part 4, Vol-1, BNBC 2020

Sec 5.9.2(c), Chapter 5, Part 4, Vol-1, BNBC 2020

Alarm System: Sec 4.6.2, Chapter 4, Part 4, Vol-1, BNBC 2020

Refuge Area: Sec 3.12.6, Chapter 3, Part 4, Vol-1, BNBC 2020

Setback: Figure 3.1.3, Table 3.1.5and Table 3.1.8 Chapter 1, Part 3, Vol-1, BNBC 2020.

Fire Separation Distance: Figure 3.1.1 of Chapter 1, Part3, Vol-1, BNBC 2020

Table 3.2.2 & 3.2.3, Chapter 2; Part 3, Vol-1, BNBC 2020

Means of Access: Sec 1.7, Chapter 1, Part 3, Vol-1, BNBC 2020

Sec 1.4.5.3, Chapter 1, Part-7, Vol-3, BNBC 2020

Note: During building operations, free access to permanent, temporary or portable first-aid firefighting equipment shall be maintained at all times.

Front Road Width: Sec 1.9.2 and Table 3.1.7, Chapter 1, Part 3, Vol-1, BNBC 2020

Occupancy Separation within a Mixed-Use Building: Sec 2.3, Table 3.2.1, Chapter 2, Part 3, Vol-1, BNBC 2020

Type of Construction: Table 3.2.4, Chapter-2; Part-3, Vol-1;

Sec 3.1.5, Chapter-3, Part-3, Vol-1;

Sec 3.1.1, Table-3.3.1 (a) (b), Chapter-3; Part-3, Vol-1;

Sec 2.2, Chapter-2, Part-4, Vol-1, BNBC 2020

Fire Zone: Sec 3.1.5, Chapter-3, Part-3, Vol-1, BNBC 2020.

Water Reservoir: Sec 4.2, Chapter 4, Part-4, Vol-1, BNBC 2020

Rain Water Harvesting System: Sec 4.3.5.1, Chapter 4, Part 3, Vol-1, BNBC 2020

Fire Pump: Table 4.4.1 and Sec 4.2.2.5, Chapter 4, Part-4, Vol-1, BNBC 2020

Fire Hydrant Point: Sec 1.4.5.3, Chapter 1, Part-7, Vol-3, BNBC 2020

Sec 1.7.5, chapter 1and Sec 3.11.2.1 Chapter 3; Part-7, Vol-3, BNBC 2020

Note: Free access from the street to fire hydrants/static water tanks, where available, shall be provided and maintained at all times.
No materials for construction shall be placed within 3 m of hydrants/static water tanks.

HVAC System: Sec 2.12.5, Chapter-2, Part-8, Vol-3, BNBC 2020

Note: Generally, HVAC system servicing zones with a total conditioned area exceeding 500 m^2 (5000 ft^2).

Pressurization Stair System: Sec 5.1.6 (g), Chapter 5, Part 4, Vol-1, BNBC 2020

Sec 5.9.2 (c), Chapter 5, Part 4, Vol-1, BNBC 2020

Electrical Room: Table 8.1.24, Chapter-1, Part-8, Vol-3, BNBC 2020

Table 8.1.18, Chapter-1, Part-8, Vol-3, BNBC 2020

Note: For residential buildings, the minimal guidelines given in Table 8.1.18 and Table 8.1.24: represent the Area Requirements for Standby Generator Room.

Server Room: Sec 5.7 (vii), Chapter-5, Part-4, Vol-1, BNBC 2020

INDEX OF FIGURES

Chapter 7. Standpipe System

Chapter 9. Automatic Fire Detection and Alarm System

Prepared Under

Project on Promoting Building Safety for Disaster Risk Reduction (BSPP)

A Technical Cooperation Project between PWD and JICA

2021