

ASSESSMENT OF EXIT REQUIREMENTS FOR FIRE SAFETY OF COMMERCIAL BUILDINGS, KATHMANDU, NEPAL

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Abstract: This research is conducted to review the NBC 107:1994 and to analysis the status of its compliance in selected commercial building. The study is significant for concerned authority to know the weakness of existing code for its improvement and to understand the present fire safety scenario of the commercial buildings. It can be helpful for the development of the fire safety and evacuation plan. It can be a guiding document to consultants and professional bodies ensuring fire safety in commercial building. It can create the awareness among occupants.

Keyword: Safety provisions, Compliance, National Building Codes

I. INTRODUCTION

Fire damage causes damage of occupant's life, structural damage and loss of properties (Sun, 2013). Fire tragedy will not only involve damage to property but also issues of life. Therefore, must be very careful when dealing with the elements having a high risk of fire ignition (Yatims, 2009).

Fire prevention is a matter of being aware of the factor which causes fire to start, then taking steps to prevent. It needs a program of education and supervision of work force, a plan for proper and regular maintenance of plant and equipment and proper location of firefighting equipment which also needs to be kept maintained and provided unobstructed access (Derek, 1986).

Exit plays a vital role in prevention and protection of fire in commercial buildings. Fire safety code of Nepal was prepared in 1994 A.D. and no revision has been done. Even, UNDP has stated the need for modern and up-to-date fire code. Since NBC 107:1994 is not a technical but also a legal document, it needs to be updated based on changing circumstances to ensure fire safety.

II. METHODOLOGY

Four commercial building; City center mall, Labium Mall, Lalitpur Mall and Star Mall were selected purposively to assess exit requirements for fire safety in terms of completeness and compliance of codes. It was conducted in two steps i.e review of fire safety code and compliance. It was based on qualitative approaches. The primary data was collected by observation with check list to understand the compliance status of NBC 107:1994 in selected commercial buildings and interaction with key informants. Key informants interview was conducted with engineer of consultant to understand the feature of fire safety design and current design practice of commercial building. Whereas, interview was conducted with fire authority of Judha Varun Yantra to understand fire safety management of commercial buildings. Whereas, secondary data was collected from various publications like journals, reports of government organization like NBC 107:1994, and other fire safety codes like IS 1644:1988, website, books etc.

III. ANALYSIS

In this chapter NBC107:1994 was compared with IS 1644: 1988 and Code of practice for fire safety in buildings (Hong Kong Standard) to highlight the advantages and short comings of the NBC107:1994.

COMPARISON OF FIRE SAFETY CODES

Finding from the above mentioned codes has been compared and presented in the tabular form.

Table 1. 1: Comparison of Exit Requirement

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Exit		
<ul style="list-style-type: none"> evacuation at short time free of any obstructions and no resistance to movement clearly visible preferably with proper signs Continuous and not interrupt into private space. 	<ul style="list-style-type: none"> Enclosed type One exit directly open to street Door locks prohibited Mirror not allowed 	<ul style="list-style-type: none"> Directly lead to ultimate place of safety Doors or gates if any readily open able Refuge area with permanent feature like handrail

NBC 107: 1994 has mentioned that exit shall meet the minimum requirement of size and be free from obstruction. IS 1644:1988 has mentioned that, enclosed exit shall be provided and mirror shall be avoided. Exit shall be required to be continuous but where it shall lead was not mention. Whereas, in case of Hong Kong Standard it was clear that exit shall directly lead to ultimate place of a safety. The main

objective of the exit is to direct occupants to the ultimate place of safety. Ultimate place of safety; its size and nature should be clear in code. Mirror should be avoided as they may confuse the direction of exit.

In NBC 107: 1994 as shown in table 1.2 only number of staircase and width of the staircase was mentioned. Detail like clear headroom of staircase was not mention which was provided in IS 1644:1988. No position and arrangement of staircase has been made. IS 1644:1988 has also mentioned that living space shall not open in staircase. Hong Kong Standard has mentioned that no exit door when swing reduce the effective width of landing.

Table 1. 2: Comparison of Staircase Requirement

NBC:107	IS 1644:1988	Hong Kong Standard
Staircase		
<ul style="list-style-type: none"> Min Width 1.5 m 	<ul style="list-style-type: none"> No living space or store open into stairs Exit door of staircase at ground ,open at ultimate place of safety beam/column and other shall not reduce the headroom and width of stair 	<ul style="list-style-type: none"> more than one stairs, shall arrange in different direction, People using one stair must be able to gain access to the stairs without passing through other private space Landings should be provided at the top and bottom of each flight not less in width and length than the width of required staircase No exit door should be at any part of its swing reduce the effective width or effective radius of such landing as the case may be. Every required staircase should have clear headroom of not less than 2000mm.
<ul style="list-style-type: none"> >500m² on each floor =nos. of stair 2 Additional in proportion with increased area 	<ul style="list-style-type: none"> >500m² on each floor and above 15 m height min 2 stairs 	-

During KII, experts mentioned that, stairs should be arranged in different directions and at maximum distance from each other so that travel distance is reduced. Living space should be avoided in staircase and position of exit door on staircase shall not create any obstruction.

Table 1. 3: Pressurization of stair

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Pressurization of Staircase		
-	<ul style="list-style-type: none"> Rise the pressure slightly above the adjacent side of building to prevent ingress of smoke in escape rout 	-

Pressurization of stairs was not mentioned in NBC:107 1994. It was included in IS 1644: 1988. Pressurization of staircase helps to prevent smoke entry to protected escape route and enhance visibility.

Table 1. 4: Travel Distance

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Travel distance		
Max 20 m	<ul style="list-style-type: none"> Max 30m Min 15 m at dead end 	<ul style="list-style-type: none"> Max 30m

Travel distance to the exit was less than IS 1644:1988, which was limited to 20 m but travel distance from dead end, was not mentioned. During KII, experts mentioned that, travel distance from dead end should be less as there is no other way to escape and should be fire protected by compartment.

Table 1. 5: Doorways

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Exit door		
<ul style="list-style-type: none"> Open to a passageway or to the corridor Not less than 90cm width 180cm height Open outward 	<ul style="list-style-type: none"> Open to stair way Not less than 100cmwidth 200cm height Open outward No sliding and overhead door Serve without key Shall not immediately open upon stair flight 	<ul style="list-style-type: none"> If constructed to open both way, have transparent view panel Doors if opens onto landing should not reduce the effective width of landing Double leaf door not less than 60cm width The self closing mechanism should not be capable of allowing a check action to hold the door open

NBC 107: 1994 has mentioned exit door shall open to passage way and open outward in the direction it serves but whether or not door locks shall be provided or closing mechanism of exit door is not mentioned. These are included in IS 16544:1988 and Hong Kong standard

respectively. Door size requirement is less than other codes which is 90 cm. IS 1644: 1988 has mentioned that no sliding door and overhead door shall be provided where as Hong Kong Standard has mentioned if exit door open in both way view panel shall be provided. During KII, experts mentioned, sliding and over head door are not acceptable because it is not readily opened and acts as obstruction. Door should serve without key.

Table 1. 6: Corridor and Passageway

NBC:107	IS 1644:1988	Hong Kong Standard
Corridor and passageway		
-	<ul style="list-style-type: none"> Not less than width of exit door Height of corridor and passage way ≥ 2.4 m 	-

It was clearly stated that exit shall open to passageway (See 2.8.1 Nepal National Building Code NBC 107: 1994) but corridor and passageway detailing were not mentioned though protected corridors and passageways are important factor of fire safety design as protected corridor and passageway check the entrance of the smoke in the escape route allowing

Table 1. 7: Internal staircase

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Internal staircase		
-	<ul style="list-style-type: none"> At least one wall on external wall Completely enclosed Should not be arrange around lift If around lift totally enclosed by material of fire resisting No gas piping should be laid 	-

There was no provision of internal staircase in NBC 107: 1994 and Hong Kong standard. IS 16644: 1988 has mentioned that at least one wall of internal staircase shall be on external wall. It shall not arrange around lift, if arranged around lift totally enclosed by material of fire resisting. If there is a provision for external staircase then internal staircase is not important.

Table 1. 8: Fire escape or External stair

NBC:107	IS 1644:1988	Hong Kong Standard
Fire escape or external stair		
<ul style="list-style-type: none"> Min width 75 cm tread 20 cm riser height 19 cm nos. of riser 15 carry user towards open space 	<ul style="list-style-type: none"> shall always be directly connected to the ground Entrance to the external stairs shall be separated and remote from the internal staircase ensure that no wall opening or window opens on to or close to as external stairs route- free from obstruction at all times Min Width of tread without nosing 30 cm max height 15 cm nos. of riser per flight 15 external stair Not inclined more than 45 Required Fire resistance door 	-

NBC 107: 1994 has mentioned fire escape and external stair as single element, whereas internal escape or staircase and external staircase can have different requirements. Minimum width of stairs, maximum height of riser and minimum tread width were mentioned but angle of inclination of stairs is not provided which was mentioned in IS 1644:1988. Detailing of opening in external wall is not provided in NBC 107:1994. During KII experts mention that, number of riser was limited per flight to ease the occupants. Opening should be distance from external exit or fire escape to protect entrance of fire and smoke.

Table 1. 9: Handrail Detail

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Handrail detail		
-	<ul style="list-style-type: none"> Height:Min100cm-max 120cm Gap between two vertical ≥ 30cm and less than 15cm 	-

Handrail detail was not mentioned in NBC107: 1994 but detailing of height of handrail was mentioned in architectural design requirements as handrail height shall not be less than 1000mm (Government of Nepal, 2003). IS 1644:1988 has mentioned the required height of handrail and gap between two vertical railing. . Horizontal division of handrail is necessary to cater the children as height varies and handrail should not reduce the minimum width required for staircase.

Table 1. 10:Basement

NBC:107	IS 1644:1988	Hong Kong Standard
Basement		
-	<ul style="list-style-type: none"> at least two separate stair case(common path permitted 15m) Every floor 2 staircase access 	<ul style="list-style-type: none"> Protected lobby should be provided

NBC 107: 1994 has not mentioned basement and type of staircase required for basement. Whereas, IS 1644: 1988 has mentioned at least two separate staircase are required for basement and Hong Kong standard mentioned that protected lobby shall be provided. The basement stairs shall be protected more than those above ground because smoke has tendency to rise. All doors to basement stairs shall be of smoke control (Malhotra, 1993). , Generally basements were used for parking, but they might have service room and generators. It is preferable to isolated generator if that is not possible then it should be fire protected from parking area. Basement should be properly ventilated and provided with protected lobby.

Table 1. 11: Horizontal Exit

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Horizontal Exit		
-	<ul style="list-style-type: none"> 100 cm At least one fire door Refuse area 0.3m² /person Horizontal exit, ramp not more than 1:10 Doors open able from both direction 	-

NBC 107: 1994 has stated that exit may lead to another building (See 2.8.1 Nepal National Building Code NBC 107: 1994) but detailing for horizontal exit was not mentioned. Whereas, IS 1644: 1988 has mentioned size, door and ramp necessary for horizontal exit. During KII, experts mentions that, commercial building has many facilities; these facilities are accommodated in more than one building. So, horizontal exit is necessary to escape from one building into another building or from one section of a building into another section of the same building.

Table 1. 12: Ramp

NBC:107	IS 1644:1988	Hong Kong Standard
Ramp		
-	<ul style="list-style-type: none"> Not exceed 1:10 limited to 1:8 Greater than 1:10 non- slipping material 	<ul style="list-style-type: none"> The gradient of every ramp forming part of an exit route should not at any part be steeper than 1:12.

NBC 107: 1994 has not mentioned ramp. IS 1644: 1988 and Hong Kong Standard had provision of ramp and required gradient. Ramp is not only necessary to support differently able people but when stairs is provided with one or two risers in lobby these increase the changes of accident. These should be replaced with ramp with appropriate gradient with non slippery material.

Table 1. 13: Signs

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Signs		
<ul style="list-style-type: none"> be clearly visible, preferably with proper signs 	<ul style="list-style-type: none"> Flush on wall Floor indication board facing place on wall 0.5mx0.5m 	<ul style="list-style-type: none"> Indicate the way of escape at suitable height with arrow to way If stair is not accessible to roof character not less than 50 mm in height

NBC 107: 1994 has mentioned that signage shall be clearly visible. Position of signage, indication of direction to be provided and size of signage were not mentioned. IS 1644:1988 and Hong Kong standard has mentioned size of signage. Directional and exit signs are necessary to indicate the location of protected exits and assist occupants with their path of travel along the exit route (International Code Council, 2009). In the absence of daylight the signs should be illuminated so that they are visible from a distance (Malhotra, 1993). Even casual worker identified the significance of signs for safety (Mishra and Shrestha, 2017).

Table 1. 14: Emergency Lighting

NBC:107	IS 1644:1988	Hong Kong Standard
Emergency lighting		
-	<ul style="list-style-type: none"> Emergency lighting and escape lighting 	<ul style="list-style-type: none"> Horizontal lighting 30 lux. Combination of natural and artificial lights with backup lighting system

NBC 107: 1994 has not mentioned emergency light and escape lighting. Whereas both IS 1644:1998 and Hong Kong standard has provision for emergency lighting. All escape routes shall be provided with lighting which comes into operation if the normal supplies fail so that occupants can find their way to the protected escape zones (Malhotra, 1993). During KII experts mentioned, emergency lighting are required when normal supply fails and escape lighting are required in all circulation areas for occupants to see the routes clearly.

Table 1. 15: Firefighting Equipment

NBC 107: 1994	IS 1644:1988	Hong Kong Standard
Firefighting equipment		
<ul style="list-style-type: none"> • Dry riser • Wet riser 	-	<ul style="list-style-type: none"> • If sprinkle head is provided should not project • More than 90mm from side wall • And not reduce the height of exit more than 105mm

NBC 107: 1994 has mentioned dry and wet riser only, other fire fighting tools like smoke detector, heat detector and fire alarm were not mentioned. Hong Kong standard has provision of sprinkle head. Active fire fighting equipments; smoke detector, heat detector etc. help to warn occupants and renders fire safety of the building.

Table 1. 16: Special Hazards

NBC:107	IS 1644:1988	Hong Kong Standard
Special hazards		
-	-	<ul style="list-style-type: none"> • If directly associated with normal hazard, should be provided with protected lobby

NBC 107: 1994 and IS 1644:1988 has not mentioned special hazards. It is a risk due to hazardous fire loads, fuel and power supplies or the heat generating equipment. These areas present additional risk to that associated with the building and therefore extra precautions shall be taken. It is important that these areas are isolated from the rest of the accommodation for normal safety. They should preferably be located external to the building or against an external wall so that entry from outside is possible (Malhotra, 1993).

Table 1.1- Table 1.16 shows that NBC 107: 1994 contains less detailing when compared to IS 1644:1988 and Hong Kong Standard. Staircase plays an important role in fire safety; preference shall be given to staircase type and detail. There is no provision for arrangement of stairs in building, not mentioned where and how the door shall be placed on the stair. No provision for pressurized staircase. Fire escape and external stair were mention as single element but internal escape too can acts as a fire escape. Protected lobby and Corridors are integral part of fire escape, they lead to ultimate place of safety but no consideration has been made in NBC 107: 1994. Fire fighting equipment and emergency lighting were not mentioned. No details for signs and notice. Horizontal exit and Special hazard were not mentioned. Requirements for special hazards and basement shall be provided.

Compliance Status Of NBC 107: 1994

To understand the compliance status of fire safety requirement case studies was conducted. Finding from the all case studies are summarized below.

City Centre Mall

One of the notable characteristics of City Center Mall was the large atrium, which provides an attractive and rather open space crossed by an open arcade midway to the top, which served as an escalator landing. Retail shops were placed at the edge of the building all facing the common circulation area, giving the characteristic of the court. Building was facilitated with four staircases, six lifts and two escalators for vertical access. Double storey Basement parking was had mezzanine floor. It was a centrally air conditioned mall, with CCTV, smoke detector, fire alarm, fire hydrant, generator backup. Open space at the exterior belt of the building consisted of the food stalls with a long footpath fitted with light poles.

Table 1. 17: Compliance status of NBC: 107, City Centre Mall

City Centre Mall	Exit 1	Exit 2	Exit 3	Exit 4	Remarks
1. No. of exit					4
2. Stair type					
Enclosed	Yes	No	Yes	Yes	
Open at street	No	Yes	No	No	
Door locks prohibited	Yes	Yes	Yes	Yes	
3. Doorways					
Open to stair way	Yes	Yes	Yes	Yes	
>= 75cm width	Yes	Yes	Yes	Yes	
>=200cm height	Yes	Yes	Yes	Yes	
Open outward	No	Yes	No	Yes	
No Sliding and overhead door	Yes	No	Yes	No	
No arrange around lift	Yes	Yes	Yes	Yes	
Width of tread >=30cm	No	No	No	No	
height of riser <=1.50cm	Yes	Yes	Yes	Yes	
Nos. of stair per flight <= 15	No	Yes	Yes	Yes	
4. Fire escape					
Directly open to ground	No	Yes	No	No	
Free of obstruction all times	No	Yes	Yes	No	
5. Signs					

Proper signage	Yes	Yes	Yes	Yes	
Visible	Yes	Yes	Yes	Yes	
Illuminate	Yes	Yes	Yes	Yes	

Source: Field survey, 2017

Exit requirements of NBC 107: 1994 that were compiled in LABIM were; Exit no. 2 opened at ground floor, door lock was prohibited in Exit no. 1, met all requirements of doorways, fire escape and signs. Whereas, requirements that were not complied to NBC 107: 1994; all three staircase were not completely enclosed and door lock was found in Exit no.

LABIM Mall

Formerly known as Lalitpur Bishal bazar; LABIM Mall is a situated in Pulchowk, Lalitpur. Lalitpur Bishal bazar was totally revitalized by contemporary design creating an exciting place in the city.

LABIM Mall spread over 20,000 sq ft has multiple accesses for pedestrian and vehicles. 50% of the total area is dedicated to the circulation space; while remaining 50 % house rental space. Escalators, elevators and stairs case assists on the vertical circulation while walkways and lobby in horizontal circulation (Bhandari, 2017).

Table 1. 18: Compliance status of NBC: 107; LABIM Mall

LABIM Mall	Exit 1	Exit 2	Exit 3	Remarks
1. No. of exit				3
2. Stair type				
Enclosed	No	No	No	
Open at street	No	Yes	No	
Door locks prohibited	Yes	No	-	
3. Doorways				
Open to stair way	Yes	Yes	No	
>= 75cm width	Yes	Yes	Yes	
>=200cm height	Yes	Yes	Yes	
Open outward	Yes	Yes	-	
No Sliding and overhead door	Yes	Yes	-	
4. Fire escape				
Directly open to ground	Yes	Yes	Yes	
Free of obstruction all times	Yes	Yes	Yes	
5. Signs				
Proper signage	Yes	Yes	Yes	
Visible	Yes	Yes	Yes	
Illuminate	Yes	Yes	Yes	

Source: Field survey, 2017

Lalitpur Mall

Lalitpur Mall is mall situated in Lagankhel, Lalitpur. Building is designed with exposed brick and glass on the facade. It has used both contemporary and traditional design elements in façade. It can be accessed by two roads. It is a mercantile building with five above ground floors. Building is characterized by atrium spanning up to second floor. The building contains stores for different types of products and services, offices, pathology lab, restaurant; food court under one roof.

Table 1. 19: Compliance Status of NBC: 107, Lalitpur Mall

Lalitpur Mall	Exit 1	Exit 2	Exit 3	Remarks
1. No. of exit				3
2. Stair type				
Enclosed	No	-	-	
Open at street	No	No	No	
Door locks prohibited	-	No	No	
3. Doorways				
Open to stair way	-	Yes	Yes	
>= 75cm width	-	Yes	Yes	
>=200cm height	-	Yes	Yes	
Open outward	-	Yes	Yes	
Sliding and overhead door	-	No	No	

4. Fire escape or External stair				
Directly open to ground	-	Yes	Yes	
Wall opening and window not close	-	No	No	
Free of obstruction all times	-	No	No	
Provision of Fire resistance door	-	No	No	
Not inclined more than 45	-	Below 45	Below 45	
5. Signs				
Proper signage	No	No	No	
Visible	Yes	Yes	Yes	
Illuminate	No	No	No	

Source: Field survey, 2017

Exit requirements of NBC 107: 1994 that were compiled in Lalitpur Mall were; all requirements of doorways, external staircase directly open at ground floor and inclined less than 45°. Signs were visible. Whereas, requirements that were not complied to NBC 107: 1994 were; all three staircase were not open to street, external escape was not free of obstructions, and proper signs were not provided.

Star Mall

Star Mall is situated in Putali sadak, Kathmandu. Mall consists of shopping, food court, multiplex, meeting rooms all at one place. It is a single complex with two large atriums, which provides an attractive visual effect. Both blocks have one capsule lift, escalator and a staircase for vertical access.

Table 1. 20 Compliance Status of NBC: 107, Star Mall

Star Mall	Exit 1	Exit 2	Remarks
1. No of exit			2
2. Stair type			
Enclosed	No	No	Semi open
Open at street	No	Yes	
Door locks prohibited	-	-	
3. Doorways			
Open to stair way	-	-	
>= 100cm width	-	-	
>=200cm height	-	-	
Open outward	-	-	
Sliding and overhead door	-	-	
4. Fire escape			
Directly open to ground	No	No	open at ground floor and continuous to basement
Free of obstruction all times	Yes	Yes	
5. Signs			
Proper signage	No	No	
Visible	No	No	
Illuminate	No	No	

Source: Field survey 2017

Exit requirements of NBC 107: 1994 that were compiled in Star Mall were; Exit no. 1 opened at street and exit route was free from obstructions. Whereas, requirements that were not complied to NBC 107: 1994 were; staircase were not completely enclosed, overhead door was provided at Exit no. 1 and no sign were not provided for emergency exit or other information.

All four building were designed with atrium but the smoke vent was not considered in the design. In such buildings additional safety measures are required to minimize the possibility of fire and smoke spread via the atrium area. Natural or mechanical smoke extraction systems shall be provided which keep the smoke layer at a high level and barriers shall be provided to prevent its entry into the accommodation area. In addition, sprinkler installation along the atrium corridors shall be provided if the building is more than 5 storeys in height (Malhotra, 1993).

IV. CONCLUSION

NBC 107: 1994 lacked detailing. Staircase plays an important role in fire safety; preference was not given to staircase type and details. There was no provision for arrangement of stairs in building, not mention where and how the door shall be placed on the stair. No provision for pressurized staircase. Fire escape and external stair was mention as single element but internal escape too could acts as a fire escape. Protected lobby and Corridors were integral part of fire escape, they lead to ultimate place of safety but no consideration has been made in NBC 107:1994. There shall be special requirement for special hazards and basement. Fire fighting system and placement of fire fighting equipments was not mentioned. No details for signs and notice were provided.

All four building were designed with atrium but the smoke vent was not considered in the design. No consideration was made for special hazards and obstruction was found in the escape route.

It was found that not all the aspects mention in NBC 107: 1994 was complied. Many aspects of door detailing and stairs detailing were considered in City Center Mall, and LABIM Mall. While, there was an obstruction on the escape route of City Center Mall and Lalitpur Mall. All four buildings semi enclosed stairs were present, whereas they shall be completely enclosed. City Center Mall has proper signage, LABIM Mall too has proper signage for exit but informative signs like floor numbering were distractive. Lalitpur Mall had exit sign on ground floor only. Star Mall lacked signage. There were no protected corridors at Lalitpur Mall and Star Mall.

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