An Evaluation of Hospital Evacuation Strategies with an Example

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Abstract

Function, aesthetics, strength, durability and economic criteria are kept at the forefront in building design. But when fire safety is concerned, due to not enough understanding of the seriousness of fire safety and lack of sufficient knowledge of architects and engineer, provisions of regulation cannot reflect to building design. How the measures architects and engineers take on the hospitals such as required special fire safety measures and regulations and what level at which they apply regulations is one of the objectives of the study. In addition, intended to be implemented through the clinical portion of the building by identification of problems that arose in the history of fire, is the purpose of the study. Deficiencies of clinics have been identified in in two stages. In the first stage determined that the hospital is appropriate to the fire regulations or not. In the second stage interviews had been made with serving staff, doctor, nurse, hospital management, patient and their relatives about recent hospital fire to determinate the defiance and proposals have been in light of the obtained information. Application this is made believed to be an example to other hospitals in the process to ensure the fire safety of the clinic.

Keywords: Fire safety, evacuation, hospital security, horizontal compartment

1. Introductıon

To provide safe evacuation of users from a fire to a safe area in the shortest possible time, it should be aimed to design escape routes appropriate to the user profile by calculating escape distances in ccordance with the regulations. Evacuation of hospitals is relatively slower and more difficult than from other buildings. Hospitals are a group of buildings which require special solutions as they are in special circumstances and have patients with limited movement capability. In addition, smoke-free waiting areas must be created for patients attached to machines. Evacuation distances are adequately determined in the fire safety regulations. However, the provisions for the evacuation of patients remain insufficient. Escape routes must have special design criteria according to the user characteristics. In the formation of these criteria, there must be consideration of the risk of sleep, the user load, movement capability, knowledge of the building and behavioural response to the alarm (Proulx, 2002).

Evacuation from a building during a fire takes longer than the spread of fire. Therefore, the principle that simple and short escape routes must be created should be applied at all design stages of the building. Two strategies have been developed for the evacuation of people from hospital buildings.

Horizontal Evacuation: the creation of compartments as areas of shelter which cannot be penetrated by smoke or fire, on the floor where the fire occurs in the building.

Vertical Evacuation:people go first to the compartment on the floor below, either aided by rescue teams or by their own efforts, then reaching the ground floor, are taken out of the building.

2. Materıal and Method

The aim of this study conducted at Uludag University Application and Research Hospital was to determine and evaluate the user evacuation procedures of the inpatient departments, referred to as the clinics, where patients are weak in perception and movement. The hospital is one of the most extensive hospitals in the Marmara Region.

By analysing whether or not the clinics met the provisions of the Turkey Fire Safety Regulations (TFSR), the most efficient horizontal and vertical escape routes were organised in the existing building. The hospital is formed of 3 blocks as A, B and C blocks connected to each other on the ground floor.

The clinics are located in B block, which is 73,248m^2 and has 7 floors. The clinics are connected to each other with vertical shafts with departments such as laboratories, the blood centre, the canteen and archives on the ground floor and below ground level.

The clinics were designed on the understanding of a double corridor system. The nurses station is located at a central point, providing a connection to both corridors. Each clinic corridor terminates with fire escape stairs. In addition, at the linking points connecting the blocks to each other, there are fire escape stairs. On the ground floor, each exit point to outside of the fire escape stairs has been especially designed for the evacuation of stretchers etc. The clinics can be connected to A and C blocks on the ground floor. Assuming the clinics to have the same determining features, these are intensified in the Orthopaedics Department, which is on the middle floor and where the patients have limited movement capability. Of 35 patients (4 can be added to give a total of 39) in the ward, a mean total of 20 cannot move. Evacuation can only be made by stretcher and bed routes. Use of the stairs puts patients at risk of their safety. The width of the existing exit doors and routes are within the appropriate evacuation limits defined in the provisions of the TFSR. The adequacy of the escape routes and passive fire precautions of the clinics is associated with whether or not the provisions of the Fire Regulations were met. Therefore 2 different methods were applied in this study.

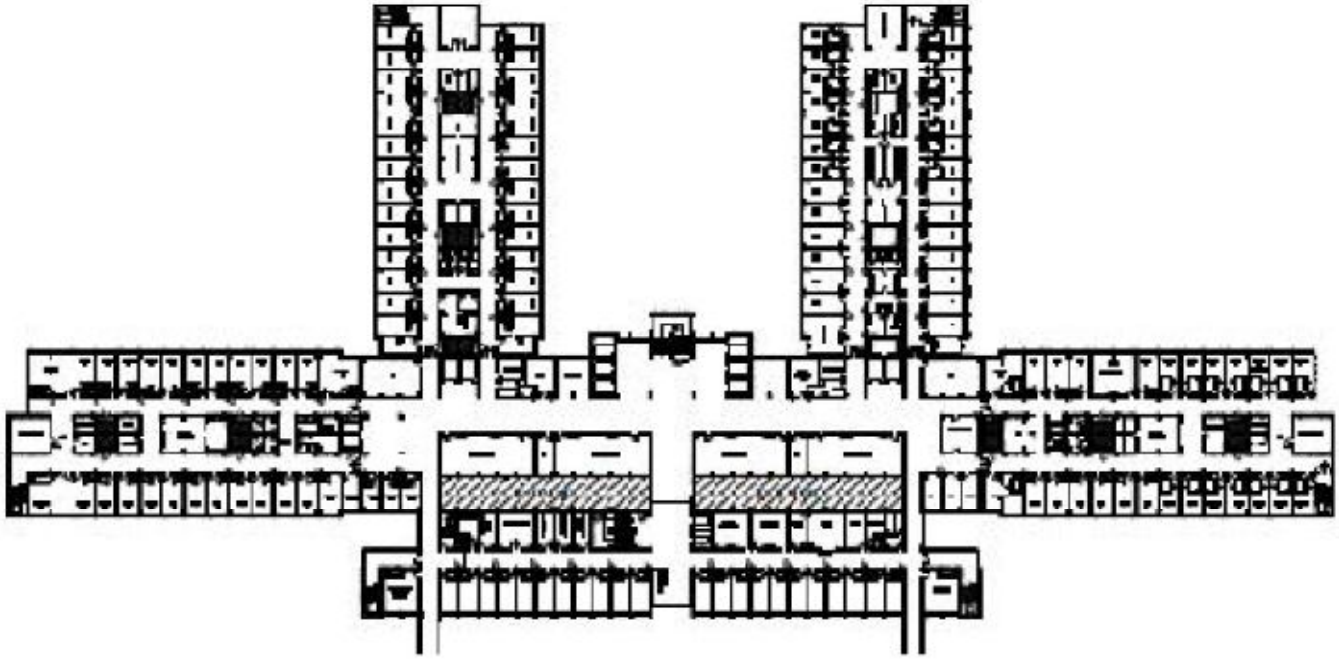

Figure 2.1:Plan of Clinical Blocs

At the first stage, the status was determined by preparing a form directed to the application of the fire safety provisions in the existing structures. In accordance with defined deficiencies, the required recommendations were made in respect of fire safety in the example clinic.

However, the regulations do not include sufficient provisions for hospitals in particular. However, whether or not the conditions resulting from positive and negative situations are adequate in respect of actual fire safety can only be evaluated during a real fire

Therefore, in the second stage, to remove the deficiencies defined by the faults experienced in terms of fire safety in a hospital fire which occurred in 2011, in-depth interviews were conducted with the personnel who were on duty during the fire. By determining the problems according to the data obtained, a clinical department was designed with ideal fire safety.

2.1 Determination of the Fire Safety Aspects Appropriate to Fireafety Regulations

The fire safety aspects form prepared for Identify existing hospital buildings fire safety condition. In this form;

- Characteristics of the stairs and ramps outside the building
- The properties of the stairs and ramps in the way of escape inside the building (risers, material, fencing and railing, e.c.t)
- The properties of fire doors,
- The ceiling features,
- Special arrangements according to the building use class,
- Building regulations for section and facilities,
- Electrical wiring and systems,
- Lighting of the stairs, entrance and exit,
- Emergency generators,
- Fire alarm and warning systems,
- Smoke control systems,
- Fire extinguishing systems,
- Storage of hazardous materials and maintenance and
- Proposals have been made by determining whether fire safety training, control, cooperation, allowance, standing orders accordance with the fire protection regulations or not.

2.2 Interviews Regarding the Experience of Previous Fires (İn-Depth İnterviews)

The exposure of a building to several fires over the years and primarily how patients and personnel behave in that situation forms the basis of important data which will be of benefit in revealing the deficiencies on this subject. Therefore, the search for a solution has been attempted using the 'in-depth interview' technique to reveal positive and negative situations experienced. The adequacy of this technique has been proven in social sciences. The interviews aim to ascertain the primary source of the event. Using a 'structured' interview technique directing open-ended questions, it is attempted to gain more detailed information about the event. Open-ended questions provide an evaluation with different viewpoints by questioning in more detail rather than obtaining a single response. Generally, it is attempted to enrich the subject by conducting a group interview of the doctors, nurses and patient carers who work in the same unit. Support of the interview with the observation technique, which is a highly accepted method by social sciences, has been shown to be beneficial in terms of obtaining additional information on the subject (Yildirim and Şimşek).

In 2010 a fire broke out as a result of carelessness and errors during insulation work in the roof and in 2011, in the same block, an electrical fault was the cause of a fire in the canteen storeroom. After these two events, the problems experienced by the people in the clinics and during smoke evacuation were defined and recommendations were made to resolve the problems. A similar scenario and problems were encountered in the fire which started in the hospital roof in 2010. The fire started in the roof and the passage of smoke via the vertical shafts at B point of the nephrology clinic on the 7th floor closed the emergency exit points which would have been used for horizontal evacuation. Smoke leaked into the Oncology Department on the 6th floor through the same route and as a result of reduced visibility distance of the smoke, horizontal evacuation was made. That there were no intubated patients (bedridden) in the nephrology clinic on the 7th floorallowed the possibility of vertical evacuation using the fire escape stairs. By revealing the problems experienced by both clinics in terms of evacuation during the fire, evacuation strategies were developed and recommendations were made for alternative solutions.

In accordance with interviews made following the fire with a total of 30 individuals, primarily the clinic personnel, civil defence team, hospital technical staff of the fire department and management, evacuation problems were determined and criteria necessary for every hospital building were defined. Conducting interviews with individuals with different duties and responsibilities provided different interpretations of the topic with their own viewpoints. Interviews were limited to 17 users as the number of people on duty at the time of the fire and the number of people with relevant information was limited and sufficient information would not be able to be obtained from inerviews with more people. Initially interviews were conducted with 30 people but responses related to the subject could be obtained from 17 individuals. Therefore, it was accepted as valid to conduct interviews with those who were closely involved in the event and had relevant knowwledge of the subject.

Individuals who were knowledgeable and had performed a function on this subject were selected for interviews. The interviews were supported by observations which were helpful in the more detailed examination of the results.

In the interviews with the hospital personnel at the 1st stage, questions were asked to determine how appropriate the positioning was for evacuation of the users and the functions of the building departments. It was attempted to obtain information about areas at high risk of fire and storage areas of flammable and combustible materials.

In the 2nd stage, interviews were conducted with the personnel of the department where the fire started, administrative personnel, civil defence and firefighting teams, to ascertain any problems experienced because of structural errors. These were conducted as group interviews with the personnel from the same team and unit together (eg, firefighting team together, clinical team together).

The questions asked at this stage were:-

- How was the fire noticed?
- When the fire was noticed, which route did it first take to which department and what was done?
- How, to where and by which route were patients evacuated?
- What kind of difficulties were encountered during evacuation?

It was aimed to determine whether or not sufficient information and available equipment had been provided by firedrills and training sessions related to fire and questions were directed to elicit what could be missing on this subject. The responses obtained were interpreted as below.

3. Results

At the first stage of the study, missimg or inadequate applications were defined by examining the current status of the building according to the fire prevention regulations.

At the second stage were the findings of the interviews made with the users and hospital personnel about the fire they experienced. Building design in line with fire safety in the clinics was obtained as a result of the collocation of the data from both stages.

3.1 Results Obtained from the Form Regarding the Determination of the Structure According to the Fire Prevention Regulations

The findings related to whether or not the clinics met the fire safety regulations are shown in **Table 3. 1**

Table 3.1: Provisions of Clinics Current State Whether Accordance with Thefire Protectionregulations or not

Escape rotes	Compartment	Fire escape	Emercency Elevator	Corridor Wight	Burning properties of interior finishes	Fire safety properties of shafts	Electrical wiring and systems
X	X	√	X	√	X	X	X
Alarm and detector	**Smoke control sytems**	**Practical fire drill**	**Fire extinguishing systems**	**Personal training**	**Storage of hazardous materials and**	**Vertical relationship with the dangerous places**	
X	X	X	X	√	√	X	

- **Escape Routes**

The horizontal evacuation area or compartment to which patients in the clinics would be evacuated were seen to have been designed (TFSR item 24). According to the TFSR (2009) the maximum area of the compartments to be created in the hospital must not exceed 1400m^2. The clinics examined had an area of 1382m^2. Therefore, each clinic can be evaluated as a fire compartment without separating into sub-units. However, neither of the clinics had the properties of fire-resistance or smoke impermeability which are required features of a fire compartment.

In accordance with TFSR item 32, there was a fire escape stairway at the end of each corridor. As the escape route was without sprinklers, this did not comply with the regulations. In addition, there was no emergency elevator in the compartments.

According to the TFSR, where there is a sprinkler system in healthcare buildings, the longest escape route is 30m one-way and 45m two-way. In the existing building, the longest distance between 2 clinics was 90m and the distance opening to the corridors of each clinic was 60m. Thus the criteria of escape route distances were not met.

According to TFSR item 33, there were inadequate points of the escape routes (room doors, corridors etc) in the buildings. The fire escape stairs and floor level exit points were not wide enough for the calculated user load. The stairs showed continuity of elevation from the start to the exit (TFSR item 40).

On the floors below ground level, no fire safety hall had been created as defined in TFSR item 34.

The escape route doors were able to be opened (unlocked, working mechanism) but there were blockages in front of them (TFSR item 35). There were open fire escape stairs on the front of B block. These should be made safe by enclosing. Open fire escape stairways can not be made on buildings over 21.50m in height (TFSR item 42).

- **Smoke perception, extinguishing and limits of spread:**

No precautions had been taken to prevent the spread of smoke in the shafts connecting the clinics on the 7th floor. In some clinics, although not all, there were not a sufficient number of working smoke detectors.

As yet, there was no smoke control system. There was a sufficient number of fire cupboards to restrict and extinguish the fire but there was no centrally automated extinguishing system.

- **Precautions against flammable and combustible materials:**

Precautions appropriate to the regulations against flammable and combustible gas, had not been taken.

- **Building Internal materials:**

In the NFPA 99 'Health Care Facilities Codes' additional to the TFSR, the properties of internal covering materials are defined. In addition, in dangerous locations (buildings with a high fire risk), how they are related vertically and horizontally and how they are related to the safety of high risk locations is defined in the regulations. Thus according to the regulations, A1 grade inflammable rockwool had been used in the ceilings of the clinics. However, it was seen that some clinics had wood ceilings (TFSR item 26). Precautions had not been taken to stop the spread of smoke between suspended ceilings and to vertical shafts.
On the floors, vinyl covering had been used to provide a hygienic environment.

- **Installations and Shafts:**

Where the installations of water, electric, heating and air-conditioning pass through the floors, the surrounding of the installation had been left open with the minimum covering and were not insulated against fire and smoke. Inflammable material had not been used in the shaft covers. In addition, in the patient beds, flammable sponge had been used which emitted toxic gas. Apart from in the furnishing materials, flammable and combustible chemicals were not used in the clinics.

3.2 Interview Findings of Hospital Staff and Users

The hospital was evacuated successfully without experiencing any casualties, in the Bursa's largest hospital's fire. It is quite natural to experience some problems during evacuation, because of the buildings old structure. These Problems provides guidance to the regulations that must be done for fire safety. Encountered problems are determined accordance with the Interviews took place in.

During the horizontal evacuation of patients it is stated that some problems encountered in the clinical exits. Clinic doors can be opened and closed automatically. Because of the power outages doors had locked, so that patient could not evacuate from clinic exits.

"After the cessation of electricity the doors had locked that opened with cards. We had to open the door manually. "

The building has plurality blocks and wide corridors. These properties were useful in terms of evacuation. Similar arrangements that have done in the new hospitals, have benefiting terms of continuity of patient care and treatment and horizontal evacuation of users after fire.

" Although not designed as a compartment of clinic, the wide range of corridors and having independent block of clinic unit has enabled the realization of horizontal evacuation."

Cannot be determined how and where the fire started and spread to accent areas cause panic. So that evacuation had to be done vertically rather than horizontally.

Evacuating patients even in the compartment not be affected by smoke and fire eviction, affected patient health adversely.

"If smoke spread out to corridors or other block-ranging, the question of where the patient would move came up."

The width of the fire escape stair is convenient to carry patients. But hospital staff working in the fire remained desperate during vertical evacuation of bedridden or very overweight patients. Hospital staff have experienced problems while carrying patients with stretcher from The fire escape, the escape stairs and the elevator.

"Incubated (lack of bedridden patients) had a great chance. Such a patient should be alive after by pulling the respirator only with an officer who perform the same function manually. 1 person can be move with the help of at least 4 staff. In this case stairs may not be sufficient. We had great difficulties carrying oncology patients with a wheelchair from download the stairs. . "It was impossible to evacuate the in mobile patients without elevator and life support unit."

The lack of audible warning system which informed people where the fire started and where will be the patients moved, delayed the evacuation in the first stage.

"Fire escape stairs used because the smoke started coming from a point close to the clinic the door opened to the corridor. Horizontal evacuation cannot be happened because of not releasing the the case of the other parts of the building."

Performing fire safety measures, repair, maintenance and control of devices continuous prevent catastrophe.
" An elderly patient moved down from 7 floors by fire stairs in attendants lap. However ıt was seen that the fire stair had been locked. But many patients went outside before the door closed. The fire escape door probably had a fault or locked in mind that everyone had reached outside. Although we quide all patients to the fire escape route, some of whom use corridors to reach safety areas."

"Fire buttons did not work. Alarm was activated using buttons placed in the exiting the corridor. But people moved after we shout loudly.

Not receipting of any importance for the smoke evacuation in building, declined visibility and made the evacuation both physically and psychologically difficult.

All of these assessments, regulations and other observations have provided basic information about identifying and defining the properties of the horizontal and vertical escape routes.

4. Evaluation

User movement occurs in two stages. First, patients are moved to the horizontal evacuation areas on the same floor and when smoke and flames reach this floor, the vertical evacuation is applied and patients are transferred to the compartments (safe areas) of the floor below. The arrangements below were seen to be appropriate in the examined clinics.

- **Creating the Compartment**

An independent fire compartment must be designed within each clinic and in each clinic department there must be a safe escape route to the ground floor. Acording to the escape distances and the positioning of the new fire escape stairs to be made, the floor plan was divided into 6 fire compartments. In addition, as it is not known where the fire will start, by creating an alternative exit in a compartment, the area between 2 stairways was divided into 2 compartments. In this context, it is appropriate to divide the clinics into 2 parts internally. However, the properties of the clinic areas to which horizontal evacuation will be made have not yet been established. To evaluate a part of the clinic as a horizontal evacuation area, all the fixtures and walls of that part must be designed to withstand fire for 90 mins***(Figure 3.1)***. Other components of the compartment which must be designed to be fire-resistant for 90 mins are the shaft covers, windows opening onto and walls facing the internal garden, and the clinic exit doors. The compartment entrance doors together with the shaft covers must be fire-resistant for 90 mins in line with the fire evacuation project measurement, there must be reinforcement with rockwool, piping which is smoke impenetrable and steel fire doors.

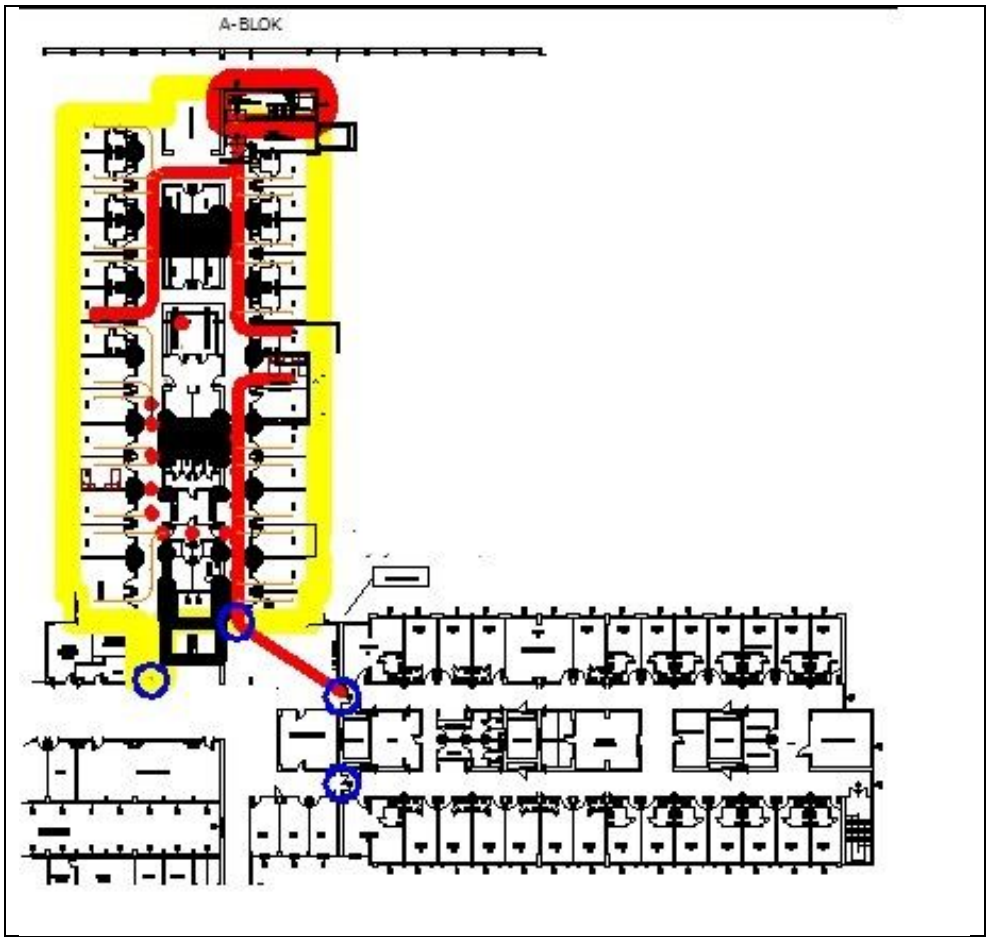

Figure 3.1. Escape Rotes of Clinics (2 Seperate Compartment)

- **Dividing Walls:**The same level of fire-resistance is not expected from the fixtures and walls which are the dividing elements between rooms within the compartment. As a result of a fire simulation in a patient room made with CFD software, in the first 300 seconds, the temperature of the locations joining the room where the fire started has been seen to increase to 240°C (Şimşek 2013). To prevent the fire spreading to adjacent locations, the use of inflammable or flame-resistant materials in the dividing walls between patient rooms can be considered to gain time required for patient evacuation.

- **Doors:** For security reasons, the doors used in the clinics open and close connected to an automatic locking system. In the last fire, as a result of the locking of the doors which are opened with a card, horizontal evacuation could not be carried out and vertical evacuation was applied. Therefore, it is seen to be appropriate that exit doors of the horizontal evacuation areas are adjusted to be opened manually.

All the horizontal exits of the bedded units were fire-resistant and seen to be appropriate functionally with winged bolted doors including solid and clear sections connecting to the corridors and fire-resistant for up to 90 minutes. The glass used in the doors must have the same resistance value. As defined in the NFPA 101-2012 regulations related to doors, in places where it is obligatory to have bolted doors, the width of the door must be 2110mm and in psychiatric and limited function hospitals 1625mm.

Doors which are on the escape route and open in the direction the reverse of the evacuation route must be removed and replaced to open in the direction of the escape route.

- **Shaft covers:** Shafts are the cavities where smoke spreads most rapidly. Most of the shafts in the clinics were closed with wooden covers and were seen not to provide impermeability to smoke in any form. The covers were fitted with intumescent piping and plaster panels were covered with rockwool or fibreglass layers. Although the wooden covers were painted with fire-resistant paint, this would not have provided a long period of resistance to fire.

- **Alarms and Perception:**Evacuation proccedure starts when the fire is noticed. For horizontal evacuation to start, the clinic personnel must be alerted to the source of the fire and the area affected. First, the whole hospital is alerted with the activation of the fire alarm. Then according to information given by all units to the head physician, horizontal evacuation is initiated. In the 2010 fire, as it could not be predicted where the fire would advance, there was indecision about which block it would pass to and evacuation time was prolonged. To start evacuation in the shortest possible time, information is given by announcement to the whole hospital of the place where the fire has started and the areas it has spread to. In this way, users will be directed to the closest safe areas.

In the same incident, nurses looked for alarms inside the clinic but the fire reaching the corridors outside activated the alarms, causing a delay both in alerting patients and other departments and in evacuation. When there is a fire alarm in the nurses room and rooms where there are always personnel and when fire alarm boxes can be easily reached and are positioned at adequate intervals at visible points, there is no need for manually operated fire alarms in patient rooms, as stated in the NFPA 101-2012 regulations.

Organisation of the Vertical Evacuation Elements: When the fire is close to the horizontal evacuation door or is in the compartment to which horizontal evacuation will be made, then vertical evacuation cannot be avoided. According to the information obtained from the interviews with qualified personnel about the health status of the patients and problems experienced during vertical evacuation, it was seen that it was impossible to evacuate every patient via the fire escape stairway. In the last fire at the hospital, a patient who weighed more than 100kg could not be evacuated in any manner and it was risky to move intubated patients in departments such as oncology and cardiology. In addition, although the fire escape stairs were wide enough for a stretcher, completely bedridden patients and the excessively overweight were seen to have remained without a solution during vertical evacuation. Therefore, for the vertical evacuation of these kinds of patients, open-sided portable elevators which can be integrated into the facade of the building, ramps or smoke imperemeable elevators are recommended (***Figure 3.2-3.3).***

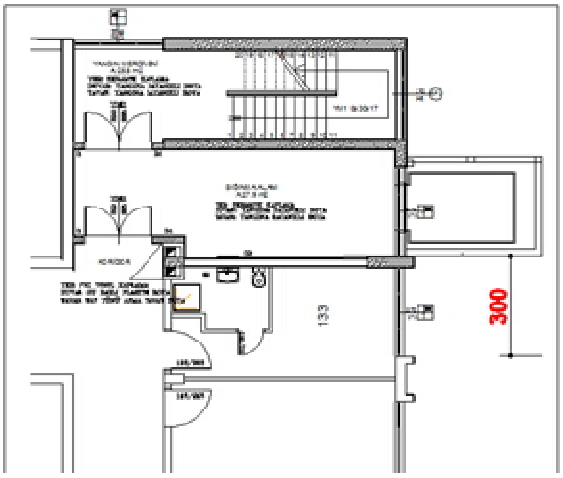

Figure 3.2: Refuge Area and Emergecy Elevator Design

Figure 3.3: Portable Open Position Patient Lift Design, Integrated Outside of The Hospital

- **Ramps:**When ramps are designed at an appropriate slope and width for stretcher evacuation, it is a useful vertical evacuation route. For comfortable turning of a stretcher, ramps must be 240cm wide and on ramps longer than 600cm, a rest area for patients of at least the width of the ramp must be created. On the fire escape stairs, resting areas must be organised of at least 200cm and more than 80cm wide to be able to rest a stretcher (Figure 4.11).

However much ramps are integrated into the external shell of the building, for users not to be affected during evacuation by smoke and flames escaping to the outside, it is necessary to comply with the condition of no opening at a distance of 3m from the wall (TFSR, 2009). Therefore, in the existing building, it can be expected that in the adjoining assistant rooms and en-suite patient rooms, the distances will be changed withfixed and 60-minute fire-resistant glass (Figure 4.12).

Although ramps have been defined as the most useful route for vertical evacuation of patients, it would be difficult to add ramps to the external shell of the existing building due to the height of the building and that the surrounding area is not empty. Therefore, it seems as if an alternative solution for vertical evacuation of bedridden patients would be a portable, open-sided, safe stretcher elevator, not in a shaft and which opens onto a safe sheltered area with a fire door.

- **Fire Escape Stairs**: To pressurise the fire escape stairs in the existing building, the existing fire escape stairs which open on to the clinics must be made safe. This is expected to be done by closing open sides with 90-minute, fire-resistant, aluminium-edged railings, sealed with fire-retardant band and with the placement of extractor fans at the highest point of the stairwell to provide smoke evacuation.

In some cases, it may be necessary to evacuate the whole building. In the interviews it was reported that those carryinng the patients to be evacuated, in their arms, in a sheet or on a stretcher slowed down to rest and even stopped. These halts caused crowding on the stairs and slowed and delayed the evacuation. Therefore, taking into consideration that 4 people would move 1 patient, it is expected that, apart from the refuge areas on the stairs, there will be short rest periods during the evacuation procedure***(Figure 3.4)***.

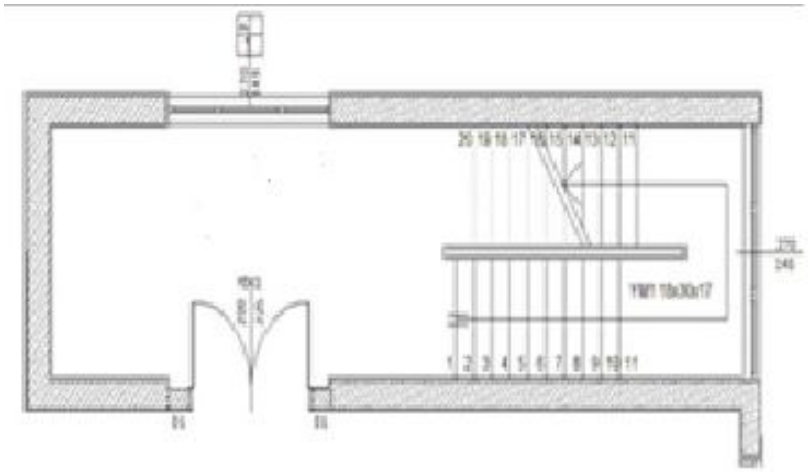

Figure 3.4: Fire Escape Stair Design

- **Refuge Areas:**

In addition, refuge areas have been designed in every compartment as safe waiting areas during patient evacuation and which prevent smoke entering the vertical circulation shafts. These areas are safe pressurised locations which open on to the ramp, elevator or fire escape stairway. The creation of these refuge areas is seen as necessary so that patients are not affected by smoke while waiting or resting. These refuges include the necessary medical equipment and a power point for vital functions to be continued in critically ill patients while waiting and a telephone for communication, thus preventing the patient from falling into life-threatening danger due to the change of location.

To be able to provide horizontal evacuation refuge areas in a compartment throughout a fire, there must be a telephone, balcony or window for communication and the doors must be self-closing and fire-resistant (Proulx 2002).

The safety of refuge areas depends on the level of fire damage, the wind, temperature and smoke control systems. Modification of the elements of general use, the stairs and elevators, for use in emergency situations is important in terms of reducing panic and shortening evacuation time. The situation can be determined by observationof these areas with a camera sytem. Windows in the refuge area provide a visual connection between the interior and exterior of the building, allowing the rescue operation to be followed and have a positive effect on the users. Patients can be directed to these areas with easily comprehensible signs. There is as yet no standardised sign to refer to these refuge areas.

The doors to fire escape stairways and horizontal refuge areas must have a self-opening mechanism which can be opened with a maximum of 110N power. If the number of users is below 100, the item of ‘opening must be provided without a handle’ can be disregarded. As refuge areas on the inpatient floors, the doors on the general use corridors which are not connected to a single floor must be fire-resistant for 60 mins and the doors of the fire escape stairways and safe halls are expected to be fire-resistant for 90 minutes as the block is more than 7 storeys.***(Figure 3.5).***

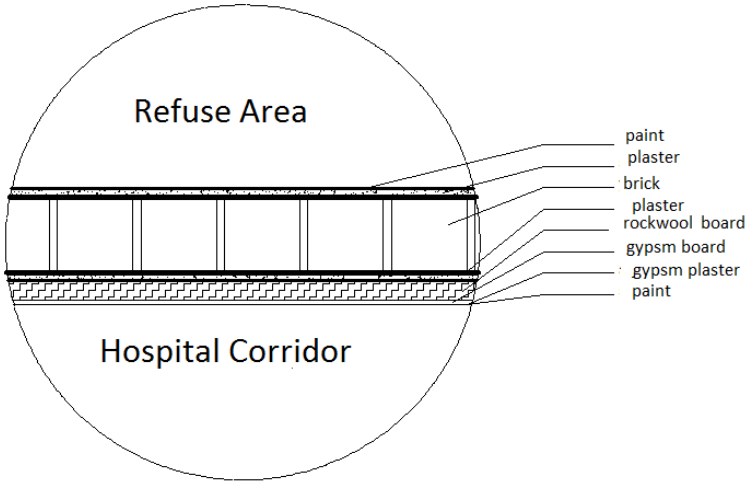

Figure 3.5: Fire İsolation of Refuge Areas

According to NFPA 2012, in low-risk fire corridors with smoke barriers at both ends, in patient rooms, examination rooms and canteens, there must be a smoke compartment of at least net 2.8m^2 per patient and on outpatient floors of at least 0.56m^2 for each user.

Taking stretcher dimensions of 80 x 190cm as the basis for patients who cannot move, the area calculated per person is 1.60m^2.The number of users is defined by the number of beds. The capacity of these areas, which depends on the general movement status of the patients in each clinic, is defined by the above stated m^2.

- **Stairways and Elevator Shafts**: The most deadly places during a fire are the stairways and lift shafts as they create a chimney effect with the smoke drawn upwards and where there is a pressure difference, it is drawn horizontally to that floor. It is extremely dangerous to use stairways and elevators during this smoke movement. To create safe escape routes, it is necessary to first prevent smoke from entering the shafts (http://irc.nrc-cnrc.gc.ca/cbd/cbd33). For users to be able to get outside the building without being affected by smoke, stairways and elevator shafts have been designed as a single compartment. Preventing smoke entering these compartments with a mechanical system must be taken as a basic principle in establishing a smoke evacuation system. In the design of these safe shafts, fire safety doors have an important role. That the doors are self-closing and are fire-resistant as defined in the regulations are basic requirements to achieve smoke evacuation. In addition, these shafts are separated from other units by structural elements which are fire-resistant for up to 2 hours.

In an emergency, when it is necessary to use the elevator refuge areas, the pressurisation of the elevator shafts to prevent the entrance of smoke and to prevent the negative effect of this system on the elevator doors, the pressure difference between the 2 doors must be kept at the lowest level.

The equipping of the machine room with the same fire safety precautions overcomes problems which may be met during a fire. In particular, the control centre for the sprinkler system and switches must be made from water-resistant materials.

It is recommended that smoke detectors are mounted in front of elevators or smoke screens which are operated automatically from a signal coming from the fire alarm panel to provide smoke impermeability of the elevator shaft. At the same time, there must be the possibility of opening the elevator cabin from the inside to get out (http://www.protek.gen.tr). Together with perception of the smoke, when the fire alarm sounds, a clear screen in the depot within the suspended ceiling is taped to the metal box of the elevator doors with strong magnetic band and moves down with its own weight, thus providing full contact with this surface, and minimum smoke leakage.

- **Smoke Evacuation:**

When there is no precaution taken against smoke evacuation in the building, the sudden reduction in visible distance makes evacuation more difficult both physically and psychologically. Therefore, smoke evacuation must be applied to each compartment where there are patients.

5. Conclusion

As hospital evacuation during a fire is restricted by the movement capability of the user profile, it is a much slower and more difficult process than from other buildings. Therefore, hospital-specific fire safety precautions must be defined and applied. However, these applications are not given a sufficient level of importance in the existing regulations.

Although there were no fire compartments because of the design of the building, the separation of the different blocks was effective in avoiding a major disaster in the fire at Uludag University Medical Faculty Hospital in 2010. This shows that the design of separation to different blocks of clinics on the same floor of the hospital was beneficial in providing fire safety. A major deficiency reported was the lack of waiting areas for patients when relocating after the fire. Therefore, if the width of the connecting corridors between clinics is made at more than the required 2m, these areas can be used as waiting areas between horizontal evacuation areas and at specific stages of relocation after the fire. Equipping these empty areas with infrastructure including working electrical installations with a generator and other medical equipment is important in ensuring the continuity of treatment for patients attached to machines.

In addition, at least two independent compartments must be designed on each floor. Separation of the compartment must be reflected in the design stage of the plan. When designing compartments to be used in the horizontal evacuation of a hospital, transfer between similar units should be considered and reflected in the hospital design. This would allow the possibility of meeting the requirements of patients in the units to which they are transferred during a fire. In the light of the data obtained, the most imprtant precautions which a hospital should take are listed below.

- From each clinic, operating theatre and intensive care unit, fire escape stairs, elevators or ramps must be added which can be accessed through a pressurised area and a refuge room should be designed for patients who cannot move, opening onto these areas.
- Each inpatient clinic must be divided into at least 2 fire compartments which are fire-resistant for up to 90 minutes
- In each horizontal evacuation area, a refuge area must be designed to open onto fire escape stairs and a pressurised elevator.
- In cases of improving an existing building, if the building is a maximum of 3 storeys and the surrounding area is open, the integration of a portable stretcher elevator is seen to be appropriate.
- If the building has more than 3 storeys and the surroundings are closed then vertical evacuation can be achieved with a smoke-impermeable stretcher elevator and ramps.
- For critically ill patients, a smoke-impermeable patient room must be created in each horizontal evacuation area that is equipped with all types of life-support units.
- Fire escape stairways must be designed with waiting areas wide enough to permit resting during evacuation.
- The location of the fire outbreak and the areas to which it has spread must be announced to the whole hospital, thereby providing direction to the nearest safe areas.
- The preparation of emergency situation plans and hanging them to be visible in all areas is important.
- Periodic fire drills must be conducted in each clinic at different times of the day.

In the current study, the main problem in providing fire safety in the clinics was seen to be patient evacuation and maintaining patient care and treatment after evacuation. Unfortunately, including the examined building, no hospital in the city of Bursa applies these types of precautions in reality. This study shows the necessity of taking fire safety precautions. In addition, it can be considered a guide on the subject of providing fire safety at the design stage of new buildings.

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