

## INVESTIGATION OF PROVISIONS OF FIRE SAFETY MEASURES IN BUILDINGS IN DAR ES SALAAM

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### ABSTRACT

*One of the major causes of damage/destruction of constructed facilities in particular buildings in Tanzania is fire. Of recently, several cases of fire outbreaks have caused serious destruction to buildings and other properties especially in Dar es Salaam. It is well known that fire damages can be significantly reduced if appropriate fire prevention and protection measures are taken into account during the design and construction stages of buildings. In this manuscript, therefore, observations and results of investigation carried out to determine the provisions of fire safety measures in the design and construction of buildings in Dar es Salaam are presented. It has been established that in some of the buildings investigated, fire safety measures have not been adequately provided and in case of fire outbreaks serious damages are likely to occur.*

**Keywords:** *fire safety, fire outbreaks, fire rating, concrete cover, compartment.*

### 1.0 INTRODUCTION

For many years, fire has repeatedly caused loss of life, injury and devastation of property particularly buildings and equipment. Buildings require fire protection in order to avoid damages in case of fire and also for the safety of users. For some buildings destroyed, consequential or indirect losses, such as interruption to business, costs of temporary reorganization, etc. are often far higher than the direct fire damage.

During the design of buildings, the aspects that most designers often pay attention to are space requirements and layout with respect to functionality and structural considerations. Unfortunately, fire safety aspects are not normally given the utmost importance that it deserves. In a number of buildings, it appears to have been given only a secondary consideration which should not be the case.

Although the origin of fire in most cases is the result of negligence, ranging from direct acts such as lighted cigarettes left burning to more indirect causes such as poor installation and maintenance of electrical wiring, it is not practically possible to eliminate completely these causes. Therefore, fire safety in buildings aims at protecting the occupants, contents and structures of buildings from the risks associated with fire. These purposes are achieved

by inhibiting the combustion of the materials from which the building is constructed and by preventing the spread of fire within the building and between buildings. It has to be ensured that the construction elements/components accomplish their function for a sufficient length of time during a fire, so that the occupants are able to escape and the fire brigade is given time to deal effectively with the outbreak and hence limit the total damage.

To mitigate the sources and spread of fire and losses due to it, consideration of fire safety measures at the design and construction stages of buildings is of vital importance. In this respect, protective measures involve suitable forms of construction, suitable planning of the building internally and its relation to adjacent buildings, and satisfactory planning and construction of the means of escape among others.

In Dar es Salaam, fire outbreaks in buildings have continued to be a problem. For example, for the past twenty years, the major fire outbreaks and damages include those at the Ministry of Home Affairs headquarters building in 1989, the Ex-NASACO building in 1995, the National Insurance Investment building in 2002, Sea Cliff Hotel in 2007 (shown in Figure 1), the Cooperative building in Dar es Salaam in 2008, Paradise and Oceanic Bay hotels in Bagamoyo in March 2009, Tanzania

Breweries in July 2009, PPF Towers in 2013 and others.



Figure 1 Fire gutted Sea Cliff Hotel in Dar es Salaam

Although the above mentioned problems are now history, but they give a warning for the future so as to avoid or minimize fire outbreaks and damages. Therefore, it is important to consider fire prevention and fire protection measures at the design and construction of buildings to ensure fire safety.

In this manuscript, observations made during investigations of provisions of fire safety measures in buildings in Dar es Salaam and some fire precautions measures, which need to be taken into account during the design and construction of buildings are discussed.

## 2.0 INVESTIGATION OF FIRE SAFETY MEASURES

Investigation of fire safety measures/aspects in buildings in Dar es Salaam applied a case study research strategy; whereby selected buildings were investigated. The investigation covered the review of buildings' designs and constructed buildings, as well as fire gutted buildings

## 3.0 RESULTS OF INVESTIGATION OF FIRE SAFETY PROVISIONS IN DAR ES SALAAM

The main objective of fire precautions which include fire prevention and fire protection is to minimize fire hazard and this can be achieved by reducing the number of fire outbreaks, providing adequate facilities for the escape of occupants should an outbreak of fire occur, providing adequate fire resistance for structural/construction elements, and minimizing the spread of fire both within the building and to nearby buildings. To achieve the above objective, the following aspects

among others need to be considered during the design of the building:

### 3.1 Fire safety planning and design

Effective fire safety design begins with conscious analysis and decision making early in the design process. The broad approach to planning for fire protection is to design the elements of construction to withstand the action of fire for a given period of time dependant on the size and use of the building, to compartmentalize the building so as to isolate the fire within a given section or area, to separate specific risks within the building and generally to prevent the uncontrolled spread of fire from its source to other parts of the building. Further, a building must be planned to allow the occupants to escape by their own unaided efforts (Foster, 1988).

Thus, besides designing and constructing buildings with fire resistant materials, it is equally important to plan it in such a way that the risk of panic due to smoke and hot gases is minimized by preventing them from spreading rapidly by means of common spaces such as corridors, staircases and lift shafts so as to avoid trapping the occupants.

#### 3.1.1 separation

In Dar es Salaam, separation in buildings is by structural elements namely walls and floor slabs which prevent horizontal and vertical spread of fire. Walls are constructed mostly with cement sand blocks and slabs with reinforced concrete which have adequate fire resistance. Some of the openings within these elements of separation are protected using fire resistant glazing materials.

The danger of spread of fire within a building is always accompanied by that of the spread from adjacent buildings. The fundamental protection between buildings is space in sufficient dimensions to prevent spread of fire by radiation or actual flame contact. The investigation established that there are cases whereby the provided space between buildings is not adequate to prevent the spread of fire from one building to the next one as shown in Figure 2 although the building materials for external walls do possess



Figure 2 Two buildings without sufficient distance in between

adequate fire resistance. However, there are cases of roofs which have been constructed of grass thatched (see Figure 3) which have a low fire resistance.



Figure 3 Hotel buildings with grass thatched roof

For the case of fire outbreak at Paradise and Oceanic Bay hotels in Bagamoyo, it was established that the hotels buildings were constructed at the common boundary with grass thatched roofs as a result fire from one hotel buildings spread very easily to the next hotel buildings.

### 3.1.2 Ducts and Shafts

In one of the fire outbreaks incident in Dar es Salaam, it was observed that a duct was a cause of the spread of fire in the building as shown in Figure 4 below as a result fire gutted the whole building. Therefore, flue-like apertures such as ducts, shafts and deep light-wells, should be avoided in the general design of buildings, but where they are necessary as in the case of lift shafts and staircase enclosures, they should be vented at the top to allow smoke and hot

gases to disperse to the atmosphere and be constructed using materials with adequate fire resistance.



Figure 4 A duct which caused the spread of fire.

### 3.2 Building materials

The selection of building materials is important as various building materials have different fire resistance rating or grading. For example, timber or wood has a lower rating compared to steel or concrete. It is recommended that structural parts of a building or load bearing parts should have sufficient fire rating. Hence the choice of building material is critical to the structural integrity of a building in the event of fire.

#### 3.2.1 Reinforced Concrete

Investigation carried out in Dar es Salaam established that the structural components/elements of most of the public buildings are constructed using reinforced concrete of carbonate (limestone) coarse aggregates that produce concrete which retain most of its compressive strength up to about 650 °C as shown in Figure 5 (Bilow, 2008).

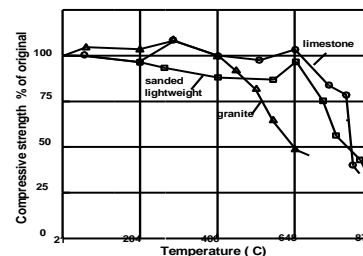


Figure 4 Effect of high temperature on the compressive strength of concrete

Further, it was established that the average thickness of most of the floor and roof slabs is not

less than 150 mm which is adequate for a fire resistance rating of not less than three hours, and for columns the average dimensions are not less than 250 mm x 250 mm hence a fire resistance rating of not less than two hours. For beams the average thickness is not less than 230 mm hence a fire resistance rating of not less than one and a half hours which are considered to be adequate (Lee, et al, 1985).

For the slabs and beams for most of the buildings in Dar es Salaam, the concrete cover provided is adequate for the fire resistance rating of about two hours as shown in table 1 below. It was also noted that there are cases in which the concrete cover is about 10 mm. This is normally due to poor workmanship. For columns the provided concrete cover is even not adequate for the fire resistance of one hour.

Table 1 Concrete covers

Element	Average concrete Cover provided (mm)	Minimum Concrete cover		
		for 1 hour	for 2 hours	for 3hours
Slabs	25.4	18.8	18.8	31.4
Beams	25.8	18.8	18.8	43.8
Columns	23.8	25.0	50.0	50.0

**3.2.2 other building materials**

In one of the fire gutted building in Dar es Salaam, a grass thatched roof burnt completely as a result plastic water storage tanks installed on the slab below the roof were exposed to fire and got damaged as shown in Figure 6. Application of building materials which do not have adequate fire resistance was observed for some buildings



Figure 6 Fire gutted plastic water storage tanks

as shown in Figures 3 and 7 where untreated against fire grass and timber are used as roofing and partitioning materials respectively. These materials are likely to contribute to the spread of fire from one building to the next one for grass thatched roofs, and for timber partitions from one room to the next one.



Figure 7 Timber partitions in an office building

Almost all buildings for Paradise and Oceanic Bay hotels, which were gutted by fire, had grass thatched roofs and this is considered to be one of the factors which contributed to the intensity of fire damages. Fire spread easily from one building to the next one.

**3.3 Compartment**

In Dar es Salaam for part of the fire gutted Ushirika building, the office partition walls were erected using timber materials which had a very low fire resistance as a result they were burnt down hence allowing the spread of fire in the building as shown in Figure 8. Unless treated against fire timber products are not recommended as building material for partition walls.

**3.4 Doors ways escapes and openings**

Buildings have openings either for getting in or out or for ventilation or for aesthetics. Unfortunately, these openings though necessary, pose a major fire risk as they are good



Figure 8 Fire gutted office partition walls at Ushirika building in Dar es Salaam.

conduits for the spread of fires. It is therefore, important to plan and install fire rated doors or windows or service ducts that will not facilitate the spread of fires. Doors and windows should be made of materials with sufficient high fire resistance and should have door closers or other mechanisms that cause them to close in the event of a fire. Recently in Dar es Salaam, the presence of windows without adequate fire resistance caused the spread of fire to another corridor as shown in Figure 9.



Figure 9 Windows without adequate fire resistance in a wall.

During an investigation carried in buildings in Dar es Salaam to assess provisions for fire safety measures, it was observed that in some buildings fire rated doors are provided as shown in Figure 10. It was also established that in some buildings, stairs in fire escape routes are made



Figure 10 Fire proof doors.

of materials with a high friction coefficient to minimize sliding (see Figure 11) as compared to materials for stairs within the normally used routes which have a small coefficient of friction



Figure 11 Stairs along the fire escape route as it is shown in Figure 12.



Figure 12 Stairs along the normal routes

Buildings have to be designed and constructed to allow occupants to escape in case of fire. During the investigation, a building shown in Figure 13 was found to have metal grills provided on all openings as a result in case of fire outbreak, rescue measures and efforts may be hindered.



Figure 13 A building with metal grills on openings

Foster, J. S. and Harington, R. (1988), Structure and Fabric part 2 London.

Lee, D. J., et al (1985), Manual for the design of reinforced concrete building structures. Institution of Structural Engineers, London

#### 4.0 CONCLUSIONS

On the basis of the investigation carried out to assess the provision of fire safety measures in buildings in Dar es Salaam, the following are the conclusions:

(i) It has been observed that in some of the buildings, fire safety measures are not consistently and adequately provided. As a result, fire outbreak and fire damages are not addressed fully.

(ii) For tourist hotels, there is a tendency of constructing grass thatched roofs which have inadequate fire resistance and this has been observed to be one of the factors which has contributed to fire damages in most of the fire gutted hotels with this type of roofs. .

#### 5.0 RECOMMENDATION

In order to reduce fire outbreak and minimize fire damages in buildings, there is a need to ensure that fire safety measures are adequately provided during design and construction. This can be achieved if the relevant authorities and organs responsible for approving building designs will also check the adequacy of fire safety measures considered/provided for buildings.

Also it is important to ensure good workmanship so as to construct buildings as per designs and specifications.

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