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FIRE SAFETY DESIGN OF A 5 STOREY OFFICE BUILDING: EARLY WARNING AND MEANS OF ESCAPE

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ABSTRACT
A fire safety design on the early warning and means of escape for a 5 storey, Asha Office Building is conducted. This is to attain realistic standards of health and safety for persons within and outside the building. Manual alarm system (type M) along with L1 smoke detector were considered. L4 smoke detectors were to be fixed in the corridors and escape routes so as to provide an early warning of fires and smokes. The kitchen is to be covered with a heat detector. Simultaneous evacuation strategy with the capacity to allow all floors to be evacuated at the same time was considered on this design building. This was based on a total floor size of 15,275 m^2 and 1,038 occupants with only one main entrance. This necessitated for alternative exits to be provided in order for all the people to evacuate on time, limit the travel distances and also to make the occupants have options to other exits should in case the main entrance is blocked with fire. The building occupants from the farthest distance on the ground floor would be expected to evacuate the building within 4 minutes. Also, by providing a safety margin, a tenability condition in the building would be maintained for a minimum of 8 minutes. For emergency lightings that would aid escape of occupants, five, four and two luminaires would be required to be arranged axially and spaced 4.8 m apart for the vertical, horizontal and dead-end corridors respectively.

Keywords: Fire safety, early warning, means of escape, office building

INTRODUCTION
Hazards in any form necessitate the need for global safety standards in order to make activities by mankind safe (Olarenwaju and Adebiyi, 2017). Basically, fire safety are set of practices meant to minimize the destruction caused by fire. Fire safety measures encompass those that are anticipated to avert the ignition of an unrestrained fire and those that are used to limit the increase and effects of fire after it starts. Furthermore, the measures comprise those that are scheduled for buildings from design, construction, and occupation to even maintenance as well as inhabitants of such buildings. In order to achieve these goals, the general fire precautions designed according to the legislation of England and Building Regulations 2010 with its associated guides for fire safety which is applicable to England and Wales would be used (ADB 2010). This could be attributed to the UK being the pioneer and leading nation in fire safety and Health Safety and Environment, HSE in general (Stay Safe, 2021).
The aspects of the fire safety of Building Regulations is geared towards achieving acceptable standards of health and safety for persons in and around buildings. Irrespective of ability, age or gender, people ought to be able to gain access into the building and use their facilities unhindered. The fire safety measures integrated into a building would take cognisance of the needs of everyone who may access the building, both as occupants or visitors (ADB, 2010). Except in exceptional situations, it is inappropriate to assume that certain categories of people will be left out from a building due to its use.
It is the duty of persons conducting building works to meet the needs of the Buildings Regulations 2010. However, due to the complex nature of certain buildings, Approved Document B (ADB) guidelines alone cannot be applicable to the entire building, therefore, fire engineering approach and other British Standards (BS) such as BS 7974, BS 9999 and its associated Published Documents (PDs) amongst others would be used where necessary. Furthermore, achieving an acceptable level of safety would be attained either through prevention, effective communication, escape, containment, extinguishment or combination of these strategies (Stollard, 1991).
Based on Approved Document B, there are five functional requirements to new buildings upon which a design building would follow. These include means of warning and escape, internal fire spread (linings), internal fire spread (structure), external fire spread as well as access and facilities for the fire service (ADB, 2010). Guidance is issued separately on each requirement, although, they are closely interlinked. This necessities the ADB be considered as a whole.
Similarly, the connection between diverse requirements and their interdependency would be acknowledged. Particular concern should be given to the condition where one part of the guidance is not wholly followed as this could have an adverse consequence on other provisions. In this paper, a fire engineering design on the first requirement (B1) which is early warning and means of escape for a 5 storey, Asha Office Building is conducted. The sole essence of the first requirement is for a building both designed and constructed to have suitable provisions for the early warning of fire, and appropriate means of escape. This is provided there is a fire from the building to a place of safety outside the building always capable of being safely and effectively used. The aim of this study is to conduct a fire safety design of a 5 story office building with emphasis to early warning and means of escape.

MATERIAL AND METHODS
Building Description
Asha Building is a proposed administrative block in Federal Polytechnic Kaura Namoda, Zamfara State Nigeria (Na'inna, 2009). It is a 5 storey building with a width, length and height of 65m, 47m and 17m respectively as well as a ceiling heights of 3m throughout except ground floor which is 4m. The building has ground floor with restaurant (kitchen, store, service and shanks), garage, stores, toilets, 39 offices and a studio. First floor has 36 offices, a council chamber, a rest

room and toilets. Second to Fourth floors have 44 offices and toilets each. The length of the corridors at each floor is 46.8 m and 27 m along the width and depth of the building respectively. Also, the ground floor has 3 dead-end corridors of 10.7 m each. The offices are of different sizes depending on the number of people design to occupy such offices. The door sizes scheduled for the following areas are main entrance (3.6mx2.1m), garage (2.4mx2.1m), offices (0.9mx2.1m), stores (0.75mx2.1m) and toilets (0.75mx2.1m) respectively. Also, the windows scheduled for the offices, main entrance, restaurant, and toilets are 1.8mx1.2m, 0.9mx1.600m, 0.9mx1.2m and 0.6mx0.6m respectively.

Fire Risk Assessment

Fire risk assessment is an arranged and logical look at premises, the exercise carried on the premises is as a result of the tendency that a fire could start and cause harm to the people in and around the building. The 5 steps in carrying out fire risk assessment have been clearly spelt out in Regulatory Reform Fire Safety Order (2005). These steps are identification of fire hazards and people at risk. Others are to evaluate, remove, reduce and protect from risk. This is in addition to record, plan, inform, instruct and train as well as review.

The following important features of the building were put under consideration. These include the presence of high number of people especially visitors who are not familiar with the building and the possibility of high fire growth from restaurant. With respect to these features, risk assessment was conducted. The first step carried out was the identification of fire hazards, people at risk, followed by the identification of source of ignition, thereafter, subsequent steps were followed. Table 1 below summarizes the risk assessment carried out on the building.

Table 1: Fire risk assessment of Asha office building.

S/N	Floor Level	Compartment	Possible source of fuel	Possible source of ignition	Occupants at risk
1	Ground to 4th floor	Offices	Stationeries, furniture, photocopier, carpet, wastebin, decorations, plastic material.	Lighting, faulty electrical equipment, Arson.	Staff (familiar), disabled persons, visitors, contractors.
2	Ground to 4th Floor	Toilets	Rubbers, plastic, tissue paper, towels	Water heater, faulty electrical equipment.	Staff, visitors.
3	Ground to 4th Floor	Corridor	Waste, dirt	Smokers' material, dirt	Staff, guests, visitors
4	Ground Floor	Garage	LPG, dirt	Smokers' material, arson	staff
5	Ground Floor	Studio	Decorations, furniture, carpet.	Arson, electrical fault	Staff, visitors
6	Ground Floor	Restaurant	Cooking oil, furniture, plastic, wooden materials, dirt.	Naked flame, faulty electrical equipment, arson.	Staff, visitors
7	First Floor	Council Chamber	Stationeries, decorations, waste storage, furniture, wall and ceiling hangings	Misused electrical equipment, naked flame, arson.	Staff, visitors, Contractors, guests.
8	Ground and First Floor	Store	Stationeries, furniture, LPG.	Arson, misused electrical equipment.	Staff
9	First Floor	Rest Room	Furniture, beddings, wall and ceiling hangings, decorations.	Lighting equipment, naked flames	Staff

The outcomes of the risk assessment reveals certain challenges associated with the Asha Office Building in terms of early warning and means of escape.

RESULTS AND DISCUSSIONS

Detection and Alarm System

Design for Alarm Detection Systems

Asha office building would be design to make use of manual electric alarm system which would initiate manually by source their power from mains or standby source. The alarm must remain clearly and continuously audible throughout the premises until restored or switched off without retaining the operator. Two types of fire detectors commonly used on this building are: heat detector and smoke detectors. Heat detectors are designed primarily to respond when a constant temperature is attained. Thermistor is the sensing element which would respond to the rate of rise of temperature. Smoke detectors (optical type) are aimed at sensing smoke through light scatter resulted from the existence of a small light source within the detector. Photoelectric chamber is the sensing element which operates by recognizing the obscuration of the light source that occurs in the presence of smoke (Koorsen Fire and Security, 2020).

Manual alarm system (type M) are to be used in Asha office building so as to enable staff in the building to activate such alarm in case a fire does occur. It is pertinent to note that human beings are the best detectors of fire in the world. Nevertheless, type L1 system (life safety) is to be used in conjunction with the M type system. L4 systems are to be fixed in the corridors and escape routes in order to provide an early warning of fires and smokes (Fire Risk, 2023). The rest room on the first floor is to be provided with an L1 system so as to wake the occupant that might likely be asleep. The kitchen is to be covered with a heat detector. Meanwhile, places with low risks such as toilets and bathrooms would not be provided with any detection system.

The minimum sound level required throughout the office building is to be 65 dB or 5 dB above any background noise which is expected to last for more than 30 seconds while 75 dB sound level is required to arouse an occupant likely to be asleep in the rest room (BS 5839 - 2002). However, consideration has been given to the attenuation caused by walls, floors, ceiling and partitions. Visual alarms are to be provided in support of audible detectors should in case the sound alarm is ineffective, excessive background noise or presence of occupants with impaired hearing.

The source of power supply is electrical which would ensure a continuity of supply through the normal mains supply and/ or a standby supply of either a secondary battery or a secondary battery with a standby generator capable of providing an evacuation alarm in all zones for at least 30 minutes. All wiring would be performed in compliance with BS 5839 (2002) and/or the latest edition of the IEE Wiring Regulations. However, for fire design purposes, cables are classified into those which must continue to function in a fire, and those that will fail having served their purpose.

Manual Call Point

BS 5839: Part 2 deals directly with the specifications for manual call points. The Asha office building is to be provided with manual call points on exits routes, main entrance and floor landings. It is to be well illuminated, kept free from obstruction and fixed on a contrasting background and ensures that it modes of operation is uniform. Manual call points are to be flush – mounted unless there is a need to be viewed along the corridor (BS 5339 - 2002). All the manual call points in this office building are to be placed 1.4 m high from floor level and ensure that no person would have to travel more than 30 m to operate the alarm from any part of the building without exposing the operator to unnecessary risk during operation.

Fire Control Panel

Fire control panel functions mainly in 3 ways namely automatic monitoring and control of circuits external to the equipment and supply of power to those circuits. Others are indicating and locating fire signals and fault signals and finally, in manual control to facilitate actions such as testing and triggering of fire signals (Koorsen Fire and Security, 2020). This equipment needs to be easily accessible to both the building occupants and fire brigade. Control panel should have both lamps and sounders built in it so that it can function both during the day (sounders) and night (lamps). In Asha office building, fire control panel is to be located on the ground floor main entrance. The ability of control panel to show more precisely in what place of the origin of the signal is, depends on zoning within the office building.

Detectors Positioning

The positioning of heat detector in relation to ceilings is 25 mm and 150 mm below a ceiling while smoke detectors are positioned between 25 mm and 600 mm below a ceiling so as to avoid the ceiling boundary layer. Moreover, heat detectors are to be spaced from the nearest detector by 5.3 m with a total coverage area of 56.2 m^2 per device. But, smoke detectors are to be spaced to ensure that no point on the ceiling is greater than 7. 5 m from the nearest detector and this will provide actual area coverage of 112 m^2 per device.

Figure 1 shows the typical layout of smoke and heat detectors positioning in Asha office building (ground floor).

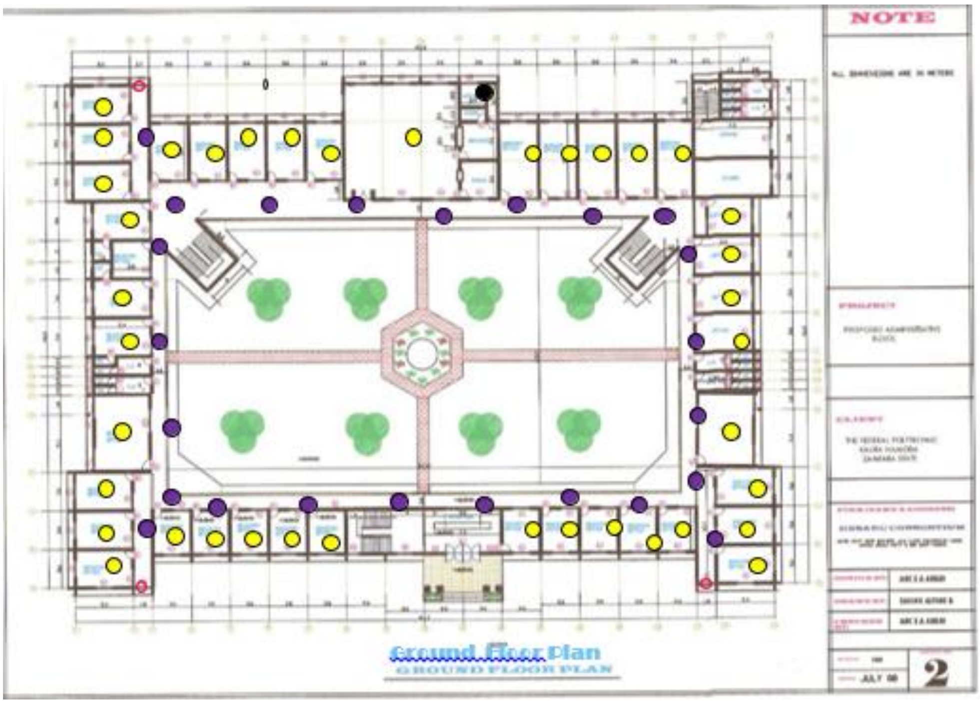

Figure 1: Positioning of smoke and heat detectors for the ground floor.

Note – L1 smoke detectors installed in all the offices.

L4 smoke detectors installed in escape routes, stairways and corridors spaced 7.5 m apart.

A heat detector installed in the kitchen only.

Means of Escape

Means of Escape Design

Means of escape could either be horizontal or vertical. The horizontal escape is that which originates from any point to the nearest storey exit. Vertical escape mostly occurs in a multi storey buildings due to sufficient number of adequately sized and protected escape stairs. Asha Office Building involves a combination of both horizontal and vertical means of escape. Final exit that will lead to a place of safety is the last component of means of escape after horizontal and vertical escape. Safe means of escape is said to be provided by availing alternative escape routes where necessary, sufficient escape routes width, limiting travel distances which all depend on the categories of the building (ADB, 2010). Simultaneous evacuation strategy with the ability to enable all floors to be evacuated at the same time is to be used on this design building. Table 2 below shows the number of occupants expected to be in Asha office building.

Table 2: Number of occupants expected to be in the building

No of floor	Floor Size (m^2)	Compartments	Occupants (Design Capacity)	Occupants (Floor Space Factor)	Comment	Risk Category
Ground floor	65 x 47	Offices	125			A2
		Restaurant	50			B2
		Studio		52	25.92m^2/0.5 =52 persons	B2
		Garage				
		Toilets				
1st floor	65 x 47	Offices	140			A2
		Rest Room	1			Cii2
		Stores				A4
		Toilets				
2nd - 4th floor	(65 x 47)* 3	Offices	140x3			A2
		Toilets				
TOTAL	**15, 275**		**986**	**52**	**Grand Total**	**1038**

Sequel to the risk assessment carried out, some challenges were identified with respect to means of escape and these include longer travel distances in both single and multiple directions, insufficient number of escape routes and exits as well as insufficient exit route in a council chamber. Others are lack of a protected stairs, restaurant as an ancillary to the main building has only one escape route and there was presence of 3 dead end corridors that exceed 4.5 m by length. Equally, it was observed that kitchen as an inner room passes through more than one room via a corridor with a longer travel distance.

Travel distances analysis of the occupants has been carried out and compared with the prescriptive guidance of ADB (2010). Table 3 below shows travel distances assessment carried out on the design building.

Table 3: Travel distance analysis on the design building compared with ADB (2010)

Building Part	Actual Distance (m)	ADB Requirement		Comment
	Single, Two	Single Way	Two Way	
Restaurant	13,77	18	45	Contrary to ADB in two ways
Office	13,54	18	35	Deviates from ADB also in 2 ways
Studio	7	9	18	In line with ADB requirement
Kitchen	20, 72	9	18	Opposes ADB
Council Chamber	16,18	9	35	Contrary to ADB in multiple ways

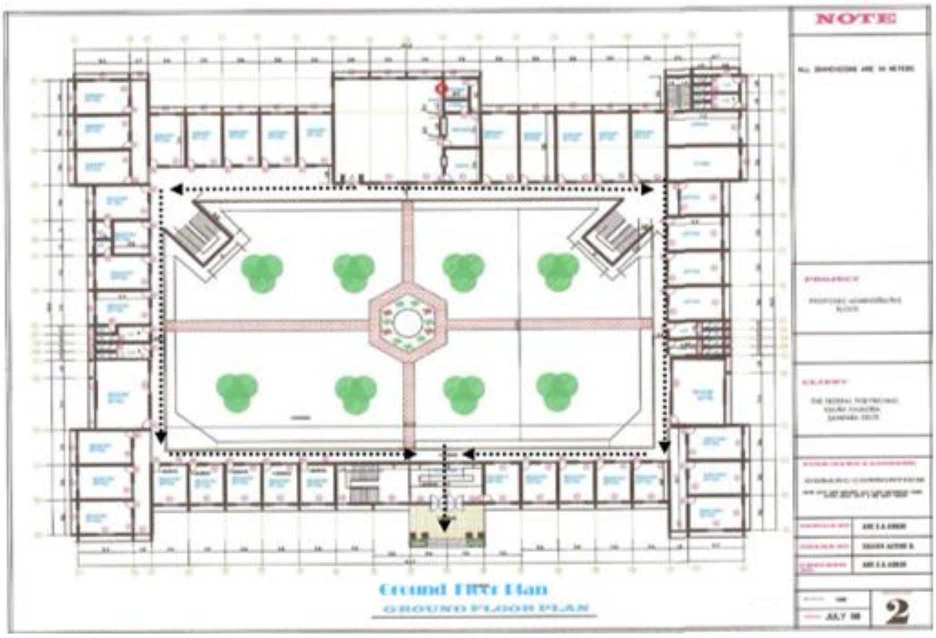

Figure 2: Longest travel distance analysis in two – ways

Figure 2 above shows the longest travel distance in two – ways i.e. from the restaurant to the final exit.

Redesign of the Kitchen

Based on the risk assessment conducted, the kitchen as an inner room is not entered directly off the access room (service); rather, it has entered via the corridor. Also, the travel distance from any point in the inner room to the exit of access room (service) is greater than that specified in Table 3 pp 34 of ADB. All these features are contrary to the requirement of ADB (2010) Section 3.10 pp35 (inner room requirements). In view of these, an alternative exit has been provided for occupants in the kitchen to escape in addition to the installation of suitable automatic fire detection and alarm system in the access room (service). This is to warn the occupants of the inner room (kitchen) in case of fire outbreak in the access room. Figure 3 shows the preferred solution to the mentioned problems.

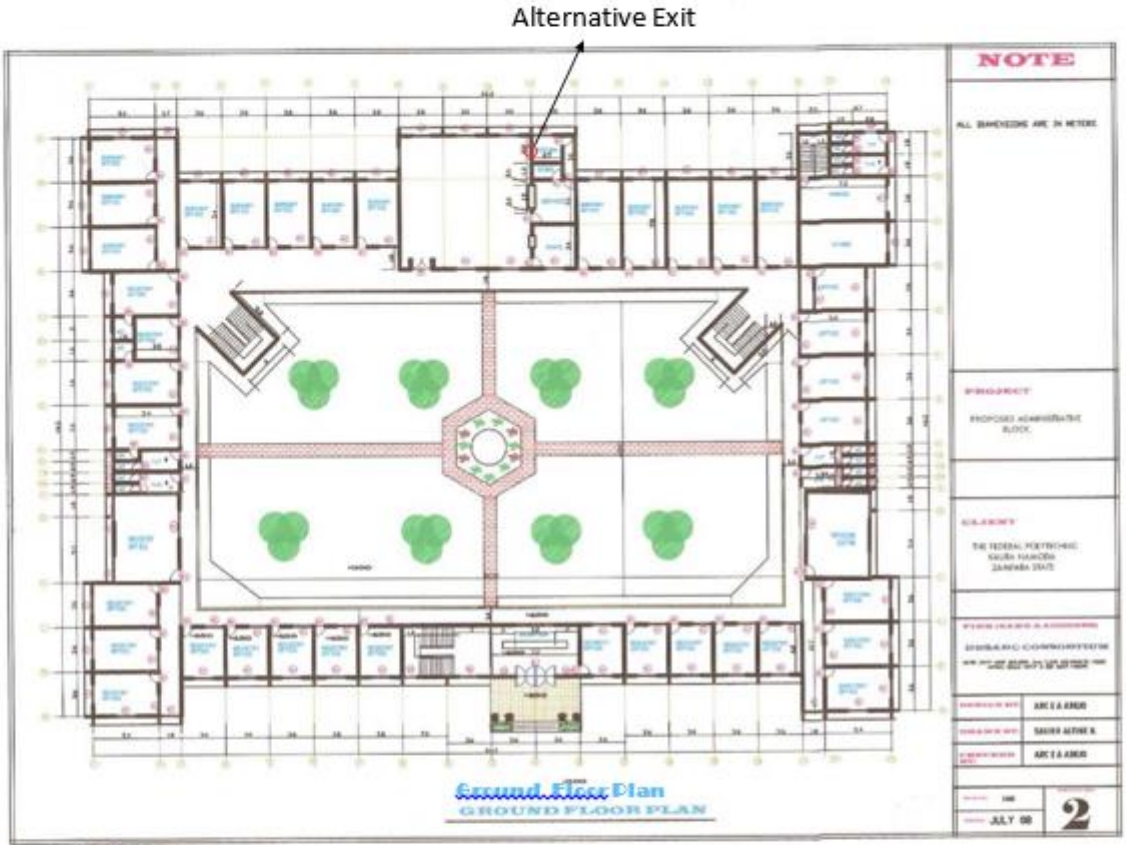

Figure 3: Redesign of the kitchen.

Number of Escape Routes and Exits Analysis and Solution

The numbers of occupants and exits requirements have been clearly stated in Table 3 pp 35 of ADB (2010). The council chamber with 250 occupants (based on design capacity) has only one exit. In line with ADB requirement, an additional exit has been provided so as to enhance the escape of occupants in the council chamber in case of a fire. Figure 4 shows the possible solution to this problem.

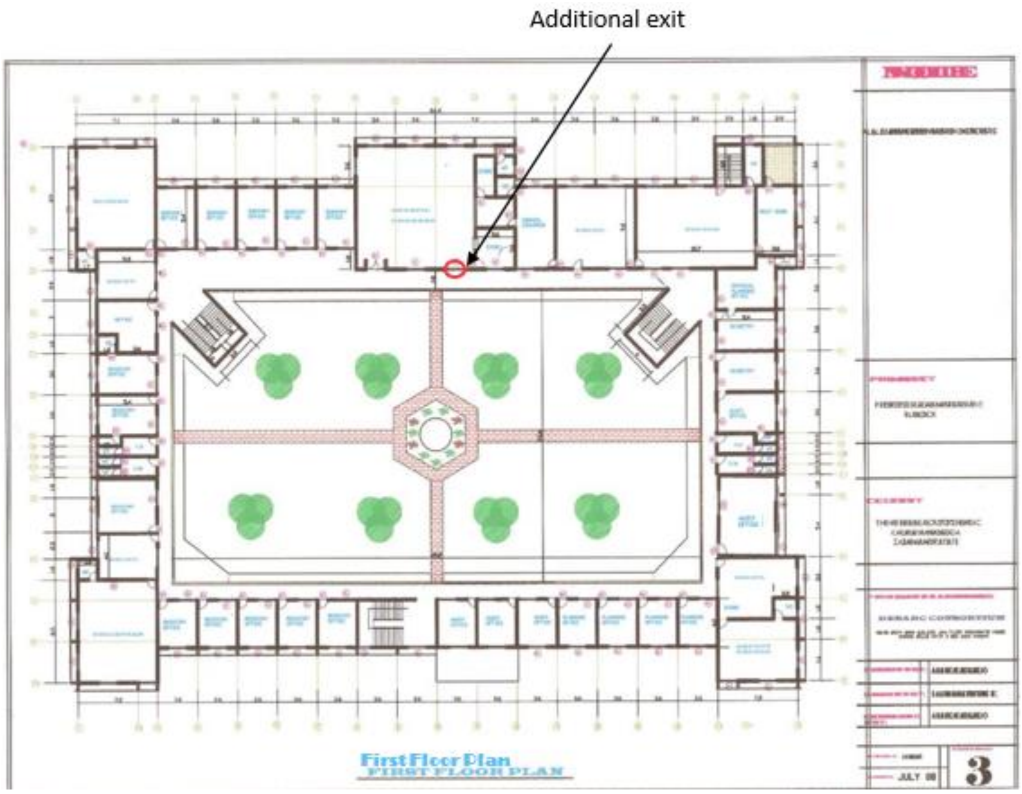

Figure 4: Additional exit provided in Council Chamber

Furthermore, the restaurant as an ancillary to the main building for the consumption of food and/ or drink has only one escape route (exit). This totally deviates from the Paragraph 3.15a of pp 37 of ADB requirements.

The building has 1038 occupants and it entails only one main entrance. According to Table 4 of ADB (2010), any room with more than 600 occupants should have at least 3 exits. This call for the alternative exits to be provided in order for all the people to evacuate on time, limit the travel distances and also to make the occupants have options to other exits should in case the main entrance is blocked with fire. Figure 5 shows the alternative exits provided in addition to the main entrance.

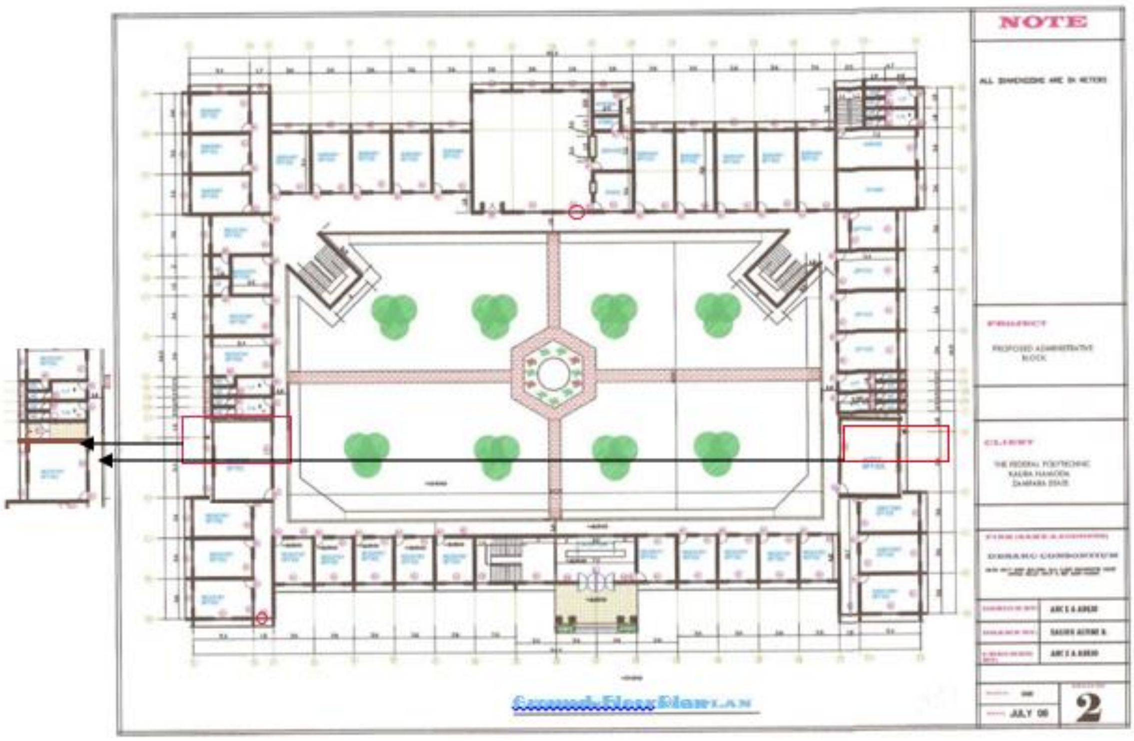

Figure 5: Alternative exits provided so as to reduce the travel distances.

Dead - End Analysis/Solution

There are 3 dead - ends in the building which are all located on the ground floor. Assuming that there are no alternative exits, the longest travel distance from the dead-end is 63m which is longer than the travel distance requirement of ADB (2010) for offices which are 18m and 45m for single and multiple directions respectively.

With respect to this, a flexible approach using BS 9999 (2008) has been used so as to make the building comply with building regulations and limit the travel distances based on the risk profile classification and people's classification. In this approach, office building has been classified under risk category A2 which has a travel distance of 18m and 55m in both single and multiple ways respectively. Also, by installing automatic detection systems in the building, the occupants of the building would be alerted at the earliest possible time about the fire and also to provide additional allowance of 15% of actual distance as stated in BS 9999 (2008). The longest travel distance problem has been solved as a result of the automatic detection systems provided. Additionally, alternative exits are to be provided at each dead-end so as to enable the occupants to escape should in case the dead-end entrance is blocked by fire. Figure 6 shows the alternative exits at the 3 dead- ends.

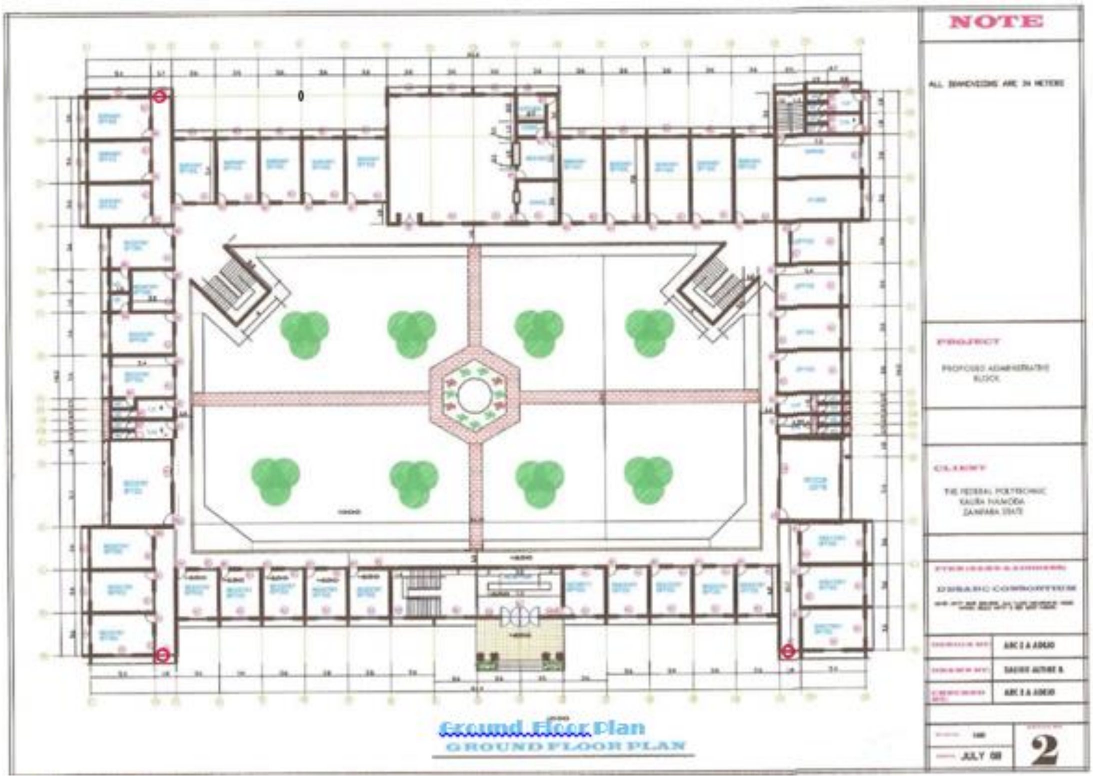

Figure 6: Alternative exits at dead – ends for safe escape and limiting travel distances

Travel Distance Analysis /Solution

The travel distances in the office building are greater than the travel distances specified in ADB. In order to tackle this, BS 9999 (2008) approach would be used to make the building comply with prescriptive guidance of ADB (2010). This approach has been adopted because of its flexibility advantage that it has over ADB. It is based on risk profile classification and occupants' characteristics. This provides additional allowance of 15% as accommodated within BS 9999 codes. Also, travel distances have been reduced by providing 2 alternative exits in addition to the main entrance.

Exit Width Assessment

Table 4 pp 37 of ADB (2010) stated the requirements of exits' width. Table 4 shows the width and number of exits with respect to each compartment.

Table 4: Exits' width analysis of Asha office building

Compartment	No of People	Number of Exits	Exits' Width (m)	Remark
Offices	685	1	0.9	Complied with ADB
Council Chamber	250	2	1.5	It is in line with ADB
Rest Room	1	1	0.9	ADB Compliance
Studio	52	1	1.6	It is OK
Restaurant	50	2	1.5	Satisfied ADB requirement

From Table 4 above, all the exits' width have complied with ADB (2010) requirements. Likewise, all the escape routes have clear headroom of 2.1m which complied with the requirement of ADB Paragraph 3.17 pp 37.

The final exit's width of the building can be calculated using the formula from ADB 3.23 pp 38, is:

$$w = \frac{\left[\left(\frac{N}{2.5}\right) + (60S)\right]}{80} \quad (1)$$

where w, is the width of final exit, in meters, N is the number of people served by ground floor which is 1038 and S is the stair width in meters which is 1.5m. From Equation 1, the width of the final exit, w is 6.315 meters.

Stairs' Width Analysis

There are 4 stairs in the office building. Three stairwells connect to all floors in the building which is used by all the occupants and visitors. The last stair of 1.1 m width is used by the Rector only while the other 3 stairs have a width of 1.5 m each. From the discounting rule of ADB 4.20 pp 47, one of the stairs would be discounted as a result of its unavailability should in case a fire occurs. Therefore, the building is left with two stairs only.

The stairs width can be compared with that of the ADB Table 7 pp 47 requirements using a formula to find the stairs' width designed for a simultaneous evacuation from ADB 4.25 pp 48.

$$w = \frac{P + 15n - 15}{150 + 50n} \quad (2)$$

w, is the width of stair in meters and P stands for the number of people, 811 that can be served except those on the ground floor that will not use the stair. The number of number, n of storey served is 4. Hence, the width of stairs calculated from Equation 2 is 2.189 meters.

The stairs' width calculated above satisfies ADB requirement. Having discounted one stair way, the remaining 2 stairs widths which are 3m can be reduced to 2.189m. This reduction in stairs' width is a benefit in cost reduction in which this design project is considering along with life safety. The escape stairs need to have an adequate fire resistance for protection of occupants during a fire evacuation. This can be achieved by adhering to Paragraphs 4.32 to 4.33 of ADB (2010).

RSET and ASET Calculations for Ground Floor

Fire safety design has been chosen for the means of escape at the ground floor. PD 7974 (2019) is the acceptance criteria used for this means of escape having regarded the complex nature of the building, longer travel distances and large number of occupants.

The basic formula used for determining the means of escape in a building according to PD 7974-6 pp11 is given as:

$$t_{RSET} = \Delta t_{det} + \Delta t_a + (\Delta t_{pre} + \Delta t_{trav}) \quad (3)$$

The above equation can be shown diagrammatically in Figure 7 below.

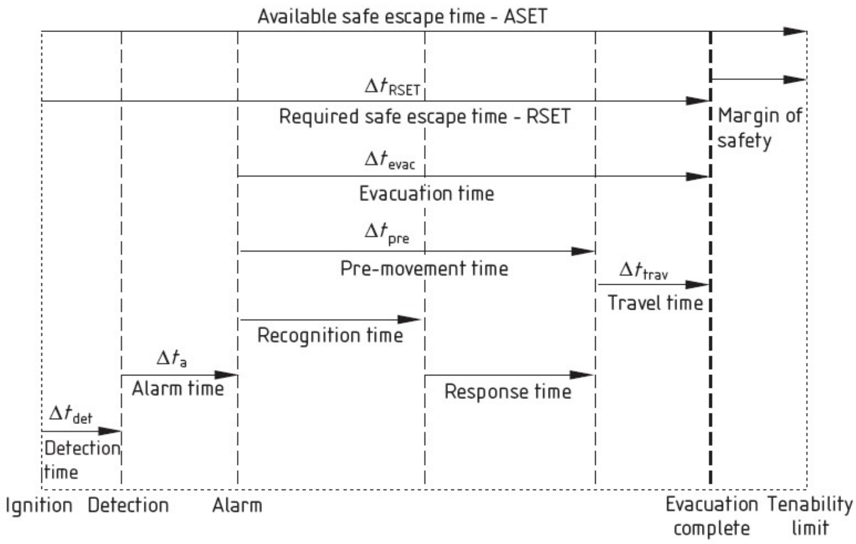

Figure 7: Comparison between ASET and RSET

Also, the design building can be classified based on the occupants characteristics, building type, proposed level of alarm and so on so as to calculate the R_{SET}. Table 5 below shows the building classification.

Table 5: Building classification under occupants' characteristics

Floor Level	Occupant Alertness	Occupants' Familiarity	Occupants' Density	Enclosures/ Complexity	Proposed Level of Alarm	Proposed Level of Mgt	Building Type
Ground	Awake	Familiar	High	Many	LA1	M2	B2
First	Awake	Familiar	High	Many	LA1	M2	B2
Second	Awake	Familiar	High	Many	LA1	M2	B2
Third	Awake	Familiar	High	Many	LA1	M2	B2
Fourth	Awake	Familiar	High	Many	LA1	M2	B2

The above abbreviations have been defined in PD 7974-6 as:

LA_1 = Automatic detection system,

M2 = Lower staff ratio and floor who are trained to a high level of fire safety but they may be absent sometime and

B2 = Occupants that are awake and familiar.

Also, 60 seconds has been proposed by the Fire Design Solutions Limited as the alarm detection time. From Annex A of PD 7974-6 pp21, alarm time is 0 second for LA_1 (because it is an automatic alarm detection system which alert the occupants in the building). Evacuation time is given as the summation of pre-movement time and travel time. Pre movement time for B2 and M2 building is given as 120 seconds at the 99th percentile as detailed on table C1 of PD 7974-6 pp25. Travel time is obtained using the formula below:

Where $t = s/v$

where s = the longest travel distance on the ground floor in meters which is 77.4m

v = the average walking speed for design purposes which is 1.2m/s according to CIBSE Guide.

$t = \frac{77.4}{1.2}$ = 64.5 seconds

Therefore, RSET = Detection time + Alarm time + Pre-movement time + Travel time

60sec+ 0 sec+ 120 sec+ 64.5 sec = 244.5 sec

At least twice the value of RSET is required so as to maintain a tenable condition which serves as a safety margin. Therefore, twice the value of R_{SET} is going to be the ASET (Fire Design Solutions Limited).

ASET = 2 x RSET

ASET = 2 x 244.5 sec = 489 seconds.

From the RSET and ASET calculations above, it can be deduced that the building occupants from the farthest distance on the ground floor would be expected to evacuate the building within 244.5 seconds (4 minutes). Also, by providing a safety margin (sprinklers and smoke control), a tenability condition in the building would be maintained for a minimum of 489 seconds (8 minutes).

Emergency Lighting Design

According to Phylakhtou (2008), three procedures are to be adopted in designing emergency lighting. These include: determining the requirements, design illuminance and operation and maintenance to form part of the design schedule.

Design of illuminance has to do with the required number of luminaires and their position to cover points of emphasis. BS 5266-1 (2005), CIBSE Guide (1997) and ICEL Guide (2008) would be used in carrying out this design. Escape routes were taken as anti-panic area having carried out the risk assessment of the office building. The minimum duration of 1 hour is to be provided in the office building which has to be recharged before re-occupation. Also, a minimum luminance of 1 lux is to be provided along the centre line of the escape route because it is applicable to all risk. All the required numbers of luminaires are to be arranged transversely to each other.

The required number of luminaires can be calculated using the following equation from CIBSE Guide E.

$$N = \frac{E \times L \times W}{UF_0 \times SF \times ELDL \times K} \qquad (4)$$

where N is the number of light fittings required; E is the average illuminance required (lux) which is given as 1.0 lux and L is the length of the escape route (m) which stands for 47 m. The width, W of the escape route (m) is given as 1.8 m whereas UF_0 is the utilisation factor at zero reflectance which is related to the room index RI and this is given from CIBSE Guide E as

$$RI = (LxW)/h_m (L+W) \qquad (5)$$

where L and W are the length and width of the escape routes (m) which are 47m and 1.8m respectively, and h_m is the height of the escape route which is 4m. This gives an RI of 0.43.

For RI of 0.43, the corresponding UF_0 from Table 6.3 of CIBSE Guide is 0.25

SF= Service factor which takes account for the effects of dirt and system ageing and this is given by the luminaires manufacturer as 0.8

ELDL= Emergency lamp design luminous flux which is 130 lumens according to manufacturer's data provided.

K= Factor to cover the reduction in light output at the end of discharge or 5 seconds after the mains failure, whichever is lower. This factor is given by luminaires' manufacturer as 0.65

Therefore, 5 luminaires are required to be arranged axially and spaced 4.8 m apart from one another as detailed on spacing Table of PP 19 of ICEL 1006.

For an escape route of 1.4 m wide and length of 47 m and h_m of 4 m, the calculated RI from Eqn 5 is 0.34. UF_0 is taken to be 0.25 from CIBSE Guide Table 6.3. The required number of luminaires calculated using Eqn 4 is 3.89. Approximately, 4 luminaires axially arranged and spaced at 4.8 m apart are required.

For the vertical corridors with a length, width and height of 27 m, 1.4 m and 4 m respectively, the RI using Eqn 5 is obtained as 0.33. The corresponding UF_0 for RI of 0.33 is 0.25 (See CIBSE Guide E). The required number of luminaires from Eqn. 4 is 2.2. Approximately, 3 luminaires axially arranged and spaced 4.8 m apart would be required.

The required number of luminaires, N at the dead-end corridor of 10.7 m long, 1.8 m wide and 4 m high would be obtained first by obtaining an RI using Eqn 5 as 0.39. Thereafter, the UF_0 of 0.25 as specified in Table 6.3 CIBSE Guide E was obtained and this gives N as 1.14. Approximately, 2 luminaires are required for each dead-end.

Figure 8 below shows the emergency lightings at vertical corridors and dead – end corridors of the ground floor.

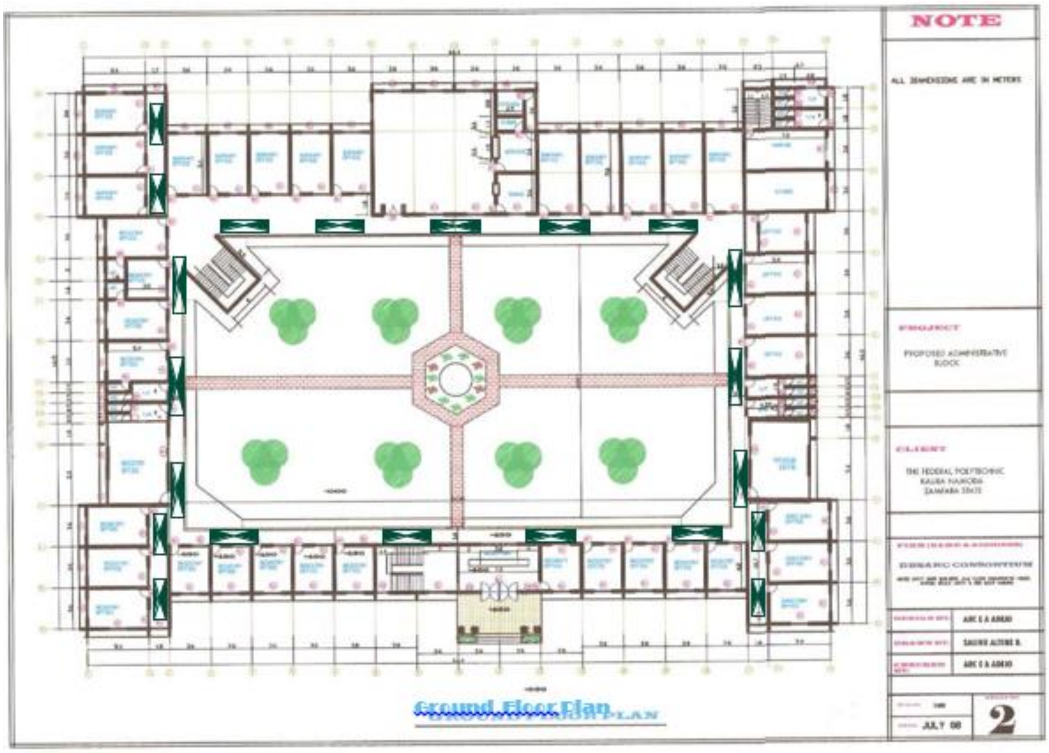

Figure 8: Emergency lightings for the ground floor.

Signs

The following locations in Asha office building are to be fitted with emergency exits signs. These locations are: near changes of direction and intersection of corridors, near stairs, near exit doors, near firefighting equipment, call points and near first aid post. The maximum viewing distances of the escape routes signs must conform to the BS EN 1838 (1999) requirements which are 200 X H and 100 X H for internally and externally illuminated signs respectively where H is the height of the pictogram. Also, Section 5 of BS EN 1838:1999 details the conditions for illumination that safety exit signs must be clearly visible for the distances mentioned above. Additionally, the colours must adhere to ISO 3864:1984 which is white figures on green background.

CONCLUSION

A fire safety design on the early warning and means of escape for a 5 storey, Asha Office Building is conducted. Manual alarm system (type M) is proposed in conjunction with type L1 system (life safety) and L4 system as well as heat detector. The minimum sound level required throughout the office building is to be 65 dB or 5 dB above any background noise which is expected to last for more than 30 seconds while 75 dB sound level is required to arouse an occupant likely to be asleep in the rest room.Simultaneous evacuation strategy with the capacity to allow all floors to be evacuated at the same time was considered on this design building. Fire safety design has been chosen for the means of escape at the ground floor using PD 7974-6 as the acceptance criteria. Considering the complex nature of the building, longer travel distances and large number of occupants, the building occupants from the farthest distance on the ground floor would be expected to evacuate the building within 244.5 seconds (4 minutes). Also, by providing a safety margin (sprinklers and smoke control), a tenability condition in the building would be maintained for a minimum of 489 seconds (8 minutes). For emergency lightings that would aid escape of occupants, five luminaires would be required to be arranged axially and spaced 4.8 m apart from one another for an escape route of 47m and 1.8m length and width respectively. For an escape route of 1.4 m wide and length of 47 m, 4 luminaires axially arranged and spaced at 4.8 m apart are required. Three (3) luminaires axially arranged and spaced 4.8 m apart would be required. The required number of luminaires for a dead-end corridor of 10.7 m long, 1.8 m wide and 4 m is obtained as 2

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