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Impact of Adjacency of Spaces in Fire Service Station on Fire Crew Response Time

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ABSTRACT

The fire has contributed positively to man development from time immemorial till today. But it also has its own negative aspect; people had lost virtually all they had in a single fire incidence including their life. It is in light of this negative side of fire that the fire service was established to prevent and extinguish fire and other emergencies that threaten the lives and properties of the people. These fire stations in Nigeria have challenges which result in late response to fire incidence and it is on this backdrop the research evolved. The research adopts an analytic approach; Systematic sampling was employed in choosing appropriate case study facilities. 36 questionnaires administered, 4 were not returned which forms about 11.1% of the total administered questionnaires. A total of 32 questionnaires were filled and returned forming 88.9% of the total administered questionnaires. A checklist was used to investigate the availability of essential activity spaces in the fire stations. Four stations were case studied. The data obtained were analysed using simple statistical method and results were presented in a simple descriptive tool (tables and figures). The research revealed that each Nigeria fire station lack one activity space or the other which is essential for a timely response like, dormitory, kitchen/dining space, day room, watchtower, etc. Beside activity spaces, adjacency of spaces is a lacking essential factor, time is lost in travelling from the gates of these fire stations to the watch room/dispatch during run-in calls, and time is also lost when firemen have to travel from different part of the station to the apparatus bay to respond to a fire call. The research then recommends the remodelling of the existing stations and a template for the design of sustainable on time fire station.

Keywords : Fire, Respond Time, Firefighting Equipment, Sustainable Fire Station, Quick Response

I. INTRODUCTION

Fire is one of man's most successful innovations of all time; fire has been in use since the period of the early man to this jet age. The discovery of fire has contributed immensely to human survival and development. When the early man discovered fire, he used it to roast his game, warm himself in the cold, cook, etc. The early man began to make fire by hitting two stone to create a spark which in the presence of a combustible material will ignite and become fire. The fire could be of tremendous gain when used for the right purpose and under the control of the user. The fire also could be of disastrous effect if used for the wrong reason e.g. arson or when it is out of the control of the user.

When the fire goes out of control in the presence of combustible material, it is often difficult to stop without the use of the appropriate tools and technique, and sometimes it is beyond the capability of one person, thus requiring a group/ teamwork(Thompson, Galea, & Hulse, 2018).

Government and institutions (both public and private) provide fire fighting services to secure the lives and properties of the people in incidence fire outbreak/ inferno, and these services are usually free. Fire-fighters require pieces of equipment to aid them in the execution on this risky task and these pieces of equipment come in form of personal protective wears, rescue equipment and fire fighting equipment(Lepoglavec et al., 2017). These set of equipment require safekeeping facilities which could be easily accessed for prompt intervention in times of fire outbreak.

Fire stations are built to accommodate men and equipment in a manner that allows for prompt attendance to emergency call which mainly has to do with fire incidence(Li, Chen, Zhang, Song, & Lv, 2014).

Quick response to fire incidence is essential to rescuing and putting out the fire before the damage escalates. The sequence of activities that lead to the response to emergency situation starts within a space, the ease of performing these activities will improve the total response time of the fire-fighters. Therefore achieving a quick response to fire starts from the station design, the quality of circulation space in and around the station and their adjacency.

The Research Aim

To determine the impact of adjacency of spaces on the response time of fire-fighters in emergency situations in a fire station.

The Research Objectives

i. To investigate the availability of essential activity spaces that aid timely response.
ii. To investigate the effect of fire station design on the response time of firefighters to emergencies.
iii. To examine to what extent the fire station has complied with the adjacency planning concept of fire station design.
iv. To determine the effect of the adjacency of spaces on turnout time

The scope of the Study

The research deals with the fire fighting activities and activity spaces that affect total response time to fire incidences. It identifies some design problems associated with existing fire stations and tries to proffer solutions in order to enhance quick response to fire incidences in Adamawa State and the country at large. This research covers only the fire fighting activities that take place within the fire station.

Expected contribution to knowledge

The evaluation is expected to generate a template for built environment professionals. The documentation of crew response indices is expected to ignite inquiry nature of architects, as to ways of improving sustainable response time in fire stations, which is also replicable in the West African Region.

The justification for the Study

On the 1st of April 2012, no fewer than 30 people were burnt to death in a tanker fire in Demsa local government area of Adamawa state (Manyam, 2012). On 28 October 2013, fire guff the store of the Adamawa State Ministry of Agriculture at the state secretariat Yola, destroying the goods that were kept in (News Agency of Nigeria [NAN], 2013). More so, on the 16th February 2014 a member of the Nigeria Television Authority, NTA Mr. Aliyu Zubairu, and his wife died when fire gutted their house in Yola (NAN, 2014).

A recent report released from the state director fire service, Alh. Abdullahi Adamu indicated that 2 persons were killed in fire incidents in Adamawa state in 2014, a total of 102 fire incidents were recorded with Yola North local government leading with 65 incidents. He also identified a lack of functional fire fighting equipment as constraints (Garba, 2015). With the high number of fire incidents and the poor attendance of fire-fighters to these infernos which has resulted in deaths, the need for a quick response fire fighting station cannot be overemphasized. Ayoosu (2016) re-echo the Vitruvius principle of utilitas: the

building has to be sustainable and useful to be able to achieve its intent.

LITERATURE REVIEW

Definition and Concept of Fire

Fire has been defined as quick, self-sustaining oxidation reaction accompanied by the ignition of heat and light of different intensities (kanyal, 2002). Furthermore, it is defined as a scenario of combustion in which combustible material is ignited in the presence of oxygen, giving up light, heat, and flame (Ammer, n.d.). Fire can happen only when fuel, heat, and oxygen are available. It can occur on land, sea, and sky only when fuel, heat, and oxygen are reacted together. Fire does not respect the place, time and persons, given that the requisite elements are present. Fire can be caused by either man-made factors or natural factors.

Causes of Fire

Manmade fire is those fire ignited by man's error/ mechanical malfunctions, e.g. Electrical short circuit fires, kitchen fires, trash fires, arson, etc. Natural fires are those fire ignited due to no man's error, e.g. Volcanic eruption, earthquake caused fire, lightning.

Element of Fire

The process combustion of fire may be regarded as a chemical triangle in its three sides consisting of fuel, heat (energy) and oxygen. The control and extinguishing of fires, in general, are brought by eliminating any one side of this triangle. If oxygen (air) can be diluted or smothered out, the flame will go out. Its heat can be removed by cooling the fuel to a temperature below that at which it will take fire, the fire will no longer exist. Headquarters, Department of the A R M Y (1971) went a step further to explain that previously, the process of chemical oxidation and combustion and that of halting combustion was shown with the familiar fire triangle in Figure 3.

This two-dimensional triangle aided in explaining the combustion process. Thus, when all the sides of the fire triangle were intact and in proper state and proportion, burning took place. When any one of the sides (factors) was removed, burning was stopped

Figure 1: Triangle of Fire

Source: Vieito and Guimaraes (2008)

Before the introduction of the modern knowledge on chemical fire extinguishment, there were only three methods of extinguishing a fire, aligned closely with each leg of the fire triangle.

Cooling the fire removed the "heat leg"; excluding the oxygen from the fire removed the "oxygen leg"; and separating the fuel from the fire removed the "fuel leg". When chemical extinguishing agents were introduced and successfully used for fire extinguishment, additional information was required to explain the action of the chemical.

This new information added another dimension to the diagram. The new diagram is known as the tetrahedron of fire (Figure 2). It has four triangular surfaces that make up a solid pyramidal form which has depth. Each of the triangular surfaces shows an element necessary to continue combustion. It shows that combustion (fire) is a continuous chemical reaction which changes constantly because of external conditions. Chemical extinguishment agents (potassium and sodium bicarbonate type dry chemicals or vaporizing liquid agents) inhibit the chain reaction of fire by interfering with or cutting off the conditions necessary, for combustion. Thus, all the three parts of the fire triangle may be present, but the chain reactions are prevented (inhibited) by a chemical extinguishment agent (or agent) which puts out the flame.

a. Oxygen

Oxygen comes from the air that we breathe. Air consists of 21% oxygen and 79% nitrogen. If oxygen can be diluted below 15% of fire will be extinguished.

b. Heat

Heat according to (Soanes and Stevenson, 2004) is seen as a form of energy arising from the random motion of the molecules of bodies.

There are three stages of temperature relative to ignition of a material namely: Flash Point, fire point and ignition temperature.

- Flash Point – is the temperature of the substance at which it will give a vapor sufficient to form an ignitable mixture.
- Fire Point – is the lowest temperature at which vapors being given off by a material can be ignited and will continue to burn.
- Ignition Temperature – is the temperature at which the vapor is given off by a substance will ignite spontaneously in the air.

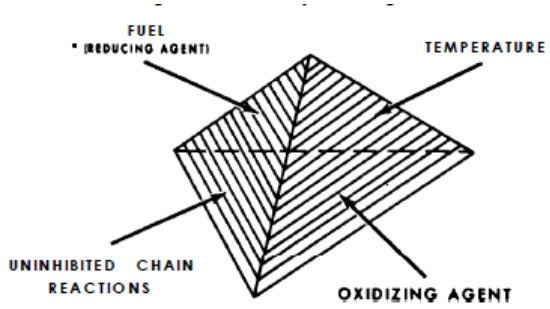

Figure 2 : The Tetrahedron of Fire

Source: Headquarters, Department of the ARMY (1971)

c. Fuel

Any combustible substance which will burn when heated to its ignition temperature.

The importance of the spread of fire to all fire fighting operations cannot be overemphasized. Fire grows as fast as they can develop a firing temperature in the surrounding material (Anonymous, 2006)

Fire Growth/ Flashover

When the three elements of fire, oxygen, heat, and fuel are readily available fire burns and continue to grow unless stopped by a conscious effort or due to exhaustion of one or more of these elements of fire. ESRI (2007) states that Regardless of the speed of growth or length of burn time, all fires goes through the same stages of growth. One particular stage emerges as very significant because it marks a critical change in conditions. It is called flashover. Measuring the time to flashover is a function of time and temperature. Fire growth occurs exponentially; that is, a fire doubles itself every second of free burn that is allowed. This can be plotted on what is known as the time and temperature curve. Figure3 illustrates fire growth over time and the sequence of events that may occur from ignition to suppression. Depending on the size of the room, contents of the room, and available oxygen, flashover can occur in less than 2 or more than 10 minutes. Flashover occurs most frequently between 4 and 10 minutes.

Fire Survival Rate

Time is of great essence when it comes to fire and rescue operation. If a person has a heart attack (myocardial infarction) and cardiopulmonary resuscitation (CPR) is started within four minutes, the victim's chances of leaving the hospital alive are almost four times greater than if the victim did not receive CPR until after four minutes. ESRI, (2007) provides a chat in Figure 6 to shows the survival rate for heart attack victims when CPR is available.

The chat shows that about 28% of those who get CPR within four minutes of heart attack survive the attack, but only about 7% of those who get CPR after four minutes survive the attack. Heart attack (2010), defines heart attack as the death of a section of the myocardium, the muscle of the heart, caused by an interruption of blood flow to the area. A heart attack results from obstruction of the coronary arteries. One of the contributing factors to a heart attack is smoke. Smoke from fire contains carbon monoxide and carbon dioxide among other gases which are Poisonous to the body.

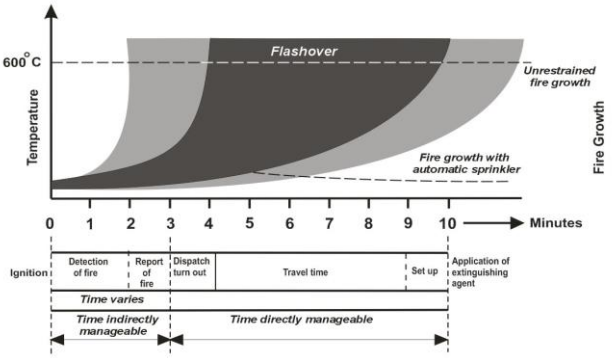

Figure 3 : Fire Growth Diagram

Source: ESRI (2007)

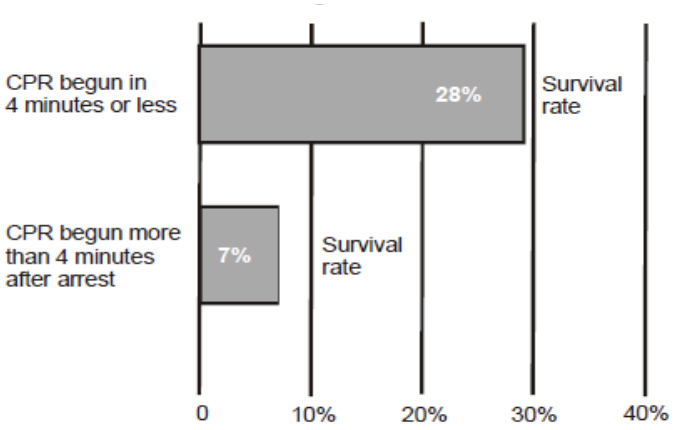

Figure 4 : Survival Rate of Heart attack Victim when CPR is Available
Source: ESRI (2007)

Therefore, it is essential that firefighter arrives at the scene of the fire within four minutes to provide CPR to victims trapped in the fire. Figure 5 shows the fate of victims depending on the time of rescue and resuscitation. Any response time above four minutes will put the victims in a very risky position, Figure 5 shows that response time between 4 to 10 minute puts the victim in a state of probable brain damage, and if the response delays over 10 minute the probability of brain death is very high. Therefore victims of disaster especially fire require speedy rescue and resuscitation to enable the live a healthy and normal life again.

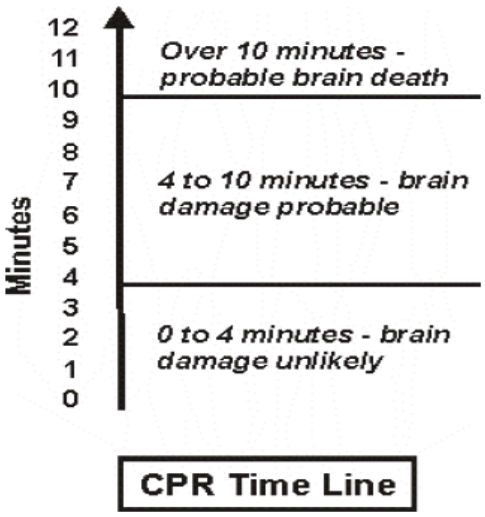

Figure 5 : Outcome for Heart Attack Victims Based on when CPR is provided
Source: ESRI (2007)

Adjacency in Fire Station Design

Chiara and Callender (1983) stated that over the past decade, Firehouse Planning and Design has become increasingly sophisticated and complex. Years of study and experience have made it apparent that by planning a firehouse properly, a safer and quicker turnout can be made. This is accomplished primarily by arranging traffic flow patterns within the firehouse to be as direct as possible. The integration of the "primary adjacency" concept for planning the firehouse will deduct considerably from the turnout time by "grouping" the fire fighting personnel in the "highest activity" areas of the firehouse. Turnout time along with dispatching time and travel time are three of the key elements in the successful containment of fire which is one of the primary goals of a fire fighting unit.

The improvements in firehouse planning have created a total upgrading of human comforts with great emphasis on physical fitness. These include well-planned kitchens, air conditioning, better lighting, well-planned toilet-shower facilities and dormitory spaces, acoustical improvements, safety features in building planning and the integration of a small gymnasium-like area, for physical fitness purposes in fire fighting needs, into the firehouse plan.

The Time to Effective Intervention by Fire Services

According to National Directorate for Fire and Emergency Management (NDFEM, 2013)The extent of area covered by a fire station, and hence the distance which may have to be travelled by a responding fire brigade to the scene of a fire, is one of a range of factors which determine the time to effective intervention by fire services. This is best characterized as the sum of a series of time segments from the start of the fire to the time the intervention begins to take effect. In the case of a typical domestic fire this would look like the following:

T effective intervention = Tperception + Treaction +TECAS/ 999 + T CAMP + T mobilisation + Ttravel + Tset up + Tperform initial tasks

Where

T (perception) - is the time that elapses before there is a perception of the fire, usually through sight, smell of smoke or activation of the smoke alarm;

T (reaction) - is the time that elapses before the person perceiving the fire reacts to take action by putting out an incipient fire, warning others and leaving the building and ringing 999/112.

T (ECAS 999) - is the time taken by the Emergency Call Answering Services

(ECAS) to process the 999 calls and to transfer it to the appropriate fire services Regional Communications Centre;

T (CAMP) - is the time taken by the fire services Regional Communications Centre to gather relevant information (address, nature of the incident, if persons reported) from the caller and process the information to identify and send a dispatch signal/ message to the appropriate fire service response;

T (mobilization) - is the time taken between receipt of the dispatch signal/ message and the first fire appliance declaring that they are on their way to the incident (booking mobile) as they leave their fire station;

T (travel) - is the time spent travelling from the fire station to the incident, and is a function of the distance to be travelled (a function of the location of the fire address relative to the fire station, the speed travelled at and familiarity with destination);

T (set up) - is the time from arrival at the scene for the Incident.

Commander to gather information, assess the situation, make a plan and issue task instructions to the crew, and for the crew to have taken initial steps (don BA and layout hose-reel/ jet and connect to the hydrant or another water source), etc;

T (initial tasks) - is the time for the fire brigade crew to perform initial tasks including entry, search, find fire (or casualty), fight fire, etc.

Approaches for minimizing the time for all stages which are amenable to action by fire authorities are set out below. Measuring trends in average response times (mobilization + travel) to primary and secondary incidents within station areas are seen as a key performance indicator.

Mobilizing/Turnout Times;

The target appliance mobilizing times from receipt of alert to booking mobile to the incident is as follows:

- Full-time stations - 1 minute
- Retained stations - 5 minutes

II. METHODS AND MATERIAL

Research Method

Primary data was collected through the use of questionnaire which was administered to the staff of the Adamawa State Fire Service and also a survey was carried out in the form of case study on both the existing Adamawa state fire service headquarters, station and two other fire service headquarters within the country. Foreign fire station design was also considered to provide comprehensive data for the template design. Secondary data was collected through journals, books, publications of associations connected with fire stations and online resources.

Research design

The research adopts an analytic approach; first, questionnaires were administered to staff of Adamawa state fire service to determine the effect of their office arrangement on their turnout time and process. Secondly, a checklist was used to analyse the provision of necessary activity spaces for the effective response to emergencies and to analyse the proximity of these activity spaces to each other.

Research Questions:

From the research field, the basic research questions can be formulated below;

i. To what extent is the availability of essential activity spaces that aid timely response?
ii. What is the effect of fire station design on the response time of firefighters to emergencies?
iii. To what extent does the fire station has complied with the adjacency planning concept of fire station design?
iv. What is the effect of the adjacency of spaces on turnout time?

Research Population:

Four fire stations were studied. Three of which are situated within the country and the fourth one is a foreign fire station.

Equipment Used in Gathering Data

Measuring Tape

Sketch pad

Sony digital camera

Garmin Gps

Sampling Technique and Size:

The 36 staff of the Adamawa state fire service was issued questionnaires. Systematic sampling was employed in choosing appropriate case study facilities for this research, the main study area (facility) being Adamawa state fire service headquarter, two other fire stations where chosen, one from the north and the other from the south, both of which are state headquarter stations. These stations were chosen because they were specifically built fire station and not converted buildings.

Table 1: Private Owned Fire Station

S/N	Location/ name of unit
1	Modibbo Adama University of Technology Yola Fire Service Unit
2	American University of Nigeria Fire Service Unit
3	Adama Beverages Limited Fire Service Unit
4	Savannah Sugar Company Fire Service Unit
5	Afcot Nigeria Limited, Ngurore Fire Service Unit

Source: Author's survey (2018)

Procedure and instrument for data collection

A total of 36 questionnaires were administered to the staff of Adamawa state fire service headquarters, Table 2 shows a tabular representation of the distribution. The Table shows that out of the 36 questionnaires administered 4 were not returned which forms about 11.1% of the total administered questionnaires. A total of 32 questionnaires were filled and returned forming 88.9% of the total administered questionnaires.

In a bid to investigate the user's opinion on the adjacency relationship of spaces in the fire station and how it affects their turnout time the following questions were asked;

i. Does the fire station have sufficient office spaces?
ii. Does the working environment affect your turnout time?
iii. Does the office arrangement positively affect your turnout time?
iv. Does the arrangement of offices within the station follow the response sequence?
v. Do persons who come in to report fire incidences to locate the control room easily?

And the result of this study will be presented below in tabular form.

Methods of data analysis

The instruments used in analysing the primary data for this study is a structured questionnaire and the observation schedule (checklist), the first check for adjacency of spaces in the facility while the second check for availability of essential activity spaces and the travel distance between key activity spaces.

The structured questionnaire was issued to 36 respondents by the researcher and the completed questionnaires were retrieved and analysed. Percentages of their response were taken and discussed. A checklist was used to investigate the availability of essential activity spaces in the fire station while the arithmetic mean of the travel distances between key activity spaces was calculated to ascertain the average distances between them.

The formula for calculating mean;

The arithmetic mean, denoted x, of a set of n numbers x_1, x_2, …, x_n is defined as the sum of the numbers divided by n:

$$X = \frac{x1 + x2 + \cdots xn}{n}$$

The arithmetic mean (usually synonymous with average) represents a point about which the numbers balance.

Research limitations

The study is limited to fire crew response time in a fire station.

Study Area: Adamawa state

Adamawa state is located at the eastern part of Nigeria, it lies between latitude 7 and 11N of the equator and between longitude 11 and 14 east of Greenwich meridian. It shares boundary in the south and west with Taraba state and in the northeast with Gombe while in the north it bordered Borno. Adamawa state was created from the defunct Gongola state on August 27, 1991. Jimeta is representing the administrative capital while Yola is the principal capital in Filibus, 2011 as cited in Ayoosu, (2016).

According to Adebayo & Tukur, (1999) as cited in Ayoosu, (2016). Adamawa has a monthly mean sunshine hour of 220hrs between January to April, there is a decline in sunshine hours between May and September due to increasing cloudiness over the state. The average mean sunshine is 8.3hrs. The mean temperature of Yola range from 26.7-27.0 degree Celsius. The relative humidity is extremely low (20%-30%) and it starts to increase from April and reaches 80% in August and September. More so, its start to decline as from October due to the cessation of rain.

The state's road system is limited. Yola, the site of Modibbo Adama University of technology, is served by an airport, and the Benue River allows for river transport. The population of Adamawa state as at the 2006 census was 3,168,101(Adamawa. 2010).

III.RESULTS AND DISCUSSION

Objective 1; Availability of essential activity spaces that aid timely response.

To investigate the adjacency of office space and its relationship to turnout time, there is a need to know if there are adequate numbers of office spaces within the station. The results from the question "does the fire station have sufficient office space" showed that 6.3% of the respondents are of the opinion that the available office spaces are adequate for the efficient operation of the fire station while 90.6% of the respondents disagreed with their opinion. 3.1% of the respondents were indecisive on the question.

Therefore Table 3 shows that the Adamawa state fire service lacks sufficient space for her operations.

Table 2: Analysis of Distributed Questionnaire to Adamawa State Fire Service

Variable	Total responses	Percentages
Number of distributed questionnaires	36	100
Number of copies not returned	4	11.1
The number of copies completed and returned.	32	88.9

Source: Author's work (2018)

Table 3: Does the Fire Station Have Sufficient Office Spaces

Variable	Number of respondents	% of respondent
Yes	2	6.3
No	29	90.6
Undecided	1	3.1
Total	32	100

Source: Author's work (2018)

Objective 2; Effect of fire station design on the response time of firefighters to emergencies

The table 4 shows that 53.1% of the respondents believe that their working environment affects turnout time, while 28.1% of the respondent is of the opinion that nature of the working environment does not affect the turnout time. 18.8% of respondents were indecisive.

It can, therefore, be said that the nature of their working environment contributes to the delay during turnout, the better the work environment the quicker their response to an alarm and other turnout activities.

Table 5 investigates the adjacency of offices and how it affects turnout time. The table showed that 25% of the respondents agreed that office position affects their turnout time positively while 59.4% are of the

opinion that the office arrangement negatively affects their turnout time. About 15.6 % of respondents were indecisive.

Therefore office arrangement contributes to delay in turnout time, the better the arrangement the quicker the turnout time which is the goal of any firefighting unit.to keep the city clean by informing about the garbage levels of the bins by providing graphical image of the bins via IOT Php web development platform.

Table 4 : Does the Working Environment Affect Your Turnout Time

Variable	Number of respondents	% of respondent
Yes	17	53.1
No	9	28.1
Undecided	6	18.8
Total	32	100

Source: Author's work (2018)

Table 5 : Does the Office Arrangement Positively Affect Your Turnout Time

Variable	Number of respondents	% of respondent
Yes	8	25
No	19	59.4
Undecided	5	15.6
Total	32	100

Source: Author's work (2018)

Objective 3; Extent to which the fire station has complied with the adjacency planning concept of fire station design

Table 6: sought the respondents' opinion on office arrangement and response sequence, the result showed that 21.9% believed that the office arrangement in the station followed the response sequence while 71.9% are of the opinion that the office arrangement does not correspond to the response sequence. 6.2% of the respondents were indecisive on the matter. Using the highest percentage it can be said that the arrangement of offices in Adamawa state fire service those not follow their response sequence and this is a major cause of delay during the response.

The first point of call during run-in calls in Adamawa state fire service is the control room, the ability to locate the control room by complaints (victims) in good time will quicken the total response time.

Table 6: Does the Arrangement of Offices within the Station Follow the Response Sequence

Variable	Number of respondents	% of respondent
Yes	7	21.9
No	23	71.9
Undecided	2	6.2
Total	32	100

Source: Author's work (2018)

Table 7 investigates the ease in locating the control room, 34.4% of the respondent are of the opinion that the control room can be easily located while 50% believe complainants have difficulty locating the control room without aid. 15.6% were indecisive.
It can be said that there is difficulty in locating the control room in Adamawa state fire service headquarters without aid.

Table 7 : Do Persons Who Come into Report Fire Incidences Locate the Control Room Easily

Variable	Number of respondents	% of respondent
Yes	11	34.4
No	16	50
Undecided	5	15.6
Total	32	100

Source: Author's work (2018)

Case Study One; Adamawa State Fire Service Headquarters – Jimeta

Appraisals

- Merit

i. Available space for future expansion of the fire station.
ii. Adequate lighting of spaces using natural lighting.
iii. Adequate circulation space

- Demerit

i. The control room/dispatch is far away from the main gate thereby increasing the run-in call time.
ii. The apparatus bay is far away from the main gate, thereby increasing turnout time.
iii. the driveway is unpaved making driving difficult and increasing the turnout time
iv. The long distance between different activity spaces (poor adjacency).
v. Inadequate activity spaces such as day room, dormitory.

Case Study Two; Taraba State Fire Service Headquarters- Jalingo

Appraisal

- Merit

i. The apparatus bay is very close to exit (gate).
ii. A watchtower is available for sighting fire incidence in the community.
iii. Adequate circulation space within the station.
iv. Available space for future expansion.

- Demerit

i. There is a long distance between apparatus bay and administration block (control room) thereby increasing dispatch time.
ii. There is long a long distance between the entrance and the administrative block (control room) thereby increasing the run-in call time.
iii. The driveway is unpaved making driving difficult and increasing the turnout time.
iv. Inadequate activity spaces such as day room, dormitory.

Case Study Three; Anambra State Fire Service Headquarter

Appraisals

- Merit

i. Well landscaped and paved compound.
ii. Minimal distance to fire engines from the watch room.
iii. There is proximity between the watch room and crew captains office.
iv. Adequate access and exit into the site (no obstruction)
v. Drive-thru apparatus bay to enhance circulation and avoid reversing the fire engines.
vi. Adequate size of apparatus bay for any type of fire engine.

- Demerit

i. No space for future expansion.
ii. The long distance between the watch room and communication room.
iii. Inadequate lighting of the apparatus bay which will affect the driver when driving from a dark space into a bright space.
iv. No sliding pole to reduce travel time from the first floor to the apparatus bay

Case Study Four; Joplin Fire Station No. 6, Joplin, Missouri

Appraisals

- Merit

i. Provision of drives through apparatus bay to enhance circulation.
ii. Provision of physical fitness facility for firemen fitness which also enhances alertness.
iii. Provision of a clean working environment for staff motivation.
iv. Provision of space for future expansion

- Demerit

i. No training facility provided in the station.
ii. No adjacency between dormitory and apparatus bay this will increase response time.

Activity Space Problems from Case Studies 1, 2 and 3

The result of Case studies carried out in three different facilities to assess the availability of necessary infrastructure to enhance service delivery.

Apart from apparatus bay, control room, administrative office, and convenience spaces one

activity space or the other are missing in these three fire stations studied. Fitness room/ gym which is a very essential activity space in a fire station is not provided in any of the fire stations studied, therefore, the firemen lack physical exercise which is a key to mental and physical alertness.

Day room is a space in which firemen wait for fire alarm, but in these fire station studied non had a day room which means that the firemen on duty will have to hang around in any space available until they are called upon during an emergency, depending on the location of each firefighter during an emergency the crew will have to wait for the last man to arrive before attending to the call.

The inadequacies prompted by the unavailability of essential activity spaces contribute negatively to the total response time of these fire stations, see Table 7. The average distance covered during run-in call in Nigeria fire station is about 73.3meters, an average plot size in Nigeria is about 15m x30m which means that during run-in calls complaints have to cover the about $2\frac{1}{2}$ plots within the station to report an emergency.

Watchtower	Not available	Available	Not available
Sleeping rooms	Not available	Not available	Available
Administrative Offices	Available	Available	Available
Fitness room/Gym	Not available	Not available	Not available
Welfare office	Not available	Not available	Available
Day room	Not available	Not available	Not available
Kitchen /dining	Available	Not available	Not available
Laundry	Not available	Not available	Not available
Emergency response center	Not available	Not available	Not available
Conference room	Not available	Not available	Not available
Test/reading area	Not available	Not available	Not available
Maintenance	Available	Not available	Available

Source: Author's survey (2018)

Table 8 : Availability of Necessary Infrastructure in Nigeria Fire Station

Activity Space	Adamawa state fire station (Built 1976)	Taraba state fire station (Built 2006)	Anambra state fire station (Built 2010)
Appliance base/apparatus bay	Available	Available	Available
Control room/ communication room	Available	Available	Available
Lecture room/training	Available	Not available	Available
Dressing room	Available	Not available	Available
Maintenance	Available	Not available	Available
Convenience	Available	Available	Available

The average distance between the apparatus bay and exit of the premises is about 36.3m. Also, the fire engine will travel an average of 36.3m from the apparatus bay to exit the fire station premises, this also adds to the total response time of the fire station. If this distance is reduced to the minutes it will reduce the turn out time of the fire-fighters, see Table 9.

Table 9 : Travel Distance between Activity Spaces (Adjacency)

A distance between key activity spaces	Case study one (Adamawa state)	Case study two (Taraba state)	Case study three (Anambra state)
Entrance gate to control room	90m	69m	61m

watch room/tower to a Control room	-	50m	33m
Watch room to dressing room	0	-	27m
Dressing room to the apparatus bay	20m	-	2m
Dressing room to store	38m	-	32
Store to the apparatus bay	56m	-	0
Apparatus bay to exit	82m	10m	17m

Source : Author's survey (2018)

Deductions from Case Studies

Case study one

i. Available space for future expansion of the fire station.
ii. Adequate lighting of spaces using natural lighting.
iii. Adequate circulation space.

Case study two

i. Apparatus bay is very close to exit (gate).
ii. A watchtower is available for sighting fire incidence in the community.
iii. Adequate circulation space within the station.
iv. Available space for future expansion.

Case study three

i. Well landscaped and paved compound.
ii. Minimal distance to fire engines from the watch room.
iii. There is proximity between the watch room and crew captains office.
iv. Adequate access and exit into the site (no obstruction)
v. Drive-thru apparatus bay to enhance circulation and avoid reversing the fire engines.
vi. Adequate size of apparatus bay for any type of fire engine.

Case study four

i. Provision of drives through apparatus bay to enhance circulation.
ii. Provision of physical fitness facility for firemen fitness which also enhances alertness.
iii. Provision of a clean working environment for staff motivation.
iv. Provision of space for future expansion

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

IV.CONCLUSION

Summary

The fire has contributed positively to man's development from time immemorial until today, it has transformed virtually every aspect of man's activity. But it also has its own negative aspect; people had lost virtually all they had in a single fire incidence including their life. It is in light of this negative side of fire that the fire service was established to prevent and extinguish fire and other emergencies that threaten the lives and properties of the people.

These fire stations in Nigeria have challenged which result in late response to fire incidence, research shows that if a person has a heart attack (myocardial infarction) and cardiopulmonary resuscitation (CPR) is started within four minutes, the victim's chances of leaving the hospital alive are almost four times greater than if the victim did not receive CPR until after four minutes. Therefore the firemen must arrive within four minutes of a fire incidence if lives must be saved.

This study shows that most fire stations in Nigeria lacks necessary activity spaces which are essential for a timely response such as day room, dormitory/ sleeping area, fitness room, etc and the absence of this spaces cause delay in response time.

It was also discovered that the distance between key activities spaces in the fire station contributes to the time lost during emergency response.

Conclusion

In conclusion, quick response fire fighting fire stations are what this nation needs to arrest the late response to fire incidences in the country. Fire stations in Nigeria need improvement in her planning concepts to enhance response time. The study showed that each Nigeria fire station lack one activity space or the other which is essential for a timely response, for example, dormitory, kitchen/dining space, day room, watchtower, etc

Beside activity spaces, adjacency of spaces is a lacking essential factor, time is lost in travelling from the gates of these fire stations to the watch room/dispatch during run-in calls, and time is also lost when firemen have to travel from different part of the station to the apparatus bay to respond to a fire call.

Recommendations

After a careful study of the problems with Nigeria fire stations, the following are some of the recommendations that will help improve response time;

1. Designs of fire station should comply with the adjacency concept to reduce travel time during run-in call, dispatch, and turnout.
2. The dispatch room should be adjacent to the crew head's office to reduce the time spent in the transfer of information, especially when there is an equipment malfunction.
3. Fire stations in Nigeria should be modified to contain a Day room which should be adjacent to the communication center and apparatus bay.
4. It is highly recommended that every fire station in Nigeria should be upgraded to accommodate a comfortable sleeping area for firemen to enable them to work effectively at night and also these sleeping areas should be adjacent to the apparatus bay to reduce travel time.
5. All fire stations should be fitted with physical fitness facilities to keep the officers both physically and mentally alert.
6. Record keeping of time lapse between activities in the sequence that lead to fire extinguishing or rescue services. This will help uncover activities that cause a delay in the sequence.
7. The template for fire station design as shown in figure 6 and 7.

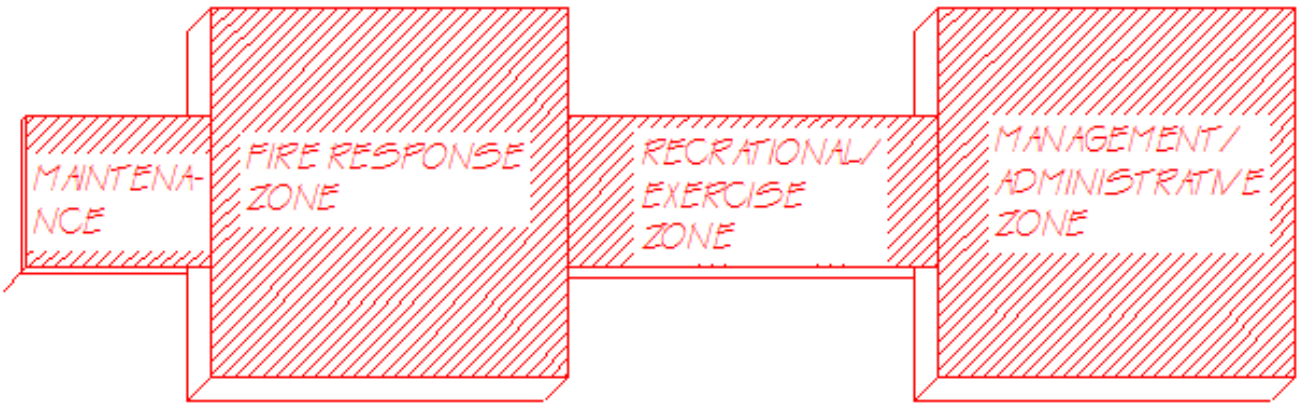

Figure 6: Zoning Template
Source: Author's work (2018)

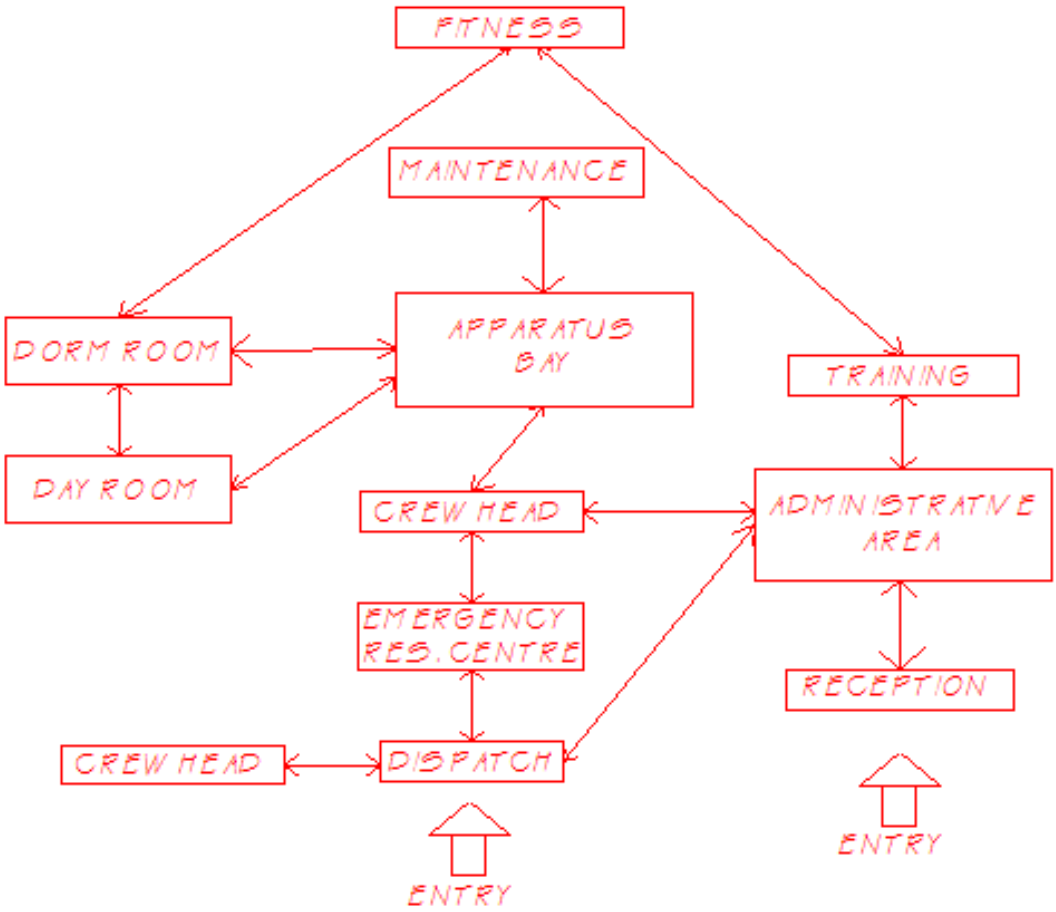

Figure 7: Template Flow Chat
Source: Author's work (2018)

Further studies are required due to the constraints encountered and scope of this study especially in the area of 'Access' and 'Setting up' stages of fire fighting. Detailed study of this aspect of fighting activity will help discover time-wasting activity and help proffer solutions that will at the end of the day improve the whole response time of fire-fighters.

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