Journal of Architecture and Construction
Volume 1, Issue 3, 2018, PP 25-33

Crowd Control in Public Building Designs: Current Trend and Strategies for Ecclesiastical Buildings in Abuja, Nigeria

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ABSTRACT

Generally, every public building design requires the consideration of the interaction of people with each other and the space to ensure the user's safety. Observations have also shown that conglomeration of a large number of individuals per space often times proved a potential circulation threat. This factor thus necessitates measures to manage and control the movement of people around and within public building as well as catering for emergency evacuation of the crowd. A major challenge to achieving this is observed in places of worship in Nigeria with two major religions. This paper aims to assess the practices in measures for passive crowd control design with emphasis on design for crowd evacuation in large capacity ecclesiastical buildings in Abuja, Nigeria. The objective is to enhance safety and security through improved design of ecclesiastical buildings to better cope with a large crowd in extreme events. The methodology being descriptive survey method are founded on extensive literature review, observation of specific features and physical measurement of elements being evaluated in the buildings. Findings from this study highlight the deficiency in ecclesiastical building design, develop design strategies for direction in crowd control and make recommendation to improve design for safety and security during events and emergency in such public places. The paper concludes the need to develop guidelines for designing ecclesiastical buildings in Nigeria with specificity for crowd control whilst recommending that due attention be given to the adequate proportion of occupants to an area of space to avoid crowd congestion or constipation.

Keywords: *crowd control, ecclesiastical buildings, emergency evacuation, extreme events.*

INTRODUCTION

Ecclesiastical buildings are public buildings as well as religious buildings that are built to domicile Christian worshippers as they congregate for the said purpose. From its beginning, a critical part of Christianity has been the gathering of people worshipping together. By virtue of this activity, the "place" where they worship has become endowed with a symbolic form (Wardell, 2004). A major challenge being posed to designers of large capacity structures is their ability to control the circulation of the users of such spaces due to the enormity of the crowd required to utilize the structure per time. The fundamental principle for safety in built environment is to ensure that the occupants in a building are safe during emergency events as well as the normal conditions.

The contributions of architects for disaster management can have various approaches from producing short-term solutions to long term actions for future developments such as building new disaster resistant buildings or rebuilding damaged structures after the formal assessment of damage in the built environment (Brown and Downey, 2006). Improvements in building construction and services need to be supported by an efficient building layout design based on the interrelations of functions in the building, circulation, and occupant characteristics to mitigate the impacts of extreme events on people (Sagun *etal.*, 2014).

Nigeria, being well known for their zeal to religious activities, and having two major religions (Christianity and Islam) with Christians summing up to about 40% of the total country's population according to Pew Research Centre, are often posed with potential crowd disasters in their Christian gatherings. Due to the ever increasing population of membership of denominations, it becomes more difficult to solve existing challenge of crowd movement. In

addition to that, due to recent terrorist attacks on church buildings in northern Nigeria, there is a need to review emergency evacuation parameters in existing church buildings to ensure optimum design considerations for crowd evacuation.

Evolution of Ecclesiastic Architecture

Wardell (2004) gave a timeline evolution of church architecture highlighting the peculiarity of each of the periods.

The House Church (from AD 30): To the early Christians the word "church" referred to the act of assembling together rather than to the building itself. As long as Christianity was unrecognized by the Romans, Christians met where they could, mainly in their own homes.

The Basilica (4th century AD): As the church began to grow, the was need for expansion of their house church meetings or the development of an entirely new structure to meet their current population standard, s thus there was the inception of new architectural style called the basilica which was a more formal worship structure.it gave emphasis to interior lightings and ornamentation.

The Monastery (344-800AD): with the fall of the roman empire and the rise of Christianity, the influences of the roman architectural philosophy on church architecture waned off and was replaced by a more spiritually expressive design concept. The architecture of this period clearly and coherently express that order. The new civic order, was founded upon and integrated with Christian values; it was, at once, grounded and spiritual. The town is an extension of the monastery and, as such, it manifests the Christian inward focus: it is a self-sufficient and walled entity with the church as its core.

Gothic and Romanesque Church Architecture (800-1450 AD): Where previously the dome at the crossing had represented the revelation of God in a discrete location, in Romanesque and especially Gothic cathedrals that revelation is symbolized by a verticality that is extended into the entire nave. Clerestory windows and vaulted ceilings intensified the connection to the sky and de-emphasized the material presence of the building. In the Gothic cathedral, God's presence is immediate and, through the cathedral, He communicates very directly with mankind.

Renaissance Church Architecture (1400AD): In this age of investigation and discovery, men sought to integrate a realistic approach to nature with an idea of divine cosmic order. As in other ages the church sought to represent this search in the architectural expression of their building. Interior and exterior space was clearly defined and design of these areas was carved out with an emphasis on mathematic geometry, a symbol of man's reason expressing God's order. The town itself was similarly conceived with an organization gathered around a central piazza. From this place, an orientation was established that could locate the major streets and public buildings of the town the church occupied. The church, as one of these major points, however, shared its pre-eminence with important civic structures of the community.

Modern/Contemporary Church Architecture (1972 to present): the modern and contemporary church buildings are upshots of the modernist and postmodern architecture. The modern church style employs an architectural form hinged on a basic shape, with facades consisting of reinforced concrete material ornamented for aesthetic purpose. The entire outlook of the church carries the basic features of a quintessential church structure existing at that time. the post-modernist idea on the design of a church structure on the other hand employs the use of visually light materials such as the glass facades, contemporary façade finishes such as titanium etc.

The Concept of Crowd Control

The term 'crowd control' literally means measures put in place to keep crowd orderly. This definition however does not specify the approach or method adopted in the quest to keep crowd orderly, whether actively or passively. Passive crowd control design is the integration of architectural elements features and principle to control crowd in both normal and extreme (emergency) conditions (Winter, 2012).This definition highlights two distinct situations that warrants passive crowd control design measures: normal and emergency conditions.

Crowd control during normal conditions are meant to incorporate features required for crowd comfort, restriction of crowd from unwanted positions, ease in circulation, while emergency conditions focuses on features responsible for crowd evacuation within the shortest possible time. According to Maslow's hierarchy of needs, safety and security constitute the second

level of human needs after physiological needs, hence more attention is required to be given to passive design measures necessary to achieve crowd safety. Winter (2012) identified two major factors that contributes to the evacuation of people in public space namely building design and the behaviour of crowd in times of emergency.

Historical Occurrence of Crowd Disasters

Crowd disasters have been quite a common occurrence in different parts of the world. below are a few accounts of crowd disasters that have occurred in a descending order of occurrence.

In the year 2017, eight people were killed and 60 seriously injured in a stadium crush in DembaDiop stadium in Senegal. (Al Jazeera, 2017).

In 2016, at least 52 people were killed during a thanksgiving festival in Ethiopia from human stampede (BBC news, 2016).

In the year 2015, no fewer than 19 people died after a stampede that occurred in a football match in Cairo Egypt. (Maher H, 2015)

In the year 2014, Tragedy occurred when about 16 to 24 recruits were killed and more than 119 were injured at several stadiums and other centres across the country of Nigeria. In many security forces fired their rifles to the air causing panic and leading to stampede. (Newswatch Times, 2014)

In the year 2013, 10 people were killed and 120 injured in Launda, Angola, when they tried to enter the Estadio da Cidadela for a new year's eve vigil that was already overcrowded. (BBC news, 2013)

Crowd Density

Crowd density is the level of concentration of people in a given space it can be mathematically said to mean the number of people per unit area of a space. Crowd density is a vital factor in circulation crowd as well as emergency evacuation of crowd during extreme conditions. Standards have been put in place as to the maximum number of people required in a space. According to events management book, the standard crowd density for a seating crowd is 1person per square meter (1 per/sqm). However, determining the right crowd density for a space goes beyond adhering strictly to these standards, the architects and engineers have to make extrapolations as to other factors affecting crowd evacuation of the space designed for and possible run a simulation test.

Crowd Dynamics

Crowd dynamics is the study of the movement of people: how, when and where crowds are formed and how they move. The behaviour of people may be affected by the conditions of their immediate environment as a result of interactions with the space and the behaviour of the other people. There may be spreading over the space in large environments and compression of groups of people in small spaces. The density of the surrounding crowd affects the speed of each person and individual behaviours due to personal characteristics and their response to environment can be included to modify the locomotion (Lo*et al.*, 2002).Moreover, the behaviour of crowds show different characteristics compared to individual behaviours and the behaviour of people during disasters differs from that of normal conditions. People do not like interruptions and interference with their activities and lives, so they would follow routines and see warning s as an "exercise" ignoring the signs in order to continue with their normal behaviour when they face d with a disaster (Boer and Skjong, 2001). After an emergency alarm, occupants may perform various actions such as searching for something/someone around, warning other people, etc. before moving to escape routes. During unexpected events, the attention of people increases, however expectations can direct them to use less than the available information (Weick andSutcliffe,2001). Decisions by users of the space are based on their current knowledge which may be limited or incorrect.

Crowd management

Crowd management is the process of controlling the behaviours of large groups of people for their safety and security. It involves planning, organization, guidance and evaluation activities (Sagun *et al.*,2008). Crowd safety and security in public areas are primarily the organiser's or operator's responsibility. A health and safety management system is required to monitor and control potential crowding risks in public areas. The four interacting elements that need to be put into consideration to minimize injuries and death during crowd situations are defined as: time, space, information and energy by Fruin(1984). He explained time as the period of crowding; space as the layout and size of the occupied area; information as the perceptions of

the people in the crowd to take some group action; and energy as the pressures created by the mass of people that can cause accidents and death. Within this context, crowd management considers the elements of events where crowds are involved dealing with the facility, size, behaviour of the crowd, means and routes of entrance and exits, communication, jamming and queuing. Another fact observed from the crowd incidents is that different types of crowds behave in different ways during disasters. It is essential to have information on different types of occupy ants (in terms of age, sex, abilities, etc.) to anticipate the problems. For instance, violent behaviours of fans can be a potential risk in sports venues, trying to evacuate people in a residential building during sleep time can slow down the rescue process.

Basic Crowd Control Design Measures in Large Capacity Buildings

As afore said, safety of crowd in large capacity buildings is of high importance. The requirements for crowd safety in large capacity buildings conflict with those required for security, as the initial seeks to increase modalities for ease in movement while the latter seeks to restrain and monitor movement (Billington*et al.*, 2002). Thus proper synergy between security and safety has to be achieved to ensure a logical balance. According to Daoliang*et al.*,2006 and Helbing *et al.*, 2002 the three most important factors that can cause reduction of evacuation time in large capacity buildings are the placement and width of exits and the placement of environmental objects. Sagun*et al.* (2008) enumerated the design variables to consider when addressing the issue of passive crowd control.

1. Size and capacity of the building
2. Characteristics of entrance to the building
3. Building layout.
4. Number of routes and doors
5. Dimension of the routes and doors

Research Methodology

Descriptive survey method was used on the selected church buildings in Abuja. Owing to the fact that the variables for evaluating passive control design measures are physically measurable variables, observation schedule was used which also involved the physical measurement of linear variables (length, breadth, depth). A total of 10 samples were selected from a study population of 447 churches using stratified purposeful sampling method which according to Palinkas (2013) will provide variation in the sample selected bringing to bear some specific features the researcher wishes to observe in the selected population sample. In this vein the criterion for selection of samples is the seating capacity of the churches, choosing a minimum requirement of 1000 seating capacity for the selection of samples. This was to afford the researcher a wide range of passive crowd control design features required to be evaluated. It is also noteworthy that no 2 churches were selected from the same denomination as this stratified sampling technique afforded the researcher a variety of design typologies as are obtained from the different samples selected.

Table1. *Churches studied*

	Name of churches
1	National Ecumenical Centre,Central Area, Abuja
2	Champion's Royal Assembly, Chikakore, Abuja
3	Holy Trinity Catholic Church Maitama Abuja
4	Living faith church Dutse, Abuja
5	Redeemed Christian Church of God Kubwa, Abuja
6	ECWA Blantire, Wuse, Abuja
7	St Bartholomew Anglican cathederal, kubwa, Abuja
8	Common Wealth of Zion Assembly, Guzapei Hills Abuja
9	First Baptist Church Garki Abuja
10	Dunamis International Gospel Centre, Area 1, Abuja

Result and Discussion

Capacity of Church Building

Capacity of the space has a strong influence on the crowding (Fruin, 1993) and bottlenecks because as Casburn*etal.*,(2005) stated that people spread out when there is enough space to avoid collisions and they bunch up without intersecting at bottlenecks. The capacity of an enclosed space is the first factor to consider when designing for crowd control.

Table2. *Capacity of Church Building*

s/n	Name of church	1000-2500	2501-5000	5001-10000	10001-20000	Above 20,000
1	National Ecumenical Centre Abuja		✓			
2	Champion's Royal Assembly, Chikakore, Abuja					✓
3	Holy Trinity Catholic Church Maitama Abuja		✓			
4	Living faith church dutse, abuja		✓			
5	Redeemed Christian Church of God Kubwa Province	✓				
6	ECWA Blantire, Wuse	✓				
7	St Bartholomew Anglican cathederal, kubwa		✓			
8	COZA Guzapei Hills Abuja		✓			
9	First Baptist Church Garki Abuja	✓				
10	Dunamis International Gospel Centre, Area 1, Abuja		✓			
	Percentage(%)	30%	60%			10%

Number of Seats Per Seat Clusters

Large capacity auditoriums arrange their settings in smaller clusters with aisles between them for circulation. The smaller the capacity of such seating clusters, the more circulation spaces are created and the less congestion is likely to be experienced.

Table3. *Number of Seats Per Seat Clusters*

s/n	Name of church	Below 25	25-50		51-75	76-100	Above 100
1	National Ecumenical Centre Abuja	✓					
2	Champion's Royal Assembly, Chikakore, Abuja		✓				
3	Holy Trinity Catholic Church Maitama Abuja			✓	✓		
4	Living faith church dutse, abuja			✓	✓		
5	Redeemed Christian Church of God Kubwa Province					✓	
6	ECWA Blantire, Wuse			✓	✓		
7	St Bartholomew Anglican cathederal, kubwa		✓				
8	COZA Guzapei Hills Abuja					✓	
9	First Baptist Church Garki Abuja					✓	
10	Dunamis International Gospel Center, Area 1, Abuja						✓
	Percentage(%)	10%	20%		30%	30%	10%

Average Crowd Density Per Seating Cluster

Crowd density shows the extent of concentration of a population per space. This is a derivative of dividing the number of seats in a cluster by the floor area of that cluster. According to Emergency Planning College Handbook, standard Crowd density for people seating is 1 person per square. meters. 47 people per 10 square meters for people standing and 10-15 persons per 10 square meters for easy circulation of people. This is also regarded as critical mass. A value which if exceeded, poses a potential threat to the safety of the occupants of that given space.

Table4. *Estimated Average Crowd Density Per Seating Cluster.*

s/n	Name of church	1 head and below per m^2	3 heads per $2m^2$	2 heads per m^2	3 heads per m^2
1	National Ecumenical Center Abuja			✓	
2	Champion's Royal Assembly, Chikakore, Abuja			✓	
3	Holy Trinity Catholic Church Maitama Abuja				✓
4	Living faith church dutse, abuja			✓	
5	Redeemed Christian Church of God Kubwa Province		✓		
6	ECWA Blantire, Wuse			✓	
7	St Bartholomew Anglican cathederal, kubwa				✓
8	COZA Guzapei Hills Abuja			✓	
9	First Baptist Church Garki Abuja				✓
10	Dunamis International Gospel Center, Area 1, Abuja			✓	
	Percentage(%)		10%	60%	30%

Emergency Evacuation Rate of Auditorium Per Time.

This analysis is an extrapolation of the obtained data (entrance/exit and capacity of the auditorium.) to derive the emergency evacuation rate of the building per unit time.

Table5. *Emergency Evacuation Rate of auditorium Per Time.*

s/n	Name of church	Capacity of church auditorium	Available exit width	Number of doors provided	Total entrance/exit width(m)	Carrying capacity of entrance/exit (no of persons per unit time)	Ratio of capacity of church to capacity of entrance per unit time
1	National Ecumenical Center Abuja	8000	1800(8),1500(12)	20	32.4	40, (16,24)	1:200
2	Champion's Royal Assembly, Chikakore, Abuja	80000	1500(12),1100(6)	18	24.6	30, (24,6)	1:2667
3	Holy Trinity Catholic Church Maitama Abuja	3000	1500	12	18.0	24	1:125
4	Living faith church dutse, abuja	2000	1800	6	10.8	12	1:167
5	Redeemed Christian Church of God Kubwa Province	1200	1800	4	7.2	8	1:150
6	ECWA Blantire, Wuse	2000	1800	6	10.8	12	1:167

7	St Bartholomew Anglican cathederal, kubwa	1500	1800	5	9.0	10	1:150
8	COZA Guzapei Hills Abuja	2000	1500	4	6.0	6	1:333
9	First Baptist Church Garki Abuja	1500	1500	3	4.5	6	1:250
10	Dunamis International Gospel Center, Area 1, Abuja	1800	1200(7), 900(2)	9	10.8	9	1:200

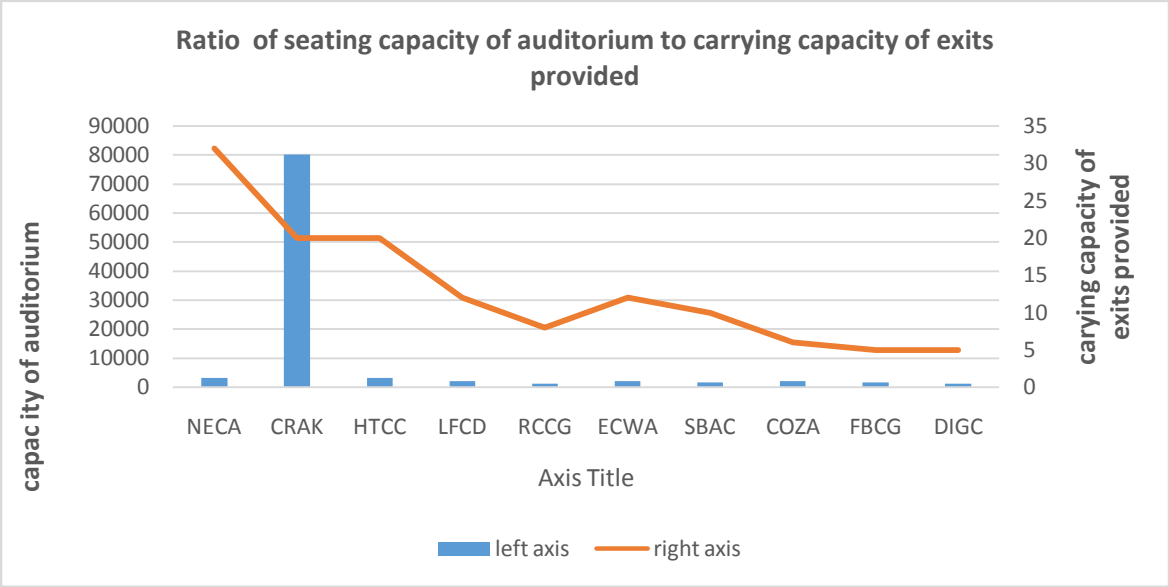

Figure1. *Chart showing the ratio of seating capacity of church auditorium to the carrying capacity of exits provided.*

Results of this analysis shows the ratio of capacity of the church auditorium to the carrying capacity of the accesses (entrance and exit doors) provided.ie for the national Christian centre, for the first person exiting the building during emergency evacuation, there is a potential queue of 200 people waiting to use the same exit if assumptions for even distribution of persons per exits are made. This gives a projection of what is likely to occur during emergency evacuation the church auditoria evaluated in their full capacity.

Fig 1 comparatively illustrates the ratio of the church capacity to the total carrying capacity of the exits provided per time.

Presence of Obstructions at movement path

The presence of elements that constitute obstructions at movement path is an inhibitor to the optimum circulation and emergency evacuation of crowd. Winter (2012) opined that placing a column at the exit point of building is a counter intuitive measure that could increase the perceived danger of an individual, which could lead to more danger than if there was no column at all.

Table6. *Shows the presence of obstructions along movement path*

s/n	Name of church	present	absent	Nature of obstruction
1	National Ecumenical Center Abuja	✓		Structural column
2	Champion's Royal Assembly, Chikakore, Abuja	✓		Structural column
3	Holy Trinity Catholic Church Maitama Abuja	✓		Structural column
4	Living faith church dutse, abuja		✓	

5	Redeemed Christian Church of God Kubwa Province	✓		Structural column
6	ECWA Blantire, Wuse		✓	
7	St Bartholomew Anglican cathederal, kubwa		✓	
8	COZA Guzapei Hills Abuja		✓	
9	First Baptist Church Garki Abuja	✓		Structural column
10	1 Dunamis International Gospel Center, Area 1, Abuja	✓		Structural column
	total	60%	40%	

It is noteworthy that the movement obstruction constituted by the structural columns supporting the galleries was not their presence but their location or positioning with respect to circulation aisles.

Conclusion and Recommendation

In adequately solving the problem of crowd control in large capacity public buildings, integrated approach needs to adopted. The evaluation conducted in this research was mainly on the existing features and parameters used in the design of the church auditoriums so assessed. The variables appraised were such influencing passive crowd control design and design for emergency evacuation of crowd. Findings from the evaluation conducted in this research provides a rationale for the following recommendations:

There is need for the designers of large capacity spaces to do an adequate appraisal on the capacity of seating clusters the church auditorium as this is a key factor that influences the level of crowd congestion in the aisles as well as the success of emergency evacuation of crowd during extreme situations. Also, for effective crowd circulation and emergency evacuation, the required crowd density for a given space has to be calculated while determining the capacity of a church auditorium and known so as to avoid potential congestion. Priority should be given to crowd safety over space maximization when determining the type of seats to be specified for large capacity buildings. From the researcher's observation, the pew seating type are the ones likely to be overloaded because there is no demarcation on them. Thus, seating arrangement should be properly monitored to prevent overcrowding. Attention should be given to the positioning of permanent design elements that could constitute movement obstruction of people especially during emergency evacuation of crowd. Findings from this research revealed that the major source of movement obstruction is from the positioning of the structural columns supporting the suspended gallery floors with respect to the circulation aisles. Thus, there have to be a synergy between structural design and interior design/furniture specification and arrangement.

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