Advances in Research
4(5): 304-314, 2015, Article no.AIR.2015.085
ISSN: 2348-0394

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An Appraisal of Sacred Spaces in Terms of Inert Strategies; a Case of Bantama, Kumasi

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Authors' contributions

This work was carried out in collaboration between all authors. Author CK designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author SOA managed the literature searches, analyses of the data collected and author CE managed the general makeup of the paper as well as the schematic diagrams. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AIR/2015/16711
Editor(s):
(1) Shi-Hai Dong, Department of Physics, School of Physics and Mathematics, National Polytechnic Institute, Building 9, Unit Professional Adolfo Lopez Mateos, Mexico.
Reviewers:
(1) Yusuf Ates, Construction and Technical Works, Süleyman Demirel University, Turkey.
(2) Zita Sampaio, Dep. Civil Engineering, University of Lisbon, Portugal.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=971&id=31&aid=8560

Case Study

Received 11th February 2015
Accepted 2nd March 2015
Published 23rd March 2015

ABSTRACT

Sacred buildings like other types of buildings have to communicate to their users. Users must be comfortable and relate to the spaces provided in a positive way. When buildings are designed to respond passively to their climate, occupants feel comfortable and energy is conserved. The current paper surveys 11 churches within the Bantama locality of Kumasi. Against the background of the immense shortage of energy in Ghana, the study aimed at ascertaining whether these buildings conform to passive design strategies.
In terms of orientation, the study revealed that only 45% of the churches were correctly oriented (longer sides facing the North-South orientation). Window to wall ratio also showed that out of the churches evaluated only one church fell within the range of 25 to 80% as recommended for buildings in the tropics. It was also recognized that these buildings did not have enough shading and as a result, there was a direct solar penetration into the indoor spaces causing visual and thermal discomfort. Adherence to sustainable design principles must be encouraged.

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Keywords: Sacred architecture; orientation; windows; passive.

1. INTRODUCTION

Today, church buildings come in so many variations, illustrating religious thoughts through form, typology and orientation. The increase in the number of church buildings, vis-à-vis the current energy demands, affords architects a great opportunity to efficiently design buildings using sustainable design strategies. That is contribute minimally to greenhouse gas emissions, offer thermal comfort and health to occupants as well as designs that consider the environmental impact throughout the entire life cycle of a building. The structure of a religious building is a function of the faith itself [1]. The idea of sacred spaces moves us to a reflective thought and gets one filled with deep emotions. There is therefore the demand for much respect and accolade once one gets to experience such spaces. Religiously, Christians make reference to the Holy Bible which quotes (Exodus 3:5 [RSV]) “Do not come near, says God to Moses; put off your shoes from your feet, for the place on which you are standing is a holy ground” [2]. [3] similarly believes that many religions associate sacred spaces with their founders’ lives and acts, and feel that their most sacred spaces represent the centre of the universe which needs to be treated with respect. Other religions; Judaism and Islam all share this attitude, albeit in different ways. Consequently, places of worship are sacred and as such, much respect and recognition is expected from individuals when they experience such spaces.

According to [4], the word Orientation comes from “oriens”, the East, thereby “Orientation” means “east-ing,” turning towards the east liturgically. Religiously, sunlight has been a major influence in the orientation of church buildings [5]. The natural light and the direction of illumination of the altar of a temple influence the choice of orientation of such buildings [5]. [5] further explains the reason by making known the importance of the altar as a place where the church Priest stays and performs all Holy ceremonies and as such, proper illumination of such spaces should be fulfilled. Generally speaking, according to Patrologia Greaca (4th century AD) the recommended orientation for a church was set by the Holy Fathers to East – West [6]. This symbolizes the entrance of a worshipper from the darkness of sin (the west) into the light of Truth (the east) [6]. This rule is allowed to be violated only if the building had been previously constructed for another purpose, or if services are conducted in a private home, for example when the entrance and main portion was arranged according to convenience [6]. According to the [7], remote antiquity of the traditional belief in the efficacy of religious ceremonials performed at dawn toward the rising sun has influenced the orientation of temples and other sacred structures. In medieval Europe and consequently in modern Europe and the Americas, it became customary to have the congregation and the priest at the altar facing east making it so strong that a custom named as "west front" came to be a generic term for the facade of a church [7]. Similarly, the [8] also defines the sacred way of orientation as the siting of a Christian church so that the main altar is housed toward the east end of the building, and it is seen as a common ritual disposition.

Scientifically, researchers such as [9,10,11,12, 13], have all suggested different ways to orient buildings as there have not been a clear answer to one particular way of orienting a structure. Moreover, a study conducted by [14] on the impact of solar radiation on the facades within a 6 month period in the tropics revealed that the north and south has the lowest sun intensity and this varied from 43.6 W/m^2 and 74 W/m^2 respectively. The eastern and western facades received the highest intensities and this varied between 86.1 W/m^2 and 89.6 W/m^2.Per these results, it could be deduced that the optimized orientation of buildings is to orient away from directions with high solar radiation; hence orientation of elongated buildings to the North-South [11] cited in [15] or to the prevailing wind direction to cool inner spaces was suggested [10].

Juxtaposing the sacred and scientific orientation with regards to solar radiation, day lighting and ventilation, it is evident from the aforementioned studies that a North-South (N.S) orientation receives less solar radiation minimizing total heat gain, thus the cooling demand. Again, such an orientation offers better day lighting levels and reduces glare resulting in increased awareness or concentration. Furthermore, a N-S orientation offers a good fenestration design that allows for natural ventilation.

Form refers to the shape or configuration of a building [16]. Form constitutes primary elements of architecture and is very essential in the design process as it can affect the energy efficiency of a building as well as the thermal sensation of

occupants if not well considered at the early stages of design consideration [16]. According to [17], the shape of a building can have a significant impact on its heating and cooling loads. Church buildings take different forms and shape that sometimes have mystical significance. Though this is a characteristic of sacred spaces, are these forms which define sacredness also energy-efficient; as energy conservation is a major concern in the world?

According to [18], Geometry is thought of as sacred when it is used as a metaphorical bridge in understanding, exploring or representing the nature of consciousness and existence. As such, the application of sacred geometry in association with spiritual idea and the worship of deity can be found in abundance in both ancient and most recent cultures [18]. Against this background, a number of researchers have come out with forms that seek to associate geometry and their interpretation as far as religion is concerned. [19] maintains that the circle or sphere is the basic shape in sacred geometry (most sacred form); for within it, is contained the duality of the human predicament. [20] suggests that Church buildings generally take the shape of rectangle (oblong) as this form is believed to imitate the shape of a ship. The author explains that as ships are under the guidance of a master helmsman and conveys men through stormy seas to a calm habour so the church building form must take as the church guided by Christ carries men unharmed across the stormy seas of sin and strife to the peaceful haven of the Kingdom of Heaven [20]. Other researchers such as [21,22] are however of different opinions concerning the oblong form. [21] believes that the form of a church building should have features common to sacred architecture in most cultures and should reflect some aspect of the Trinitarian God we worship. [22] is also of the opinion that the Cube and Dome are the most sacred and universal forms in architecture and as such this form should influence church buildings as the Cube (square) represents the earth and the Dome symbolizes the sky.

Sustainably, most researchers such as, [17] and [23] have all studied and analyzed different built forms and even generated supposed sustainable and efficient building forms through simulation processes. In that, with their experiments and outcomes, emphasis was placed on building forms whose impact on the environment in general were minimal (i.e. Minimal greenhouse gas emission and utilization of renewable materials and energies). Hence, compact forms tend to minimize the influence of the external environment, thereby ignoring orientation [24]. Further conclusion is made that the more the form of a building is spread out, the larger the surface area exposed to solar radiation [24]. It could be concluded that a compact cube Church building form, is ideal for both sacredness and energy efficiency. It is also important to note that, some other scientific research shows these shapes are also found to be most advantageous in terms of earthquake protection (building safety) [25].

Windows are very important component of the building envelope, in addition to providing physical and visual connection to outside; it also allows heat and light in and adds beauty to the building [26]. In religious architecture, daylight application is tied with a divine concept as their windows are perceived to hold a celestial quality [27]. Proper day lighting in a space for comfort of occupants is a major influence from the window to wall ratio on a façade [28]. [27] conclusion on an experiment undertaken to study the effective Window-to Wall-Ratio (WWR; area of exterior openings divided by total wall area of exterior facade) on church buildings in the tropics (Malaysia) resulted in the following; that any consequent increment in WWR with 0.1 intervals yields 0.5% increase in average daylight factor provided that WWR varies between 10% and 50%. This is suggested as the efficient total WWR of church buildings. [29] from their research also concluded that a range of 25% to 35% WWR is the best and optimum ratio for effective cooling in the tropics after studying office buildings in Malaysia. In spaces that cannot be easily lit, highly reflective surfaces and light redirecting elements could be used to improve the quality of the space [28]. Additionally, [30] study on the Mahoney tables recommends large openings covering 40 – 80% of north and southern wall areas (This is a passive design strategy for buildings in the tropics for comfort), medium openings covering 20 – 40% of wall areas, very small openings covering wall areas greater than 20%. From the aforementioned, it can be concluded that a range of 25% to 80% is considered optimum for an efficient WWR in the tropics, whereby attempts must be made to achieve high WWR for thermal comfort reasons.

Buildings tend to impact the environment negatively if not planned properly by orienting them to minimize energy use. According to [31],

proper building orientation and efficient planning reduces heating and cooling with no increase in cost. In the wake of the current energy crisis in Ghana, coupled with the global need for more sustainable buildings, very little knowledge exist on the impact of passive design strategies on church buildings. To this end, there is the need to add up to the growing knowledge of sustainable buildings as far as religious buildings are concerned. Under the present circumstances, this research sought to investigate into the scientific and sacred means of orienting buildings and the effective window to wall ratios employed.

2. RESEARCH METHODOLOGY

Bantama is a suburb of Kumasi and is at the centre of the Ashanti Region. It is within Kumasi Metropolitan Assembly district [32]. It has surrounding suburbs such as Suntreso, Abrepoand Krofrom. It has a lot of church buildings in a particular locality with different building forms and orientations. The case study approach was used for this research as it provides detailed contextual analysis and entails collection of data from the field. The study area (Bantama) is home to a number of churches, eleven in use, one under construction, and one abandoned (old Rivoli Cinema). All these different churches (13) are located between the Bantama market and Nurses Quarters. In lieu of this, the 11 church buildings within the study area were surveyed. The churches include; The Methodist Church, Pentecost Church, Deeper Life Church, Christ Revival Church, Church of the Lord, Living Christian Global Church, Action Chapel Church, Apostolic Church, St. James Baptist Church, Harvesters Church and Experimental Church of Christ. Fig. 1 shows the location of the various church buildings.

The field work which lasted for six weeks (01 March-12 April, 2014) made use of a compass and a surveyor's tape measure. The compass was used to determine the orientation of respective church buildings. In addition, a measured drawing of the various church buildings was done using Autocad and the surveyor's tape measure was used for taking field measurement (wall lengths, breadths, floor, and façade areas). All these aided the researchers in drawing schematic floor plans and values from the façade measurements were inserted into the equation below to find the window to wall ratio.

$$WWR = \frac{NGA}{GEW} \quad \text{----------equation 1}$$

Where; NGA is Net Gross Area; GEW is Gross Exterior Wall; and WWR is Window to Wall Ratio. Values were then compared to accepted efficient mean WWR obtained by secondary sources. See [33,30,27].

3. RESULTS AND DISCUSSION

The eleven churches in use were evaluated based on their orientations, building forms and the impact from their window to wall ratios. [4,5,6] share the view that a sacred orientation (location of alter and entrance) of a church building is towards East-West axis which signifies the entrance of a worshipper from the darkness of sin (the west) into the light of truth (the east). Also for scientific orientation

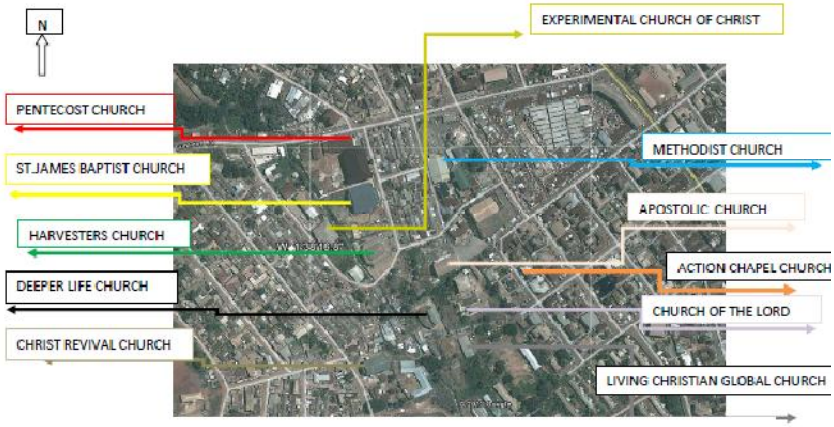

Fig. 1. Location map showing the case study church buildings
Source: (Google earth images, 2013)

(architectural science recommendation) authors such as [9,10,13] recommend orientation of elongated buildings to the N-S or to the prevailing wind to cool inner spaces. Based on this, the orientations, location of altars and main entrance locations were determined with compass. Table 1 shows orientation of the eleven church buildings based on sacred (E-W) and scientific orientation (N-S) as well as a combination of both.

Per the deductions drawn from the aforementioned authors, the study revealed only 18% of the church buildings evaluated were both oriented sacredly and scientifically. The churches include Christ Revival and Church of the Lord. 45% of the church buildings were oriented scientifically (N-S) and they include; Pentecost, Harvesters, Christ Revival, Church of the lord and Apostolic church. However, 55% of the church buildings were neither oriented scientifically nor sacredly. The churches include; Experimental, Living Christian Global, Action Chapel, Deeper life, Methodist and St. James Baptist church.

[21,22,19,20], all believe forms like the cube, oblong (rectangular), cross (cruciform), dome, octagon and ellipse are sacred and recommend them for church buildings. Ten church buildings were all rectangular in form with one, Harvesters church building in an octagonal form. Table 2 illustrate the various building forms of the studied church buildings.

According to [20], the octagonal forms were no more in use because of difficulties in internal arrangement. This was evident in the case of the Harvesters church building. There were a lot of dead spaces within the building (Fig. 2). Moreover, there is difficulty in getting daylight into the building because of its large depth (35.7 m). The church building has high level windows to admit daylight into the space but the use of artificial light shows the inefficiency of the high level windows in providing extra day light. Light reflective façade elements and highly reflective surfaces should have been constructed by the designer to improve on the amount and uniformity of day light [29] in the church building see (Fig. 3).

The total Window to Wall Ratio of all the churches were calculated and compared to the conclusions drawn from other authors [33,30,27, 28,34]. A range of 25% to 80% was established to be the optimum Window-to-Wall Ratio for visual and thermal comfort. Pentecost church had a total of 25% WWR on all facades, Action Chapel had a total WWR of 21% and Apostolic Church with a total WWR of 18%. Baptist had a total WWR of 16% on all façades, Christ Revival Church with 15% and Experimental Church of Christ with 13%. A total of 9% WWR on all facades of on the Living Christian Global Church and Harvesters Church had a total of 8%. Methodist church had a total of 7% WWR on all facades; Church of the Lord had a total WWR of 5% and Deeper Life with 3%. Tables 3 to 13 summarize the window to wall ratio per façade orientation of all evaluated church buildings.

Table 1. The orientation of churches based on sacred (E-W) and scientific orientation (N-S)

Name of church	Sacred orientation (location of alter and entrance, E-W)	Orientation (architectural science recommendation, N-S)	Sacred (E-W) and scientific (N-S) orientation
Methodist	○	○	○
Pentecost	○	●	○
St.jamesbaptist	○	○	○
Harvesters	○	●	○
Deeper life	○	○	○
Christ revival	●	●	●
Church of the lord	●	●	●
Action chapel	○	○	○
Apostolic	○	●	○
Living christian global	○	○	○
Experimental church of christ	○	○	○
Total	● =18%	● =45%	● =18%

Note: ● = YES; ○ = NO

Table 2. Building forms of the studied churches

Name of church	Building form
Methodist	Compact rectangular
Pentecost	Rectangular
St. James Baptist	Compact rectangular
Harvesters	Octagonal
Deeper life	Rectangular
Christ revival	Rectangular
Church of the lord	Rectangular
Action chapel	Rectangular
Apostolic	Rectangular
Living Christian global	Rectangular
Experimental church of christ	Rectangular

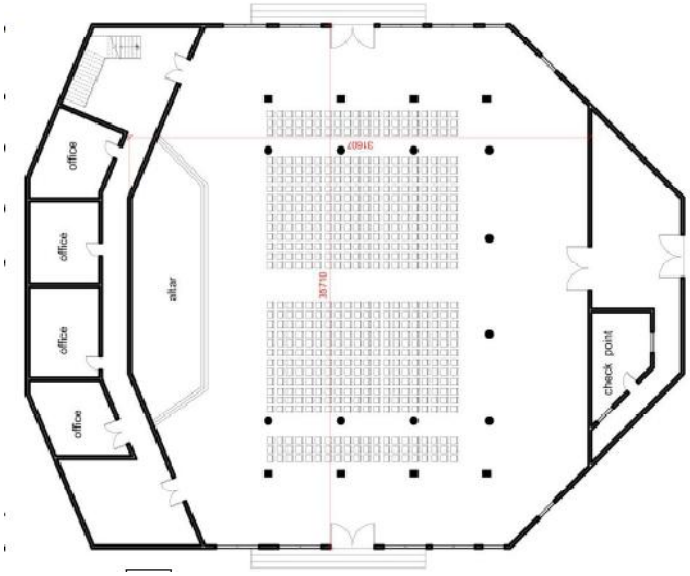

Fig. 2. A schematic ground floor plan (with seats arrangements) of the Harvester church building

Fig. 3. Image showing the position of windows and the use of artificial lighting at the Harvesters church

Table 3. Total area of facades and windows, WWR of Pentecost church

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Pentecost	North	180.00	78.21	43%
	South	308.64	77.94	25%
	East	95.20	8.32	8%
	West	115.74	13.36	12%
	Total	699.58	177.83	25%

Table 4. Total area of facades and windows, WWR of action chapel

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Action chapel	North	74.10	22.50	30%
	South	74.10	0	0%
	East	106.20	26.51	25%
	WEST	106.20	26.51	25%
	Total	360.6	75.52	21%

Table 5. Total area of facades and windows, WWR of Apostolic church

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Apostolic church	North	216.60	45.56	21%
	South	216.60	66.12	31%
	East	195.50	18.75	10%
	West	188.60	15.80	8%
	Total	817.3	146.23	18%

Table 6. Total area of facades and windows, WWR of Baptist church

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Baptist church	North	216.00	59.66	28%
	South	216.00	48.87	23%
	East	378.33	40.91	11%
	West	387.55	44.10	11%
	Total	1197.8	193.54	16%

Table 7. Total area of facades and windows, WWR of Revival church

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Revival church	North	343.80	54.53	16%
	South	343.80	64.15	19%
	East	206.56	6.30	3%
	West	132.93	29.71	22%
	Total	1027.09	154.69	15%

Table 8. Total area of facades and windows, WWR of expt. church of Christ

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Experimental church of christ	North	277.61	34.30	012%
	South	360.15	35.94	10%
	East	257.64	34.0	13%
	West	257.64	47.91	19%
	Total	1153.04	152.15	13%

Table 9. Total area of facades and windows, WWR of L.C.G.C

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
L.c.g.c	North	78.00	5.40	6%
	South	78.00	0	0%
	East	112.00	13.65	12%
	West	112.00	13.65	12%
	Total	380	32.70	9%

Table 10. Total area of facades and windows, WWR of Harvesters church

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Harvesters church	North	468.00	32.94	7%
	South	468.00	32.94	7%
	East	428.00	25.92	6%
	West	428.00	46.98	10%
	Total	1792.00	138.78	8%

Table 11. Total area of facades and windows, WWR of Methodist church

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Methodist	North	399.03	39.20	10%
	South	474.66	14.76	3%
	East	748.00	55.60	8%
	West	648.40	62.88	8%
	Total	2306.09	172.44	7%

Table 12. Total area of facades and windows, WWR of Church of the Lord

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Church of the lord	North	221.20	9.59	4%
	South	221.20	9.59	4%
	East	98.0	8.94	9%
	West	123.95	5.37	4%
	Total	664.35	33.49	5%

Table 13. Total area of facades and windows, WWR of Deeper life church

Church	Facade	Area of façade (m²)	Area of window (m²)	Wwr
Deeper life church	North	54.00	0 (nil)	Nil
	South	54.00	4.42	8%
	East	84.00	10.93	13%
	West	84.00	11.29	13%
	Total	876.00	26.64	3%

Among the evaluated buildings, only Church of Pentecost was within the established mean range of minimum WWR for comfort. Its total WWR is 25%. However, it is evident that the building has much daylight entering from the Northern (WWR of 45%) and Southern (WWR of 25%) sides which enforces the use of curtains to cut down the amount of glare during times of service. Fig. 4 illustrates the position and penetration of daylight into the space.

The building is characterized by two window types on the north facade with the window, W1 of size 2.5 m by 3.3 m (3 bay) and nine in quantity. Window, W2 is 1.8 m by 1.1 m (2 bay) and the quantity is two as seen in Fig. 5. The total area of the facade is 180 m^2 and that of windows on that facade is 78.21 m^2 occupying 43% of the facade. The area of opening on the N & S is adequate to achieve comfort [27,34].

Fig. 4. Internal view of the Pentecost church showing the position of openings

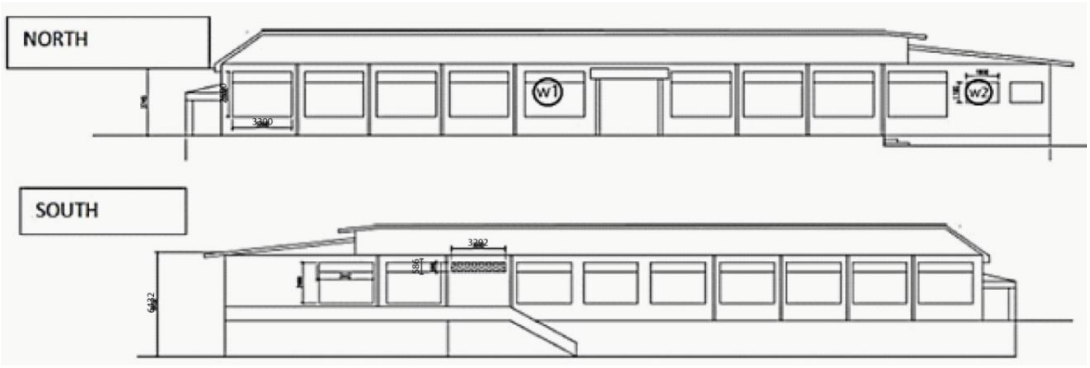

Fig. 5. North and South elevations demonstrating the extensive openings of Pentecost church, Bantama

4. CONCLUSION AND RECOMMENDATIONS

The aim of this research was to evaluate church buildings in relation to sacred and scientific recommendations in their orientation, building forms and window to wall ratio employed.

The study revealed for both scientific and sacred orientations only 18% of the evaluated churches satisfied this requirement. Also 55% of the church buildings were neither oriented scientifically nor sacredly. It should be noted that for scientific orientation, only 45% of the church buildings were oriented in the North-South axis (architectural science recommendation). From the above iterations, it is evident church buildings can be designed so that the longer facades face north and south, and only the shorter façade face to east and west and also meet the requirement of sacred orientation (i.e positioning of the alter to the east and entrance of worshipper from the West).

Concerning building forms, all were sacred and the only form that had difficulties in internal arrangement was the octagonal form. This form has no shading and its surfaces are exposed to solar radiation. The rectangular buildings were less spread out exposing less surface area to solar radiation. Building facades with effective window to wall ratio, light up spaces well without the use of artificial means. The following recommendations are made based on the findings; an orientation towards the prevailing wind direction; thus a North-South orientation is recommended for buildings in the tropics (Ghana) as it would help cool the building for the comfort of occupants. Additionally, compact cubic form, (sizes of all sides of form being equal) is recommended as the efficient building form, ideal for church buildings. This form is both sacred and energy efficient. Finally a range of minimum 25% to maximum of 80% total WWR is also recommended as the effective range for the comfort of occupants in church buildings as any ratio within this range is able to light up the spaces without the use of artificial lighting systems. However, glare and thermal problems

could arise. Designers are advised to make informed decisions when positioning windows, building forms and shading devices.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the assistance of Mr James Appah Dankyi and Mark Agyepong all of the Kwame Nkrumah University of Science and Technology for their immense contributions in putting this manuscript together.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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