INNOVATION IN ARCHITECTURE: THE CORRELATION OF VISUAL ART AND MATHEMATICS AS INSTRUMENT

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Abstract

The state of buildings in Nigeria is giving course for concern. While some collapse in the course of construction, others collapse shortly after, killing people and destroying property. Some buildings though durable do not serve the purpose, are not aesthetic and do not affect people favorably. This paper shows that the drawing of a structure limits architecture to fine art, the addition of the capability through mathematics to determine the strength of materials and then of structure extends the design to science. This paper also opine that a building is more than a structure of wood, concrete, steel and glass, however pleasing the shape these materials are made to assume; it sums up that the visual arts embellish a building while mathematics provides the strength. Therefore, it recommends interdisciplinary education in the visual art, mathematics, architecture and engineering as a solution for design and constructional problems.

Introduction

The state of many buildings in Nigeria today evokes so much anxiety that attention must be directed to their design and construction. While some buildings collapse during construction some others shortly after, killing people and destroying property. Additionally, most buildings, which are durable, are not desirably purposeful and aesthetic. That is, they are not "commodity", "firm" and "delightful" enough, using the expression of Vitruvius. Therefore, they do not impart favorably enough on the people they are meant to serve. If the current trend must change for the better, the role of visual arts, mathematics, architecture and, perhaps, structural engineering as well as civil engineering must be harnessed both in the design stage and in construction.

Although, architecture is both art and science of designing and constructing buildings and a style or fashion of building typical of a period of history, this paper is interested in the art aspect. Now, that architecture is art is not debatable. One can narrow it down that architecture is descriptively a social art. Further still, architecture, painting, and sculpture are visual arts (VA) contrary to music, dance, drama that are performing arts (PA). They are distinct media of expression.

Each has its materials or elements and skilled men who harness them into meaningful forms at a time, place and for a purpose. Those who specialize in them are artists who are a product of time and place and are influenced socially, politically, philosophically and religiously. At maturity, these artists contribute creative leadership in a specific field of art.

The arts are interdependent. Fleming [1995] writes that architecture, to complete itself, must rely on sculpture and painting for embellishment and that sculpture and painting, for their parts, must search for congenial architectural surroundings. However, Fleming is deficient with the use of 'search' and 'surroundings' in this context of contemporary art. In contemporary art, sculpture, graphics and painting are intrinsic in architectural design. Even the performing arts find architecture fundamental and that architecture itself, for some purposes accommodate performing arts in the design of buildings.

The theatre or any other building as a structure of concrete, wood, glass and steel extends its architectural design, which is fundamentally art to structural, and civil engineering. This is in respect of determining the strength of structures - accurate calculation of weight, quantity and strength of materials, dimension of space and tensile quality of structures using mathematical measures and principles. The innovation that results from the use of visual arts and mathematics as correlatives in the design and construction of buildings is the thrust of this paper.

Commonalities

When the artists, or better still, designer, engineers and mathematicians face a practical problem of representation, two main concerns come to mind. This is to represent objects and space as they appear either to the physical eye or to the mind's eye. In one case, they may emphasize nature, in the other, imagination. Whatever the choice is, the artist and engineers, as designers, and mathematicians, as quality control measure, reduce the problem first to numbers, lines and shade, working with limited space as a common factor. From here, they can divert according to their peculiar materials, tools and medium of expression. The architect into what is deviant of gravity [Getlein, 2002], humanizes perception of space; the engineers humanize experience of force, the visual and performing artists humanize the experience of time and place and the mathematician, according to Pythagorean theory, "all things are numbers".
Wassel [1998] observes:

> The artist M.C. Escher created works, which embodied a variety of mathematical concepts, e.g. Symmetry, self – similarity, recursion, and topological equivalence. And the engineer and architect R.B..Fuller made an art out of structural purity, using simple geometric forms for aesthetic as well as functional purposes

Inference evident in Wassel concludes the products of visual art, architect and mathematics (and engineering) a harmony of quality and function. M.C. Escher (1896-1972) was a renowned Dutch Graphics artist while R.B. Fuller (1895-1983) was a renowned American engineer, inventor, designer, architect, writer, educator, philosopher, and poet.

The international Society of the Arts, Mathematics and Architecture (ISAMA), which was founded by Nat Friedman in order to further interdisciplinary education relating to arts, mathematics and architecture, organizes annual conferences on the trio. Last year's conference held from 16 – 20 June 2008, in Spain.

On commonalities as limited to this paper are proportion, ratio, symmetry, diagonal and scale drawing.

Proportion

The artist, architect, engineer and mathematicians consider proportion in terms of relative size, quantity and quality; that is, the size, quantity and quality, amount and degree of one part in relation to that of others of the whole. Reducing proportion to number mathematically, a proportion is an equation stating that two ratio are equal. That is, every proportion has four terms. The first and fourth terms are the extremes while the second and third terms are the means.

Note: The product of the means equals the product of the extremes.

Example of proportion 2 is to 3 as 6 is to 9, here 2 and 9 are extremes while 3 and 6 are means. Again 2 x 9 = 3 x 6.

To mathematicians and engineers, that is, scientifically, the sense of proportion is tied to mathematical measures, to the artists, it is visual. Therefore, whether scientifically or visually a representation or an expression is surface-inviting and proportionally correct if the length, breadth and height agree in size; and this translates in visual aesthetics.

Apart from the visual aspect of representation or expression of materials, the material itself is elastic in nature. If attention is directed to only the visual aspect in structural design without determining the strength and tensile quality of structures such structures will fail. It must be noted that external force introduces deformation on materials since all materials are elastic. The resistance of the material per unit area to deformation is known as stress, which can be represented mathematically as the force per unit area. That is, $\sigma = \frac{P}{A}$ where P = load or force acting on the body, and A = cross sectional area of the body. The deformation per unit length is strain and is mathematically stated as the deformation per unit length. That is, $\varepsilon = \frac{\delta l}{l}$ or $\delta i = \varepsilon . l$ where $\delta l =$ change of length of the body, and $l =$ original length of the body.

For the visual arts, attention is paid to linear, areal and volumetric proportions. The objective of the proportion is visual aesthetics. First, linear proportion considers internal and external dimension of a structure; the length, breath and height. Secondly, it relates the external dimension of one structure to that of another. It is two-dimensional or three-dimensional depending on the form of art under consideration. Areal proportion considers the dimension that exits between two or more structures or of two or more forms within a structure. The area of dimension is differentiated by colour, texture, tone or by dividing lines. Volumetric proportion refers implied weight or mass of structure. This is common with the plastic arts, sculpture and ceramics.

Ratio

Ratio compares a division of two quantities expressed in the same unit of measure. A line 'WX' with length '2cm' and another line 'YZ' with length '6cm' is in the ratio 1 is to 3.

Now consider a mean ratio given as $\frac{\alpha+\beta}{\alpha}=\frac{\alpha}{\beta}=\psi$

Method

Given a line XY in the form below

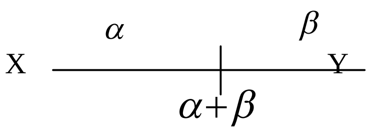

Figure 1

Then $\alpha+\beta$ is to α as α is to β. That is, $\frac{\alpha+\beta}{\alpha}=\frac{\alpha}{\beta}=mean$ ratio where mean ratio is denoted with ψ. Applying $\frac{\alpha}{\beta}=\psi$ we have $\alpha=\beta\psi$. Substituting for α in $\frac{\alpha+\beta}{\alpha}=\frac{\alpha}{\beta}$ we have $\frac{\beta\psi+\beta}{\beta\psi}=\frac{\beta\psi}{\beta}$. Therefore, $\frac{\beta(\psi+1)}{\beta\psi}=\frac{\beta\psi}{\beta}$. Hence, $\frac{\psi+1}{\psi}=\psi$. Cross multiplying, we have a quadratic equation which is $\psi^2-\psi-1=0$. To solve the quadratic equation we need to apply the quadratic formular, that is, $\psi=\frac{-b\pm\sqrt{b^2-4ac}}{2a}$ where a = 1, b = -1 and c = -1. Substituting these values into the formula gives $\psi=\frac{--1\pm\sqrt{(-1)^2-4(1)(-1)}}{2(1)}=\frac{1\pm\sqrt{1+4}}{2}=\frac{1\pm\sqrt{5}}{2}$ Therefore, the only positive answer is $\frac{1+\sqrt{5}}{2}$.

The designer and producer cannot do without application of the knowledge of ratio. When this is not followed correctly in design or production, the result is failure. In fact, the non-compliance with principle of ratio has brought the application of science, and technology to serious reproach in this country.

Symmetry and Diagonals

Symmetry bisects lines into equal parts while diagonals run from corner to another corner. This explanation can be seen in the diagram below.

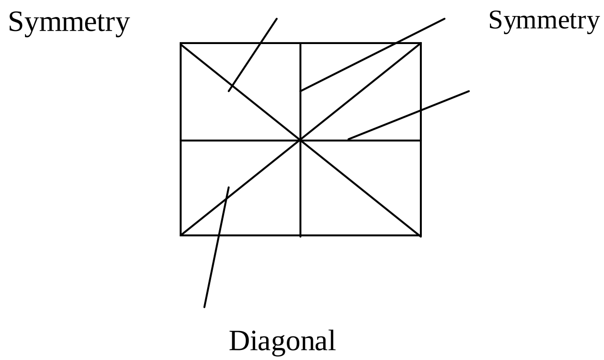

Figure 2

The result of failure to apply these in design and production is waste of materials and increase in labor.

Scale Drawing/Contract Drawing

This represents an object in the smaller form, using a particular scale. For example, 1cm is to 5cm. Given αcm is to βm and a length of ηcm. The actual measurement is thus: $\frac{\beta m}{\alpha cm} \times \frac{\eta cm}{1} = \left(\frac{\beta \eta}{\alpha}\right) m$.

For example, given a scale drawing of 2cm is to 10m and a drawing measuring 120cm, the actual measurement is $\frac{10m \times 120cm}{2cm} = 600m$

While in engineering, contract drawing provides location information in the art, contract drawing is the prototype, which must be followed in the final work, as it provides the fundamentals.

Innovation

The first goal of the correlation is to harness the skills of plan drawing with those of structural designing rather than the division that exists. The division defeats the commonalities, indeed, the commonalities provide the necessary technical know how to harmonize these areas from which a functional (architecture), durable (mathematics/engineering) and aesthetic (visual art) buildings can emerge. Then buildings will be inviting rather than repelling the viewer (Adams, 1999).

A building in construction uses materials with standard and none standard. The correlation will enable the designers to specify dimensions in the plan to cut down on wastage. The roof will adopt a triangle slanting enough to ease off rainwater, wind and any other foreign body. The exterior and interior walls and ceilings will have artistic forms/images that comment on society. This embellishment has functional and aesthetic dimensions. Our public buildings on one hand will bear images/forms that condemn fighting, corruption, killing and other forms of vices, doing the work of a preacher. The admiration of the aesthetics offered by the forms/images on the other hand relaxes our nerves; drawing on us such emotion that makes us stay younger and longer. More also, the images/forms will expose us to the culture of other people. So without traveling round the country one will have the gist of other cultures. Before now, this would be possible only with the few museums in the country.

Durability of buildings is a great need in the country. The knowledge and application of mathematics supply the technicalities that provide strength to an entire building by determining the quality, quantities, weight and strength of materials. Finally, the correlation will resolve the problem of collapsing of building and provide buildings that are durable, aesthetic and functional.

Conclusion

Functionally, the visual arts and religion are complementary. While religion needs the visual arts to facilitate its content, the visual arts need religion for patronage and as subject matter. Therefore, religious *faithfuls* should not destroy works of art, for they are not profane.

Recommendation

The following recommendations are to the appropriate government agencies and institutions of higher learning.

- Interdisciplinary education be encouraged in the visual art, mathematics, architecture and engineering.
- Harness visual art and mathematics in the solution of constructional problems.
- Site engineers must supervise construction of buildings.
- Visual art must be integral part of the architectural design.
- The study of visual art and mathematics is helpful.

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