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Reflections Of Ergonomics And Human Factors On The Use Of Customized Ceramic Tiles For Finishing Projecting Architectural Facets

Uju Sylvia Okoronkwo

Clement Etim Ekong, PhD

Department of Fine and Industrial Arts, University of Uyo, Uyo

Abstract: ***For many years, the opportunities of ergonomics and human factors have been acknowledged basically as a reactive design approach. They have often been engineered by the practical application of knowledge and skills through experiences. With reference to architecture, many civil engineers and interior decorators are already incorporating the concept of ergonomics and human factors into some areas of their executions. Studies of the diversities in human behavioural changes and challenges have unmasked the dangers of sharply defined projecting tiled facets of buildings. However, the novelty effect of the ergonomic finishing of convex facets are limited to a few instances of which ceramics, being a material widely used for modern and contemporary building finishing is still less of the number. The objective of this paper is to analyse the recent state of ergonomics and human factors on tiled convex ceramic wall and floor edges by responding to these basic questions often raised by ceramic tile users when faced with the obvious challenges of conventional tile designs and applications: why are tiled convex ceramic edges of spaces harmful? What remedial steps can be observed to improve on the eco-friendly interactions between tiled facets and users? Do we have enabling technologies to mass produce an appropriate ceramic tile design customized for convex facets? If yes, why are they not visible in the market and if no, what is the way forward? To answer these four questions, this paper develops five propositions which may after all expound on the roles of ergonomics and human factors that could be applied before/during design processes of ceramic tiles to guarantee consumers the satisfaction they desire. They are misplacement of design purpose, knowledge of the terms ergonomics and human factors and their practical applications in design processes, the state of proper empathy, relevance of adequate research bodies, consumers' responsiveness to new products.***

Keywords: ergonomics, human factors, design, convex facets, customized.

I. OVERVIEW OF CERAMIC FLOOR TILES

The use of ceramic tiles in today's society for architectural finishing has lent a number of advantages and comforts to consumers. Wrapped up in their aesthetic factors or visual richness and appeal are more adaptable qualities which recommend them as materials to be used with architecture for their durability and technical properties (Blignaut, 2009), ease in maintenance and safety in usage, in fact their importance to architecture cannot be over-emphasized. It is in the means architects, civil engineers and tillers or masons use them that generate or define their final results or finishing**.**

Over the years, ceramic tiles have been applicable to adorning both interior and exterior spaces. The earliest and crudest form of ceramic tiles ever used by man is traced to the era of prehistory. These 'tiles' were products of accidentally broken fragments of unglazed earthenware pots called shards or even in rare cases, purposefully broken pots. They were irregular in shapes, thicknesses and sizes and were not specifically designed as finishing materials. The smallest size of a prehistoric tile could be as tiny as dust particle and

installation was on the basis of modularity. Cases of shards adapted for tiling could also be traced to historic time in various cultures around the world. A typical instance is the Yoruba culture in Nigeria where they were used particularly for traditional religious architectural landscape (Akinde, Odeniyi and Abiodun, 2013). Igbo and Ibibio also used pottery shards as tiles. It was a thing common to communities with pottery tradition. Shards were probably used to control or check slipperiness or water-logging due to their slip resistant quality, modular installation which provides for more grouts where necessary and their impermeable nature to liquids (though not absolute due to presence of pores, body type and firing temperature).

II. BRIEF HISTORY OF THE PRODUCTION OF CERAMIC TILES

On Bridge's (2013) account, the first clay tiles were produced as early as about 7000 to 8000 years ago (approximately 5000BC-6000BC respectively) in an area now known as Holy Land. These tiles were probably floor tiles as it is evident in Bridge's writing and since then, it is believed they had been in use. Grimmer and Konard (1996) explained that the use of ceramic floor tiles dates back to about 4000BC in the Near East and Far East. Evidently, the two locations mentioned by the authors are similar. Holy Land is in the Near East but the dates are quite contradictory. It is therefore historically safe to use the oldest date which is 6000BC. However, Shaw (1987) attested that fired roof tiles were found as early as the 3rd century B.C (which is approximately 2200 years ago) in Lerna Greece. According to Shaw, debris found at the site in the Early Helladic House in Greece contained thousands of fired and unglazed tiles which had fallen from the roof. Therefore, floor tiles were actually the first type of ceramic tiles to be used by man. Terracotta tiles gradually replaced the crude forms of shard. Sizes and shapes of tiles gained precision but they were characterized by heavy thickness and overweight. Installation became easier though, and with the advent of glaze technology, maintenance also became cheap. Before the 12th century A.D, Roman immigrants introduced modern tile making to Western Europe. However, the art was forgotten until the 12th century when it was reintroduced by Cistercian monks who developed a method of making encaustic floor tiles with inlaid patterns for the cathedral and church floors (Grimmer and Konard, 1996). Since then till the 20th century, the technology had evolved and production became heavily mechanized due to the Industrial Revolution in Europe in the 19th century. As a result, there came an influx of various modern tile designs with high aesthetic appeal, thinner thicknesses, varied textures, large surface areas and with much impervious materials such as stoneware and porcelain. The art or technology was spread. Ceramic tiles are consequently produced in all the continents of the world.

WHY ARE EDGES OF TILED FACETS HARMFUL?

Man and his environment (both natural and artificial) are bonded by inevitable relationship that brings about a balance in the ecosystem. Innovations and inventions have become his ways of creating comforts in the forms of necessities and luxuries to create his "eco-friendly environment" which has been borne often by curiosities, enthusiasm and agitations for mimicking nature and replicating imaginations to produce aesthetics and utilities. The production and use of ceramic tiles however have become a necessary parcel of ancient architectural finishing to this contemporary period but wrong installation or use of flat tiles on convex building facets has lent a number of mayhems which include poor connectivity due to the mismatch of flat tile structures on convex surfaces, degradability as a result of poor installation, poor interface and, of course, defeated functionality and eco - friendliness. According to Busta (2013), surfaces of edges should be considered elements of high design and sustainable surfacing therefore is the push for eco-friendly architectural products inspiring critical cases of creativity.

PROPOSITION 1. Mislaying the design intent which is a key proactive strategy to good designs alters the effectiveness and efficacy of a predestined design. Manipulating flat ceramic tiles for use at the convex areas of architectural facets has its economic and ecological disadvantages and does not guarantee fit between the tile structures, architectural facets and users.

III. FUNDAMENTALS OF GOOD DESIGN AS IT RELATE TO CERAMIC TILE DESIGNS

Every design is proposed and purposed to solve human problems. The problem of man as asserted by Ross (1901) resolves itself into two questions: what to do and how to do it. 'How to do it' Ross expressed is the question of design. The context of design quality has stirred up contentions over the years. Many scholars had argued what could be termed a good or bad design. This could be as a result of a priori judgments and sentimental preferences of aesthetics (simple visual/sensory appeal) over the functionality of a design. However, a good design can be said to be that which involves the end user from the design process, and provides him optimal satisfaction as the design elements are used at the appropriate places to create an overall balance for safety/ergonomics and sustainability. Martin, Legg and Brown (2012) strongly believe that the most effective design is one that achieves all standards, ergonomics, environmental, production, quality and occupational health as well as meeting the needs of all stakeholders. Contrarily, there has been an insatiable approach towards the enhancement of sustainable facets of tiled structures resulting in hazardous tile handling, unsatisfactory creativity, increase in building cost, and increased physical effort during installation and poor eco-friendly finishing to what would have otherwise been a good design. Consequently, the loss of ceramic tiles during installation as a result of cutting tiles to fit spaces on angular facets makes a mockery of quantification of tiles as building materials and therefore could discourage the use of ceramic tiles for several constructions and designs.

Good designs are pertinent to human development and environmental sustainability in relation to time and space. As Cotton (2003) adduced, there is no already-made solutions to

creative design. This suggests that the design of the new system (in this context, convex ceramic tiles) is prompted by and channeled to the 'design-ready' community of users. This further implies that designing Customized Convex Ceramic Tiles (CCCT) is spurred up by the prevalent need for new tile designs as a solution to the current problems of sharpness, poor eco-friendly interaction between tile users and convex tiled edges and dislocation of tiles observed where conventional ceramic tiles are installed at the projecting interface between floors and walls.

The design of a new system is the process that happens from the conceptualization of the artefact until when the product is being used by the people for whom it is intended (Canas, Velichkovsky and Velichkovsky, 2011). This relates to delineating the function/intent/purpose before a form is executed to be used as a designed product, and that is, allotting priority to design before its execution. The use of conventional ceramic tiles for tiling angular building facets is a deterrent to economic sustainability, speculated aesthetics, user satisfaction with designed products, and energy saving. Therefore the need for a new tile design, CCCT is acknowledged to curb these unwanted certainties and sustain an appropriateness of the design to its purpose or intent.

The Fundamentals of good tile designs for convex building facets therefore incorporates effective and efficient conceptualization of an appropriate form which includes the art and design of CCCT that will reveal the correlation of the integral parts and their fitness to the parts of the rest of the tiled floors and walls and the perfect organic utility of the whole that provides the fit between the entire design and its user. Design is a phenomenal activity. As Dowel and Long (1998) accounted, it is at the heart of the profession of ergonomics. The time is yet since 1857 when the term 'ergonomics' was first coined by Jastrzebowski due for absolute incorporation of ergonomics and application of human factors into the creation of value systems for sustainability and this leads us further to two propositions.

PROPOSITION 2. Deficiency in the knowledge and application of ergonomics and human factors obstructs practical implementation in designing systems for sustainability. Installation of ceramic tiles at the convex regions of buildings does not witness reflections of ergonomics and human factors because of the stereotype or monopoly of tile structure design and usage.

PROPOSITION 3. Empathy with design patrons is not practiced adequately within the productive class especially in developing countries. Most times, users are seldom integrated into product (prototype) creation and this defeats the purpose of design.

IV. THE TERMS- HUMAN FACTORS AND ERGONOMICS AND THEIR RELATEDNESS TO SUSTAINABILITY

The phrase "ergonomics and human factors" is always used together. The literature of ergonomics is impressively vast, yet condensates to the International Ergonomics Association's (IEA, 2000) defined concept as understanding the interaction between humans and other elements of a socio-technical system. Ergonomics is a word borne out of two words from Greek origin- "Ergon" and "Normos" meaning work and law respectively. Etymologically, it is simply the science or law of work. If ergonomics is the law of work and the purpose of design is its function, it therefore implies that ergonomics should be obeyed and applied in line with anticipated design function. The discipline cuts through all areas of human sciences yet, since 1857 the issue of ergonomics was first addressed by B. W. Jastrzebowski, it has barely gained penetration into relevant areas such as engineering, architecture and design. This is to say that ergonomics should intercede in the design of ceramic tiles for safety and sustainability. Martin, Legg and Brown's (2012) opine that sustainability is a recurrent global challenge that has attracted attention worldwide but the role of ergonomics in designing for sustainability is poorly understood and seldom considered. This statement reminds us of Jastrzebowski's (1857) caution on harmful work which brings deterioration, which is relatively design that is devoid of sustainability. He stated what ergonomics 'can do' yet emphasizing on what it 'should do' while dissecting the dichotomy between useful and harmful work. The source also observed that sustainable buildings are energy efficient and can offer major *cost* savings. Evidently, harmful work or designs are not only detrimental to human health but also to human capital resources on the long run.

What remedial steps can be taken to improve on the eco-friendly interactions between tiled facets and users?

Through the production stage to the installation of ceramic tiles, empathy is a key proactive design strategy which helps designers to understand the users' need, pretest a prototype design for ergonomics as well as assist in the mass customization of the sustainable, ergonomic-inclined final design for the end-users.

V. THE INFLUENCE OF EMPATHY ON HUMAN FACTORS AND ERGONOMICS

Brown, Sklar, Solomon, Wyatt and Spaicher (2008) posited that as a working principle of management, plans that take into consideration the clients capabilities must be provided- these plans can only be made feasible via empathy. Many studies hold that it is important to engage users in the design process and this is pertinent because in a healthy market cycle, the newly designed system ends up with the user and not the designer. It is the user who enjoys and manages the design on acquisition. Contrarily in most cases, the users rarely interact with the designers directly. Their relationships seem to start and end with the supplier or distributor due to poor marketing cycle and the nature of the society- except in a few or scanty instances. But empathy requires that there should be a healthy interaction between users and designers through the design process to negotiate their product specifications for their comforts.

A necessary 'luxury' that must be considered vital and indispensible preliminary design strategy, empathy alongside ergonomics should be regarded as the fuel for design. It is a genuine means and model designed to understand the needs and specifications of a consumer or a design-ready entity.

Piller (2005), Canas, Velichkovsky and Velichkovsky (2011) and Hollnagel and Woods (2007) supported user-centered design in their theories. Piller posited that customers are integrated into value creation by defining, configuring and modifying an individual solution; Canas, Velichkovsky and Velichkovsky affirmed that the concept of user-centered design aims at describing the human being who interacts with the system from the viewpoint of cognitive science; Hollnagel and Woods emphasized that a person and her working environment should be considered as a highly cognitive system. These similar views hold that user interaction or consultation is considered a very indispensible and crucial activity when dissecting the ergonomics of ceramic tiles installed on the edges of architectural facets such as staircase, countertop, pavements and walls. It is evident that empirical factual knowledge of the design, user's activities or behaviour is necessary for a successful and sustainable design. As Kopec (2009) posited, sustainability can also be considered from health perspective, with an emphasis on the use of human and environmentally friendly products. Therefore, designing a sustainable convex ceramic tile must consider facts about natural occurrences and human behavioural changes and challenges as obtained from the user during empathy. This brings us to customization of ceramic tiles to meet customer's specifications such as functionality, aesthetics and fit.

CUSTOMIZATION OF CERAMIC TILES

The commonality of flat tiles for regular finishing of convex building facets does not supplant the pertinence of an ideal design. The misplacement of design purpose of convex tiles for convex facets does not guarantee absolute acceptability of the yet conventional tiling of convex facets. Steady shifts in the values, demands, behaviours and trends/styles of individuals spurred by reflections of new technologies and the influx of new knowledge has exposed the long endured misplaced design purpose. In today's world with the issues of ergonomics and sustainability being raised globally, design of new systems for the evolving and ageing world should be updated and absolute. From the research carried out on the use of conventional flat tiles for convex facet finishing by Okoronkwo (2017), it was gathered that aside slipperiness of glossy and large surfaced ceramic tiles which consequently have less grout lines used in spaces such as bathrooms, kitchens and other moisture-prone spaces, the edges of projecting angles have been potentially rebellious to the push for a highly interactive joint cognitive system and eco-friendly environments.

Customized Convex Ceramic Tiles (CCCTs) are personalized convex shaped tiles defined with ceramic make-up, designed with specifications on size, degrees of angularities and beveled projecting surface specifically for finishing the interface between floors and walls. There are convex roof tiles specifically for roofing purposes, but as stated, CCCTs are for wall and floor edges. Piller (2005) observed that customization is not practiced to an extent that justifies all the talk and buzz around the term. As a matter of fact, many production outlets do not practice mass customization while a greater number of people do not understand the concept at all. Therefore, for a customized product to be said to be sustainable, it must satisfy these features:

- ✓ *FUNCTIONALITY*

In design, function precedes form. Inasmuch as the entire design visually presents its form, its function or usage drives the conception and design of the form for the most effective and efficient applications. Mace, Hardie and Plaice (1991) affirmed that universal design is an approach to creating environments and products that are usable by all people to the greatest extent possible. This depicts that the usability or functionality of every designed product is indispensable. A product or design which is aesthetically stable but does not exhibit optimal functionality is useless and bad. Take for instance, vertical and horizontal interface of tiled countertop, or pavements burrow into the skin of the laps when sat upon for even a few minutes or cut the skin or nerves when hit accidentally. Constant hit on such areas also causes them to detach and therefore rebel against sustainability. Olgunturk and Demirkan (2009) supported by stating the principles of universal design which include: equitable use, flexible in use, simple and intuitive use and space for use. By these, it is clear that CCCTs do not only solve the tile users problems of sustainability but also the tile setters need for easy and flexible installation.

- ✓ *AESTHETICS AND PATTERN*

Arrangement and pattern should have a flow to define a subject and boost its aesthetics. In Dewey's (1934:191) writing on artistic and aesthetic theory, he emphasised that "practical emphases on aesthetics pursuit are form and organization and every art used some manipulation of the media, space and time to project its aesthetics". Deductively, the execution of the CCCTs with flat tiles on convex and flat spaces respectively reveals modifications prompted by the combination of convexivities and flatness and the way in which they are being combined and arranged to suit specific spaces and to create fluidity that appeal to ones senses in identifying the beauty in such newness.

- ✓ *FIT*

Fit defines sustainability, appropriateness and correctness for a specific purpose. CCCTs are first designs for the purpose of comfort between users and the convex spaces. Secondly, to impact appropriateness to convex spaces using an appropriate ceramic tile structure to define the angularities while creating fluidity in space and eliminating sharp projections from such spaces. Olgunturk and Demirkan (2009) stated that *space for use* is one of the principles of universal design. The principle however gave directives that propelled the design of CCCTs. To further ensure definite fitness in using CCCTs, measurements of convex spaces are vital so as to match the spatial dimensions with the dimensions and degrees of angularities of the CCCTs.

Do we have the enabling technologies to mass produce the appropriate tile design customized for convex facets?

Yes. Every problem has a possible solution or preventive measures. The age long problems of unsustainable surfacing and loss of tiles at the edges are experienced by a large percentage of tile users. With the acquired know-how, a prototype has been produced at the studio level by Okoronkwo Uju during her MFA programme at the university of Uyo, Uyo, Nigeria. The work was a success but, however, requires industrial methods for more successful implementation and mass production since it was found to require highly mechanized dust-pressing systems like any other ceramic tile productions.

PROPOSITION 4. Research and developmental knowledge lack adequate implementation at the industrial level. This makes strategies for meeting conceived innovations on products or designs for the design-ready masses blurred and seemingly invisible.

The culture of almost perfect disregard for research authenticity and practical implementation of genuine research findings has been a shibboleth in recent time in some academic/research institutions. Research is geared towards the production of utilities or problem-solving which in turn drives development of every entity either as an individual, organization/firm or country. The Institute of Chattered Accountants, India (ICAI) (2015) asserted that "production is the original activity of transforming resources into finished products in the form of goods and services". These resources could be in the form of ideas defined through researches upon which a country's wealth is determined. Through research-based experiences, the early man through his experiences shaped the world with the technology of making various tools for both domestic and wild (hunting) purposes. Today, the world through further researches has improved on the ideas and makes innovations. However, not all the fragments (societies) of the world are actively involved in this research and developmental activities. This is the reason there are dichotomies between poor countries and rich countries. Irrespective of a country's wealth of natural resources, her actual wealth is valued based on the turn-over of results of creative thinking channeled into the optimum utilization of available information and or raw materials to create wealth/utilities within.

Past and present world powers and leading economies of the world were able to extend and express their visions and concepts into exploring these realities to participate relevantly in the competitive world. Nigeria, for instance, has not been able to do much in research and industrialization in most areas, especially, in ceramics. This is grossly due to corruption on every level of administration - clan-based appointments leading to employment of incompetent personnel into service to man key positions. Embezzlement of public funds and capital flight also constitute setbacks to research and developmental institutions. It is factual that the academy is shedding off its values faster than they were ever imbibed. Many researches carried out in some tertiary institutions appear to be less authentic with little or no ground work carried out. The purpose of some researches are barely or never met in real practical terms as relevant firm representatives are not invited to hear a proposal made by the student researcher so as to relate the research objectives to real industrial praxis.

PROPOSITION 5. Fashion-inclined and trendy consumers seem to give heuristic responses to designs as a result of enthusiasm towards newness and aesthetics. However, designs seem to undergo severe scrutiny, skepticism and testing when they are less aesthetically (visually) appealing even though their functionality and safety are guaranteed.

VI. CONCLUSION

It could be quite irrational to conclude that a design would be accepted by a larger percentage of a given population without proper survey, yet it is common that consumer's seem to develop an initial skepticism for new designs based on their sensual dispositions until the design proves useless. The new tile structures, CCCTs proposed for specific spaces (where consumers have found most perturbing based on survey-convex facets/spaces-) does not only exhibit the aesthetics consumers crave, but also better functionality, sustainability, fit and safety - ergonomics and eco-friendliness. Lancaster (1966) affirmed that the value of a customised design can be measured as the increment in utility that the customer gets from a product that fits better to their needs than the second best solution available. This explains that every consumer goes for the design that guarantees him optimal satisfaction-without compromise. And in the area of interior design, finishing or tiling, CCCTs offer a better comfort and security than the conventional tiles for finishing convex spaces or facets.

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How can ergonomics and human factors improve health and safety? Applying ergonomics to the workplace can: â– â– reduce the potential for accidents; â– â– reduce the potential for injury and ill health; â– â– improve performance and productivity. Taking account of ergonomics and human factors can reduce the likelihood of an accident. For example, in the design of control panels, consider: â– â– the location of switches and buttons â€“ switches that could be accidentally.Â Some of these tasks still required the use of vibrating tools, but the overall personal exposure was halved. As a result of the modifications there was: â– â– a reduction in vibration exposure; â– â– no need to adopt poor and constrained postures; â– â– reduced boredom and fatigue for Eddieâ€™s team; â– â– improved productivity.