design methodology of ceramic tiles in the light of technical variables

Color and texture design

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Abstract:

The relationship between the design of ceramic tiles and the rapid technological development; as well as the diversity and richness of the available products; has provided the designer with an opportunity for visual replenishment, but at the same time it has made the prospect of preserving the designer's originality and identity a more difficult task, especially in light of the flow of knowledge and visual replenishment.

Therefore; I find it necessary to refer back to the general basics and concepts in the field of ceramic tiles with quantitative production patterns; as the designer needs such foundations as his/her basis to achieve the balance between regeneration and development on one hand; and authenticity and identity on the other hand.

In order to obtain this objective; the structure of this research depends on three main concepts; the first is the gigantic and continuous development in the field of ceramic tiles production; and its relation with the visual appearance of tiles. The second discusses the fundamentals of design in the two dimensions and the determinants of the environmental and usage context. Finally; the third is a design methodology according to the technical variables and design fundamentals through applied models that were effectively executed by the students of the ceramics in their graduation project at the Department of Applied Arts; over nine consecutive graduation classes.

Problem

- The complex relation between design and technology in the field of ceramic tiles production; as well as the rapid and continuous developments in the tiles industry; which directly affect the passages of design.
- The rapid changes in the field of ceramic tiles design, the openness of markets and the gigantic offered products have forced the designer to face many obstacles, including competition and continuous rapid development.
- The relation between ceramics, the architectural context and interior design elements; as they are products which are used for long years during which furniture trends and fashion change; and it has to correspond and integrate with these different and rapid variables.

Objectives

1- To set the basis for a methodology to design quantitatively produced ceramic tiles that can correspond with the ongoing technological developments, to develop design students' experiences.

2- To provide design solutions for quantitatively produced ceramic tiles according to the technologies available at the ceramics factories on the national level.

Hypothesis

1- Studying and analyzing the design fundamentals for quantitatively produced ceramic tiles and porcelain slabs provide the new designers with tools for continuous improvement and creativity.

2- Commencing from the general-basis design fundamentals provides the designer with the ability to achieve the values of authenticity and identity in his/her design.

Methodology

An analytical applied study.

Keywords

Ceramic tiles design – design fundamentals – digital printing

Introduction

Achieving balance between the aesthetic values and technological rapid development; and between modernity and authenticity; always enforces the designer to set clear concepts of beauty from which he/she commence their vision and creativity. One of the most important beauty concepts could be what Aristotle said "To create harmony between the shape and content; and that beauty is based on three main elements: wholeness, consonantal and radiance or clarity". Afterwards; the ideas of harmony, balance, proportion, golden ratio and numerical proportion have emerged reaching "Kant" in the 18th century; who considered beauty to be a type of free playing of the genius imagination and affirmed the abstraction of beauty judgment from utilitarian passion; and its liberation from logical thinking" [3].

Also; the designer has to recognize the dimensions of aesthetic expertise of the consumer and its relation with what is called "familiarity and preference"; as explained by Dr. PhD Shaker Abd-Elhameed in his book titled (Aesthetic Preference): "when the aesthetic stimuli is unlike any that we have encountered; the experience will be absolute. But we usually deal with the comparative expertise, i.e. the unprecedented formulations, but they consist of elements which we have recognized in the past. In all cases; it is said that novelty brings about a specific level of stimulation giving that it corresponds to the public taste of the individual or the society, as it loses the boredom element associated with familiarity". [3]

Then comes the issue of conformity with the public taste; and the confusion between beauty; as an actual value in all our surroundings; and the rapid spread of products which lack aesthetic values and are largely produced to the extent that they change the shape of our world; resulting in the need to identify the concept of (Trash Aesthetics).

This might be due to the fact that the sharp drop in the public aesthetic taste is bounded by the concept of "fashion and trend", which is hard to practice in architecture or the architectural products which are intrinsically linked to the architectural structure with a life expectancy from 20 to 50 years. Thus; despite the rapid changes of the technology in the ceramic tiles production field; as an example of architectural products very coherent with the architectural mass; these technologies are the main engine in the design processes and the product's capability to maintain; despite its diversity; the general basics that can be recognized in a rapid follow-up of the development of the ceramic factories products during the last twenty years. That is the actual problem of this research; which is the potentiality of achieving balance between the aesthetic

standards and the architectural pattern and its components; with the rapid technological changes in the field of quantitatively produced ceramic tiles; what are the aesthetic, functional and environmental fundamentals that we have to keep in mind?

There is also the bigger problem and the challenge that always appears when designing architectural coating products – ceramic tiles; which is the balance between (novelty and familiarity) in a product which is used for many years and is usually associated with long hours of proximity in all architectural spaces. So; how can the design obtain this balance between the two elements; the intriguing novelty and the preferable familiarity, while minimizing boredom and monotony, and at the same time; not over exaggerate stimulation and jamming?

This research attempts to set basics for the quantitatively produced ceramic tiles in the hope to achieve this desirable balance.
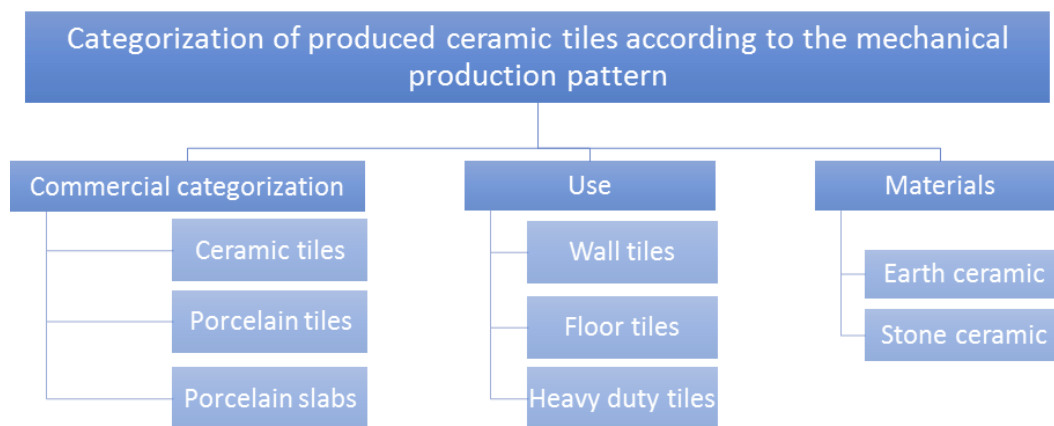
As already mentioned; the technological variable is the main factor in the field of the quantitatively produced ceramic tiles, therefore; it is important to discuss the latest production technologies of ceramic tiles and the decoration methods adopted for quantitative production patterns.

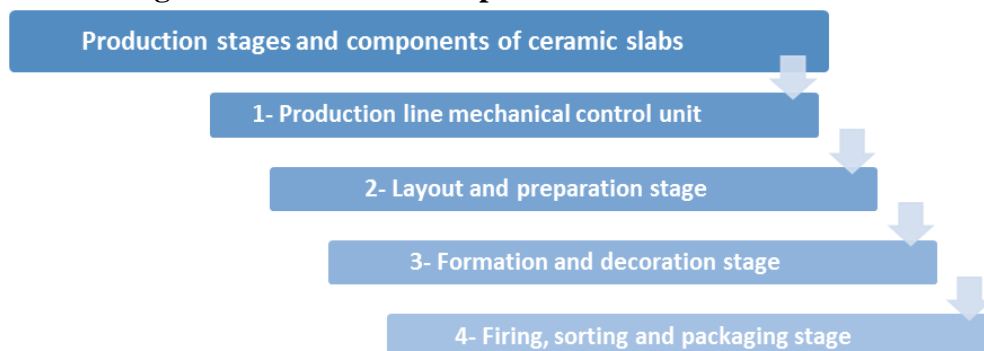**First aspect: digital technologies and ceramic surfaces treatment**

a- Types of ceramic tiles:

Despite the continuous technological development in the field of ceramic tiles production and manufacturing; the diversity in the products range is very limited on the level of the product type or material despite the development in the materials and their treatment methods.

Ceramic tiles can be categorized according to a number of considerations; such as the materials, use or commercial categorization.

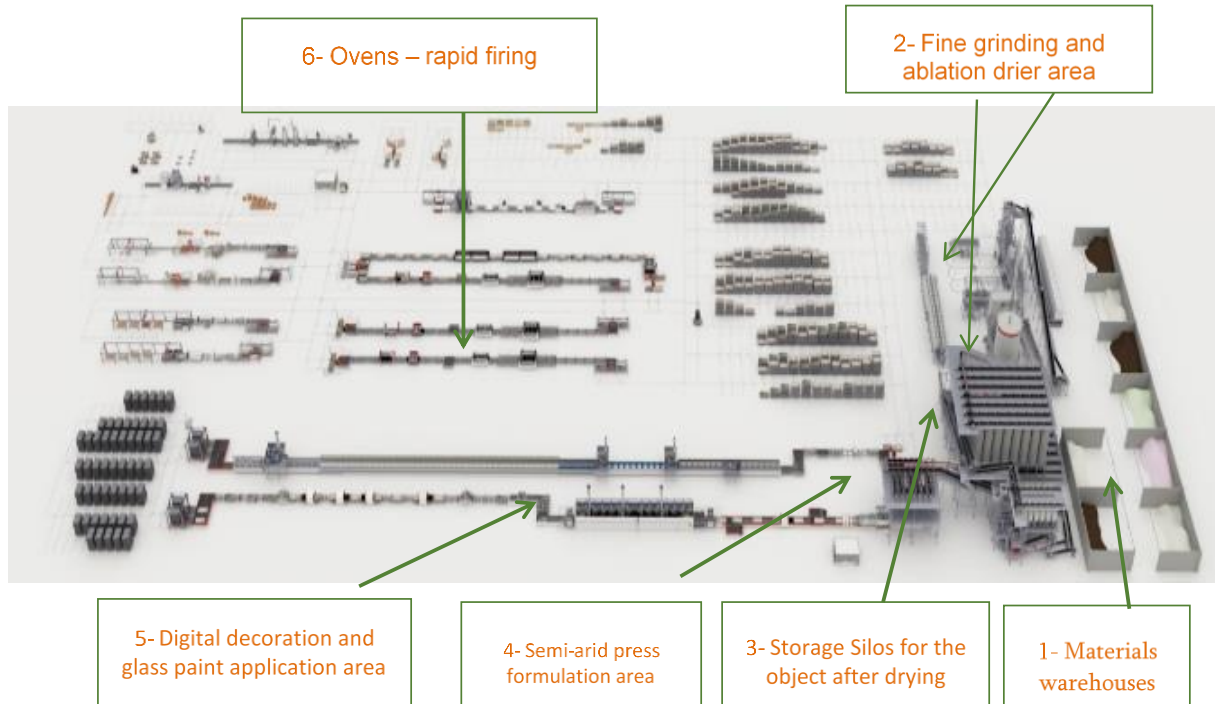**b- Production stages of ceramic tiles and porcelain slabs**

6- Ovens – rapid firing

2- Fine grinding and ablation drier area

5- Digital decoration and glass paint application area

4- Semi-arid press formulation area

3- Storage Silos for the object after drying

1- Materials warehouses

Fig. (1) Ceramic tiles production stages diagram - SACMI

3- Formation and decoration stage

3-1 Formation

Thermal hydraulic presses with compressive force up to (350 kg/cm²) are used to form the ceramic tiles – floors and walls – and compressive force (15 tons/sm²) to form porcelain slobs; then the edges are cleaned to remove residuals.

Also; tiles and slobs varies from each other in regards of size; as tiles sizes do not exceed 120 cm², while porcelain slobs' sizes can reach 150 X 350 cm. The thickness of the porcelain slobs is 70% less than the ceramic tiles; as the porcelain slobs thickness is up to 3 mm., while ceramic tiles thickness is between 9:11 mm., also; the body density and absence of porosity at the firing temperature for the porcelain slobs are between 1220 and 1250 c°, while ceramic tiles are fired at 1150 c°.

3-2 Decoration of ceramic tiles

1- Deep digital decoration.
2- Roto-Color printing machine.
3- Digital printing.

1- Deep digital printing

Porcelain deep digital decoration is done before the compressing process, as the surface is fed with materials according to the design and color distribution; normally in an imitation of natural materials such as marble and rocks; followed by the compressing process to formulate the slobs, then cleaning the edges; porcelain slobs produced by this method can be of sizes up to 120 cm X 350 cm.

2- Roto-color printing machine

This printing machine consists of several main parts, which are; silicon printing cylinder, moving strap, cleaning and color feeding.

The ink is transferred to the surface by two methods; the first is clumping by flowing from the deep parts of the silicon surface to the tile surface; the second is ink contact with the tile surface.

The maximum operating speed of the rotating cylinder is measured by the number of linear meters per minute; ranging from 33 to 40 meter/per minute.
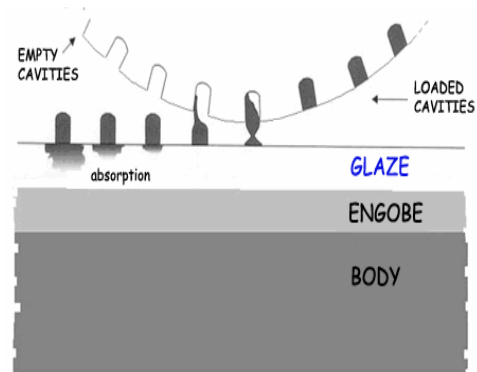
Roto-color machine operation patterns:

- Random mode
- Synchronized mode.
- Centered mode.
- Up & down mode. [2]

Fig. (9) a detailed sector of the rotating cylinder that shows the printing mechanism

3- Digital decoration

3-1 Digital printing

Wet digital printing depends on the inkjet printing techniques, as inkjet printing is the simplest non-confrontational printing type. In regards to the mechanical composition of the inkjet printing machines; it has a large number of print heads up to 1000 nozzles which puff the ink, it operates with a various number of inks which started with the range of (1-6) colors and nowadays has reached (8-12) color. It operates with (CMYK) system and the printing speed can reach (30-50) meter/per minute according to the product, with a high accuracy up to 1000 dots/square inch, but the accuracy range of 200-300 dots/square inch is the most common in the Egyptian factories.

Inside the machine; the liquid ink is transformed into micron ink drops which are puffed through very precise tubes which end with a microscopic nozzle, from which they emit to settle on the printing material surface forming a shape of an image. It is not like any contact between the print heads and the material surface; providing the capability of printing on 3D tiles with surface diversity up to 10 mm, which is done through digital data that represents the image intended to be produced.

Technical properties of digital high definition (DHD) inkjet printers [11]	
Technical features	**Properties**
Width of printing surface mm.	903 : 2024
Number of colors	8 : 12
Printing quality and speed	400 DPT at 40m/min.

3-2 Dry decoration (digital decoration and glazing – DDG)

In which the glass coating is applied in the form of a powder as well as all three-dimension glazing materials according to a digital system; this has become a strong substitute to the silk-screen and roto-color production methods, as 3D textures can be digitally added. [11]

3-3 Digital decoration advantages

1- High flexibility to various designs in accordance to the market requirements and demand.

2- A high stable product quality up to 99%.

3- High flexibility in regards to improvement and alterations, as well as the rapid transformation from one design to another, which provides the designer with the potentials to develop and experiment in favor of the design quality.

4- Reduction of the product final cost due to the minimal damaged products and risks in regards of production, labor, time and space.

5- Higher accuracy and formation & color capabilities in comparison with roto-color and silk screen methods.

6- Potential high quality printing on ceramic tiles.

Fig. (16): Application of the glass powder responsible for forming 3D textures
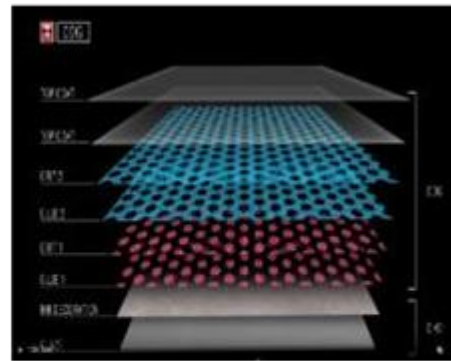
Fig. (15): Digital 3D printing

Fig. (14): A diagram of the digital printing potentials for glass coating and 3D glass materials [11]

Second aspect: The fundamentals of design in two dimensions

1st: Elements and sources of design

Natural sources

Geometrical sources

Historical sources

Heritage sources

Clip art

Photos

Color treatments

Textures (sensory – visual)

Texture

Texture is defined as an expression of the superficial properties of the surface; these properties are firstly recognized through the visual system then through touching. Textures vary between imitating natural textures such as wood, marble and rocks; in addition to textures inspired from some techniques such as the Rocco Effect, tying and binding techniques, Batik art …etc.

Color and light features

a- Color groups: the designer depends on earth and autumn color groups, they seldom uses strong colors or spring color group due to many reasons; the main one is that the architectural product is used to coat large architectural spaces with an average life expectancy of 20 years, therefore; it is essential to use neutral colors that harmonize with the rapidly changing fashion trends in the interior space elements of furniture and accessories. Also; large steady spaces of color require soothing colors; which are consistent with neutral colors.

Fig. (24): Tiles that use the basic colors & solid color spaces

But the designer uses strong and contrasted colors in limited quantities for decorative and belt tiles to inlay large spaces of neutral and earth color spaces; especially upon reviewing its distribution and utilization in the architectural space; and ensuring that they are not largely visually overbearing. On the other hand; we find that strong colors are largely used in commercial spaces such as restaurants, in addition to using solid color spaces and some sensory textures on the ceramic surfaces.

b- Light features

They vary between shiny, matte and half-shiny coatings.

a- Sensory features:

These features vary between visual texture, sensory texture or solid color spaces; the designer usually more commonly depends on visual and sensory textures; while using solid color spaces in special orders requesting basic colors such as in commercial spaces.

b-1 Visual texture

Visual textures vary between imitating natural, technical and historical textures. Among the most common natural textures are wood, rocks and marbles, the technical textures include cement and metal textures, as well as special ceramic firing techniques such as Rocco, salt coating and the effect of water colors; the historical textures include feet imprints and erosion of different materials such as bricks and metals.


Fig. (27): Tiles that use the traditional coatings effect; such as salt paint, Rocco and brush drawing

b-2 Sensory textures

Sensory textures have started to form a main part of the ceramic tiles design groups; as a concept have emerged to design by the diversity of visual textures, color harmony and light and shadow; it has become largely common and corresponds to a large sector of the higher class of consumers. The sensory texture varies between geometrical and plant decoration textures, as well as natural materials textures such as wood and rocks; and technical textures, such as mosaic.

Fig. (28): 3D tiles with sensory textures

Categorization of light and sensory features [5]
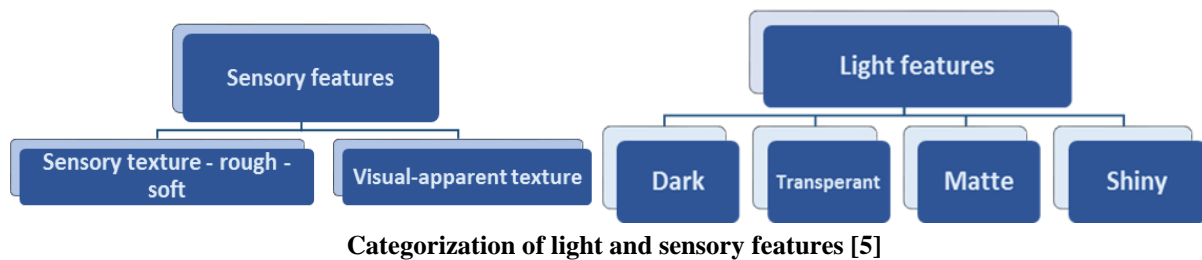
Formative fundamentals related with structure

Line

It is the trace of a moving point, it has a length but doesn't have a depth or width; and has a specific place and direction.

Space

It is the two dimensional area in the void which is covered by the line movement, space is the exterior borders of the geometrical shape. Space is the abstract model of the surface from which the surface launches to the three dimensions.

Integration between the line and the space

The designer depends on the distribution of spaces and lines; as well as the thickness of the line itself.

The formative foundations that express the relation of the design elements in a specific area or in a 3D void vary; this relation specifies the distribution and size of elements and creates the shape and space. Some of these formative relations; which is widely used in the design of quantitatively produced ceramic tiles; are (repetition, center force, appearance and invisibility, integration between more than one concept, pattern, rhythm, unity and variety, continuity, overlapping, strong dividers); the following is an analytical study to these concepts.

1- Repetition

Repetition means reusing elements – shapes, colors or lines; repetition of the design elements is distinguished with a clear sense of unity, harmony and coherence.

Repetition can be regular or irregular; it can be in a radiant form in which repeated elements radiate from a central point, it can be in a gradual form in which the repeated elements slowly become smaller or bigger.

1-1 Sequence and repetition

Repetition plays a major role in the design as it affirms a specific value; it never lacks the diversity value resulted from various forms of sequence.

Element pattern

It is the design unit which is repeated individually or among other visual elements the design is based on. The visual items used as a design source for ceramic tiles; or on the tile itself within the used repetition arrangement; can be called pattern.

Tiling

Using the term (tiling) is among the key foundations on which the process of designing ceramic tiles is based. The researcher thinks that the translation of the term concept agrees with the (definition of tiling) both in linguistics and terms; as (Warren, 1943) has defined the word "tiling" to mean setting things with each other in an organized and coherent shape; or that it is "a group of things or facts connected with each other through reciprocal interaction or reliance"; but the most important and broader definition is "The tiling is a group of parts or elements of the whole; there are relations and interaction that exist between these elements and they work together to do a specific function. The tiling differs in its level of complexity and degree of

Fig. (34): the concept of pattern repetition and using repeated shapes – "Ceramic design studio" curriculum

comprehensive (from broadness to tightness); its parts can be of a large or limited number".

a- The first style "whole" Tiling

In this pattern; the tiling idea is based on the repetition concept on one unit (the tile as an external frame) specified with the four directions which is called (tiling). It is steadily used in tiles design and production and is connected with the quantitative production which adopts limited dimensions for tiles; the color and decoration treatment can be similar or vary for each tile. Changing these dimensions represents financial cost as well as technical alterations that consumes the time of production lines that are completely mechanical, leading to a very high cost; in addition to the speed and sequence which also costs more. At first; factories were committed to producing the square shape, then they added various ratios and sizes of the rectangle shape; and finally different geometrical shapes have begun to take their place in the production lines; among which are the hexagon and some Islamic geometrical units.

b- The second style "pattern repetition"

This is based on the tile being the steadily repeated pattern in all its details of formative components; the line, color, space and texture; through various patterns of repetitive grids.

It is where repetition is in the structure of the pattern itself and the distribution of spaces, textures and color.

1-2 Rhythm

Rhythm in its various forms means repeating movement in a regular form that combines between unity and diversity; we can say that rhythm itself is one of the
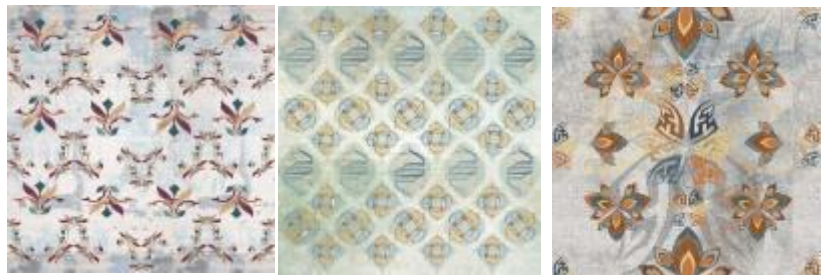

Fig. (35): Rhythm in the repetitive grid –graduation project of class 1439 Hijri

repetition styles for more than one pattern together. This can be achieved through lines and levels; or masses, spaces and color. It is no wonder that trying to achieve rhythm in the design is a clear concept in our daily life; the repetition of the shape elements through – line, space, color and texture – and achieving rhythm in the design confers dynamism and sense of movement. It is one of the powerful design tools used to overcome the monotony and boredom resulted from the stereotypical repetition; this can be achieved through many methods, among which are:

1-3 Gradation

Properties slowly and precisely change in the space to become something else, within the frame of the size, void, density and character. Gradation can be achieved through the design items such as color and shape (space and line), distribution, movement and position, as the eye moves around the elements of the design surface according to the gradation directions; and the eye movement is connected with the rhythm caused by the change in the previous elements.

1-4 Continuity

This is a quality that distinguishes the design to achieve coherence and unity; it might be unseen but is recognized through the repetition pattern of the shapes and lines within the design; it is important that it is not so obvious to the level of superficiality and naivety so that it can be visually recognized as soon as it is seen; neither so vague to the level of ambiguity and inability to be visually and mentally recognized. The concept of continuity has emerged in the design process in two different styles; the first is linked to ceramic tiles production as a unit; it is represented in figure (38); the second style is linked to designing an area in which ceramic tiles represents a printing surface, not a repetitive unit; figure (40) represents this style in the ceramic tiles as well as porcelain slabs, as the size of the slabs in the picture is up to 12 cm X 300 cm.

Fig. (40): Shows the concept of continuity in designing ceramic tiles and porcelain slabs; models 1,2 & 3 are for big size porcelain slabs and the mechanism of using sensory and visual textures of natural materials such as marble and rocks; and using space in the concept of continuous design in a complete moral design; while model 4 represents ceramic tiles through a continuous repetition pattern

Center force

Center is not just that geometrically shaped point; but it is also the relations surrounding it; which together with the spaces and shapes around it create the sense of centralization. Centralization obtain coherent relations and is achieved by affirming it in the small and big parts alike; as well as every relation and space; as found in nature. [4]

Fig. (39): Center force

The value of appearance and invisibility

(Ambiguity and entanglement):

Invisibility and ambiguity are stimuli for curiosity; they motivate the human being to discover; as they fulfill the need of knowledge or answering questions through disclosing what is hidden; invisibility includes the conclusion that the human being can learn more through movement.

While **entanglement and coherence** usually control the relations between the things that surround us; for example; the hallway which is a part of the building binds us inside it and at the same time; it is a part of the exterior world; it achieves a fusion between the building and the surrounding environment.

The value of **clarity or appearance** is a distinct character of the environment that seems to be discoverable by the human being without getting lost.

The value of appearance and invisibility has arisen in the design of a various number of products; among which are ceramic tiles, rugs and different printed textiles.

This concept is applied by either using the element itself so that many very-detailed elements are used- usually famous pattern units of historical styles- and a part of the unit is removed or cut, or; using color and its integration with the background to obtain the concept of appearance and invisibility.

Fig. (43): Transforming monotony and stereotype in the design into diversity using the value of appearance and invisibility

The concept of appearance and invisibility has spread with the emergence of the patchwork style and dense decorative elements in order to minimize overcrowding and jamming the design.

Dividers and strong boundaries

In the living system; strong dividers are considered to be a type of transformation or exchange between spaces; usually very contiguous and sharp ends are not enough to separate them; dividers usually aim to control the interaction level between spaces. [4]

Fig. (45): Strong dividers are a main concept of design

Among the most famous artists who adopted the concept of strong dividers as a design fundamental is Piet Mondrian who reflected the effect of strong boundaries between different color spaces suggesting that it is an element that has its own shape; and that is not just a divider. Figure (45) represents the use of strong boundaries; either by using regular formation of the ending levels; or by using the style of nature imitation or traditional stone construction styles.

2- Intersection

It is very much similar to penetration; but intersection is the visual area, the concept of intersection is usually used when the designer uses line in their design, in which intersection results in a variety of spaces and shapes. The designer can utilize the resulted spaces using color or by keeping the nature of the line and confirming it using the concept of intaglio and relief or thickness; as shown in figure
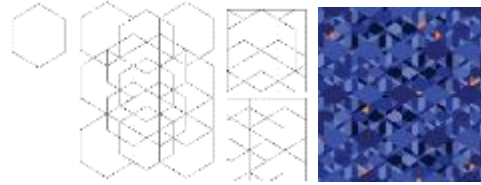

Fig. (46): Intersection as a methodology to generate various spaces; model 1 is line intersection and model 2 is color gradation, the graduation project of class 1439 Hijri

(46), the graduation project of class 1439 Hijri, executed with digital printing; it represents the stages of using the hexagonal shape and intersection to generate various and connected spaces.

3- Coherence, Variety and Unity

This property is concerned with the easiness or flexibility by which the organization or formation process is executed; or the formation of a specific environment. The ability to organize what an individual can see into few coherent identifiable units is a key factor here; and the suitability of a specific element in the whole formation is an important aspect of coherence. Also; repetition or demonstration of the visual unit itself (e.g. a tree) in few variations every time helps in the formation of the scene and its easy recognition.

This is what we mean by the balance of two important elements in the design, in figure (48); the graduation project of class 1442 Hijri, executed by digital printing; we can recognize the achievement of unity by using elements that are connected in regards of their style – Islamic decoration; Iznik ceramic in specific- it is also achieved through a color group in all the design units (tiles); it achieves variety by using different structure of elements that vary between geometric, plant, repetition, overlapping, appearance, invisibility and center force; as well as distributing the color group in different ratios and color gradation.

<u>Variety</u>

Variety can be achieved in dimension, movement, colors and lines to develop a complete design; the variety feature enriches the design and lets the eye always discovers the new relations and connections between the elements of the work, creating a sense of excitement.

The design of ceramic tiles is based on the concept of variety in a way that doesn't make it lose its unity; as variety is based on a kind of system to maintain unity, the more the variety exists among the design elements of ceramic tiles giving that it provides unity; the more this design expresses the actual dynamics. In figure (46) we can see the variety in the tiles sizes, using the effect of natural stone in a rural style and using natural plant decoration, as well as tiles distribution in the placement; the design achieved coherence by one color group in all tiles as well as using one visual texture in all tiles with color variety; which is the metal texture.
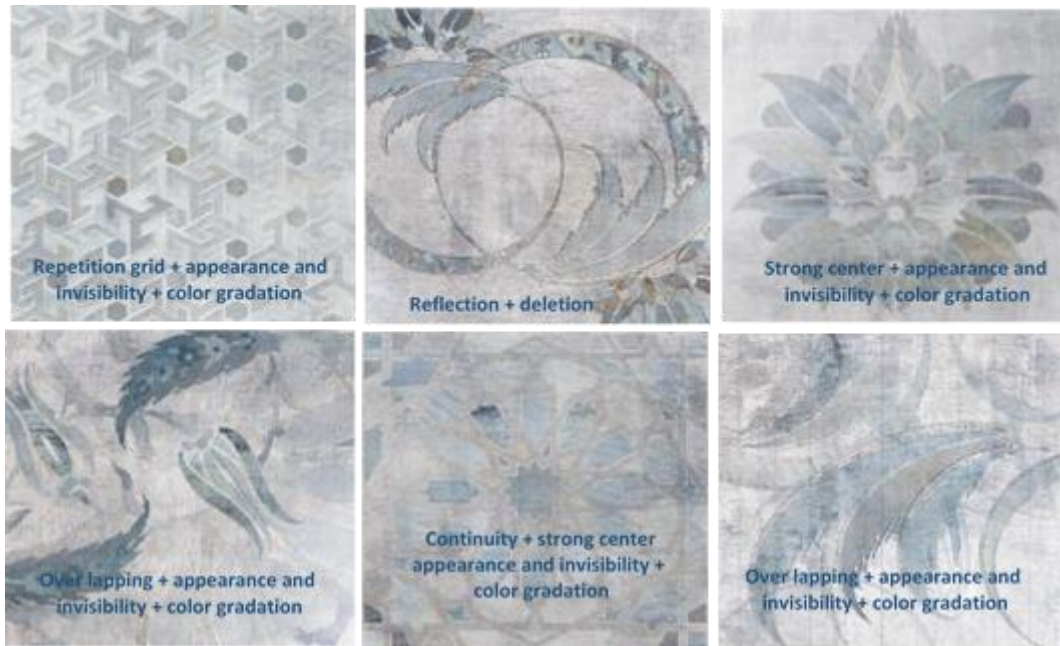
Fig. (46): the concept of patch work and achievement of the unity and variety concepts through the design source and color group; graduation project of class 1442 Hijri

4- Echoes

It is the profound basic similarity as it is found, for example; ethnic symmetry such as Indians or Africans, or the rural homes in a specific area such as Nubian houses, it depends on the common appearance of the design which reflects what we call echo; this is obvious in the tiles designs in the "ceramic design studio" curriculum, where Islamic art is very clear in the design.

Fig. (47): The Islamic echo with its basic features that affirms the concept of echo in design – "Ceramic design studio" 1443 Hijri

9- Contrast

The designer usually uses contrast to achieve more powerful attraction towards the product and to avoid monotony and boredom of the space and processing, contrast also creates dynamics which result from the sight movement around contrasted spaces, but; keeping the balance between the two concepts of contrast and coherence is still a key factor to ensure the success of a design. Contrast can be achieved in ceramic tiles through colors or the nature of the utilized lines, or through textures; the diversity between soft and rough, shiny and matte.

Fig. (48): Contrast between soft & rough, matte & shiny textures

10- Breaking the system

Breaking the system is a type of contrast in the design, but it includes one dominant concept so that the appearance of this new concept breaks the general pattern [4]. Figure (51) is from the graduation project of class 1438 Hijri; in which the design depends on the repetition and reflection as a design pattern; then it deletes some elements and changes the color of others; as a new pattern to overcome space monotony and boredom.

11- Shape and background – positive space

This is one of the most difficult properties in regards to being recognized; it is a deep manifestation of wholeness. While each shape has a strong center; every space has a strong one as well, so that both the shape and space affirm each other. There are different styles of the relation between the shape and background, as follows:

11-1 Integration

In this relation; the structure is based on both the shape and background in the construction of the element and design, so that the design recognition depends on the relation between the shape and background; this is usually in the design that uses two colors only.

11-2 Overlapping

The distance increases until two shapes overlap and the result is that one shape cuts the other; so that the upper shape appears to be on top of- and covering a part for the lower shape. Overlapping can be between various spaces or lines; or between spaces and lines.

Fig. (49): Developing the repetition grid by breaking the system using deletion and addition to the color group in the design, graduation project class 1439

11-3 Intervention or penetration

It is closely similar to overlapping, but there is not an upper shape and lower shape; as they both appear on the same level.
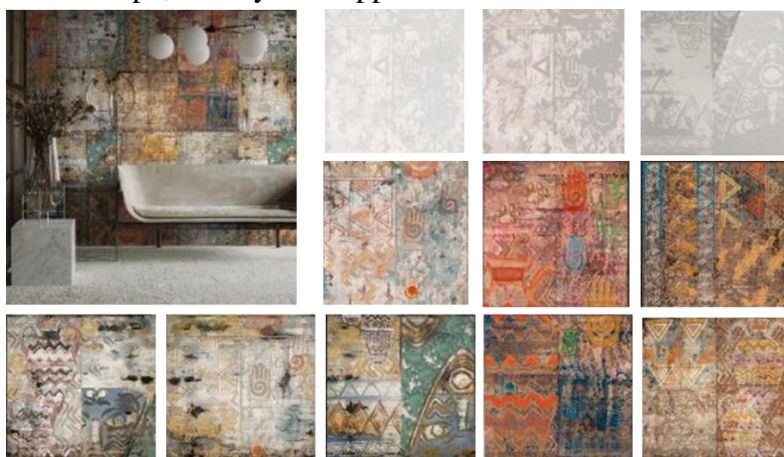

Fig. (50): The design represents number of the fundamentals of ceramic tiles design: including echo; using the African art for inspiration, overlapping and intersection in the distribution of the decorative elements; which are usually simple; to transform it into the stronger and richer elements through diversity of the used lines, as well as overlapping and intersection in order to successfully use the distinct color group of the African art, also by changing the color spaces into various visual textures, finally; the design achieves unity and diversity in the patch work formulation, graduation project of class 1441 Hijri.

Configurations

With the emergence of digital printing and its potentials represented in design flexibility, also; changing the number of tiles –or any other change- no longer needs a number of settings; such as films and silk screen preparation, changing them and their sequence on the production line; as now this is all connected with a number of software settings of the printing machines which only needs a few minutes and don't add any further cost on the factory. This has resulted in large diversity in the number of tiles which are included in one design group, so that it has changed from only one or two tiles in the silk-screen production line; to a number that can increase to 14 different tiles in the same design group.

Items of the design group
Repetitive tiles
They are the tiles that are mainly used for walls and floors; they are decorated using natural visual textures and usually uses two or more colors.

Decorative tiles: They are the tiles which are used when the repetitive tile is used as a background for the design; and are processed using the decorative methods; mentioned before in the design fundamentals section; and they can have separate designs or can be a group of tiles with one design.

Belt
It is a tile which thickness is around 2 cm and not more than 10 cm; it is usually used to separate the spaces in the overall design.

Surface formation, Intaglio and relief
These styles have largely appeared with the development and spread of the molds modeling methods whether using stainless steel or silicon; they represent a main orientation in the ceramic factories which increasingly adopt this style because it corresponds to different architectural styles and is appropriate for residential and service architecture, as well as interior and exterior spaces.

Third aspect: An educational methodology for quantitatively produced ceramic tiles using digital printing techniques
The researcher has adopted more than one methodology to teach the fundamentals of quantitatively produced ceramic tiles design, through the supervision and execution of the graduation project of nine classes; and teaching the "ceramic design studio" curriculum for 12 classes over the course of seven years. The results have shown the importance of setting a methodology and basis for the process of ceramic tiles design, in order to achieve the skills required for the ceramics designer.

Imitation
1- Measuring the skills of visual reading and recognition of the ceramic product nature.
2- Improving the visual production skills in the field of ceramic tiles design.
3- Utilizing the computer skills in the visual production – computer design.
4- Recognition of the considerations related with quantitatively produced tiles design in regards to the shape, color and texture; in its relation with the context.

The models shown in figures (51), (52) are some outcomes of an exercise to imitate ceramic tiles produced by international companies; executed by the female students of the "Ceramic design studio" curriculum within the Applied Arts program; it is the first curriculum for ceramics education to be taught to the female students; and these are the results after attending four lectures from the beginning of the course.

Fig. (51): An example of design source imitation – geometric shape - "Ceramic design studio" curriculum 1443 Hijri

Fig. (52): An example of design source imitation – nature - "Ceramic design studio" curriculum 1443 Hijri

Re-design

This stage aims to teach the stages of the design process (source analyzing, primary ideas, variables and substitutes, initial filtration, ideas improvement, final product design, utilization in the appropriate context) by working through a specific design methodology according to the selected model to re-design and imitate. In this stage; the female students use the re-design methodology by analyzing the original design and identifying a grid for the relations that change based on the design fundamentals, visual textures, color groups and structure. The re-design exercise usually takes one week (02 lectures per week) to provide the outputs presented in figure (53).
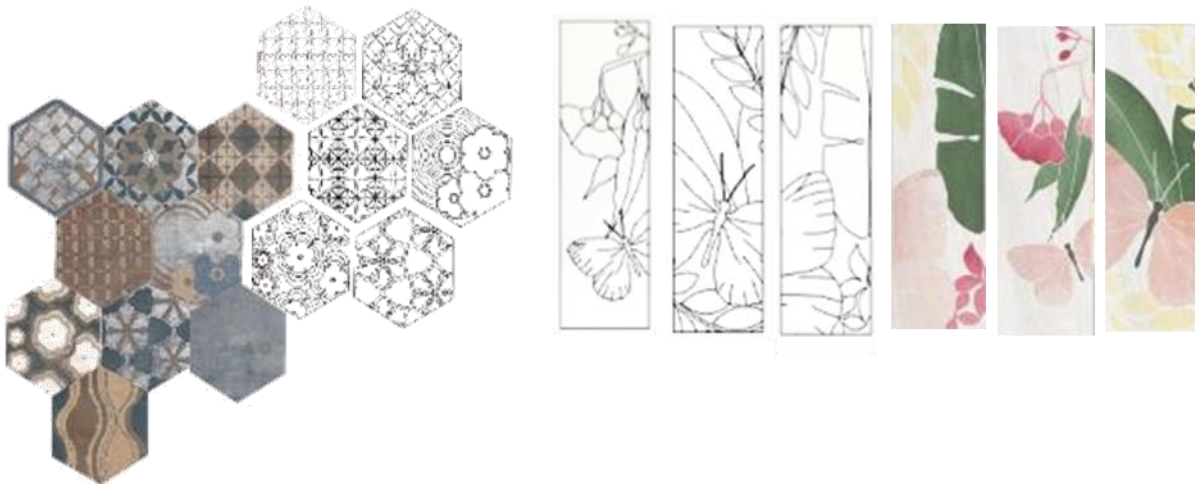

Fig. (53): Outputs of the source re-design exercise for the previous imitation models, Ceramics design studio 1443

New design

The third exercise includes measuring the student's skill in regards to constructing and organizing the ideas; and practicing the design methodology according to the previous inputs; which can be completed in a 4-hours exam; figures (54) & (55) show some examples.
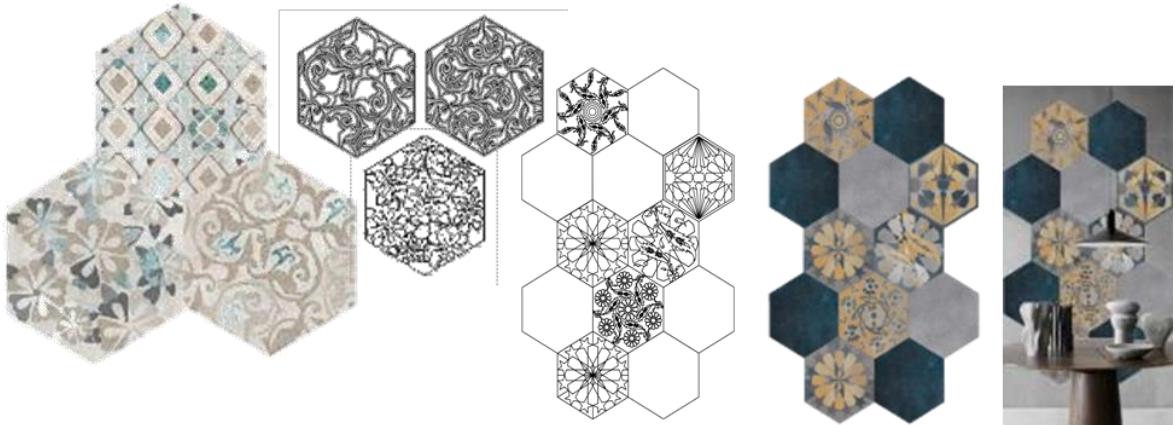

Fig. (54): New design, source: Islamic art, we can see a great diversity in the students' outputs despite using one geometric grid and plant decorated tile; as the students have applied the various design fundamentals in the structure, ceramics design studio class 1443 Hijri

Analyzing the digital printing outputs for some tiles examples

Fig. (55): Computer design before printing – graduation project – class 1442 Hijri
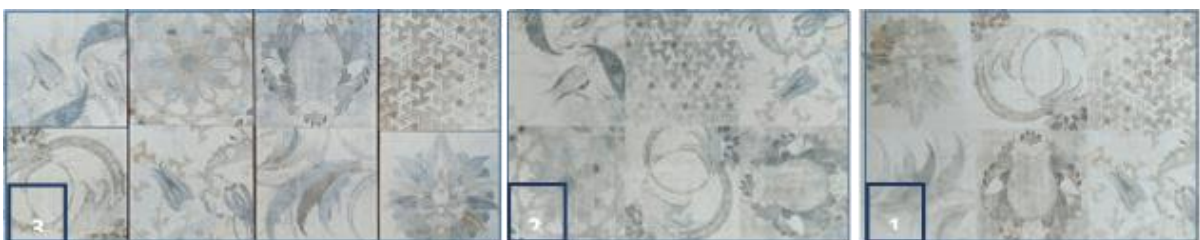

Fig. (56): three samples were printed with changes in the printer settings; the first and second samples show the great differences in the color degrees and effects; the third sample succeeded to match the original design

Fig. (57): Effects created using silk-screen to produce texture and reflection of the material and color

Fig. (58): These tiles are some of the best samples; as they matched the computer design, graduation project – class 1441 Hijri; the design used the concepts of overlapping and intersection and was inspired by the Jazan and Asiri Katt styles

Conclusions

1- Ceramic tiles design and production have become a complete digital process; which were reflected in a great development in the production methods and materials, thus; in the design.

2- The development in the digital technologies was accompanied by a development of materials which allowed conferring the Bedouin style and traditional techniques on a product that was completely mechanically produced.

3-Despite the great changes in the design methodology, production methods and materials, ceramic tiles; as an architectural product; adopt the concept of (trend) and (public trend) in its design process, it is seldom to present a design based on the concept of (fashion).

4- The continuous improvement of the ceramics design methodology (ceramic tiles) with the local industry styles of the Kingdom of Saudi Arabia has gained the female graduates the skills that match the demands of the local labor market; this was reflected in the employment of 7 graduates in two years at the same company; which was the one that executed the graduation projects; noting that this company is located in Riyadh, while the program and its graduates are located in Jazan; and they are the first Saudi female ceramics designers working in factories in the whole Kingdom.

Recommendations

1- The great and rapid development in the field of ceramic tiles production on the level of materials and technologies require similar developments on the level of tiles design methodology and its variables.

2- The ceramics industry is gaining a great increase and spread on the local level; which provides increasing number of job opportunities, thus; the educational programs specialized in ceramics should keep pace with this increase by qualifying the graduates with the labor market requirements in regards to design; techniques, materials and computer applications.

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