From Clay Cones to Tesserae: the Generative Art of Mosaic Making

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Abstract

The story of mosaics began over 5000 years ago in Mesopotamia when tiny baked-clay cones were first used as a strong finishing material for mud-brick structures. The head of these cones were sometimes colored in black, white or red, and a pattern was achieved by inserting them into the mud plaster on the walls; this was the earliest form of mosaic which has been discovered to date. Since then, many variations have been generated in many parts of the world.

After Mesopotamia the art of mosaic-making in the region, which is now called Turkey, developed in the Hellenistic era, flourished during the Roman Empire continued in the Byzantine period, stagnated during the Ottoman Sultanate and revived in modern times as a decorative finishing material. Over the centuries mosaics have been produced with different material and techniques, textures and colours, motifs and patterns, icons and themes, and on different surfaces and objects; for different reasons and beliefs, the most important reason being to provide a lasting, meaningful and aesthetical finish to the surface it is being applied on.

A study was conducted to trace the development of mosaics in Turkey from the point of view of the types of material and tesserae used, the techniques employed, the colours, motifs, scenes and themes developed in these mosaics. This paper presents the salient features of this transformation through a period of almost two thousand years. The journey starts in Antioch (Antakya), continues in Constantinople (Istanbul) and ends in the Turkish capital, Ankara. Photographs of historical mosaics in Antakya and in Istanbul were taken to collect pertinent visual data; and historical facts were obtained from a survey of literature. Information on modern mosaic-making techniques was gathered during visits to two mosaic workshops in Ankara. Both of these workshops produce mosaics by first fashioning tesserae out of left-over or faulty material, and then using the recycled tesserae to create handmade borders and panels with modern techniques. One workshop dealt with stone, marble and ceramic tiles and the other with glass off-cuts or recycled broken glass.

1. Introduction

The first evidence of mosaic-making in Turkey is attributed to the discovery of baked clay cones in the rubble of ancient mud-brick houses of the Sumerian period (3100 - 3000 B.C.). These cones were similar to those used in the mosaics of the 1st Ur dynasty in Iraq (2600 B.C.). Ancient cone-mosaics were followed by the black and white pebble-mosaics of the Greeks in Delphi (600 B.C.). Although, classical Greek mosaics were being executed with small cube shaped stone tesserae (450 to 350 B.C.), coloured marble was used for the first time in 300 B.C. During this period, geometrical motifs, animal forms and also human figures were being used in the mosaic panels; however, the use of cut stones instead of pebbles in pavement-mosaics started much later, in 200 B.C. Finally, colored glass tesserae started to be used for domestic mosaics in around 150 B.C. [1]

The finest examples of early mosaics unearthed in Turkey belong to the Roman era in Antioch (Antakya) and the Hellenistic era in Zeugma. These mosaics were prepared with stone and glass tesserae embedded in lime plaster; and were executed on a grand scale with excellent techniques and naturalistic effects [2]. The mosaics uncovered in Antioch are representative of the iconographic and stylistic changes in Roman art history over a period of four centuries -- from 2nd to 6th century C.E. -- in the Mediterranean region and its environs. [3]

Mosaics are the most splendorous form of architectural decoration and mosaic-making became an art form during the Ptolemaic period in Egypt, from where it spread to the near and far east as well as the Roman provinces [2]. The art of mosaic-making developed by copying old paintings; especially, during the period from 150 B.C. to 200 C.E. When Christianity spread in the Roman Empire and became the official religion during the 4th century C.E. mosaics became recognized as a Christian art and became a medium for large-scale wall decoration in the form of religious murals [1]. These mosaics or stone paintings had superlative permanence and splendor of color compared to frescoes; their grandeur was enhanced when gold started to be used with colored glass tesserae for mosaics in palaces and churches. Examples of such mosaics, which belonged to the Byzantine Empire, can be seen in the churches of Chora and St. Sophia in Istanbul. Gold foil was combined with glass in a special technique to produce the golden tesserae; these were then inserted at a slight angle to catch and reflect the dim light in church interiors, especially the walls and vaults. Figure 1 shows a mosaic from Hagia Sophia, which was built in the 6th century and its mosaics were executed from the 6th to 11th century C.E.

Figure 1. Byzantine mosaic on the vault of Hagia Sophia in Istanbul, Turkey.

Mosaics lost popularity with the coming of Renaissance when paintings became more fashionable; especially since mosaics were more expensive to execute and could not be transported like paintings[1]. On the other hand, Constantinople (Istanbul) had been taken over by the Ottomans who preferred tiling as a decorative art and an architectural finish. Nevertheless, examples of pebble-mosaic pavements can be seen in the 15th century. Ottoman Palace of Topkapi in Istanbul which is remarkably similar to the 1st century mosaic in Russi, Italy (Figure 2). The palace also has a marble mosaic in the Opus Sectile technique next to the swimming pool. After almost 5 centuries of neglect the art of mosaics finally revived in the first half of the 20th century and gained popularity towards the second half [4].

(a)

(b) photo by S. King [4].

Figure 2. The black and white pebble-mosaic pavement of Topkapi Palace in Istanbul (a), executed in the 15th century, resembles the 1st century mosaic in Russi, Italy (b).

With the passage of time, the technology of designing and producing mosaics underwent a change, which was not always progressive. The most important aspects in determining the techniques of production of a mosaic were the availability of material to be used as tesserae and the surface it was to be applied on; while the design depended upon the colour, texture and size of the tesserae, as well as the intention, importance and social relevance of the mosaic. Some of the techniques, motifs, and themes have continued over time while others have been abandoned. Although hand-drawn and hand-crafted mosaics maintain their originality and allure, modern mass-produced mosaics are being fashioned with the help of CAD CAM technologies.

2. Generating mosaics

Mosaics are created by inserting small pieces of stony material in a bed of plaster; these pieces are called tesserae, which are available in many shapes, sizes, materials and colors. The transition from pebbles to cube tesserae was not abrupt but a refining process [1]; and the evolution of tesserae from clay to recycled material occurred in the following chronology: clay cones (3000 B.C.) to limestone and shells (2600 B.C.) to pebbles (600 B.C.); to cut stone (200 B.C.) and marble (450 to 350 B.C.) and then glass (150 B.C.); and finally ceramics, metals, and recycled material such as broken pottery, tiles and mirrors (1900 C.E). . As the variety in material increased, so did the variety in colour and texture. Colours of older pavements are restricted to the colours of marble and stone available in the region. However, with

the spread of glass tesserae the colour palette was extended and enriched. For example the mosaics in Hagia Sophia have been executed in 23 colors, including gold.

Modern mosaics are produced with many different materials used in conjunction, such as: glass, ceramics, marble, stone, metals, shells, pebbles, *etc*. Ceramic tiles are cut into regular shapes; squares or rectangles of desired size, the smallest being 1cm x 1cm; with the help of cutting machines or broken into irregular pieces in-situ (Fig. 3). Marble / glass tesserae are produced from thin marble slabs / glass sheets in the same way as ceramic ones are with the help of machines and special tools. Conversely, they are fashioned from off-cuts or waste pieces of marble or glass. Sometimes, glass or ceramic tesserae are factory produced in the desired colors, shapes and sizes; the glass tesserae in the workshop surveyed are produced from recycled glass.

Figure 3. Preparing tesserae in a workshop in Ankara, Turkey.

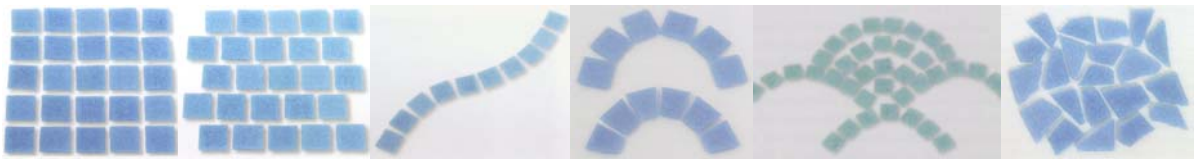
Along with the transition in materials there also existed a continual transition in the themes, motifs and techniques. For example, in Antioch the educated elite preferred to commission literary scenes in their homes, such as 'the judgement of Paris'; while some themes were of a moral value, such as 'the drinking competition'. Superstition was another theme in residential mosaics, such as warding off 'the evil eye'. Labelling is found from 3rd century C.E. onwards where abstract concepts were portrayed, while lengthy inscriptions were used to immortalise quotes or biblical verses.

2.1 Designing mosaics

The first mosaics consisted of simple geometric patterns such as bands, grids, zigzags, triangles etc; as in the Temple of A-anni-padda belonging to the 1st dynasty of Ur. These geometric patterns evolved into more complicated designs which were later combined with panels of stylized scenes, as in the Hellenistic and Roman mosaics. On the other hand, imagery in mosaics changed from pagan gods to literary scenes and then to religious ones with the spread of Christianity in the Roman Empire [1].

Mosaic patterns can be classified according to the shapes and order or disorder of the mosaic tesserae [4]. For instance, when cubic tesserae are fixed in a rectangular geometrical grid the pattern is called *Opus Regulatum*. However, if the rows in the grid are offset to resemble the common brick bond it is called *Opus Tesselatum,*

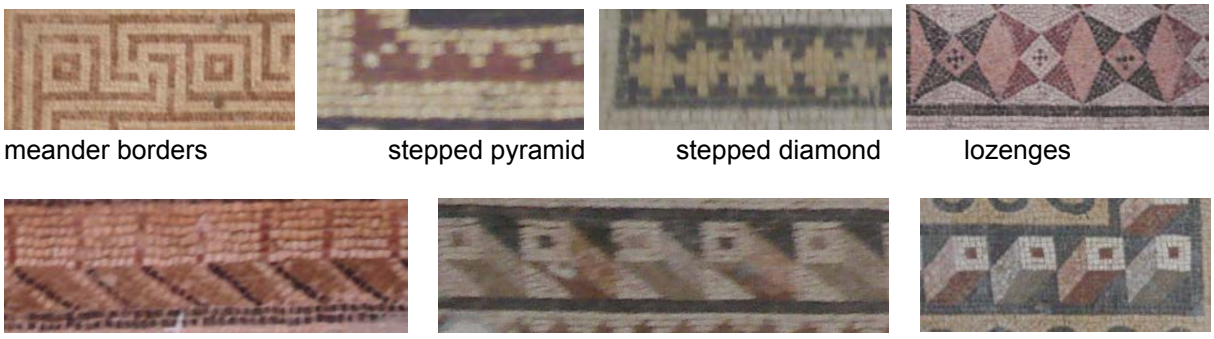
which is mostly used for mosaic infill or background. On the other hand, if the tesserae are inserted in a worm-like winding pattern, which is often used for outlining or emphasizing a shape for pictorial effects, it is called the *Opus Vermiculatum*; and when this style of fixing tesserae is used to cover entire vaults or walls, as in the early Christian mural mosaics, it is called *Opus Musivum*. Finally, if the cubic tesserae are fixed in the key-stoning curves and a repeated fan-shaped pattern is achieved, it is called *Opus Circumactum.* To execute a mosaic in an *Opus Sectile* pattern, the tesserae are cut to fit the contours of the design, as in the 15th century C.E marble marquetry of the water channel in Topkapi Palace in Istanbul, belonging to Ottoman times (figure). Conversely, if the tesserae are not only randomly shaped but also laid in a random manner the pattern is referred to as *Opus Palladianum*; this style of executing mosaics has become very popular in contemporary times and the most remarkable examples can be cited as Gaudi's Parc Guell in Barcelona.



Regulatum *Tesselatum* *Vermiculatum* *Musivum* *Circumactum* *Palladianum*

Figure 4. Mosaic patterns are classified according to the shapes and order or disorder of the mosaic tesserae [4].

The *Opus Regulatum* is used to create the meander borders and the stepped pyramid shape; the latter then generated the stepped diamond pattern. The diamond was transformed into the lozenge, which in turn generated the dentil and solid borders (Fig. 5). The solids were used in varying configurations to create smaller emblemata (Fig. 6).



meander borders stepped pyramid stepped diamond lozenges

Dentil border solid borders

Figure 5. Opus regulatum used to generate various shapes and border designs

Figure 6. Solid box motif used to generate various emblemata.

The *Opus Vermiculatum* is used to create the wave-crest and folded ribbon borders; the latter was transformed into a twisted ribbon by creating a three dimensional effect with bands of colors ranging from dark to light to give it the feeling of depth (Fig. 7). This style is also used to create the guilloche borders which become more and more complicated with the addition of strands (Fig. 8). The guilloche, which is a pattern of interlacing bands forming a plait, is also a forerunner of the gradually complicated knot emblemata (Fig. 9).

Figure 7. Opus vermiculatum used to generate various shapes and border designs

Figure 8. Opus vermiculatum generating 2, 3, 4 strand- and loop- guilloche borders

Figure 9. Generating emblemata from meander to knots and loops

Traditional techniques:

The mosaic school of Eastern Arts extended beyond the workshops of Antioch. In these workshops there used to be teams of mosaicists consisting of a designer and the apprentice workers just like the team consisting of a figure specialist, an ornament painter and a plasterer for producing murals. Mosaicists traveled to far off places to practice their trade which is why the style and iconography of mosaics produced in the workshops of Antioch can be seen in places like Cyprus and Israel [3].

The mosaics had depth and three dimensional effects similar to paintings, which is why they were often called stone paintings. The mosaicists were known for the sophisticated handling of foreshortening, shading and lighting that produced these effects. Their style was a continuation of the Hellenistic artistic tradition in the selection of Greek themes and patterns, and illusionistic treatments in painting style. The iconography in these mosaics had messages of social and moral nature [2].

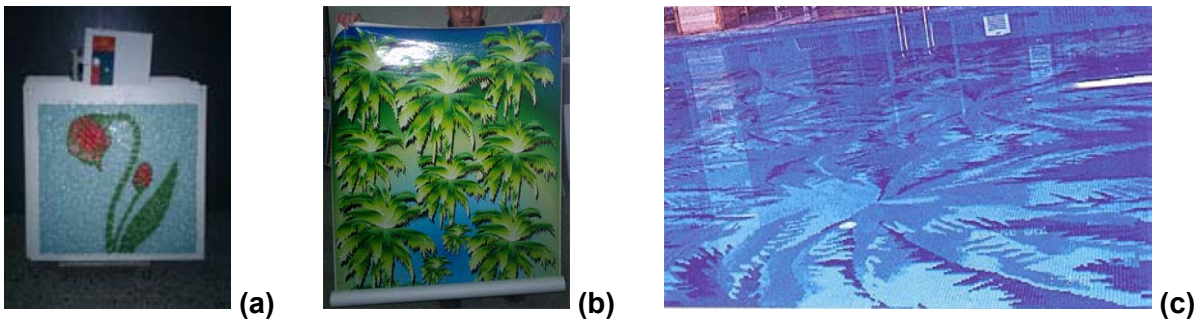
The three dimensional effect was created with various techniques shown below, such as: coffered panels; lozenges and a square to give the solid box and a square within the square to give an open box effect; meander pattern in isometric; empty cubes; inscribed boxes; folded ribbon, etc.

Figure 10. Generating three dimensional patterns from meanders and solid boxes.

The basic composition of a mosaic consisted of square or rectangular panels of geometric patterns or scenes from religious or literary stories. The panels were encircled with geometric borders or rinceau, which were wide borders of vines, leaves and flowers interlaced with birds and masks. The geometric borders were composed of plaits, solids, row of dentils, guilloche (2, 3 or 4 strand or looped-), stepped pyramids, meanders, tangent diamonds, wave-crests, twisted ribbon, folded ribbon, trellis, or bead and reel. Sometimes a panel would contain a rectangular, circular or octagonal emblema instead of a scene. It was also possible to create a panel with semis of florets, crosses, rose-buds, stars, diamonds, etc. The smaller emblemata would contain rosettes, simple knots, zigzag bands or a Solomon's knot.

Modern techniques:

Computer programmes such as AutoCAD or CorelDraw are used to generate the pattern, which is either provided by the client's architect or chosen from ready made ones in the mosaic catalogue If a photograph is used then it is scanned and imported into a CAD programme, where it is subdivided into manageable panels. The panels are numbered sequentially and printouts are produced; these printouts serve as the stencil for the mosaic panel. A 160 square meter swimming pool was finished with glass tesserae mosaic by first enlarging the chosen pattern and then dividing it into 30x30cm tiles. These tiles were produced using the direct mesh method and numbered according to their sequence in the pattern. They were brought together on site and installed in their designated places to assemble the pattern (Fig. 11).



(a) **(b)** **(c)**

Figure 11. Transforming design into mosaic tiles and panels: (a) post card to mosaic (b) wall-paper panel (c) wall paper pattern executed as mosaic for swimming pool

2.2 Production Techniques

There are mainly two ways in which a mosaic can be produced: in-situ or in a workshop. When a mosaic is executed in-situ, the outline of the pattern is drawn directly on to the surface on which it is to be applied; mortar or adhesive is then spread over small sections of the pattern and tesserae are inserted into it piecemeal; once the pattern emerges the background is filled in. Since the pattern is stenciled in directly this technique is called the 'direct method'. The direct method can also be used in workshops to produce panels of mosaics on a solid base that can be transported to the site and fixed in place. Although, in-situ mosaic production was common in the past and although it is still used to produce smaller objects, it is no longer practical to execute mosaics for architectural decoration purposes using this technique. Due to time and space constraints, it is more convenient to install made-to-order mosaics, which have been prepared in workshops.

Mosaics created in workshops, to be applied on walls or floors elsewhere, can be prepared using one of the following three techniques: the mesh, reverse-stencil or template-tray. In the mesh technique the tesserae are glued on to a glass-fibre mesh according to the pattern drawn on a paper stencil placed under the mesh. Since the pattern is drawn normally on the stencil and since the tesserae are fixed face up it is considered to be a direct method. On the other hand, the reverse-stencil and the template-tray techniques are considered to be indirect methods.

In the reverse-stencil technique, the pattern is sketched in reverse on paper and tesserae are fixed face-down onto the pattern with a temporary adhesive. When panels so prepared are inserted on to a layer of fresh plaster or stucco the paper is peeled off to reveal the mosaic and the gaps between the tesserae are filled in with grout. In the template-tray technique, the mosaic is prepared in modular plastic trays which have the pattern molded in like a template. The tesserae are placed face-down on the template-trays and glue is applied to their backs with a roller; the mesh is then stuck to the tesserae and once the glue dries it is possible to lift off the mosaic from the template-tray and store it in boxes to be transported to the installation site. At times these mosaic tiles are part of a very large pattern or scene which is assembled on site and inserted in the proper sequence.

Figure 12. Glass tesserae and template trays used to produce mosaic tiles and panels.

Traditional techniques:

Early mosaics were always executed in-situ; plaster was laid on a foundation coat of cement on which the principle features of the design were drawn and coloured. This

plaster was removed bit by bit and replaced with binding cement and tesserae. Sometimes the design was scratched into the base plaster with the colour of the larger areas indicated on it. The design was thought out by the master mosaicist who also laid out the contours of the design and the main panels; the rest was filled in by his assistants. The grout that would be applied to fill in the spaces between the tesserae was sometimes coloured; e.g. the grout used in the Hagia Sophia mosaics was deep red so as to bring out the splendour of the gold tesserae [1].

The surface to be decorated was covered with a thick plaster of powdered marble lime mixed with pozzulana (volcanic rock), to make it smooth. The mosaic pieces were inserted into a second layer of stronger plaster that was applied in sections small enough to allow the work to progress before the plaster had time to dry out. The tesserae were not absolutely regular in shape, ranging from 0.4 cm to 1.8 cm; smaller ones were used for detailed work and larger ones for the background. The tesserae were never set flush but at slight angles, with the darker coloured ones set deeper to give an illusion of three dimensions [1].

In Antioch mosaics, the glass, marble or stone tesserae were set in a lime plaster. Each mosaic was designed by improvising on a standard theme composed of borders and a scene or emblema within [2]. The direct technique was also used in Roman times to prepare portable panels, called emblemata, in the mosaic workshops and carried to the site to be inserted in the pavement; the rest of the panel and borders were laid in-situ [3]. It is believed that the complicated and main figures as well as the emblemata were prepared by the masters and the minor work such as filling in the background of the mosaic or its simple border was done by the apprentices [4].

Modern techniques:

A black and white photocopy of an old pattern is obtained from a scanned picture which is enlarged to the desired size; or a life-size printout of the design is obtained of the computerized pattern to be used as a stencil for the mosaic. The print-out is laid out flat on the ground or a worktop. A nylon or plastic sheet is fixed to the stencil to protect the paper and to prevent it from sticking to the back of the mosaic. A nylon- or glass- fibre netting/mesh is fixed temporarily to the plastic sheet to stick the tesserae on to. White water-soluble PVA glue is applied over bits of the pattern area visible through the nylon. The tesserae are glued to define the outline of the pattern first and then the rest of the pattern is filled by sticking the rest of the tesserae according to the colour copy of the pattern being produced.

Depending upon the complexity of design and the size of the tesserae, it can take anytime from one day to one whole month to finish one square meter of mosaic; for example a copy of an ancient mosaic is produced in 25 to 30 days by one skilled mosaicist. When the panel is finished, it is lifted off the paper stencil along with the nylon sheet and put into boxes to be transported to the building it will be installed in. Mosaic panels produced in workshops are applied to the surface (floor or wall) with a thin mortar and, when dry, cement grout is spread on it liberally to fill in the spaces between the tesserae. The surface is then wiped to remove the excess grout and reveal the mosaic pattern.

3. Concluding remarks

Visual information presented in this paper demonstrates clearly that there exists a very strong relationship between tradition and the innovative generative approach. Simple shapes were used to generate compound motifs, which were then used to further generate borders and emblemata of increasing complexity; nonetheless maintaining the quality achieved.

Throughout the ages, some motifs and themes have been transformed, some changed and some remain all time favorites. For example the superstitious evil-eye theme in the Antioch is continued in modern Turkish mosaics as well, albeit, with different motifs; while the meander and guilloche borders are still being used in modern designs. Due to the ease of producing and controlling the transformation of the design idea into reality with computer aided tools and modern equipment, the techniques have changed for the individually crafted mosaics to mass produced ones.

Acknowledgement

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