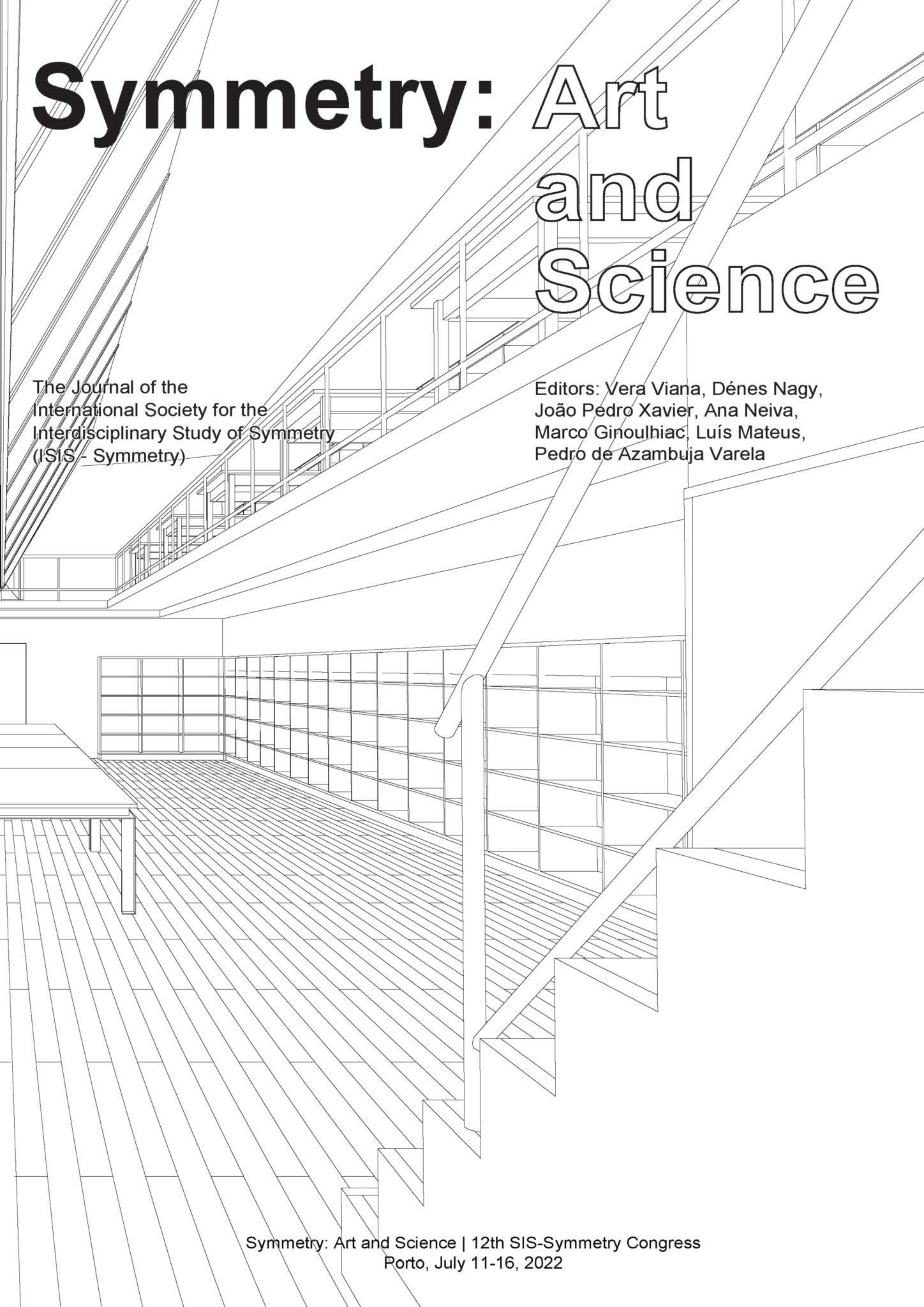


Symmetry: Art and Science

The Journal of the
International Society for the
Interdisciplinary Study of Symmetry
(ISIS - Symmetry)

Editors: Vera Viana, Dénes Nagy,
João Pedro Xavier, Ana Neiva,
Marco Ginoulhiac, Luís Mateus,
Pedro de Azambuja Varela

Symmetry: Art and Science | 12th SIS-Symmetry Congress
Porto, July 11-16, 2022

Symmetry: Art and Science, 2022 (1-4)
Special issue for the 12th SIS-Symmetry Congress

Congresses of the International Society for the Interdisciplinary Study of Symmetry:
1989 (Budapest, Hungary) | 1992 (Hiroshima, Japan) | 1995 (Washington, D.C., United States of America) | 1998 (Haifa, Israel) | 2001 (Sydney, Australia) | 2004 (Tihany, Hungary) | 2007 (Buenos Aires, Argentina) | 2010 (Gmünd, Austria) | 2013 (Crete, Greece) | 2016 (Adelaide, Australia) | 2019 (Kanazawa, Japan) | 2022 (Porto, Portugal)

SYMMETRY: ART AND SCIENCE
12TH SIS-SYMMETRY CONGRESS

Porto, Portugal
July 11-16, 2022

Editors: Vera Viana, Dénes Nagy, João Pedro Xavier,
Ana Neiva, Marco Ginoulhiac, Luís Mateus, and Pedro de Azambuja Varela.

Host Institution:
Faculty of Architecture, University of Porto

The digital edition of this Special Issue is hosted in the Scientific Repository of the University of Porto.
More information about the publication in https://symmetrycongress.arq.up.pt/proceedings/

Printed edition:
Viana, V., Nagy, D., Xavier, J., Neiva, A., Ginoulhiac, M., Mateus, L. & Varela, P. (Eds.). (2022). Symmetry: Art and Science | 12th SIS-Symmetry Congress [Special Issue]. *Symmetry: Art and Science*. Porto: International Society for the Interdisciplinary Study of Symmetry.
Printed by Nozzle, Lda. (nozzle@sapo.pt)

Vale, C. P. d. (2022). Symmetry Relations in Crossed-Arch Domes. Comparison Between the Persian and Spanish-Muslim in Viana, V., Nagy, D., Xavier, J., Neiva, A., Ginoulhiac, M., Mateus, L. & Varela, P. (Eds.). Symmetry: Art and Science | 12th SIS-Symmetry Congress [Special Issue]. *Symmetry: Art and Science*. International Society for the Interdisciplinary Study of Symmetry. 062-069. https://doi.org/10.24840/1447-607X/2022/12-07-062

SYMMETRY RELATIONS IN CROSSED-ARCH DOMES: COMPARISON BETWEEN THE PERSIAN AND SPANISH-MUSLIM TRADITIONS

CLARA PIMENTA DO VALE

Name: Clara Pimenta do Vale (b. Barcelos, 1967)
Profession: PhD researcher, Professor, Photographer
Fields of interest: Architecture, Construction History
Affiliation: University of Porto
E-mail: clara_vale@arq.up.pt
Homepage: https://sigarra.up.pt/faup/pt/func_geral.formview?p_codigo=240758
Major publications and/or exhibitions:
Figueiredo, R., Vale, C. & Tavares, R. (2013). Aliados Avenue and Centre of Porto: Memory, Reality and Permanence (Porto Vivo SRU, Ed.) https://hdl.handle.net/10216/137630
Vale, C. (2018, 10-13 April). The social rise of a housing intervention: Álvaro Siza project for Bouça Neighbourhood 42nd IAHS World Congress - The housing for the dignity of mankind, University of Naples Federico II, Telematic University Pegaso, Naples, Italy. https://hdl.handle.net/10216/111685
Sampaio, M. d. L., & Vale, C. P. d. (2021). The garage building: an answer to the new automobile mobility in Porto during the decade of 1930. In M. d. R. Monteiro & M. S. M. Kong (Eds.), Tradition and Innovation (pp. 115-121). CRC Press/Balkema. Taylor & Francis group. https://doi.org/DOI 10.1201/9780429297786-18

Abstract: *Karbandi, crossed-arch domes or ribbed domes are strategies used to cover large span spaces that depart from a set of arches that are secant to the tracing base circumference, and are rotated several times along the vertical central axis. The number of divisions, rotations, juxtaposition, and the relations with the space layout establish symmetrical relations or define symmetrical modules. In this paper, a comparison between East and West traditions is made, highlighting the similarity of early examples and the increasing complexity, sophistication, and levels of systematization of the Eastern tradition.*

Keywords: Karbandi; Ribbed Dome; Tracing; Iran; Iberian Peninsula.

INTRODUCTION

Karbandi, crossed-arch domes, or ribbed domes (according to different denominations and geographical locations) are strategies used to cover architectonic spaces that don't depart from the spherical shape of the dome, but from arches, whose vertical planes usually are secant to the base circumference, intersecting each other several times. Sometimes a lattice structure is produced. In other cases, the ribs and the dome are parallel to the same surface of revolution. These structures are used as early as the 10th century in Cordoba, Spain (Fuentes González, 2009; Torres Balbás, 1955) and Shiraz, Iran (Naeeni *et al*., 2017) but the roots of the probable earliest examples are still not clear. The nine different small domes in Cristo de La Luz, in Toledo, seem to invoke previous, but unknown, examples. A similar tradition is also encountered in Arménia, and the relation between the three, or a common ancestor, is also still unknown (Sakkal, 1995-97).

in a certain way, they could be seen as integrated into the strategies used to bridge the difference between the square shape of a room and the circular base of a dome that rises above it, like (the also used) squinches or pendentives, but can also cover other geometric shapes like rectangles, octagons, and triangles (Mohamadianmansoor *et al*., 2012; Mohammadi *et al*., 2018). However, the decorative and symbolic aspects would be as important as the constructive one, as these structures were used to cover spaces as small as 1,80 m wide. That is the opinion of Sakkal (1995-97) relating these star-shaped domes with the representation/invocation of the celestial dome.

THE RESEARCH

This research was triggered by the participation on a Vernadoc camp survey in Tabriz bazaar (Malekabbasi & Oloumi, 2020, pp. 57-76) where a *karbandi* had to be represented in section and in plan (Figure 1). The need to first understand the geometrical alignments underlying the structure and its construction rules determined the initial contact with the work of Bozorgmehri (1992 [1982]). In Iran, Karbandies are used to cover many types of spaces, from mosques and bazaars to the domestic interiors of traditional houses or palaces, and the underlying geometric and constructive knowledge reached our days, by live tradition, but also by the register of old master experiences in some books and articles (mostly in Farsi).

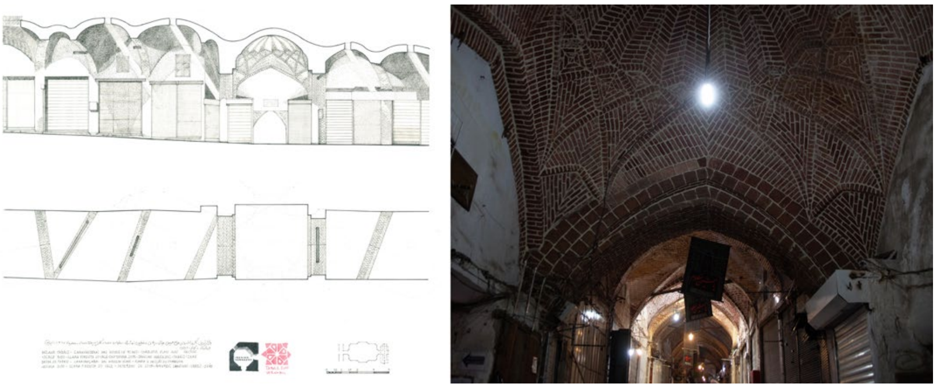


Figure 1 Geometric survey of Tabriz Bazaar corridor with a *karbandi* dome in the centre [left], and a photo of the *karbandi* dome [right] (author, 2018).

A *karbandi* is a very recognizable dome in Persian tradition. From the point of view of its geometric construction, a regular/simple *karbandi* is obtained by discrete rotation of an arch (Figure 2-1) whose vertical plan is located over a chord of the base circumference. As shown in Figure 2, 1 to 4, the i) number of times the circumference is divided, the ii) chord angle, the iii) number of times the arch is rotated, and also the iv) 'omitted' parts, will determine the v) number of times the arches intersect, and will define the different traces of karbandi. The chord makes the connection between 2 points of the circumference division, and the number of divisions that are between the chord end points is called the *karbandi* pass 'n+x' (Pour Ahmadi, 2014). The pass n+1 draws the inscribed regular polygon (hexagon, octagon, etc); n+2 and higher passes will give more crossings between the arches, and a smaller 'void' in the middle, usually covered with another structure – the Shamseh. More elaborated combinations are also found, with the use of 'bended' arches (called out of plomb karbandi) or like in Figure 3, the combination of several karbandies in the same space (Pour Ahmadi, 2014). The 'bended' arches also produce a smaller Shamseh and a more decorated karbandi. Omitting (or cutting) part of arches will 'lower' the *karbandi* pass (Figure 2-4).

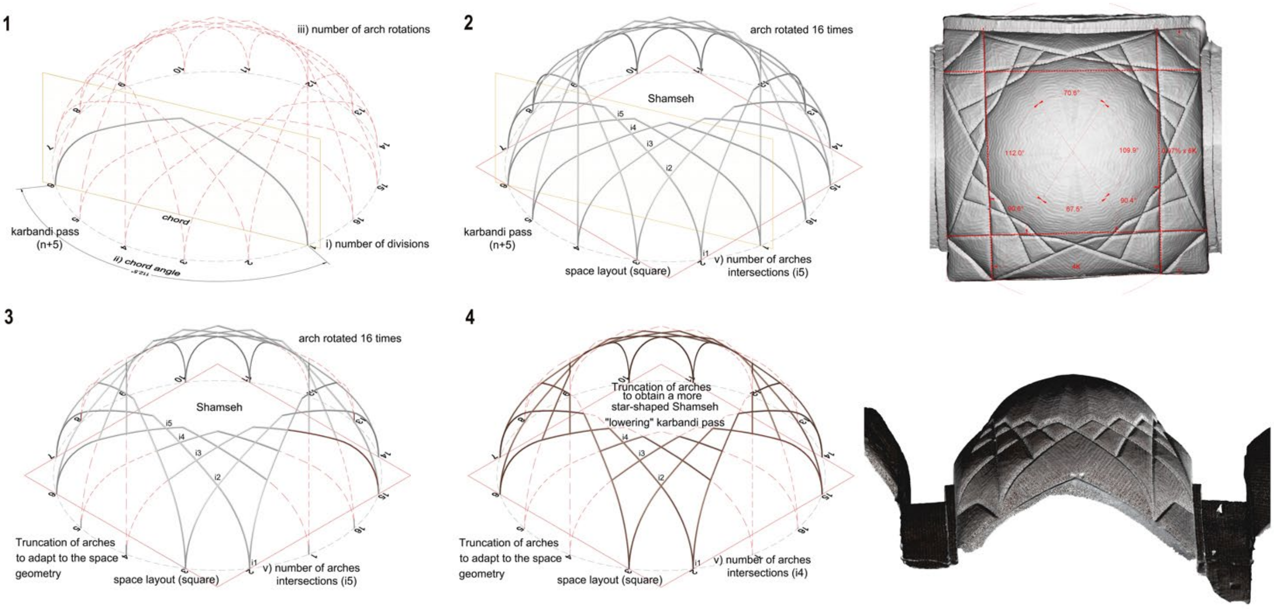


Figure 2 Tracing of a 16 side karbandi, with a pass of n+5 [left], like the surveyed in Tabriz Bazaar [right], in section [bottom-right] and in plan [top-right] comparing proportion and angles (author, 2021-22).

In Spanish Muslim tradition, crossed-arch domes or ribbed domes use the same mains principles of Persian tradition, but with less systematization, with, usually, simpler solutions and without juxtaposing domes, and without 'bended' arches.

REGULATING TRACING AND SYMMETRICAL RELATIONS

The regulating tracing of this type of structure starts from the division of a circumference in (sensibly) equal parts, in even number, usually above 6. Examples with divisions lower than 8 are rare due to their simplicity in decoration, and less structural benefits. The tracings can also start from rectangles with certain proportions (Bozorgmehri, 1992 [1982]). Although the rectangle rule does not guarantee the same rigorous division of the circumference, it facilitates the relationship between the space plan development and the dome structure, or the dome layout (Vale, 2022).

In these structures usually there is a search for regularity and symmetry, often stressed by decorative elements that can even mask some irregularity in the execution. In fact, the symmetrical relations in the karbandies, with several axis of symmetry (mirroring or rotating axis), will emphasise regularity even when there is a lack of rigor in the *karbandi* layout.

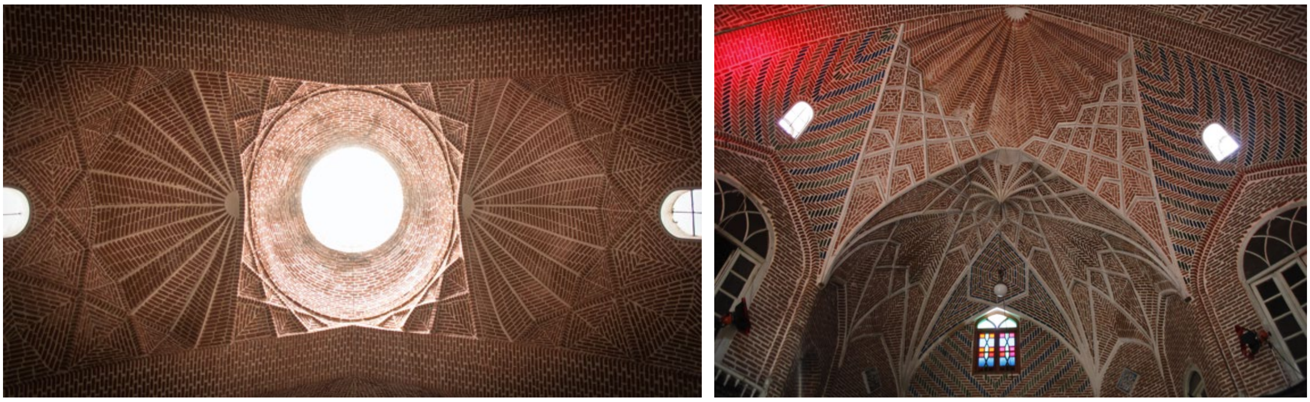


Figure 3 Examples from the Tabriz Bazaar. Combination of one *karbandi* with 2-half karbandies in each side [left] and a combination of 2 sectioned karbandies [right] (Author, 2018).

The symmetry, when only the dome is analysed, often corresponds to the repetition of modules in a number related to the number of divisions of the circumference (half, the same or twice the number of divisions), which 'fill the space' by angle rotation and by mirroring.

However, when analysing the relation between the dome and the space it covers, the situation usually changes. First, because of the way the bridging between the circumference of the dome, and the polygonal shape of the space (square, rectangle, octagon) is made, using different strategies. Second, because of the directionality of the spaces it covers, that usually will determine that there is only a single axis of symmetry, longitudinal and perpendicular to the organising element of the space, whether it is a mihrab, an altar, or a corridor in a bazaar, or, in domestic interiors, the location of windows and doors. And third, by the combination of several *karbandi* structures to cover the same space, which occurs mainly in Iran, that will emphasize one orientation.

Being, as we have seen, the geometric construction of these structures based on the rotation of certain elements around the vertical axis that passes through the apex of the dome, the modules of symmetry are determined by characteristics proper of each of the structures, that are: i) the relation between the form of the space and the form of the dome; ii) the base circumference number of divisions; iii) the chosen decorative elements; iv) the omitted elements; v) the axiality of the spaces; vi) the conjugation of several structures. All these characteristics will promote different perceptions of the spaces, and even when not strictly symmetrically placed, they will give us a sense of order and regularity, hiding the imperfections of execution as the example of the Tabriz dome shows by the great misalignment of one side of the "inside square" (Figure 2 – top right and Figure 4).

Over the last couple of decades there has been an effort to study and fully inventory these existing structures in the western world, as their number is not very high (Fuentes González, 2013; Fuentes

& Huerta, 2010; Galdieri, 1983; Sakkal, 1995-97; Velázquez Bosco, 1894). In Iran, where the quantity of karbandies is difficult to calculate, the study has followed the path of discovery/definition of systematization rules of geometric design (Mohamadianmansoor *et al*., 2012; Mohammadi *et al*., 2018; Mohammadi *et al*., 2019), denomination (Naeeni *et al*., 2017; Pour Ahmadi, 2014), and construction (Ainechi *et al*., 2019; Nazari, 2021). The variations are so many, dependent on masters and regions, that even the systematization is a difficult task. For this reason, our ongoing work is based on different principles in both universes. In the Spanish-Muslim tradition, the aim is to analyse the totality of the documented structures, as in the Persian tradition, the choice results from personal knowledge of the structures, or from bibliographical sources, and is used mainly in comparative terms.

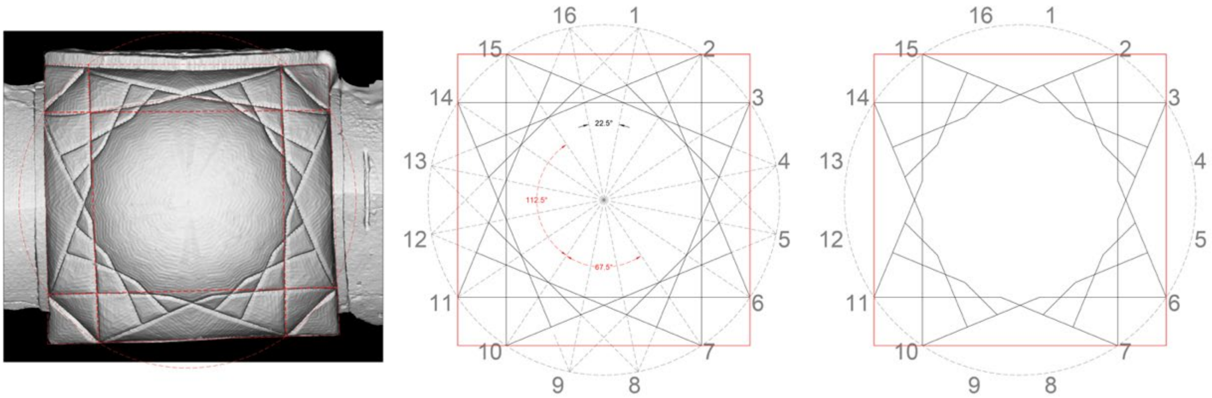


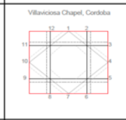
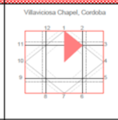
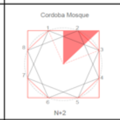
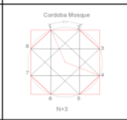
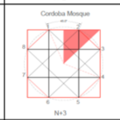
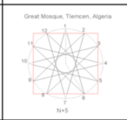
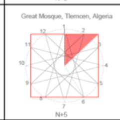
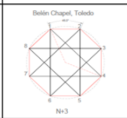
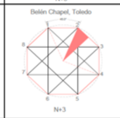
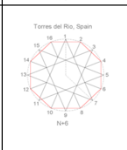
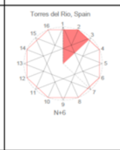
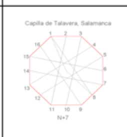
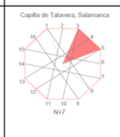
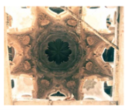
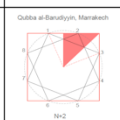
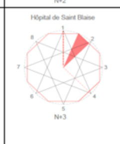
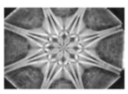
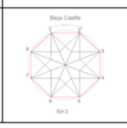
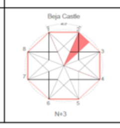
Figure 4 Photogrammetric survey of the *karbandi* versus tracings, making evident the omitted parts of the arches and misalignments (author, 2022).

SYMMETRICAL RELATIONS IN SPANISH-MUSLIM TRADITION

Table 1 shows 12 of the inventoried and analysed structures of the Spanish-Muslim tradition. The parameters of analysis are of two types: i) [marked in grey] a set that follows the same systematization rules of karbandies, that is, a) number of divisions of the circumference, b) angle of the arc chord, and c) angle of rotation/repetition of the arc; ii) and [marked in light red] a second set that analyses the relations of symmetry within the structure, and in relation to the space in which they are located, that is the a) the module angle, b) the module layout and c) the symmetrical type.

The study cases range from examples with fewer divisions (8), such as the early ones from Mosque of Cordoba in Spain to those with larger divisions, such as the one of Mosque of Tlemcen, in Algeria (12) or the Abbey of Santa María la Real de Las Huelgas, inBurgos, Spain (16). In all the 12 chosen examples, the minimum module of symmetry related to the dome, ranges from 22.5º to 45º, and the symmetrical type is mainly obtained by mirroring and rotation. In one of the examples, the very interesting Talavera Chapel in Salamanca, a sought misalignment between the location of the ribs and the shape of the space, determines that only rotation is used in geometrical definition, and despite the existence of a repetition module, at first sight no symmetrical arrangement is perceived.

Table 1. Crossed-arch domes of Spanish-Muslim tradition. Parameter's definition and analytical systematization. (Author, 2022).

Building | Location	photo	Geometric schema	Type 1	Type 2	Base Plan	Base geometric generation	Circumference divisions (rotation angle)	Crossed Arc Step (chord angle)	Step between arches (Array)	Room base shape	Dome base shape	Module angle	Repetition Module	Symmetrical Type
Cordoba mosque, Villaviciosa Chapel | Cordoba [Spain]			Group of arches (2)	Latice	Rectangle	2 sets of parallel arches rotated 180º	n/a	n/a	n/a	rectangle		45º		Mirror and rotation, but only in the inside part of the dome
Cordoba mosque, Macsura central dome | Cordoba [Spain]			Karbandi	Latice	Square with squinches	Regular octagon inscribed in the square. Rib begins in the octagon angles.	8 (45º)	N+2 (45ºx2=90º)	N+1 (360º/8=45º) Single array	Square	Octagon	45º		Mirror and rotation
Cordoba mosque, Macsura lateral domes | Cordoba [Spain]			Karbandi	Latice	Square with squinches	Regular octagon inscribed in the square. Rib begins in the octagon angles.	8 (45º)	N+3 (45ºx3=135º)	N+1 (360º/8=45º) Single array	Square	Octagon	45º		Mirror and rotation
Mezquita of the Palacio de la Aljafería | Zaragoza [Spain]			Karbandi	Latice	Octagon	Circumference that inscribes the octagon. Rib begins in the octagon angles.	8 (45º)	N+2 (45ºx2=90º)	N+1 (360º/8=45º) Single array	Octagon	Octagon	22,5º		Mirror and rotation
Great Mosque | Tlemcen, [Algeria]			Karbandi	Latice	Square	A square defined by the "short leg" of the Karbandi. Rib begins in the circumference.	12 (30º)	N+5 (30x5=150º)	N+1 (360º/12=30º) Single array	Square	Dodecagon	45º		Mirror and rotation
Belén Chapel, Santa Fé Monastery | Toledo [Spain]			Karbandi	Revolution	Octagon	Rib begins in the octagon angles (but with missealignents).	8 (45º)	N+3 (45ºx3=135º)	N+1 (360º/8=45º) Single array	Octagon	Octagon	22,5º		Mirror and rotation
Santo Sepulcro Church | Torres del Río [Spain]			Karbandi	Latice (?)	Octagon	Circumference that inscribes the octagon. Rib begins in the circumference corresponding to the centre of the octagon side.	16 (22,5º)	N+6 (22,5x6=135º)	N+2 (360º/16x2=45º) Double array	Octagon	Circumference	45º		Mirror and rotation
Abbey of Santa María la Real de Las Huelgas | Burgos [Spain]			Group of arches (2)	Revolution	Octagon	Circumference that intersects the octagon on rib location. Two ribs in each side of the octagon	16 (22,5º)	N+7 (22,5x7=157,5º)	N+2 (360º/16x2=45º) Double array	Octagon	Circumference	45º		Mirror and rotation
Talavera Chapel | Salamanca [Spain]			Group of arches (2)	Revolution	Octagon	Octagon. Each rib starts in an angle of the octagon and finish in the middle of the opposite side of the octagon	16 (22,5º)	N+7 (22,5x7=157,5º)	N+2 (360º/16x2=45º) Double array	Octagon	Circumference	45º		only by rotation
Qubba al-Barudiyyin | Marrakech [Morocco]			Karbandi	Latice	Square	Regular octagon inscribed in the square. Rib begins in the octagon angles.	8 (45º)	N+2 (45ºx2=90º)	N+1 (360º/8=45º) Single array	Square	Square	45º		Mirror and rotation
Church | Hopital Saint Blaise [France]			Karbandi	Revolution	Square with squinches	Circumference that inscribes the octagon. Rib begins in the circumference corresponding to the centre of the octagon side.	8 (45º)	N+3 (45ºx3=135º)	N+1 (360º/8=45º) Single array	Square	Octagon	22,5º		Mirror and rotation
Beja Castle | Beja [Portugal]			Karbandi	Latice	Octagon	Octagon. Rib begins in the octagon angles.	8 (45º)	N+3 (45ºx3=135º)	N+1 (360º/8=45º) Single array	Octagon	Octagon	22,5º		Mirror and rotation

SYMMETRICAL RELATIONS IN PERSIAN TRADITION

In Iran, as above-mentioned, there was a continuous use of *karbandies* until the present, with a large dissemination, both territorial and functional. This results on a hight level of sophistication and systematization, and on the investment in strategies that increase the decorative impact of the structure, such as the aggregation of several *karbandies*, according to one or more axes of symmetry, or the interpenetration of structures (Figure 3). In many of these cases of *karbandi* aggregation, the integration is fundamentally aesthetic and not constructive, with an underlayer coating of decorative ribs. The almost exclusive use of bricks or adobes for these structures in certain parts of Iran, with their contrasting joints, amplifies the decorative effects of these structures. Fundamentally when compared with the Spanish-Muslim tradition, where the joints are absent or not easily visible, a secondary symmetrical texture became very present. The omission of parts of the arches also stresses the chosen axial orientations and modules of symmetry in the *karbandi* layout, as shown in Figure 2, 3 and 4. The taste for the decorative aspect of the crossed arches, in today's Iran, is one reason for finding many perfectly regular and symmetrical examples, and more elaborated, contrasting with the examples from the Iberian Peninsula, with less rigorous traces. However, if we observe the older examples, like those of the old mosque of Isfahan (Figure 5), the similarities between the two traditions are more evident. Those are 'simpler' *karbandies*, with fewer circumference divisions (8) and lower passes and fewer intersections of arches (N+3). An example of a system of intersecting arches, like those of the mosque of Cordoba, that don't follow the strict rules of *karbandi* in the location of the ribs, is also found (Figure 5, left). In Iran, the geometrical and symmetrical relations in the design of this kind of domes was something sought after, in design and in terms or perception.

Figure 5 Crossed-ribbed domes of the old Mosque (Masjed-e Jāmé) of Isfahan. (Author, 2019).

CONCLUSION

The use of elements that visually reinforce an idea of regularity and symmetry is a mechanism used both in the Spanish-Muslim tradition and in the Persian tradition. In the latter, in some cases, these elements are already stripped of any structural function and act only as spatial and decorative references. From all the analysis made so far, the fundamental reason for the use of this type of structure is not constructive but symbolic and decorative - as an order that is brought to the spaces through rhythms, repetitions, symmetries but also of an enhancement of the function of the spaces by its decoration. This last question is more decisive in the Persian tradition, since for religious reasons only is permitted the representation of geometrical elements and of the word of the Koran, and other decorative strategies had to be invoked.

REFERENCES

Ainechi, S., Valibeig, N., & Tehrani, F. (2019). Karbandies' Traditional Construction Technique in Tabriz and Isfahan. *International Journal of Architectural Heritage*, 1-18. https://doi.org/10.1080/15583058.2019.1618971

Bozorgmehri, Z. (1992 [1982]). *Hendese Dar Me'ma ri (Geometry in Architecture)*. Sa zma n-e Mira s-e Farhangi-ye Keshvar (Iranian Cultural Heritage Organization). (In Farsi).

Fuentes González, P. (2009). *Las cúpulas de arcos entrecruzados: origen y desarrollo de un tipo único de abovedamiento entre los siglos X y XVI*

Fuentes González, P. (2013). *Bóvedas de arcos entrecruzados entre los siglos X y XVI. Geometría, construcción y estabilidad* Universidad Politécnica de Madrid]. Madrid. http://oa.upm.es/22174/

Fuentes, P., & Huerta, S. (2010). *Islamic domes of crossed-arches: Origin, geometry and structural behavio* Arch' 10. 6th International Conference on Arch Bridges, Fuzhou, China.

Galdieri, E. (1983). Contributi Alla Conoscenza Delle Strutture A Nervature Incrociate. *Rivista Degli Studi Orientali*, *57*, 61-75. https://doi.org/10.2307/41881192

Malekabbasi, A., & Oloumi, A. (2020). *Two Years Perfomance Report of Iranian Vernadoc 2017 - 2019 : Yazd, Tabriz, Nashtifan, Mashad*. Iranian Ministry of Cultural Heritage, Tourism and Handicrafts & Iranian VERNADOC. https://drive.google.com/file/d/1ajYEH42Nz9Y9KBMrPYFxB9PoWYk6unqg/view

Mohamadianmansoor, S., Faramarzi, S., Akbari, M. & Hatamimajd, F. (2012). *Karbandi: The ground of applying Dome on different contexts in Iranian architecture* "Domes in the World" International Scientific Congress, Florence, Italy. http://www.tuttocongressi.it/website/congresses/congressDetail2.aspx?idc=2032&cont=101

Mohammadi, A. A., Asefi, M., & Ebrahimi, A. N. (2018). The Geometrical Regularization for Covering Irregular Bases with Karbandi. *Nexus Network Journal*, *20*(2), 331-352. https://doi.org/10.1007/s00004-018-0373-0

Mohammadi, A. A., Ebrahimi, A. N., & Shahbazi, Y. (2019). Geometric design of a masonry lattice space dome titled KARBANDI in Persian architecture. *International Journal of Space Structures*, *34*(1-2), 22-39. https://doi.org/10.1177/0956059919845631

Naeeni, D. S., Esfahani, H. A., & Hosseini, I. M. (2017). Recognising Karbandi in Iran's Architecture and a Review of its Decorative-Structural Role. *Iran*, 173-183. https://doi.org/10.1080/05786967.2017.1406789

Nazari, S. (2021). The practical geometry of Persian ribbed vaults: A study of the rehabilitation of the Kolahduzan Dome in the Tabriz historic bazaar. In *History of Construction Cultures* (pp. 439-446). https://doi.org/10.1201/9781003173434-161

Pour Ahmadi, M. (2014). A Basic Method for Naming Persian Karbandis Using a Set of Numbers. *Nexus Network Journal*, *16*(2), 313-343. https://doi.org/10.1007/s00004-014-0192-x

Sakkal, M. (1995-97). Geometry of Ribbed Domes in Spain and North Africa. *Journal for the History of Arabic Science*, *11*(1&2).

Torres Balbás, L. (1955). *Artes Almoravide y Almohade*. Instituto de Estudios Africanos.

Vale, C. (2022, 6-8 July 202). *Karbandi and crossed-arch dome, from a possible common ground to constructive and geometric differentiation* ICSA 2022 – 5th International Conference on Structures & Architecture, Aalborg University, Department of Architecture, Design & Media Technology.

Velázquez Bosco, R. (1894). *Discursos leidos ante la Real Academia de Bellas Artes de San Fernando en la recepción pública del Excmo. Señor Don Ricardo Velázquez Bosco el día 24 de mayo de 1894*. Establecimiento Tipográfico de Fortanet. http://bibliotecavirtualdefensa.es/BVMDefensa/i18n/consulta/registro.cmd?id=4445

Clara Pimenta do VALE

Clara Pimenta do Vale is an Architect by the University of Porto (FAUP 1991), who specialized in building physics and Portuguese 20th century construction history. She holds an MSc in Building Construction from the Faculty of Engineering (FEUP 1999) and a Ph.D. in Architecture (FAUP 2012). Currently, she is an Assistant Professor at the Faculty of Architecture and a integrated Researcher of FAUP Centre of Studies of Architecture and Urbanism, in the DFL (Digital Fabrication Lab) and PACT (Architectural Heritage of the City and the Territory) groups, in the line "Actions of Architectural Rehabilitation of the Built Heritage" and in the line "Studies in History of Construction"' which she coordinates.