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Redesigning an Italian Lake Chapel with Existing Proportions

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Abstract

This paper is based on the analysis of an existing Italian octagonal Chapel ruins known as San Giovanni Chapel in Val Di Lago, Italy, to renovate it into a pilgrimage center to participate in an architectural design competition, organized by ReUse Italy in 2021. The whole paper can be divided into three major steps. Firstly, two of the major relevant analytical methodologies are studied, followed by an analysis of the existing structure, and finally, with the findings the design proposal is derived according to the requirements of the competition organizers. In terms of methodology, the theories and processes for determining golden ratios by Vitruvius and Morgan are applied that was later clarified by Williams during an analysis of the Medici Chapel by Michelangelo. Another framework for defining the divisions of space with regulating lines by Balmer and Swisher is then reviewed. Two different frameworks are considered for prioritizing the presence of the ideal ratio in the proportion system of the existing Chapel. Impressively, both frameworks show evidence of the ratio of 2:3, among others, in its proportion system. This ideal proportion system is subsequently found to be prevalent during the analysis of the existing chapel ruins. Finally, a pilgrimage center design is proposed following this derived ratio that shows further experimentation of the findings.

Keywords

Classical framework; 2:3 Proportion; Octagonal Chapel

1. Introduction

The architectural design competition requires the redesign of a lake chapel to create a pilgrimage center, following the existing proportion of the ruins and this paper includes an analysis of the existing structure using the methodologies proposed by Vitruvius (1960) and Balmer and Swisher (2019). Following the design brief provided by the organizer ReUse Italy (2021), the proposed design includes a masterplan, roof for the chapel ruins, an open-air theater with public toilets, and accommodation for 10 visitors along with the necessary amenities, such as a kitchen, dining room, and toilet. According to the competition organizer (2021), the existing structure known as San Giovanni Chapel is in the ancient city of Viterbo, Italy. This classic octagonal chapel, also known as the Lake Chapel ruins, stands in the middle of a beautiful natural landscape with a lake to the south. The organizer expects the design proposal to motivate pilgrims to take a longer path than usual to experience the nearby lake along with the pilgrimage center during their holy pilgrimage (ibid.).

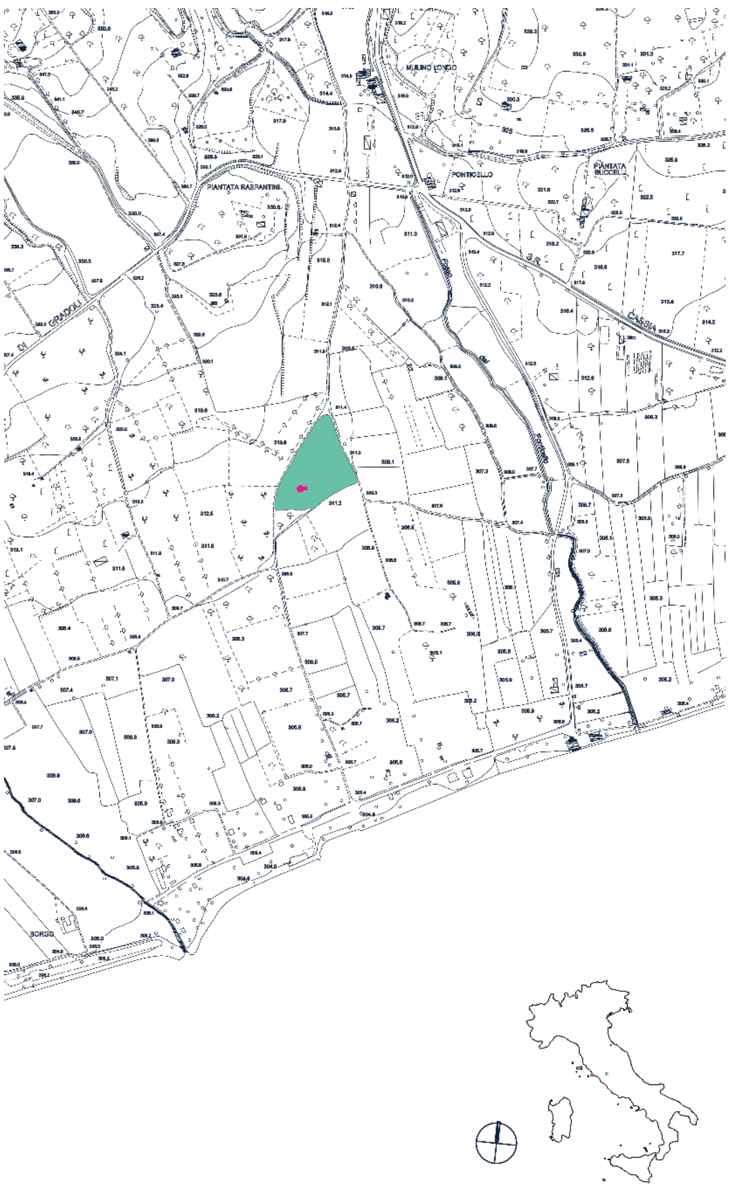

Figure 1 Location of San Giovanni Chapel in Viterbo, Italy (following ReUse Italy, 2021).

From an initial study of the photographs depicting the chapel ruins, it is evident that a circular natural pedestrian path surrounds the chapel, denoting the paths taken by people visiting this religious place in the past. No human habitat is visible near the site, and thus the old chapel demonstrates a form of hierarchy compared to the surrounding context. Hence, the proposed design is expected to be lightweight and less prominent than the existing landscape. To respect the existing natural circulation of people, a circular design for bringing people together is considered an ideal concept for the overall design of the proposed pilgrimage center. Here, to align with the proposed design philosophy, the point noted by Munari (2008) regarding the circular form is considered. Reiterating the quote by Voltaire, "God is a circle whose center is everywhere and circumferences nowhere," Munari also claims that when people gather for a discussion, they often organize themselves in a circle subconsciously.

Figure 2 Perspective and a top view showing the circulation pattern on the existing chapel (following ReUse Italy, 2021).

Besides, the circular form also represents the hierarchy in terms of the windows used in the octagonal chapel mass, initially designed to illuminate the interior space. The presence of thick load-bearing walls used to support the roof of the chapel, have been redesigned to make the windows smaller and provide a dark interior atmosphere. A circular window is placed above the main entrance on the west side of the chapel. It is different from the other seven rectangular windows placed at the same level on the other seven walls of the octagonal form. The design of the San Giovanni Chapel follows a north-south axis, exposing the entrance to the west. This characteristic is like the other octagonal-shaped churches in the zone, as evident from the studies on the Chapel of St. Jean of Le Liget (Munteanu, 1977).

Figure 3 Hierarchical circular window on the west wall (following ReUse Italy, 2021).

After considering the presence of a circular form in both the window hierarchy and circulation, the proposed design is expected to respect this characteristic. Following the methodologies used by Vitruvius (1960) and Balmer and Swisher (2019), the desired proportion has been derived which is found to be used repetitively in this San Giovanni Chapel. This derived proportion is then used to develop the master plan of the design proposal, as well as the desired height of the proposed chapel roof.

2. Research Methodology

The methodology section aims to review the process of finding the proportion system in the existing classical architecture, widely used to analyze and divide spaces, followed by the measurements. Two separate methods are used to analyze the existing chapel ruins. Firstly, the complex analytical methods employed by Vitruvius (1960) are reviewed, subsequently used by Williams (1997) in analyzing the renowned Medici Chapel by Michelangelo for clarification. Lastly, the methods for dividing the spaces used by Balmer and Swisher (2019) along with their arguments are also reviewed. These two different analytical methods are used to derive an ideal proportion system. The final proposal is designed following this derived proportion system which is proven to be prevalent in the existing structure.

2.1 Analytical Methods used by Vitruvius & Morgan (1960), and Williams (1997)

Several analyses indicate that the simplest method is often the most pleasing both in geometry and music (Tallon, 2016). The typical simplified proportions are 1:1, also known as unison, 2:1 as octave, 3:2 as fifth, and 4:3 as fourth, respectively (ibid.). In terms of architecture, apart from these ideal ratios, which are often found in the dimensions, several other means of proportion are used to create the desired harmony. For example, Vitruvius (1960), while analyzing two circular temples at Tivoli and Vesta in Rome, respectively, concurred that the thickness of the wall often depends on the height of the temple and is often one-tenth of the total size. This theory is subsequently used in this research by deriving the peak of the chapel roof as part of the competition proposal requirements. However, Vitruvius (1960) also claimed that in terms of circular form, the distance between the columns would be equivalent to their height of it. This theory is to be tested to see if it fits this specific San Giovanni Chapel proportion system that is being considered for this research.

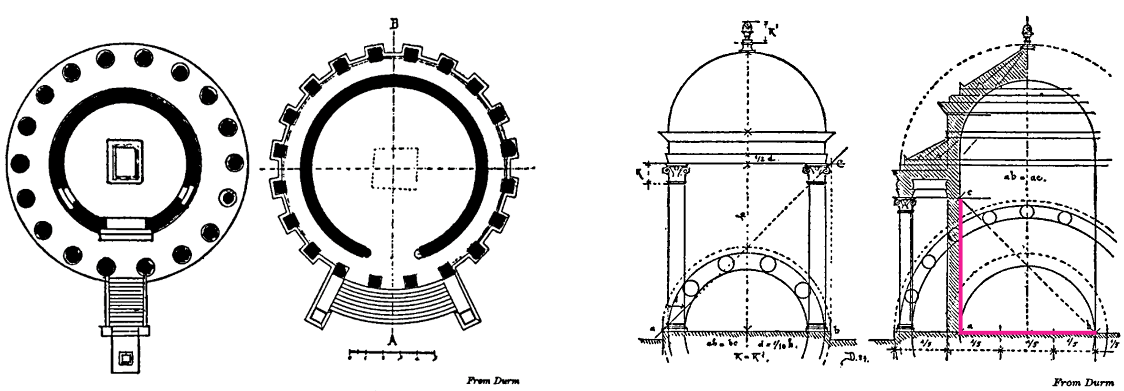

Figure 4 Left – Circular temple at Tivoli and plan of the temple of Vesta in Rome, respectively. Right – Sectional analysis of a circular temple according to Vitruvius (following Vitruvius (1960)).

Similarly, following Alberti's work "Ten Books on Architecture," Williams (1997) concluded that the ideal ratio of 2:3 is prevalent in the golden ratio analysis of the Medici Chapel designed by Michelangelo. The author pointed out that the ratio 2:3 is often known as diapente or sesquialtera, meaning the generation of ratios (ibid.). In Figure 5, the diagonal DE is the geometric means of the sides AD and GE, measured after multiplying the two extremes and then taking the square root of the results. For example, here, AD as 27, with GE as 18 denotes the presence of the ratio 2:3.

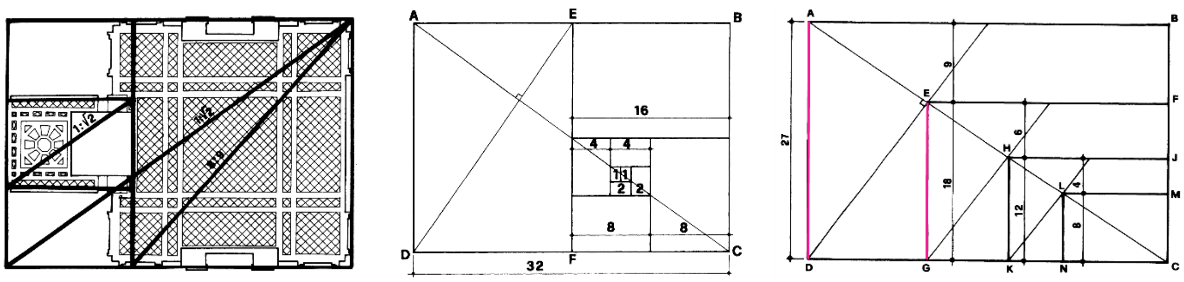

Figure 5 Left – Diagrammatic representation of root-2 rectangles in the Medici Chapel. Middle – Continuous subdivision of root-2 rectangles. Right – Division of root-2 rectangles into smaller ones with the ratio of 2:3 (following Williams, 1997).

Moreover, along with these two theories, the following method is considered to provide more evidence when analyzing the existing plan of the chapel to prove the presence of the ratio 2:3 in its proportion system.

2.2 Analytical Methods used by Balmer and Swisher (2019)

Balmer and Swisher (2019) noted that Greek temples were built using various mathematical systems and terrain. They laid out the structural measurements using strict geometrical methods involving mathematics and philosophy. However, the Romans also used these geometrical layouts to create a strictly proportional system in military camps and towns for harmony in design (ibid.). This proportionate system that brings balance to design is also relevant to various art forms. Concerning the ratio of architecture and music, Tallon (2016) referred to the experiment conducted by Pythagoras on the vibrating string under constant tension. An instrument with a single string and moveable fret called a monochord was used in this experiment. After dividing the string in half, the sound produced was like the one made by the original length (ibid.). This means that despite the equal division, the result remains unchanged and hence proportionately balanced. Similarly, from another perspective, when multiplied rather than divided, the proportion should also remain unchanged. Balmer and Swisher (2019) clarified the methods used to divide the space using regulating lines following several steps. A brief explanation of the process shown in Figure 6 is presented below:

1. In step 1, a quartered grid is generated by defining the centers and then extending the center lines in both axes of the main cube or on the main drawing being analyzed.
2. Then in step 2, to derive the grid with added ninths of the main cube, a third is defined from the intersection of the regulating lines and edges of the main cube. In step 2b, the thirds in both axes are marked.
3. To generate a grid with added sixteenths, in step 3, the halves are first subdivided into quarter measures, from the intersection of which regulating lines are then extended to both axes.
4. In step 4, to derive a grid with added eighths, firstly, the quarter measures are subdivided into eighths. Then from the intersection points, lines are extended and added to both axes of the main cube.

5. Finally, at the start of step 5, the sixth measure is defined by the same diagonal lines used in the previous step. Then, the intersection lines are extended in both axes to find the grid with added twelfths.

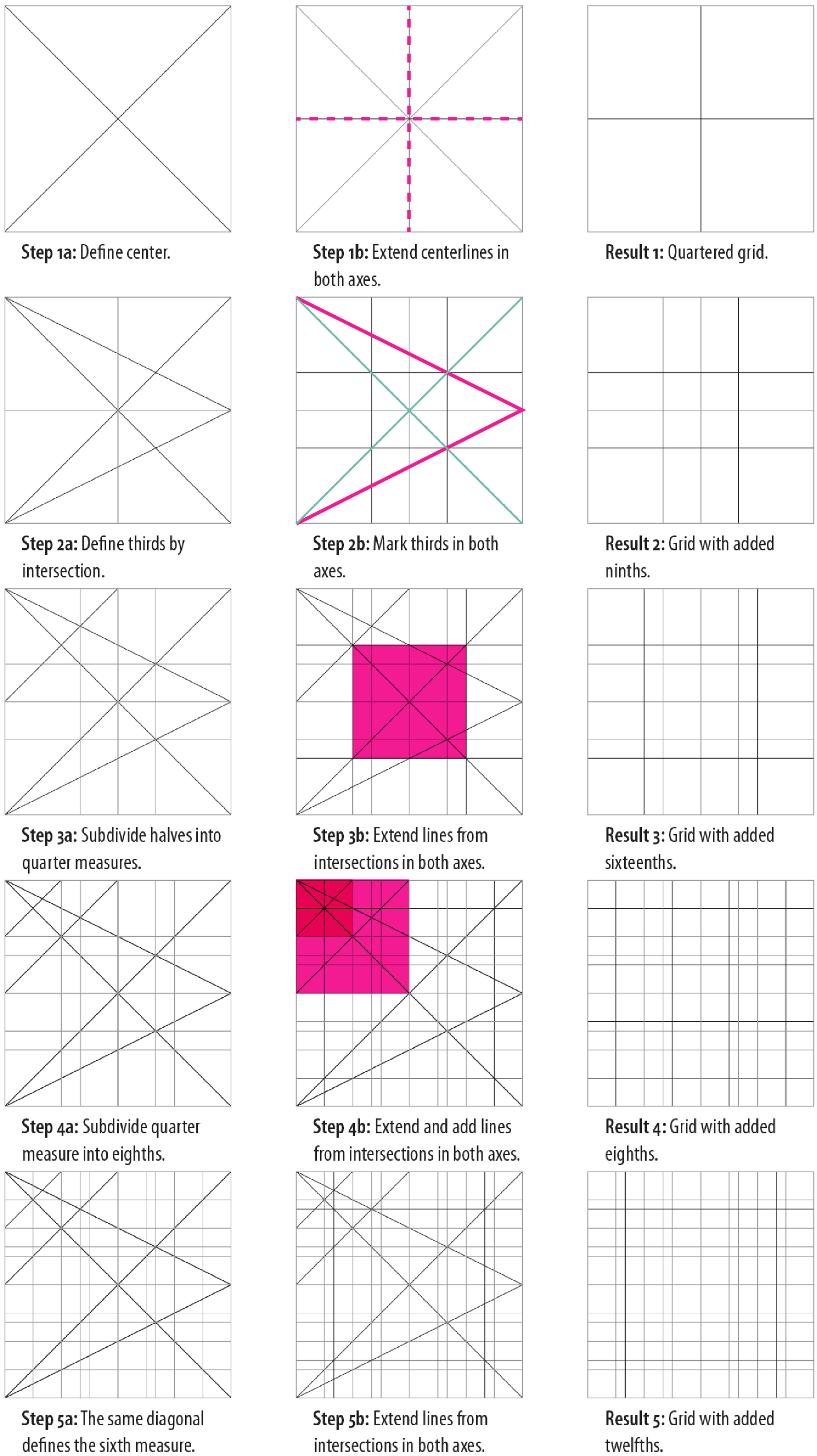

Figure 6 Regulating lines for dividing space (following Balmer and Swisher, 2019).

Following the methodology clarified by Balmer and Swisher (2019), an ideal ratio is generated from repetitive patterns to create the design proposal. The existing chapel plan is analyzed and the dimension is considered to generate the desired proportion. In the following section, the existing structure is analyzed following the two methods reviewed.

3. Analysis of the Existing San Giovanni Chapel

The analysis of the existing San Giovanni Chapel is outlined using two different methods according to the existing drawing provided by the competition organizer (2021). Firstly, the golden proportion of the existing plan is identified, following the methods used by Vitruvius (1960) and Williams (1997). However, unlike Williams (1997), the approximate values are considered in this research to better understand the analysis. The second analytical method includes the division of space using a grid system (Balmer & Swisher, 2019). In both frameworks, the main goal is to highlight and derive the ideal ratios in terms of the dimensions of the two elements (length and width), which are used to determine the approximate height of the roof and eventual design proposal for the pilgrimage center.

3.1 Analysis to Identify the Golden Proportion

To analyze the ideal proportion prevalent in the existing drawing of the chapel, the framework for identifying the golden proportion by Williams (1997) is used. This argument is based on the renowned work, "Ten Books of Architecture" by Leon Battista Alberti. As shown in Figure 7, the diagrams of the existing chapel drawings are used in the analysis conducted for this research. Figure 7 should be studied chronologically from left to right, following the Roman numerical order stated beneath each diagram. In this figure, diagrams i to iii show that the ratios 1:3 and 2:3 are present in the chapel's proportion system. Diagrams iv to vi illustrate how the rectangular mass is added to the octagonal form, as evidenced by the golden ratio analysis. A brief explanation of this analysis in the Roman numerical order is provided as follows, and each diagram is discussed.

i. Firstly, to study the existing plan following the framework, a rectangle ABCD is drawn in diagram i, depicting the entire form, including the octagonal shape and additional rectangular structure to the east. A diagonal AC is constructed, upon which the perpendicular FB is drawn, where F is the intersecting point between AC and BF.

ii. In the next step, two perpendicular lines FG and FE are drawn on DC and BC, respectively, to create the rectangle FGCE. Here, FE: AB is 9.1247 m: 12.8398 m, equivalent to 2:3 considering the approximate value. Here, approximate measurements are considered since the edges of the existing ruins are not sharp enough to show the exact dimensions.

iii. Following a similar process, in diagram iii, a perpendicular EI is drawn on AC using the identical method from E, and a rectangle IJCH is constructed in the same process. Here, IH: FE is again 6.4845 m: 9.1247m, which is equivalent to the ratio of 2:3 approximately. However, it can be observed that FG is in the ratio of 1:3 when compared with AD and BC. Similarly, for IJ, the distance from FG to BC is 2.6402 m: 6.4845 m, or equal to 1:3. Henceforth, in this process, both the ratios 1:3 and 2:3 are prevalent in the existing plan.

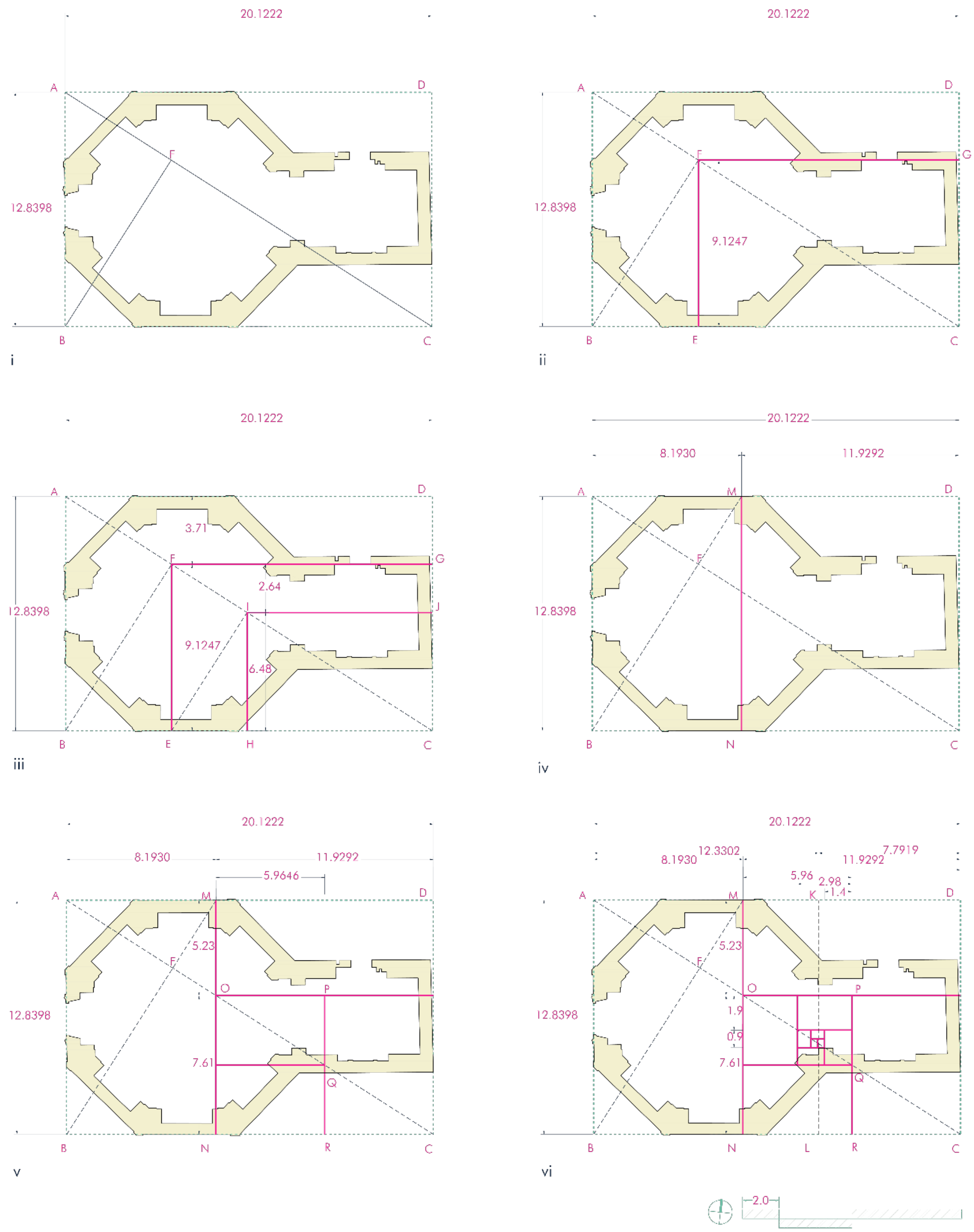

Figure 7 Analysis of the existing plan of San Giovanni Chapel to define the golden proportion.

iv. In diagram iv, through the division of the rectangular shape, the ratio of 2:3 is evident. To achieve such a result, this time the perpendicular line BF is extended from F to intersect at M on AD. Now the perpendicular MN is constructed on BC. Here, the distance between AM or BN to MD or NC of AD and BC, respectively, is 8.1930 m: 11.9292 m, which is equivalent to the desired ratio of 2:3, considering their approximate values.

v. Then in diagram v, following the rules of golden proportion (following Williams, 1997), the intersecting point O of MN is identified on AC. From O, a perpendicular line is constructed on CD with P as the middle point. From P, the perpendicular PR has been drawn on BC with Q as an intersecting point on AC. From Q, a further perpendicular line on the initially constructed MN is extended to achieve a smaller rectangle.

vi. Lastly, in diagram vi, following these simple steps of dividing the rectangle centering the diagonal OQ on AC, continuous subdivisions of up to seven times can be constructed. Finally, from the last rectangle, an edge is ultimately achieved, which, when extended on both axes, a KL line parallel to the initial MN can be obtained. This derived KL is also the approximate edge of the octagonal form. Besides, the ratio of AK: KD on AD or BL: LC on BC is also equivalent to the ratio of 2:3 considering their approximate values.

Henceforth, from this analysis, the ratio of 2:3 is prevalent in the dimensions of the existing chapel. Although only when the approximate dimensions are considered can this desired ratio be derived. Whereas, when the exact dimensions are considered, the derived proportion cannot be achieved. This may be due to several reasons, and further research is required on this issue.

3.2 Analysis of the Subdivision of Space

Apart from the methods for determining the golden ratio, as described in the methodology section, Balmer and Swisher (2019) presented the process of grid division to determine the plan order. This popular method of dividing the geometry helps to identify subdivisions of space and its boundaries to determine the axes, figures, fields, center, and edges of the building (ibid.). Although the process is similar to the previous framework, it proves the presence of the desired ratio from another perspective. Identical to the previous analysis in Figure 7, Figures 8 and 9 consist of 12 chronological diagrams illustrating the framework used in the plan. Here, the process is divided into two parts for clarity and ease of understanding of the diagrams. An explanation of this analysis is provided as follows:

Part 1 of this analysis, as shown in Figure 8, is described below in Roman numerical order.

i. As in the previous method, the rectangle ABCD covers the whole structure, including the octagonal and additional diminutive rectangle form. Here, the purpose of this framework is also to derive the ratio of 1:3 and 2:3 in the existing layout. The dividing line KL found in the previous framework is also considered to generate the approximate square of ABLK. Additionally, diagonal lines AL and BK are drawn to find the center.

ii. Perpendicular lines as extensions are marked on the axes of the square ABLK, as shown in diagram ii.

iii. In diagram iii, one-thirds are defined by intersecting lines.

It is then evident that, in diagram iv, the intersecting points on the KL line are also the center of the entrance to the smaller rectangular mass from the octagonal form. In comparison, the other on the AB is the entrance to the main octagonal structure from the outside.

iv. The intersecting point of thirds and diagonals are marked in diagram v, creating a grid upon the extension on the axes of the square ABLK. Here, the subdivision of the grid obtained from the thirds is drawn to generate a quarter. When extensions are made from the latest intersection of the quarter, a diagonal line is achieved parallel to the side of the octagonal form. In other words, it defines the edges of the octagonal structure.

v. Besides, from the intersection defining the quarter, a new grid can be generated on the initial axes of the square, as shown in the final diagram vi.

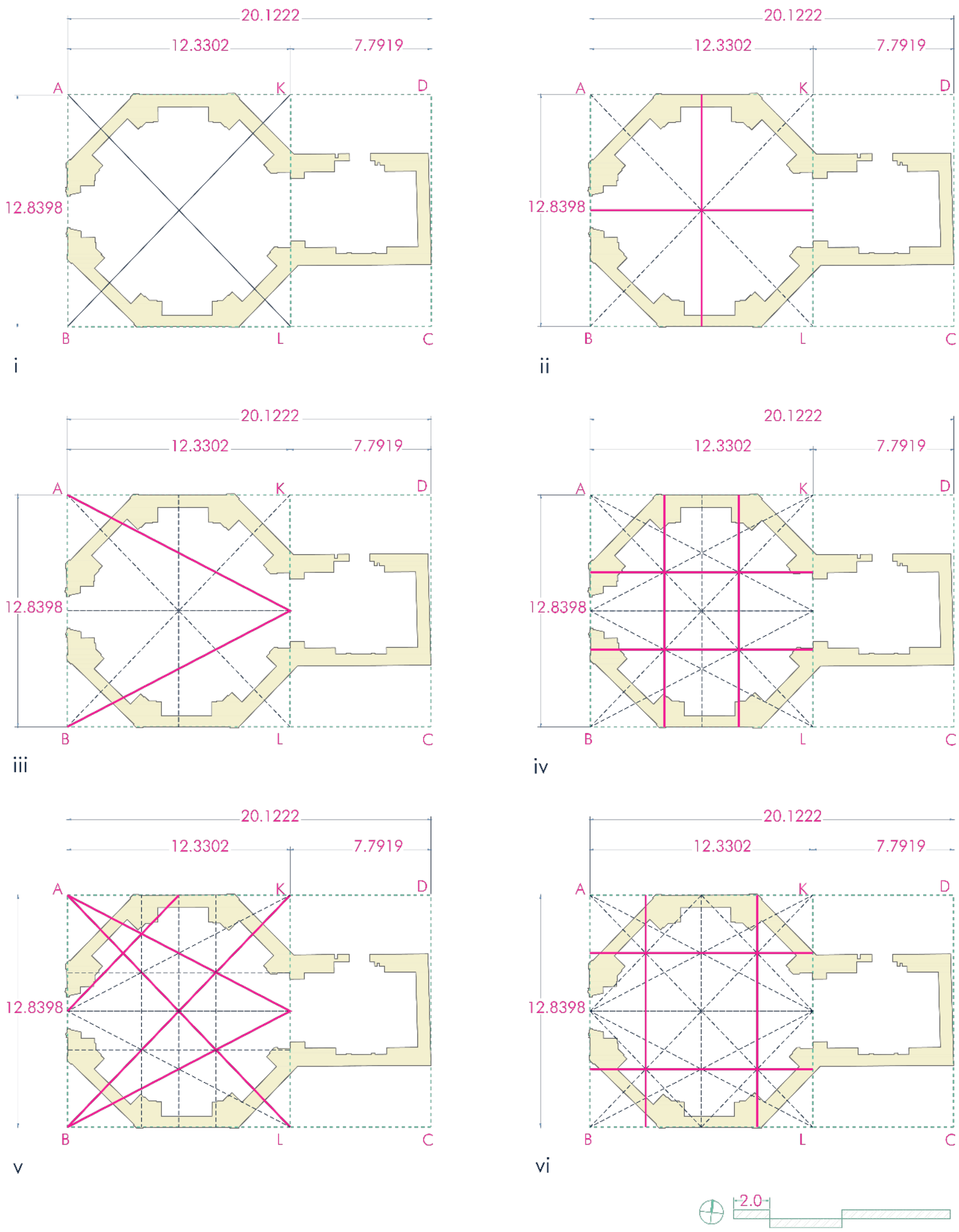

Figure 8 Part 1 of the existing plan analysis to derive the order through the subdivision framework.

In part 2 of this analysis, as shown in Figure 9, a similar explanation method is used, presented in Roman numerical order below.

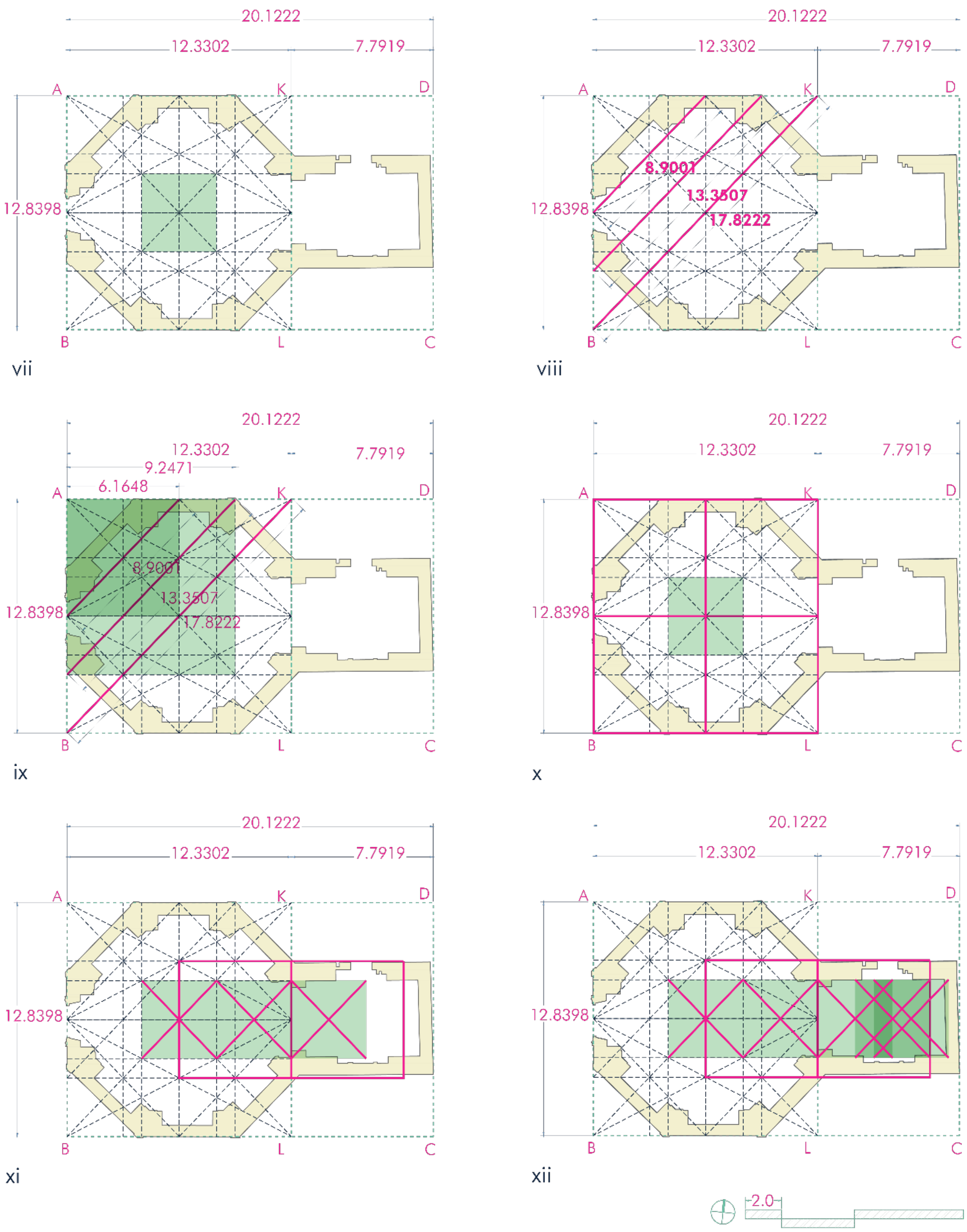

Figure 9 Part 2 of the existing plan analysis to derive the order through the subdivision framework.

vi. In diagram vii, a nine-square grid can be obtained from the grids generated by the thirds highlighted.

vii. In the following diagram viii, from corner A of ABLK, a square is constructed that is smaller than the initial one. Here, the diagonal of this smaller square is measured at 8.9001 m, consisting of half the intersecting lines of the center of ABLK. Similarly, another oblique is considered measuring 13.957 m parallel to this smaller one and the initial diagonal line of the ABLK square.

viii. From diagram ix, the distance from the edge of the first smallest identical square is measured from point A, which is 6.1648 m. The ratio of 3:4 can be achieved here from the two approximate dimensions of this smallest square. Similarly, the second square is measured with a diagonal of 13.3507 m and 9.2471 m approximately, equivalent to the ratio of 2:3. However, if the dimensions of any two of these three squares, including the original one, are compared, the ratio of 2:3 can be achieved from their approximate values. For example, considering the smallest to intermediate square, the lengths would be 8.9001 m to 13.3507 m when compared with their diagonal lengths, and 6.1648 m to 9.2471 m, when considering the distances on side AK. In both cases, the ratio of 2:3 is evident when approximate values are considered. Similarly, when the intermediate square is compared to ABLK, from the diagonals 13.3507 m to 17.8222m, the ratio of 2:3 is also evident considering their approximate values. Moreover, referring to the example provided by Tallon (2016), the proportion system remains similar when multiplied or divided.

ix. Furthermore, in diagram x, four identical squares are generated from the existing grid achieved so far.

x. Here, each square is equivalent to the outer edge of the smaller rectangle of the existing structure, as evident from diagram xi.

xi. Finally, to determine the existing proportion of the smaller rectangular mass, following the nine-square grid derived in diagram vii, one square unit is taken and placed in diagram xii at the starting edge of the smaller rectangular mass. From this intersection, a second square unit is placed. The third square unit is placed on the intersecting diagonals of these two square units. The outer edge of the final square unit is approximately equal to the edge of the interior space of this smaller rectangular mass. Following this method, the proportion of the existing small rectangular mass can be generated.

Moreover, from both of these analyses, the ratio of 2:3 can be taken under consideration for use as the findings to generate the desired height of the chapel and eventual design of the pilgrimage center.

3.3 Deriving the Height of the Chapel with the Findings

From the analysis, the ratio of 2:3, which is prominent in the existing design, is considered to derive the height of the chapel in two major ways. Similar to the previous process, a brief explanation of this derivation using the ratio is described below, following the Roman numerical order.

i. In diagram i, the rectangular unit between the two columns is drawn with a ratio of distance to the height of 6.0800 m to 4.0690 m, which is equivalent to 2:3 considering their approximate values. Here, it is to be noted that following the theories argued by Vitruvius (1960), the distance to the height between the columns was supposed to be equal for circular structures. But here the Chapel that is being discussed is not entirely a circular form but octagonal. Henceforth, they are in the ratio of 2:3 in this case as part of their relationship in terms of proportion.

Besides, the diagonal is measured at 7.7912 m of the drawn rectangle. This rectangle is then extended in the direction of the facade, as shown in diagram ix of Figure 5. One edge of the newly constructed bigger rectangular unit is then also the interior edge of the octagonal form measuring 11.6868 m in diagonal length. Here, the ratio of 2:3 is also prominent considering the approximate values of these two diagonal lengths. Additionally, the diameter of the existing octagonal form is 10.8281 m. Hence, considering the distance to height ratio of 2:3, the approximate height can be considered as 15 m.

ii. Again, considering the theories argued by Vitruvius (1960), the average width of the wall is 1.4 m, and the approximate height could be 15 m, as shown in diagram ii. This measurement is derived according to the thickness of the wall, which is assumed to be one-tenth of the height (following Vitruvius, 1960).

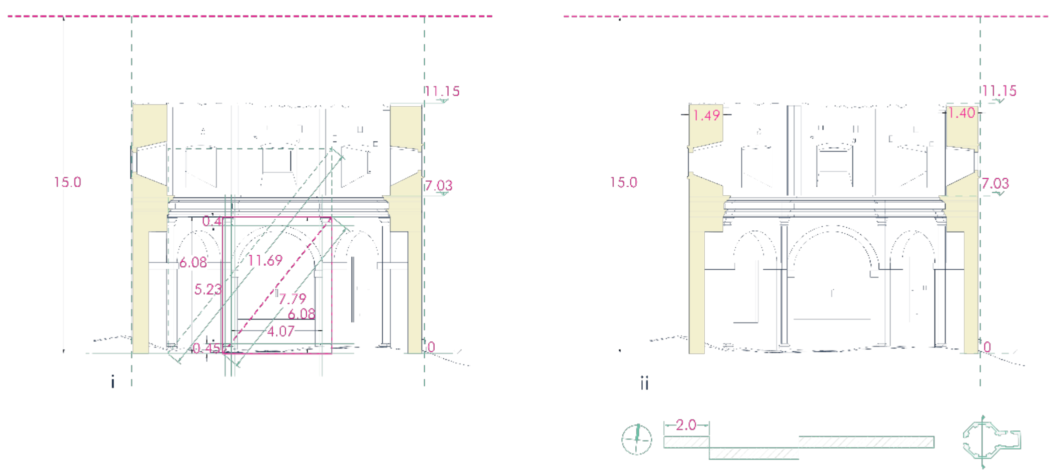

Figure 10 Derivation of the chapel roof height from an analysis of the section.

In the following section, the proposed design of the pilgrimage center is explained, generated following the ratio of 2:3.

4. Proposed Design of the Pilgrimage Center

The proposed design of the pilgrimage center can be divided into two major parts. The design proposal is derived from the required spaces. Firstly, the master plan of the proposed space is generated following the ratio of 2:3 using the initial design ideas. Following the same ratio, the required spaces are also derived. The design of accommodation, circulation and an open-air theater along with toilets as required by the competition brief are clarified here. A brief description of the process is provided in the following section.

Figure 11 Collage of the design proposal using existing photographs (following ReUse Italy, 2021).

4.1 Design Derivation

As with the process presented in the methodology and analysis of the existing plan, the derivation of the design proposal can be divided into six steps. The use of the ratio 2:3 derived from the analysis is prominent in developing the main design. The steps are briefly described as follows in the Roman numerical order presented in Figure 12.

i. From diagram ix in Figure 9 of the analysis section, the rectangular form surrounding the edges of the main structure is considered, along with two smaller cubes inside the main octagonal form. These cubes are in the ratio of 2:3 when compared to the adjacent value.

ii. In diagram ii, the circulation inside the existing chapel is marked according to the door width. The width of this circulation is taken into consideration in deriving the overall design. The center of the octagonal form is also marked following the smaller square, to be used as the opening for the skylight in the proposed roof of the chapel reconstruction.

iii. A parallel cube is considered, as shown in diagram iii. This form is equivalent to the main cube covering the octagonal chapel structure. The existing circulation reference is considered in the division of these two cubes.

iv. From the newly constructed cube, a bigger rectangle is considered following the ratio of 2:3. As shown in diagram iv, another parallel circulation is then considered from the edge of this newly drawn bigger cube on the entrance side of the main chapel. Lastly, another cube like that of the octagonal chapel is drawn. The bigger cube and adjacent cubes then provide two separate functions, such as accommodation and an open-air theater, respectively, by the design requirements.

v. In diagram v, an outer circle is drawn to determine the periphery of the proposed construction and includes all the other forms. The center of this circle is marked at the outer corner point of the initial smaller cube prevalent inside the one containing the octagonal form. A parallel circulation form is considered for the open-air theater to connect it with the toilet facility mass. The stage is also marked following the cube considered for the skylight opening inside the chapel.

vi. Finally, as drawn in diagram vi, the overall design can be laid out, marking all the circulations previously derived. The accommodation unit mass is drawn inside the bigger cube considering the skylight cube. Each should contain 1–2 dwelling rooms, depending on the design. The created L-shaped amphitheater diagonally faces the existing main structure.

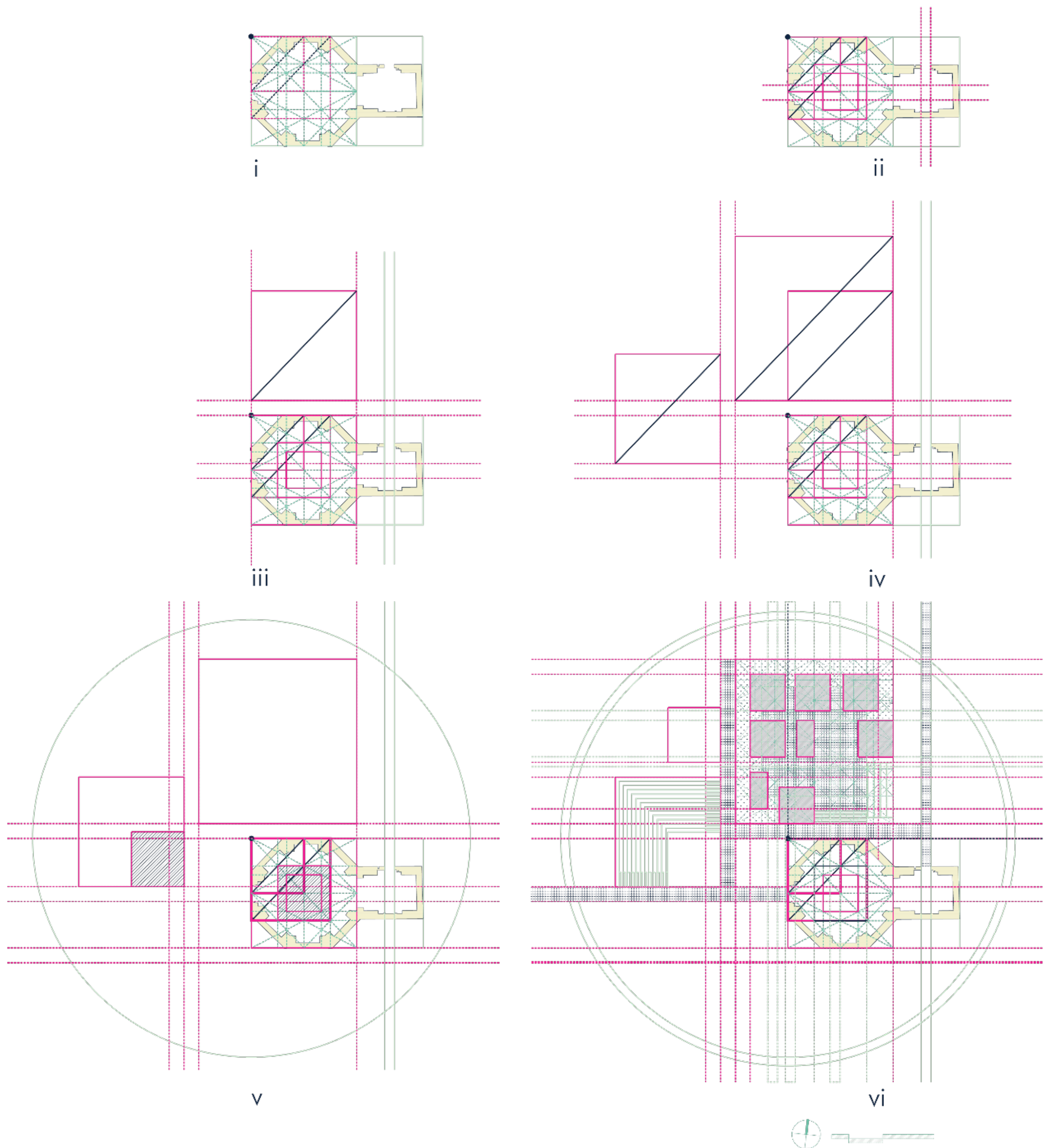

Figure 12 Derivation of the proposed masterplan following the analysis.

The following section briefly describes the designed spaces to better understand how the derived findings of the ratio 2:3 have been incorporated into the proposal for the pilgrimage center in this competition.

4.2 Designed Proposal with Derived Spaces

To design the proposal according to the framework created earlier, several functions must be incorporated into the master plan. Firstly, referring to the initial idea concerning the importance of a circular form, benches are designed around the proposed structures, following the circular line previously presented. People visiting this pilgrimage center are allowed to sit on these benches and contemplate if desired. Besides, no structures should be above the ground to respect the existing natural landscape. Hence, the ideal ratio of 2:3 is considered to derive the depth of the structure.

The roof of the octagonal chapel ruins is redesigned using a contrasting material, defining the edge of the existing ruins to match the derived height of 15 m. The opening of the skylight is retained as previously derived. The accommodation units are also derived from the ratio of 2:3, measuring 2 m wide and 3 m high. This figure is then multiplied to generate the cube, inside which undulating lines create the partition walls of the rooms. To represent the fluidity of life, which does not need to follow this strict proportion system, an earthing antenna is depicted since the project is in the middle of nowhere, also in the ratio of 2:3 to the proposed height of the chapel. This marks the half-circle covering the proposed benches in the design.

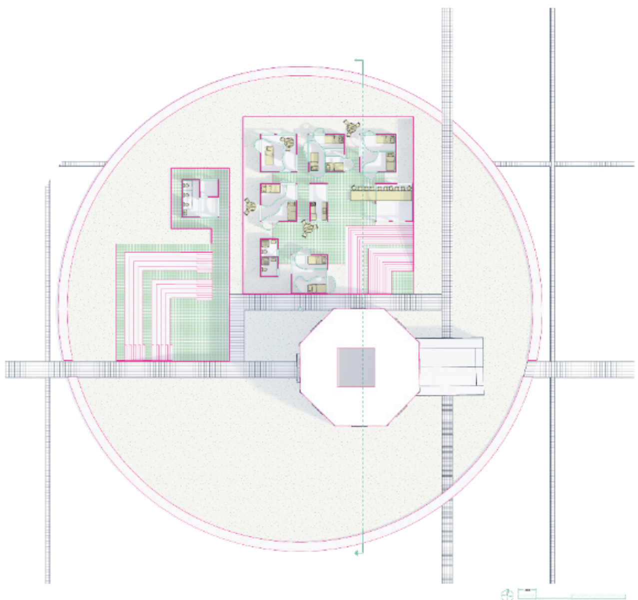

Figure 13 Proposed plan of the pilgrimage center.

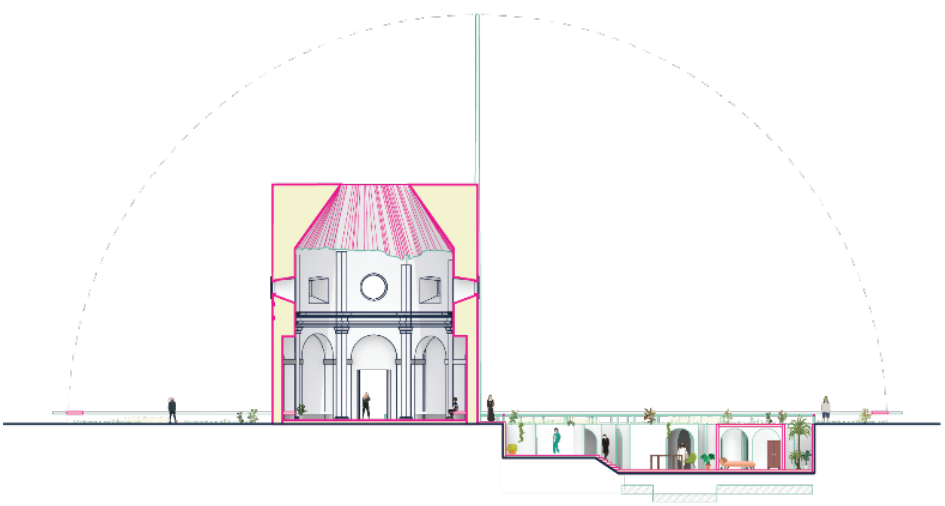

Figure 14 Proposed section of the pilgrimage center.

5. Conclusion

This paper can be concluded by claiming that to renovate classical architecture, the analytical framework employed by Vitruvius (1960), Williams (1997), and Balmer and Swisher (2019) is useful for deriving the existing ratio that is prominent in the ruins. In this case, the derived ratio of 2:3 is experimented with to define the height of the existing Chapel, which is now in ruins. The spaces of the proposed pilgrimage center can also be generated along with the framework of its master plan, proving the effectiveness of the derived ratio of 2:3. Although, some contradictions are found in determining the proportion in terms of the height to distance between the columns. In this Chapel, the height to the distance between the columns are with 2:3 ratio and not equal to them, unlike the arguments provided by Vitruvius (1960). To clarify this contradiction, it can be argued that the discussed Chapel is octagonal and not circular. Whereas the theories provided by Vitruvius (1960) were based on circular structures.

Moreover, this process is expected to benefit similar restoration projects as well as adaptive reuse schemes. Apart from the layout used for the proposal in this research, several other design layouts could be explored with different concepts following the ratio of 2:3. Here, unlike Williams (1997), only the approximate values are considered for ease of understanding and clarification in the design proposal. Identifying why such approximate values had to be considered could be an option for further research. Whether or not the extensive use of ornamentation such as the pilasters used instead of columns is one of the reasons for such derivation requires further research.

Author Contributions

Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing-original draft preparation, review and editing, visualization, supervision, project administration, and funding acquisitionby S.A.. The author has read and agreed to the published version of the manuscript.

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