THE ARCHITECTURAL GEOMETRY OF THE CHURCH OF CRISTO OBRERO Y NUESTRA SEÑORA DE LOURDES

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ABSTRACT:

The object of study of this paper is the Church of Cristo Obrero y Nuestra Señora de Lourdes, in the city of Atlántida, Uruguay, designed and built by Uruguayan engineer Eladio Dieste between 1956 and 1960, and proclaimed as a UNESCO World Heritage Site in 2021. Furthermore, the object of study is the outset of Eladio Dieste's experimentations with reinforced brickwork, which resulted in innovative thin-shell structural typologies. Hence, the objective of this article is to verify the geometrical relationships within the continuous gaussian vaults of the Cristo Obrero' roof and the ruled surfaces of its lateral walls. The proposed methodological procedures for this research were the *in situ* visitation of the object of study, followed by the consultation of original construction drawings, as well as the exploratory parametric modeling and polynomial regression of the architectural geometry of the Church of Cristo Obrero. Amongst the expected contributions for this research reside the dissemination of Latin-American modern architectural heritage sites within European academic journals, digital design technologies within Latin-American research centres, as well as the fostering of the comprehension of the design and construction process of the Uruguayan engineer Eladio Dieste.

1. INTRODUCTION

The object of study of this research is the Church of Cristo Obrero y Nuestra Señora de Lourdes (Fig. 1), in the city of Atlantida, Uruguay, designed and built by Uruguayan engineer Eladio Dieste between 1956 and 1960. The importance of this work of architecture is due to its embodied experimentations in the field of structural design and construction technology conducted by Uruguayan engineer Eladio Dieste. The Church of Cristo Obrero y Nuestra Señora de Lourdes was the first most prominent implementation of continuous gaussian vaults in reinforced brickwork in thin-shell roof modules by the engineer, as well as ruled surfaces on its lateral walls. Such design and constructive endeavours were made possible by the conjugation of tradition and ingenuity, with construction site adaptations such as mobile frameworks. The continuous gaussian vaults were the predecessors of the dominant gaussian vault structural typological variation, the discontinuous vaults. Such discontinuous vaults are characterized by skylights interrupting the roof modules and the possibility of much larger spans (Fig. 2).

Alongside all these technical and design novelties, both exterior and interior spectacular architectural spaces were created, with economy in the construction process, rendering Eladio Dieste the quality of an *structural artist* (Ochsendorf, 2004; Melachos, Florio, 2018). It is only fair, yet a late sign cultural and technical recognition, that the Church of Cristo Obrero y Nuestra Señora de Lourdes was included in UNESCO's World Heritage List on the 27th of July of 2021, as the entity's homage to the contributions of the engineer Eladio Dieste (World Heritage Convention, 2021).


a


b

Figure 1. (a) Continuous gaussian vaults of the Church of Cristo Obrero y Nuestra Señora de Lourdes rooftop and ruled surfaces of its lateral walls; (b) and its frontal façade.
(a) © Leonardo Finotti.

The interaction between the gaussian vaults on the roof modules and the ruled surfaces on the lateral walls (Fig. 1.a) makes the architectural geometry of the Church of Cristo Obrero hard to grasp through the mere analysis of its architectural drawings. Hence, the objective of this article is to verify the existence of underlying geometrical relationships within the continuous gaussian vaults of the object of study’s roof and the ruled surfaces of its lateral walls.

a

b

Figure 2. Transverse take (a) and longitudinal take (b0 of the Discontinuous Gaussian Vaults of the Durazno Gymnasium, in Durazno (Uruguay), designed and built by Eladio Dieste between 1973 and 1975.

The proposed methodological procedures for this research were the *in situ* visitation of the object of study, followed by the consultation of original construction drawings. Given the aforementioned difficulties in the geometrical apprehension of the object of study’s form, its architectural geometry was examined by means of exploratory parametric modelling associated to digital fabrication, as well as the polynomial regression of the key cross sections of its continuous gaussian vault roof modules and ruled surface walls. Posteriorly, the surfaces of the object of study’s modules were subject to gaussian curvature and flattening analysis pertaining to assess their quality as developable surfaces.

The usage of traditional drawing software for the representation of complex geometries is suboptimal (Florio, 2011; Kolarevic, 2003), giving way to the conjoint usage of parametric modelling with digital fabrication techniques for its geometrical apprehension (Veiga and Florio, 2015; Picon, 2004). This is especially so due to the manner hand manipulation of physical models enhances the apprehension of its geometrical features, tectonic aspects and different spatial relationships (Sass and Oxman 2006). Eladio Dieste himself criticized the limitation of traditional technical drawing representations in the comprehension of complex geometries (Gutierrez, 1998).

In this research, the concept of parametric modelling is aligned with the writings of Monedero (2000), Hudson (2010), and Woodburry (2010), where it can be defined as the modeling of a given geometry through the definition of a set of rules or parameters. Such modeling strategies are based on associative relationships and dependencies amongst objects and their relationship to the whole.

Recent research such as Balzani and Rossato (2022), Brumana et al (2020), Balzani et al (2020), Iadanza et al (2019), Monaco et al (2019) establish that the association of 3d integrated survey and HBIM as the state-of-the-art regarding the documentation of architectural geometry of cultural heritages. However, the usage of Rhinoceros 3d® associated to Grasshopped 3d® is an established method of parametric modelling when it comes to vault modeling (Capone, Lanzara, 2019; Capone, Lanzara, 2021), especially when it comes to doubly-curved geometries (Bechtold, 2013; Capone, Nigro, 2017; Melachos, 2020; Coenders, 2021; Meibodi et al, 2021). Dynamo® could also be an option when it comes to parametric modeling, but Grasshopper’s extensive system of open-source plugins makes it more disseminated than other software alternatives such as Dynamo® (Melachos, Amorim, 2022).

The gaussian analysis of surfaces is an important verification tool to assert the developability of surfaces, an important characteristic in the structural analysis of thin-shell and monocoque structures, assuring economy of material during construction and contemporary manufacturing efficiency (Bechthold, 2013; Kolarevic, 2003; Pottmann, 2013). Hence, within the parametric modeling process, the architectural geometries of the object of study were subject to experimental process to verify its developability. In Rhinoceros 3d©, Mcneel (2020) suggests that developable surfaces to be flattened with the tool “UnrollSrf”, while non-developable surfaces be flattened with the “Squish” tool. Both of those tools display area contraction and expansion data, allowing for further developability analysis.

The adoption of polynomial regression as a methodological procedure in this research came as an empirical tool to explore eventual geometrical relationships in the object of study upon its proven success in Melachos (2020) with the key transverse and longitudinal sections of the discontinuous gaussian vaults of Eladio Dieste. The polynomial regression strategies used in this research are based on the fitting method of the least squares (Mendehall, Beaver, Beaver, 2006).

Amongst the expected contributions for this research, first, reside the dissemination of Latin-American modern architectural heritage sites within European academic journals and scientific literature as a whole. Only in recent years has the coverage of Latin-American modern architecture has proven to go beyond canonical modern masters in European literature such as in Rossato (2016) and Tagliari et al (2020). Furthermore, the usage of digital design tools and digital fabrication techniques as methodological procedures for this research presents an opportunity for the diffusion of such means in Brazilian public universities. Lastly, the explorations presented in this article present an opportunity to further comprehend the design and construction process of Eladio Dieste’s continuous gaussian vaults designed and built in reinforced brickwork.

This paper has its object of study, objectives, justification, a synthesis of the proposed methodological procedures, and expected contributions outlined in its section 1 “Introduction”. Section 2 “Related Works” discriminates the state-of-the-art pertaining to the object of study as well as the methodological procedures adopted within this research. In Section 3 “Developed Methodology”, the methodological procedure and its respective results are illustrated as according to the references examined in Section 2. The “Conclusion”, section 4, represents the original contribution of this research, where the results of the applied methodological procedures are analysed and confronted with previous studies in the same field, seeking to further the knowledge pertaining to the object of study. Lastly, there is also a synthesis of the paper’s objectives and accomplishments are made, in a reflection geared towards future academic endeavours.

2. RELATED WORKS

As aforementioned, Latin American modern architectural heritage is yet to be thoroughly explored in European and North American Academia, more even so when associated with 3d vault modeling procedures and HBIM integration techniques aiming its architectural comprehension and conservation. However, the first decades of the 21st century have seen a welcomed inversion in this trend, with theses and papers such as Rossato (2016), Balzani et al (2018), Balzani et al (2019), Balzani et al (2020).

The consultation of established academic data-bases has shown that the literature regarding Eladio Dieste is not abundant. The engineer’s design and constructive premisses are illustrated in Carbonell (1987) and Torecillas-Perez (1996), enriched with texts from Eladio Dieste himself. Pablo-Bonta (1963) is important for its analysis of Dieste’s early works during the time of their doing, while Pedreschi (2000) and Anderson (2004) are important for contemporizing the importance of Dieste’s construction techniques in academic research groups. Those writings focus on both the discontinuous and continuous gaussian vaults of Eladio Dieste, with mentions of his ruled surface structural typology as well. The Church of Cristo Obrero and Nuestra Señora de Lourdes has a dedicated section in each of those references, with a body of floor plan and sections, as well as extensive photographical registry, and physical description and/or introduction regarding the architectural design.

Carvalho (2006) demonstrates the logic of the “rib sheets” (Fig. 3), present in the geometrization of continuous and discontinuous gaussian vault designs and formwork, while Melachos et al (2019) demonstrates the logic of the “geometry of the vault” sheets, responsible for the geometrization of latter discontinuous gaussian vaults and their formwork. The graphic primer of Larrambebere (2004) is important for gathering a commented photographic registry of the construction of discontinuous gaussian vaults and their formwork. These bibliographical references constitute the state-of-the-art regarding the construction process of continuous and discontinuous gaussian vaults of Eladio Dieste.

Regarding the Church of Cristo Obrero and Nuestra Señora de Lourdes itself, the dedicated literature is lead by the Getty Foundation’s Keeping it Modern report: *Iglesia de la Parroquia de Cristo Obrero: Plan de Conservación y Manejo* (2018). This extensive report presents a conservation management plan for the object of study, where it is important to note the presence of important construction drawings and design and construction protocols utilized by Dieste and his worker in this particular design, as well as chapters pertaining specifically to the architectural design and to the construction process. This report is the most detailed account of the design and constructive process of the object of study in the state-of-the-art.

Amen and Alvarez (2017) analyse the geometry of the Church of Cristo Obrero and Nuestra Señora de Lourdes with the assistance of digital fabrication, producing a 1:20 model and demonstrating the importance of physical models in the apprehension of complex geometries such continuous gaussian vaults and ruled surfaces walls. Fritz and Lammers (2016) and Lammers (2017) parametrically modelled the ruled surfaces of Church of Cristo Obrero and Nuestra Señora de Lourdes, but not the gaussian vaults, and did not thoroughly demonstrate their algorithms. Such computational modeling procedures were accompanied by physically and digitally fabricated models to further comprehend its geometry, design, and construction process.

Melachos (2020), however, performed the parametric modeling and discontinuous gaussian vaults of Eladio Dieste and has provided a step-by-step follow through of the algorithms used the construction of analysed architectural geometries. Such parametric modeling was accompanied of exploratory polynomial regression in Microsoft Excel® based on the fitting method of the least squares (Mendehall, Beaver, Beaver, 2006). Posteriorly all the obtained polynomials were grouped in *R*® for further experimentation using the Loess method (Cleveland, 1979; Cleveland et al, 1990; Dagum, Luati, 2003) for the obtention of a generating equation for the discontinuous gaussian vault sub-typology of Eladio Dieste.

Melachos also performed the gaussian analysis as to verify the developability of the discontinuous gaussian vaults of Eladio Dieste through parametric modeling and Rhinoceros 3D®, but did not use further flattening checking techniques as suggested by Mcneel (2020). Capone and Lanzara (2018) did use such further flattening techniques to verify flattening possibilities of doubly-curved surfaces, providing a methodological path with the analysis of the readings of enlargement and shortening of surface areas.

3. DEVELOPED METHODOLOGY

The methodological procedures adopted in this research can be synthesized in Figure 3, whereas the investigation began with a thorough search in academic databases for analogous books, theses, papers, web material and technical standards which could lead to the primary sources needed to advance the paper. Those primary sources were found with the assistance of Eladio Dieste’s still existing office, Dieste y Montañez S.A., Universidad de la República de Uruguay’s (UdelaR) Instituto de la Construcción, located at UdelaR’s Facultad de Arquitectura, and Getty Foundation’s Keeping it Modern grant initiative.

Once the drawings were located, its comprehension was fostered by the visitation *in-situ* of the Church of Cristo Obrero and Nuestra Señora de Lourdes, in the coastal city of Atlántida, distancing a half-an-hour drive from the Carrasco International Airport in Montevideo, Uruguay. The main challenge within these visitations was to understand the gaps left in the construction drawings (Fig. 4), such as the intersections between ruled surfaces in the lateral walls and the continuous gaussian vaults shown in Fig. 1.a.

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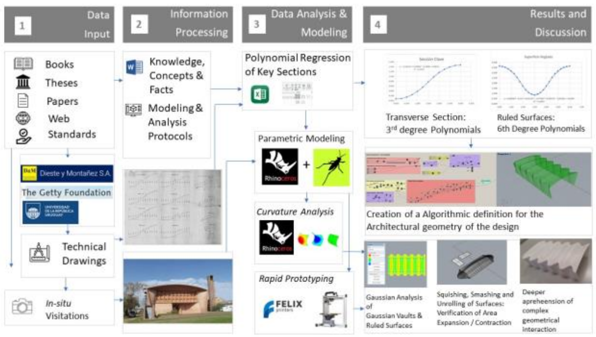


Figure 3. Research Methodological Procedures

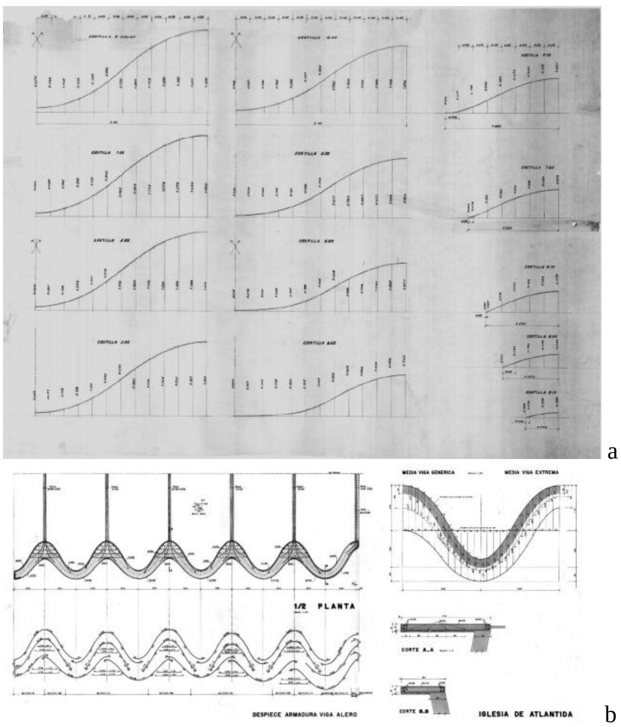


Figure 4. Construction Drawing for the Transverse Sections of the continuous Gaussian Vaults (a) and the ruled surfaces of the walls (b).
© Dieste & Montañez S.A.

The continuous gaussian vault coordinates, both height and length, for the key section were inserted in Microsoft Excel® for polynomial regression using the fitting method of the least squares (Mendehall, Beaver, Beaver, 2006). The coordinates from the construction drawings of the ruled surfaces were also processed in the same manner. For the key transverse section of the gaussian vault, the polynomial regression yielded a 3rd degree polynomial (Fig. 5.a), whereas the ruled surface module yielded a 6th degree polynomial (Fig. 5.b). The resulting 3rd degree polynomial (1) for the key transverse cross section of the continuous gaussian vault has an R^2 factor of reliability of 0,9993. The resulting 6th degree polynomial (2) for the lateral ruled surfaces walls has an R^2 factor or reliability of 0,9997. If the formwork of the whole of the continuous gaussian vault module (Fig. 6.a.) is taken into consideration for polynomial regression, it yields a 4th degree polynomial (Fig. 6. b) with an R^2 factor or reliability of 0,9987 (3).

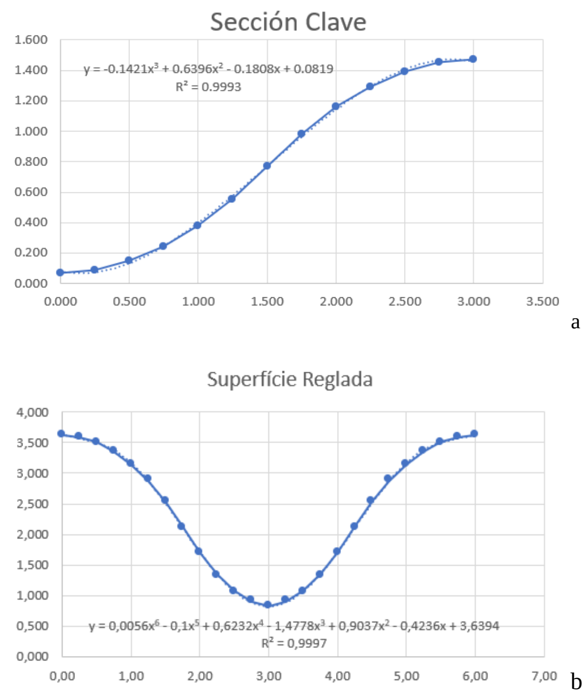


Figure 5. Polynomial regression for the key transverse section (a) and the ruled surface module (b).

$$y = -0{,}1421x^3 + 0{,}6396x^2 - 0{,}1808x + 0{,}0819 \quad (1)$$

$R^2 = 0{,}9993$

$$y = 0{,}0056x^6 - 0{,}1x^5 + 0{,}6232x^4 - 1{,}4778x^3 + 0{,}9037x^2 - 0{,}4236x + 3{,}6394 \quad (2)$$

$R^2 = 0{,}9997$

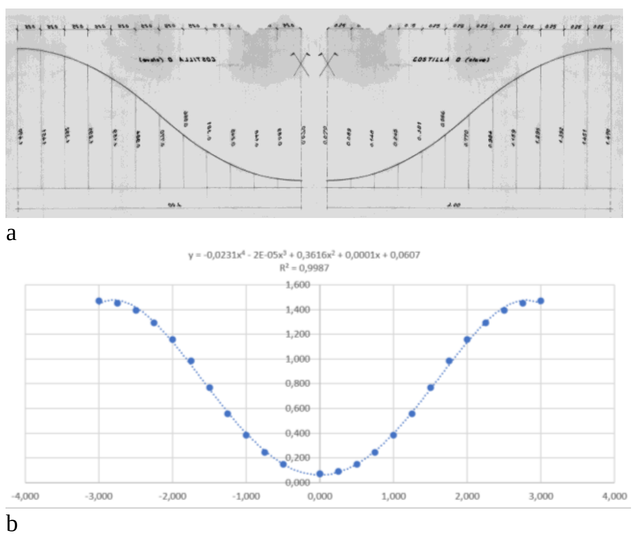
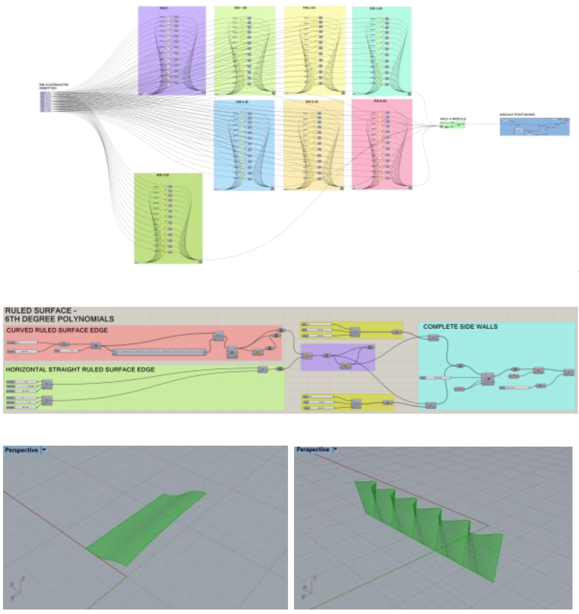


Figure 6. Formwork module for the Church of Cristo Obrero Worker and Nuestra Señora de Lourdes (a) and its respective polynomial regression (b)
(a) Dieste & Montañez S.A.

$$y = -0{,}0231x^4 - 2E\text{-}05x^3 + 0{,}3616x^2 + 0{,}0001x + 0{,}0607 \quad (3)$$

$R^2 = 0{,}9987$

The coordinates from the continuous gaussian vaults ribs construction drawings were inserted in Grasshopper 3d® in order to conceive an algorithmic definition for the architectural design. The rib length data were inserted as X coordinates with the aid of “number sliders”, and then used to parametrically interpolate each rib with “construct point” and “interpolate” (Fig. 7.a). The result of this portion of the algorithm is the central portion of the roof surface module (Fig. 7.c). Posteriorly, the 6th degree polynomial from the ruled surface module (2) was plugged in Grasshopper 3d® with “expression” and interpolated with the “ruled surface” component to conceive a single surface module, which was then geometrically repositioned, and duplicated to complete the side walls. The result of this portion of the algorithm is the whole ruled surface lateral wall (Fig. 7.d).



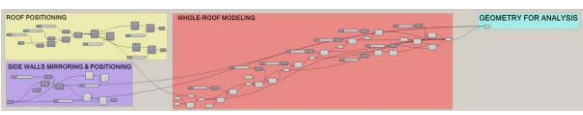
a

b

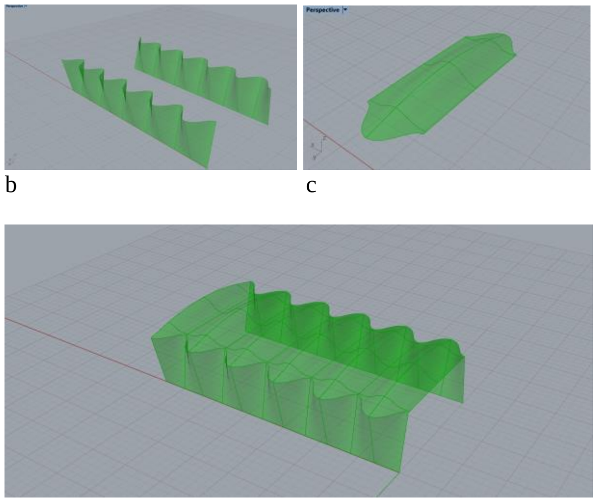
c d

Figure 7. Definition of the continuous gaussian vault roof module (a) and its modeled result (c); definition of the ruled surface lateral wall (b) and its modeled result.

Afterwards, the lateral ruled surface and gaussian vault roof modules were plugged in another definition which was conceived to generate the final geometry for analysis (Fig. 8). The objective of this definition was to reposition the modules and ruled surfaces previously generated as according to the position in the original architectural design when it comes to height and length regarding each other. The lateral walls were mirrored and spaced as according to the construction drawings dimensioning (b). Another important aspect of these portion of the drawing was the completion of the gaussian roof modules using the “loft” component, being guided by the edge curves of the central roof modules and the ruled surfaces (c). Ultimately, the roof modules were mirrored and moved as accordingly to the construction drawings dimensing, thus generating the architectural geometries object of analysis in this research (d).



a

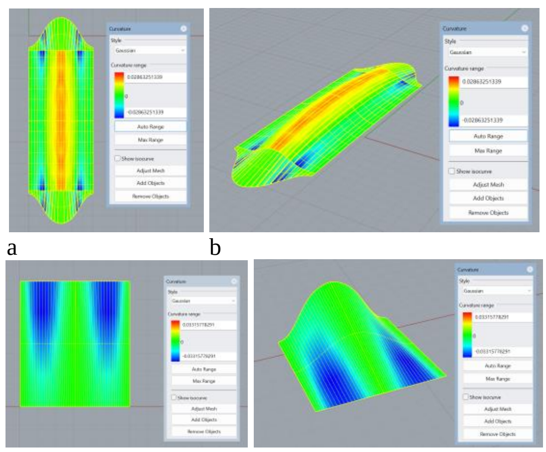


b c

d

Figure 8. Definition of the continuous gaussian vault whole-roof module and ruled surfaces (a), ruled surfaces positioning (b), roof module completion (c), and architectural geometry final assembly (d).

Posteriorly, both, a continuous gaussian vault roof module and a ruled surface wall module were analysed regarding their surface curvature, hoping to verify their potential as developable surfaces. For that purpose, their respective geometries were “baked” from Grasshopper 3d© into Rhinoceros 3d© and underwent surface gaussian curvature analysis. For the continuous gaussian vault roof, it was observed that the central portion of the module is predominantly developable (green in Fig. 9.a-b), acquiring positive gaussian curvature in its central axis in its most accentuated curved region, where it is mirrored for the completion of the framework (blue in Fig. 9.a-b). Its lateral, complementary surfaces, are also mainly developable, with portions with negative gaussian curvature in its transition from a curved to a planar surface (blue in Fig. 9.a-b). When it comes to the ruled surfaces lateral wall module, it was observed that its surface its partially developable (green in Fig. 9.c-d), with considerable mirrored negative gaussian curvature along the central axis, exactly in the transition from a curved to a planar surface (blue in Fig. 8.c-d).



a b

c d

Figure 9. Gaussian Surface Analysis for the Continuous Gaussian Roof Module (a-b) and Ruled Surface Module (c-d).

Another verification as to the potential of the architectural geometries object of study of this research as developable surfaces is the usage of the "UnrollSrf" toll in Rhinoceros 3d©, which flattens effectively developable surfaces into planar surfaces (McNeel, 2020). For the continuous gaussian vault roof, the "baking" of the geometries from Grasshopper 3d© into Rhinoceros 3d© produced a division of its geometry into a "central portion of the module" and a "lateral portion of the module", which obliged this verification to be made separately for each. Given the fact that the gaussian curvature analysis for both the continuous gaussian vault module and the ruled surface module did not render numerically developable surfaces, it is natural that the "UnrollSrf" gave out errors (Table 1). However, the tool worked for the ruled surface module, yielding a flat pattern with a 5,26% area expansion.

Mcneel (2020) recommends the flattening of numerically non-developable surfaces through the "Squish" tool, which flattens such surfaces into a flat 2-D pattern. Such procedure was applied to the modules in Table 1. The results yielded expansions and contractions compatible with numerically freefrom, non-developable, surfaces for all analysed modules. Whilst the central continuous gaussian vault module's area rendered only a 0.001% contraction when flattened, its lateral portion's area expanded only 0.003 % when flattened. The ruled surface module's area contracted considerably more compared to the continuous gaussian vault module. The ruled surface module's area contracted 0.013 %.

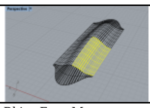
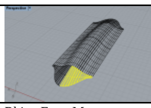
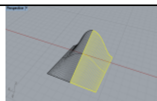
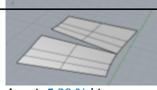
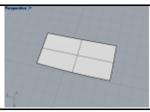
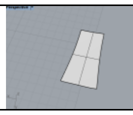
Rhinoceros 3D© Command	Continous Gaussian Vault Central Portion of the Module	Continous Gaussian Vault Lateral Portion of the Module	Ruled Surface Module
			
Unroll Srf	Rhino Error Mssg: Unrolling doubly curved surfaces will produce inaccurate results	Rhino Error Mssg: There was an error unrolling that surface.	 Area is 5.26 % bigger.
Squish			
	Area: **contracts 0.001% (3d area is smaller)** **Compression:** average=0.04%, maximum=0.27% (in 2% of pattern) **Expansion:** average=0.05%, maximum=0.27% (in 98% of pattern).	Area: **expands 0.003% (3d area is larger)** **Compression:** average=0.03%, maximum=0.08% (in 4% of pattern) **Expansion:** average=0.05%, maximum=0.27% (in 96% of pattern)	Area: **contracts 0.013% (3d area is smaller)** **Compression:** average=0.46%, maximum=1.44% (in 4% of pattern) **Expansion:** average=0.45%, maximum=1.94% (in 95% of pattern)

Table 1. Margin settings for A4 size paper.

Another methodological procedure aiming to further the comprehension of the architectural geometry of the object of study was its digital fabrication. The readied geometry (Fig. 8.d) was "baked" from Grasshopper 3d© into Rhinoceros 3d© and given enough width (2mm) in Rhinoceros 3d©, to sustain the digital fabrication process. Each ruled surface wall (Fig. 10.a) and the whole roof (Fig. 10.b) were processed separately, to optimize the production time, being properly positioned and prepared for operation in Felix 3.0© Simplify 3d©. The ruled surfaces took an hour and a half each to produce, while the whole roof took four hours to produce (Fig. 10.c). Upon their completion, the pieces were glued together with material recommended by the printer's suppliers. The digital fabrication of the whole-roof and lateral model was produced in a scale of 1:200 to better fit the Felix 3.0 tray (Fig. 10.d-f), whereas its ruled surface isolated piece was modelled in 1:125 for further comprehension and tray fitting purposes as well (Fig. 10.d)

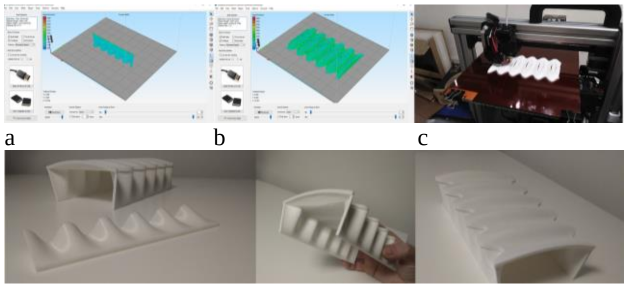


Figure 10. Digital Frabrication of the roof.

4. CONCLUSIONS

In the same manner as the discontinuous gaussian vaults in the diverse case studies of Eladio Dieste analysed in Melachos (2020), the key transverse sections of the continuous gaussian vaults of Eladio Dieste in the Church of Cristo Obrero and Nuestra Señora de Lourdes are also constituted by a 3rd degree polynomial with a high degree of reliability given by its R^2 factor. However, the mirrored transverse continuous gaussian vault module, constituting its formwork module, differs from its discontinuous counterpart being a 4th degree polynomial instead, also with a high degree of reliability given by its R^2 factor.

Unlike as in the body of construction drawings of architectural designs of discontinuous gaussian vaults available in the Dieste y Montañez S. A. and Udelar Archives, the drawings of the continuous vaults of the Church of Cristo Obrero and Nuestra Señora de Lourdes did not present the "vault of the geometry" drawing sheets as shown in Melachos et al (2019). The transmission of the designed geometry of the continuous gaussian vaults to the construction site was done through "rib sheets" (Fig. 3.a.), as in Carvalho (2006), whereas the formwork geometry was obtained by the mirroring of the sections (Fig. 5.a).

The "vault of the geometry" sheet possesses coordinates tables, which allow for the extraction of polynomials for both the key transverse and longitudinal sections. Those polynomials could then be parametrically interpolated into surfaces as in Melachos (2020). Such interpolations result in a much more compact algorithmic definition than that of the object of study. The 3d digital fabrication models were frequently consulted, along with the construction drawings coordinates, as to verify the interpolation of such curved geometries.

Due to the nature of the documentation of the original drawings of the object of study, its roof geometry was modelled by the parametric insertion of the coordinates from transverse sections of the "rib sheets", one step at a time (Fig. 6.a), resulting in a sub-optimal and enlarged definition for the roof. Consultations in the Dieste y Montañez S. A. and Udelar Archives for posterior Dieste designs indicated that drawings for both continuous and discontinuous gaussian vaults tended to possess "geometry of the vault" sheets. This could be interpreted as a transition in design and construction processess from the less effective "rib" sheet system, which only explicitly showed the transverse sections, towards the "geometry of the vault" sheets, which showed both sections and a coordinate table, along with enlarged construction details.

The gaussian curvature analysis for the continuous gaussian vault and ruled surface modules of the object of study shows that they are numerically freeform, yet predominantly developable in a chromatic gaussian analysis (Fig. 8), and a body of flattening experimentations (Table 1). The tendency towards developability of the ruled surface module is demonstrated in the "squish' experiment, for its flattening via "unroll srf" did not render optimal results. These experimentations show a similarity in the gaussian curvature of both continuous and discontinuous gaussian vaults of Eladio Dieste of Melachos (2020), despite their geometrical interruptions by the skylights. The numerically freeform characteristic of the ruled surfaces of the object of study is indeed a 'network of errors' as coined by Lammers (2017), that was rationally fit for the construction site. After all, its ruled surfaces wall modules were able to be parametrically modelled with the 'ruled surface' and respect the construction drawing coordinates. As mostly developable, its roof and wall modules, the latter being also ruled, prove to be geometries partially compatible to contemporary manufacturing construction sites, demanding further study and comprehension.

As to future research, the researchers involved in this academic exploration are currently seeking funding for the 3d-scanning of the Church of Cristo Obrero and Nuestra Señora de Lourdes. Such procedure would allow for the confrontation of the original construction drawing geometry and the built geometry, generating a digital twin by means of HBIM associated with parametric modeling associating the methodological premisses of Melachos (2020), Balzani et al (2020), and Capone and Lanzara (2021) in a scan-to-HBIM method.

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