

For references, quote as:

Alberto T. Estévez, Yomna Abdallah, "Gaudí and the Apocalypse: Biodigital Bridge for the Sagrada Familia in Barcelona", in Alberto T. Estévez (ed.), *4th International Conference for Biodigital Architecture & Genetics*, iBAG-UIC Barcelona, Barcelona, 2020, pp. 286-307. ISBN: 978-84-09-22004-5. Dep. Leg. B 13784-2020.

Available in: <https://www.bubok.es>.

"Gaudí and the Apocalypse: biodigital bridge for the Sagrada Familia in Barcelona"

Alberto T. Estévez, Yomna Abdallah

Abstract. Faced with an unresolved problem, such as the design of the access that the main facade of the Sagrada Familia by Antoni Gaudí should have, an architectural design is proposed here, using as methodology, digital techniques, organic forms, biological approaches and symbolic backgrounds. Searching solutions more in the line that a Gaudí's work as this deserves, appropriate to our times, to our *Zeitgeist*, when we have already started the third decade of the 21st century. Since the pragmatic drawings that his earliest collaborators made for this purpose are far from contributing to something else, far from adapting to what the Sagrada Familia now is and means. On the other hand, with this excuse, the study of a very particular symbolism of the Sagrada Familia is also developed on the first pages of this writing: the relationship that Gaudí establishes for the design of the Sagrada Familia with the book of the Apocalypse (VV.AA., 2002), concentrating these lines only in this symbolism, which is also the less known and most "secret".

Keywords. Biodigital; Digital Architecture; Digital Organicism; Sagrada Familia; Gaudi.

"...the river of life-giving water, sparkling like crystal,
flowing from the throne of God and of the Lamb."
Apocalypse, 22, 1 [1]

1. Introduction

Most people know Gaudí's unique works which attract millions of tourists to Barcelona every year. Thanks to the Internet, it is easy to immediately find out about some aspects of his biography, so we are not going to cover this in the present pages (or check Estévez, 2002, 2010 A, or 2010 B)].

Certainly, the Sagrada Familia has always been the captivating marvel of Barcelona city, with its geometrical supremacy, typological originality and richness in symbols and meanings. The variance of its elements and the fact that it is the result of synergetic work of more than 100 years of building, emphasize on the brilliance of Gaudí's models and their explicit geometrical analysis that enabled the work to continue through all these phases. It is no secret that these models are learned from nature thus they never failed to be regenerated through different ages, with different technical and technological potentials, and never failed to be as full of symbolic meaning as sufficient functioning as well. Since

the Facade of Glory is designated to be the main entrance and the most prominent in meaning resembling the “Second Coming of Jesus Christ”, described in the book of *Revelation*, also called *Apocalypse* (“Ap.” from now on quotes), of the end of times (VV.AA., 2002). This indicates the importance of initialization of the leading passage to the facade to render two main purposes, to give an ample entrance to the temple, and to surmount the challenge of the unevenness of the plant of the facade with respect to the Mallorca street. Gaudí’s collaborators designed only a functional flight of steps over Mallorca Street, in such a way that all the traffic will have to pass underneath, the stairs should reach the opposite side. This can be seen in different drawings of Gaudí’s time, still with Gaudí living (Figure 1).

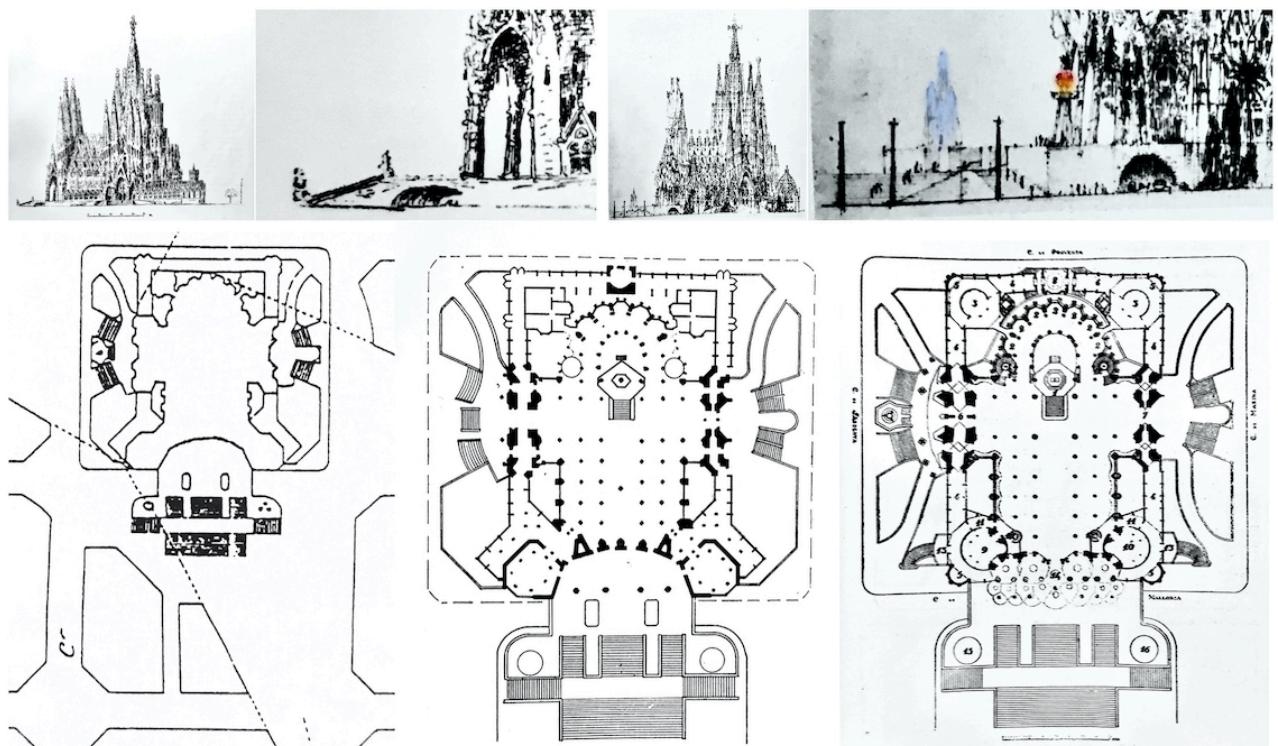


Figure 1. Drawings where it can be seen the intention of solving the main entrance with a large staircase above Mallorca street. Above, the two on the left, a general drawing of the Sagrada Família and its detail, by Gaudí, edited by his collaborator Joan Rubió in 1902 (Bonet, 2000, p. 24), and the two on the right, a general drawing and its detail, by Gaudí’s collaborator, Lluís Bonet, who was recomposing in a single set all the details that Gaudí was making evolve in his project (Bergós, 1974, p. 110). Below, plan of the complex with staircases above Mallorca street, collected respectively among others, for example, from left to right, by Jordi Faulí (Faulí, 2006, p. 16: drawing signed by Gaudí and dated 1916), by Josep Francesc Ràfols (Ràfols, 1999 (1928), p. 147), and by Juan Bergós (Bergós, 1974, p. 114).

This would be translated through this research to a pedestrian bridge that achieves not only the functional requirement, but also the morphologic and symbolic of Gaudí, and regenerates Gaudí’s idea of linking the Facade with the surroundings. Designing such an important passage to Facade of Glory indicates obeying Gaudí’s natural geometries and symbolic meanings. In this paper, a Gaudí’s spirit in design was tackled through morphologic and symbolic approach to couple both the spiritual symbolistic meaning of Apocalypses oracles with the efficient, learned from nature geometries of Gaudí. This is realized using algorithmic modelling tools to generate ruled surfaces of hyperbolic paraboloids, hyperboloids and conoids that were employed in the designs by Gaudí, to

design a pedestrian bridge that leads to the Facade of Glory, still developing, waiting for more definitive and detailed version of it. In turn, integrating into such a bridge design the requirements that currently exist –by legal regulations– for the inclusion of access ramps.

2. Gaudí and the Apocalypse: The Basilica of the Sagrada Família in Barcelona (Symbolical background)

Less than 7 years after the centenary of Gaudí's death, of the possible completion by then of the Basilica of the Sagrada Família, set in principle for that year 2026, when the 144 of his initiation are also fulfilled – $144 = 12 \times 12$, which is the number of the New Jerusalem as it appears in the book of the Apocalypse (Ap. 21, 12-21)– we wanted to present this work, as a possible proposal for access to the facade of Glory. With the desire to contribute something, for free, for the illusion of participating in such a great work as this Temple, and perhaps even being useful for it.

Starting from the beginning with the statement that among believing architects, designers and artists, for centuries, the Celestial Jerusalem described in the book of Apocalypse has been taken as a theme of inspiration. As it consists as a city, an entire building, whose architect, designer and artist is God Himself. So, it remains for Christians as a divine, ideal, model of construction. Only that Gaudí is the human being who has developed such an ancient vision in the most sublime, complete and complex way. It is intuited in Figure 2 really as a heavenly building, the heavenly Jerusalem: "the holy city Jerusalem coming down out of heaven from God. It gleamed with the splendor of God. Its radiance was like that of a precious stone, like jasper, clear as crystal" (Ap. 21, 10-11).



Figure 2. The Sagrada Família of Gaudí, presented in this image (photomontage of the authors) as the heavenly Jerusalem: "the holy city Jerusalem coming down out of heaven from God. It gleamed with the splendor of God. Its radiance was like that of a precious stone, like jasper, clear as crystal" (Ap. 21, 10-11).

Here and now, comparatively, it can be brought up any of the images of the history of

different artists, interpreting their version of the New Jerusalem, as seen in Figure 3, from the Book of the Revelation of Bamberg (c. 1010), from the Beato de Liébana (1047), or from the Apocalypse of Durero (1498), for example. In all of them, 12 towers appear clearly, according to the translation of that passage from the book of Apocalypse: “I also saw the holy city, a new Jerusalem, coming down out of heaven from God (...) the city had twelve towers, on which where inscribed the twelve names of the twelve apostles” (Ap. 21, 2 and 14). Although it can be seen in other translations the word “foundations” or “courses of stones”, instead of “towers”. Be that as it may, they are 12 strong construction elements, spread over the outer wall, which in times of castles and walls were well understood as “towers”. So, Gaudí will take that idea, also converging with the historical Christian iconography, of a New Jerusalem with 12 towers around it, as it endowed the Sagrada Família (Figure 2). Besides to inscribe on them “the twelve names of the twelve apostles”, taken literally from the Apocalypse (Ap. 21, 14).

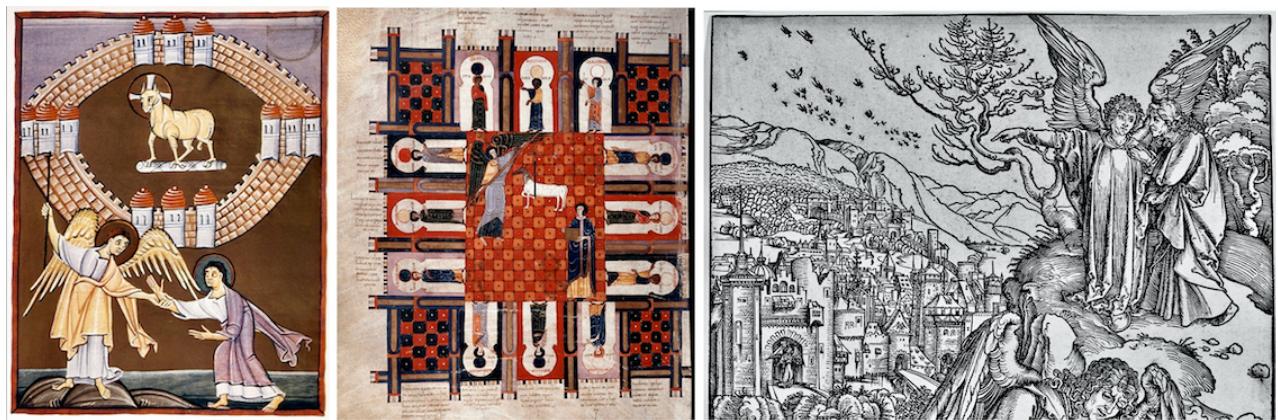


Figure 3. Left, the 12 towers of the New Jerusalem, *Book of the Revelation of Bamberg* (c. 1010). Center, 12+12 towers of the New Jerusalem, *Beato de Liébana* (1047). Right, 12 towers of the New Jerusalem, *Apocalypse of Durero* (1498).

Obviously, Gaudí was thinking very concretely of the Sagrada Família as that divine city of the end of times, since there is no other type of church throughout history that has 12 towers around with the names of the 12 apostles. More so, when as “a new Jerusalem, coming down out of heaven from God” (Ap. 21, 2), Gaudí also states that a model of the heavenly Jerusalem –designed with the exact shape described in the Apocalypse– must be hung in the middle of the dome central, from the structure, at the top, this arrangement being almost the central heart of the entire building (Figures 4-5). Thus, again literally representing the apocalyptic vision of Saint John. This time thought of as a lamp of rich and translucent materials (Ràfols, 1999 (1928), p. 148), as commented: “the holy city Jerusalem coming down out of heaven from God. It gleamed with the splendor of God. Its radiance was like that of a precious stone, like jasper, clear as crystal” (Ap. 21, 10-11). Quote that describes in a sublime way the light experience that is actually in the Sagrada Família (Figure 6).



Figures 4-6. Left and center (detail), section of the Sagrada Família where a model of the “new Jerusalem, coming down out of heaven from God” is seen (Ap. 21, 2), floating in the middle of the building, in the form of a radiant lamp (section drawing: Faulí, 2006, p. 21). Right, the spaces of the Sagrada Família that literally seem “gleamed with the splendor of God. Its radiance was like that of a precious stone, like jasper, clear as crystal” (Ap. 21, 11).

In fact, already as a student of architecture, he had in mind the story of the Apocalypse. In an exercise in the subject of Projects, still in the first year, in 1875, which was to draw the door of a cemetery, he did it following “an artistic representation of the Apocalypse, a book for which Gaudí felt a strong inclination, reappearing in other works of his, throughout his career” (Bassegoda, 1989, p. 24): the apocalyptic symbolism of this project is well described in detail in the great book by Juan Bassegoda (Bassegoda, 1989, p. 59).

And there are many traces that can be found in the Sagrada Família that appear as inspired by the Apocalypse. Elements that the author of these lines has been commenting on in numerous conferences for years. Some have been included in his writings since 2002 (for example, Estévez, 2002, 2010 A, 2010 B). And here such elements will be culled, but concentrating only on the apocalyptic symbolism, without further elaborating on their complete symbolic explanation. This can in any case be checked in the bibliography just cited.

For example, one of those most spectacular elements, apart from the 12 mentioned towers, is without doubt an absolutely unique, gigantic and architectural representation of the apocalyptic Tetramorph. For centuries and centuries, the representation of the figure of Jesus Christ surrounded by the Tetramorph (Figure 7), taken directly from the Apocalypse, has been habitual in Christian pictorial and sculptural iconography: “In the center and around the throne, there were four living creatures (...) The first creature resembled a lion, the second was like a calf, the third had a face like that of a human being, and the fourth looked like an eagle (...). Day and night they do not stop exclaiming: ‘Holy, holy, holy is the Lord God almighty’” (Ap. 4, 6-8). Only here it is converted into architecture, by means of 4 enormous domes, each culminating with its corresponding “living creature” (sculptures of lion, calf, man and eagle), which surround the highest central dome, dedicated to Jesus Christ, with the characteristic Gaudí’s 4-armed cross crowned all his buildings since 1888 (Figure 8).

Therefore, the two most important architectural design decisions that Gaudí made, to

establish the unique typology of the Sagrada Família, are totally linked to his direct inspiration from the Apocalypse: the 12 surrounding towers and the gigantic central Tetramorph. And then, the second part of the quote, in which those “living creatures” “do not stop exclaiming: ‘Holy, holy, holy’” (Ap. 4, 8), is spread by Gaudí “coiled” helically by the 12 towers that surround the 5 central domes, in triple groups of three, 9 in total (Figure 9). Recognizing that it is a praise to the Holy Trinity following the Christian tradition. And it is for this Christian belief of the three persons in one single God that Gaudí puts every three “Sanctus” (“Holy”, in Latin) in a different color: yellow dedicated to God Father (gold, divinity), red dedicated to God Son (Jesus Christ: blood, martyrdom), and orange in the middle dedicated to God Holy Spirit (color that comes from yellow and red, as the Catholic Church teaches, that the Holy Spirit comes from the Father and the Son).



Figures 7-9. Left, an example of history, out of thousands (Church of St. Trophime, Arles, late 11th century - early 12th century), typical of Christian iconography, which, following the Apocalypse, Jesus Christ is surrounded by the Tetramorph. Center, the 4 domes of the apocalyptic Tetramorph around that of Jesus Christ, all architecturally represented in a very unique way (infographic of the Technical Office of Sagrada Família). Right, the “Holy, holy, holy” of the Apocalypse helically coiled in the 12 towers that surround the 5 domes (Ap. 4, 6-8).

Then, came a long string of references to the Apocalypse that filled the rest of the architectural composition of this unique work. For example, following the verse that says “around the throne was a rainbow (“halo” in other translations) as brilliant as an emerald” (Ap. 4, 3), literally, the “throne”, the altar in this case, is surrounded by all rainbow colors. These run from the background of the naves to the altar on their left, from violet, indigo, blue, and even green. And it turns next to the altar to return towards the back of the naves on its right, from green to yellow, orange and red. Therefore, green, the central color of the rainbow, the tone of the emerald, is the one closest to the altar on both sides of the naves. While the rainbow stains the entire interior space with reflections that a human would say “heavenly”, or “divine”, in his way of saying (Figure 10).

Or other curiosities, such as the clue that Gaudí leaves so that their interpretation will lead to think about the end of times. On the facade of Life, where the birth of Jesus is represented, magnificent trumpeter angels appear (Figure 11). When, however, the angels who announced the arrival of the Messiah had no trumpets. While it is in the Apocalypse where angels announce the second arrival of Jesus Christ with trumpets, this time in Glory: “The seven angels who were holding the seven trumpets prepared to blow them” (Ap. 8, 6).

One verse, which also offers Gaudí the possibility of continuing along this line of creating the widest synthesis of the Christian religion never before seen in art, is “produces fruit twelve times a year, once each month” (Ap. 22, 2). For it will place 12 fruits on twelve pinnacles of the lateral facades: a new synthesis if they are also understood as the 12 fruits of the Holy Spirit, which appear on the highest part of the mounts, as if the material and stone gave their fruit as they got closer to the high, towards Heaven, towards the rays of light of divine grace, symbolized in turn by the lights that will come down from the towers. Always masterfully uniting the human and the divine. Ordered, 6 fruits typical of spring and summer (cherries, peaches, plums, etc.), on the facade of Life (of Jesus), facing east, where the sun rises and the light comes, according to how nature awakens “life” in those seasons. And 6 fruits typical of autumn and winter (chestnuts, persimmons, almonds, etc.), on the facade of Death (of Jesus), facing west, where the sun goes down and the light goes out, according to how nature approaches “death” in those seasons (Figure 12).



Figures 10-12. Left, “around the throne was a rainbow (“halo” in other translations) as brilliant as an emerald” (Ap. 4, 3): literally, the “throne”, the altar, is surrounded by all the colors of the rainbow, and next to it, to the right and left, emerald green. Center, trumpeter angels of the Apocalypse, announcing the coming of Jesus. Right, fruits on the pinnacles of the lateral facades, arranged according to the seasons, spring-summer in the photo, and autumn-winter on the opposite facade: “produces fruit twelve times a year, once each month” (Ap. 22, 2).

It is linked to the mentioned fruits that it is spoken of the tree of life. Thus, the representation of its leaves is also sculpted under the pinnacles of the fruits (Figure 13), as it is confirmed that there in the New Jerusalem “grew the tree of life that produces fruit twelve times a year, once each month; the leaves of the tree serve as medicine for the nations” (Ap. 22, 2).

On the other side, in the western corner of the built complex, finished not so long ago, one of the sacristies stands (Figure 14). It is on their facades that the words of the Apocalypse appear literally inscribed again: amen, thanksgiving, honor, power, etc. As it is written “Amen. Blessing and glory, wisdom and thanksgiving, honor, power, and might be to our God forever and ever. Amen” (Ap. 7, 12). And it appears culminated with the figure of “a Lamb that seemed to have been slain” (Ap. 5, 6), and some grapes in vintage, in memory of the words “cut the clusters from the earth's vines, for its grapes are ripe” (Ap. 14, 18), which allude to the end of times.



Figures 13-14. Left, facade with leaves around the windows, under the pinnacles of the fruits, according to “the leaves of the tree serve as medicine for the nations” (Ap. 22, 2). Right, the sacristy, with more allusions to the Apocalypse: “Amen. Blessing and glory, wisdom and thanksgiving, honor, power” (Ap. 7, 12). Culminated with the figure of “a Lamb that seemed to have been slain” (Ap. 5, 6), and grapes in grape harvest, in memory of the words “cut the clusters from the earth’s vines, for its grapes are ripe” (Ap. 14, 18), which allude to the end of times.

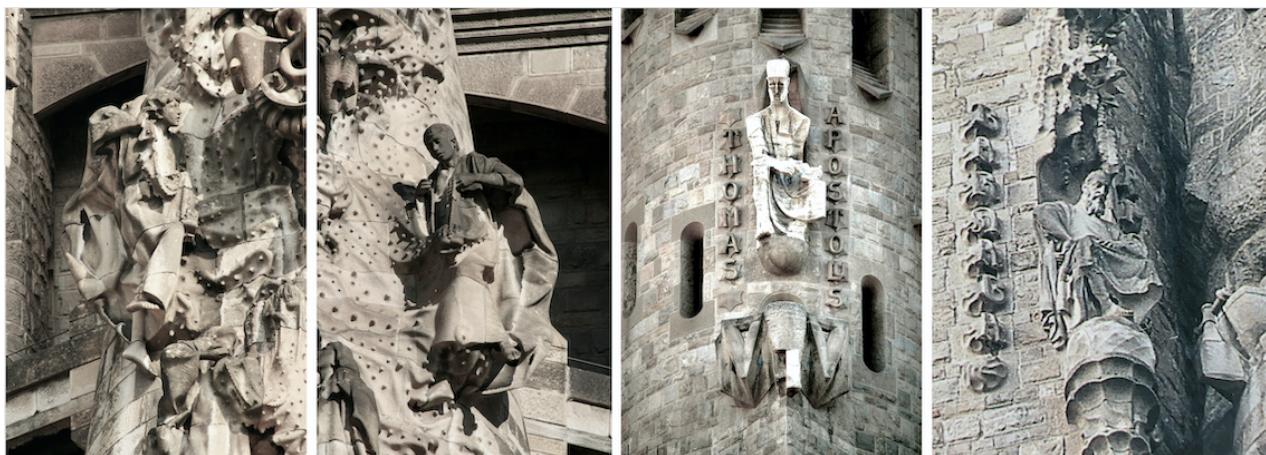
Equally present will also be the darkest and more tenebrous face of the Apocalyptic story. Just behind the Sagrada Família, around its apse, in the place least illuminated by the sun and furthest from the main facade of the triumphal coming of Jesus Christ at the end of times. Thus, separated from divine glory, as fleeing to the ground, escaping from the light of grace that comes from the towers that remain above, appear animals symbolically linked to hell: the reptiles, who crawl on the ground, through the filth, toads, lizards, snakes (Figures 15-18). Resounding in them the words about “the ancient serpent, who is called the Devil and Satan, who deceived the whole world, was thrown down to earth, and its angels were thrown down with it” (Ap. 12, 9), transfigured into reptiles as they are seen here, “thrown” down to the ground. Like this other verse resonates that “the woman was given the two wings of the great eagle, so that she could fly (...), far from the serpent” (Ap. 12, 14). Well just above the serpent in the apse (Figure 17), the great dome dedicated to the Virgin Mary rises like a fly, with a star as a crown: “a woman (...), and on her head a crown of twelve stars” (Ap. 12, 1). The woman that Christian iconography has also painted stepping on the serpent “with the moon under her feet” (Ap. 12, 1). Prophesied from “the beginning of times”, in the first book of the Bible, that of Genesis, to “the end of times”, in the last book of the Bible, that of the Apocalypse. There, in Genesis (Gn. 3, 14-15), it is recorded that “God said to the serpent (...) the woman (...) will strike at your head” (VV.AA., 2002). Likewise, there will be no lack of frogs in this part of the temple (Figure 18), also following this vision: “I saw three unclean spirits like frogs” (Ap. 16, 13).



Figures 15-18. Apse of the Sagrada Família: the reptiles, symbolizing animals from hell, fleeing, “thrown down to earth” (Ap. 12, 9), to the ground: lizards, snakes and frogs...

There are also more delicate quotes. Like the two angels that appear towards the middle of the facade of Life (Figures 19-20), who delicately follow this verse: "Another angel came and stood at the altar, holding a gold censer. He was given a great quantity of incense to offer, along with the prayers of all the holy ones, on the gold altar that was before the throne. The smoke of the incense along with the prayers of the holy ones went up before God from the hand of the angel. Then the angel took the censer, filled it with burning coals from the altar, and hurled it down to the earth" (Ap. 8, 3-5). So, located in the middle of the facade of Life, it can be seen in a pre-eminent place an "angel", looking up, who "stood at the altar, holding a gold censer". While it is also represented in stone how "the smoke of the incense (...) went up before God from the hand of the angel". And on the other side of the scene it is seen an angel, as looking down, and that "then the angel took the censer (...) and hurled it down to the earth". All closely following the Apocalypse.

Just as the Apocalypse is literally followed by placing "the twelve names of the twelve apostles" (Ap. 21, 14) inscribed on the 12 towers, along with their seated sculpted figure (Figures 21-22), as previously exhibited. Of course, the majority of the apostles are always represented standing throughout the history of art. Especially in the sculptures that usually adorn Christian temples. And the fact that they appear seated in the Sagrada Família recalls the verse that says "surrounding the throne I saw twenty-four other thrones on which twenty-four elders sat" (Ap. 4, 4). When the 24 can also be interpreted as 12 of the Old Testament and 12 of the New Testament. According to the 12 patriarchs of the 12 tribes of Israel in the Old Testament, and the 12 apostles of the New Testament. Therefore, it would follow that interpretation to see the 12 apostles sitting and "surrounding the throne", as are those 12 towers of the 12 apostles surrounding the entire space of the temple. Not only with towers at the main entrance, as is usually the most common in Christian churches. This is more so when the Apocalypse speaks both of "the twelve names of the twelve apostles" (Ap. 21, 14) and of the "names were inscribed, (the names) of the twelve tribes of the Israelites" (Ap. 21, 12).



Figures 19-22. On the left, in a pre-eminent place, located in the middle of the facade of Life, an "angel" can be seen, looking upwards, who "stood at the altar, holding a gold censer. (...) The smoke of the incense (...) went up before God from the hand of the angel". While to the right it is seen an angel as looking down, and "then the angel took the censer (...) and hurled it down to the earth" (Ap. 8, 3-5). All closely following the Apocalypse. Just as it is followed literally, when seeing in the two images on the right (Figures 21-22) the example of how "the twelve names of the twelve apostles" (Ap. 21, 14) appear inscribed in the 12 towers, together with their seated sculpted figure (Ap. 4, 4).

Meanwhile, the facade of the Death of the Sagrada Familia is flanked on either side by a “triumphant” lion and by a lamb (Figures 23-24). Just as the quote from “the lion of the tribe of Judah, the root of David, has triumphed (...). Then I saw standing (...), a Lamb” (Ap. 5, 5-6). Representing in turn respectively David and all the prophets, and Abraham and all the patriarchs, inscribed their names to the left and right of that facade: as mentioned about that “names were inscribed, (the names) of the twelve tribes of the Israelites” (Ap. 21, 12). As an Alpha and an Omega were also placed in the center of that same facade, as is repeatedly read in the Apocalypse “I am the Alpha and the Omega” (Ap. 1, 8; 21, 6; 22, 13) (Figure 25): from the facade of Life and the representation of Jesus birth, to the other side of the temple, to this facade of Death and the representation of Jesus crucifixion, Life and Death, the Alpha and the Omega, the beginning and the end of times.

And yet another quote, which has been literally fulfilled for some years now, is that it has really appeared “a great multitude, which no one could count, from every nation, race, people, and tongue” (Ap. 7, 9). Something that Gaudí knew would happen sooner or later. Millions of people who now come every year to see the Sagrada Familia, with faith and without faith, from all over the world (Figure 26). So, resounding those other words about that “with your blood you purchased for God those from every tribe and tongue, people and nation” (Ap. 5, 9). Something also represented with the Lord’s Prayer written in many different languages on the main doors of this temple.



Figures 23-26. Left, in a triumphal gesture “the lion of the tribe of Judah, the root of David, has triumphed” (Ap. 5, 5). While to his right “Then I saw standing (...), a Lamb” (Ap. 5, 6). In the center, there is an Alpha and an Omega, according to the repeated verse of “I am the Alpha and the Omega” (Ap. 1, 8; 21, 6; 22, 13). And to the right of these images, it looks like today, with millions of visitors coming from all corners of the planet, literally “a great multitude, which no one could count, from every nation, race, people, and tongue” (Ap. 7, 9).

It would still remain to observe the profusion throughout the Sagrada Família of the symbolic number 7, as can be seen in Figure 27, in spaces, chapels, sections of naves, doors, windows, etc. This number is also present throughout the book of Apocalypse. For example: “this is the secret meaning of the seven stars you saw in my right hand, and of the seven gold lampstands: the seven stars are the angels of the seven churches, and the seven lampstands are the seven churches” (Ap. 1, 20). Or “seven flaming torches burned in front of the throne, which are the seven spirits of God” (Ap. 4, 5). Or “seven horns and seven eyes; these are the (seven) spirits of God” (Ap. 5, 6). As well as many other examples of Gaudi’s symbolic use of numbers can be found. Some more linked to apocalyptic numerology (columns of 12 vertices that become 12 in 12 meters), others to the Trinitarian (sequences of 15, 30 and 45 meters in columns), and a long etcetera.

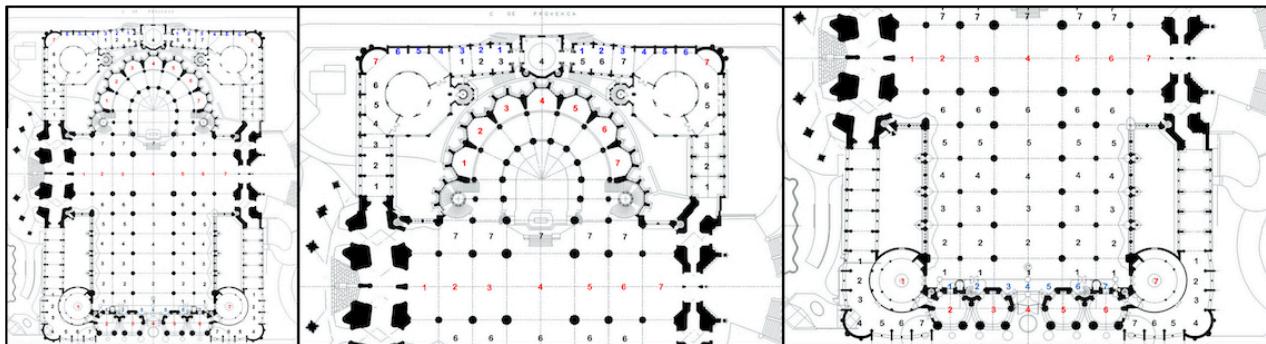


Figure 27. Plan of the Sagrada Família (plan drawing: Faulí, 2006, p. 63), with indication of spaces, chapels, sections of naves, doors, windows, etc., following number 7, according to the author of this writing.

The dedication of the main facade of the Sagrada Família to the second coming of Jesus Christ at the end of time, as it has been advanced at the beginning of this writing, is definitive for the interpretation of what is intended in these lines. It is usually the main facade of the churches that responds most to the mystery to which they are dedicated. And it is Gaudí who has the Glory facade as the main facade. The manifestation of the Glory of Jesus Christ in full view, as announced already from the beginning of the book of Apocalypse: "Behold, he is coming amid the clouds, and every eye will see him" (Ap. 1, 7). Following that "then I looked and there was a white cloud, and sitting on the cloud one who looked like a son of man" (Ap. 14, 14), figure of Jesus Christ. And for this Gaudí configures such a facade with clouds that surround Jesus Christ (Figure 28). Representation of Glory also emphasized as this is the facade that faces south, towards the glory of the sun when it is at its zenith.



Figure 28. Facade of Glory, made up of the second coming of Jesus Christ "amid the clouds" at the end of times (Ap. 1, 7): (left) drawing and detail of Ramón Berenguer exposed in the Museum of the Sagrada Família, Barcelona, (center) model of the set exhibited in the Sagrada Família Museum, Barcelona, and (right) original model of Gaudí (photo: Bonet, 2000, p. 121), showing the entire main facade made up of clouds.

In brief, above all this enormous display of architectural elements of strong and directed symbolism, inspired by the Apocalypse, only one part that usually goes unnoticed would remain to be solved: the accesses to the main entrance of this magnificent temple, today

not yet resolved. And not because of their predisposition to spend more in hiding than the entire complex they serve, they should avoid a Gaudinian “updated” morphology. In due symbolism too. And even to the adaptation to the times we live in and to its signs. Taking advantage of the new technological possibilities that these times offer: The Basilica of the Sagrada Familia deserves access according to everything it entails.

3. Biодigital bridge for the Sagrada Familia in Barcelona: architectural design of the access to the main facade

To resolve access to the future main facade of the Sagrada Familia that is several meters above the level of the adjacent Mallorca street, it is about tracing more than just a few functional steps and its corresponding tunnel over the Mallorca street, as they are collected in the drawings of Gaudí and his collaborators, as seen before (Figure 1). Therefore, some idea is offered here that continues with the symbolic logic of Gaudí's Apocalyptic vision. And not only symbolically, but also offer something morphologically and technologically in line with the whole and with our times, as already mentioned.

Thus, this project of access to the main facade of the Sagrada Familia is presented as something open. Where the important thing is the idea and not so much the exact dimensions and shapes that appear here designed, which can always be varied and adjusted. When the idea responds precisely to unite symbol, morphology and technology, as Gaudí has always done.

It is then when symbolically part of the appointment that today takes a greater relevance, a greater adaptation to the times, to the *Zeitgeist*, to the current problems for the next decades and perhaps centuries. More precisely when it has also been included as the heading of the first chapter for the papal document of the Amazon Synod of October 26, 2019, a key document for the development of a comprehensive ecology:

“...the river of life-giving water, sparkling like crystal,
flowing from the throne of God and of the Lamb.”

Apocalypse, 22, 1 [1]

Thus, it seems very appropriate that this “river” of the entrances be the one that through it allows ascending to the “throne (of God) and sacrificial altar (of the Lamb, Jesus Christ) from which Life emanates”, as understood by the Christian liturgy that is an altar in a church. Also, in line with what is described in the book of Apocalypse. This is morphologically what is adopted for the accesses to be designed, a “river”. And “sparkling like crystal” (Ap. 22, 1), thanks to translucent and gilded concrete ramps, with night lighting inside, which flow technologically following a display of algorithms that guarantee their harmony from digital design. Just as Gaudí advanced to his time, his successors also, until today, when for example they were the first to start applying digital manufacturing in a real-scale work (with the first CNC in the history of architecture applied to the realization of architectural pieces on a natural scale 1:1). Gaudí would surely be currently working from the digital organicism that the new media allow for this project.



Figure 29. General location of the Sagrada Família. Left, view of the current state, with the block in front filled with buildings. Center, minimum demolition intervention to house the access ramps. Right, plan of the set.

Ultimately, as can be seen in Figures 29-30, what is proposed is this set of ramps, which, from the space of the urban block in front (still to be liberated, now filled with buildings), gently flow up to the facade of Glory. This directly addresses not only the aforementioned symbolism, but also the functional need that in recent years has become socially very aware of “design for all”, full accessibility.

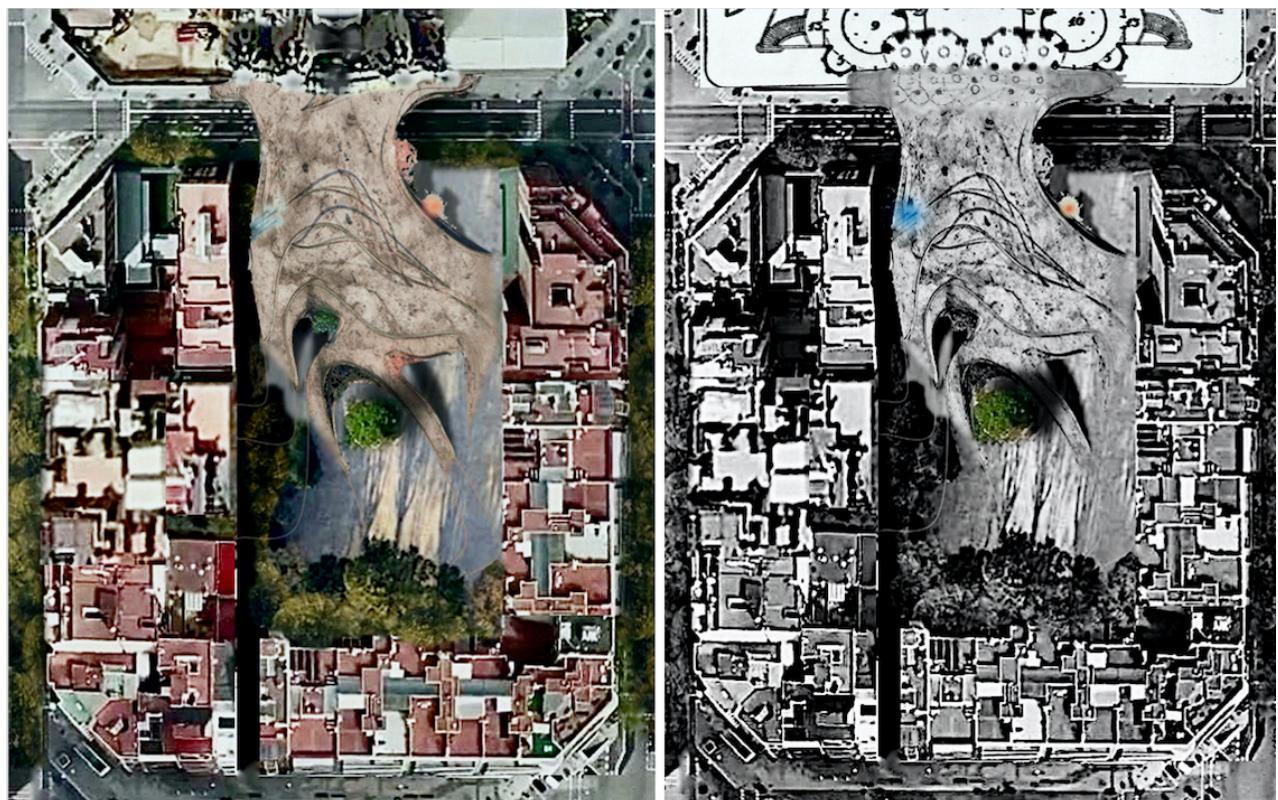


Figure 30. Plan of the access ramps to the Sagrada Família, above Mallorca street, with the fountain (water) and the torch (fire) on the left and right provided by Gaudí in front of the main facade, and with the “tree of life” (Ap. 22, 2) in the center (earth), while the metallic structures rise as if flying in wide arches over the ethereal translucent ramps (air).

As Gaudí proposed a large fountain (water) and a torch (fire) on each side in front of the main facade, due to its corresponding symbolism (see Estévez, 2002, 2010 A or 2010 B),

it is proposed here also in the center of the ramps that a large tree (earth) appears. Specifically, a *Moringa oleifera*, also sometimes called “the tree of life”, for being completely edible, very rich in nutrients, also with leaves that “serve as medicine”, for health. This completes the set with the quotation of the “tree of life”, that is in “the middle of its street. On either side of the river grew the tree of life that produces fruit twelve times a year, once each month; the leaves of the tree serve as medicine for the nations” (Ap. 22, 2). Around it, then, the ethereal translucent ramps will eventually flow (Figure 30). While the metallic structures rise as if flying in wide arches (air) as seen in Figure 31. Recalling in turn one of Gaudí’s most brilliant contributions to architecture, his mechanical studies using strings and sacks simulating the loads of the roofs, dramatically applied to the design of the Colonia Güell church, Santa Coloma de Cervelló, 1898-1917 (Figures 31 and 33).



Figure 31. Left, reverse photograph of the “polifunicular model” that Gaudí used to design the Colonia Güell church (Bassegoda, 1989, p. 366). Center, elevations southeast (above) and northeast (below) of the set of projected ramps, showing the wide arches of the metal structures and a *Moringa oleifera* in the center, as a “tree of life” (Ap. 22, 2). Right, seen from the south.



Figure 32. Left, view of the atrium of the crypt of the Colonia Güell church, under the ramp (staircase) that surrounds a tree, in a photo from 1915, before the reforms that at the beginning of this 21st century sadly distorted Gaudí’s original idea. Right, from the east, view of the atrium, under the ramps that surround the “tree of life”, projected to give access to the church of the Sagrada Família.

Therefore, the ramps house not only the tunnel that solves the traffic on Mallorca street, but also a covered and translucent atrium as it has been said, “sparkling like crystal” (Ap. 22, 1), “day and night” (Ap. 4, 8). Covered atrium that, with another scale, would resemble the crypt atrium of the Colonia Güell church, created by Gaudí to give access over the aforementioned crypt to the main entrance of that church that was unfinished (Figure 32). And since Gaudí was experiencing in that project located in Santa Coloma de Cervelló what on a large scale he was projecting in parallel for the church of the Sagrada Família, it seems therefore a good relationship to also establish that figure for the case of this “atrium” proposed here under the ramps (Figures 31-34).

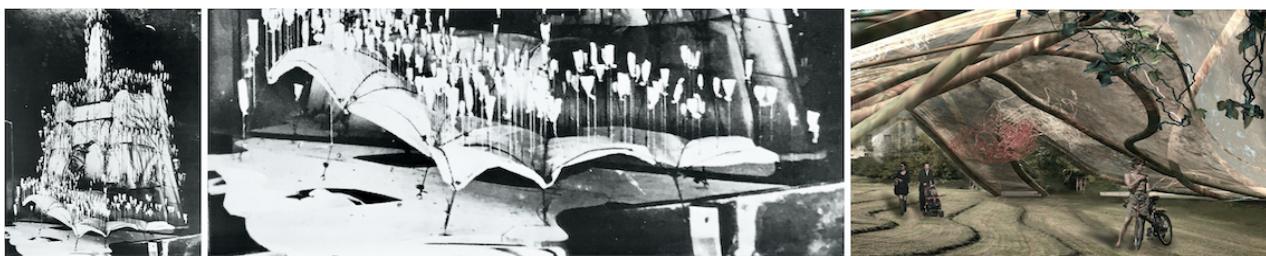


Figure 33. Left, reverse photograph of the model for the “mechanical study” of the church in Colonia Güell, “using strings from which suspended sandbags, proportional to the weight of the construction” (Bergòs, 1974, p. 87). Center, detail view of the model of the atrium of the crypt of the church of Colonia Güell. Right, detail of the atrium under the projected ramps for the Sagrada Família church, made of translucent concrete, “sparkling like crystal” (Ap. 22, 1), “day and night” (Ap. 4, 8).

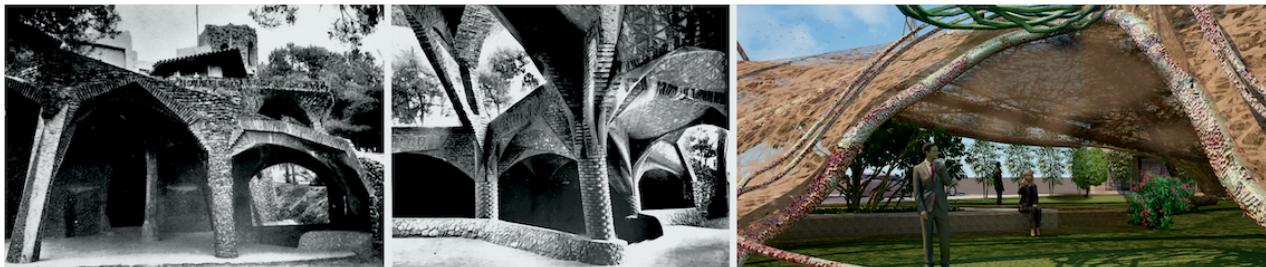


Figure 34. Left and center, atrium of the crypt of the Colonia Güell church (photos: Martinell, 1967, p. 358). Right, atrium under the projected ramps for the Sagrada Família church.

Thanks to that cylindrical metal structure that arises as arches, smaller pieces also become entangled, the vegetation and lighting elements as “swarms” of clouds. In reference to the Glory facade itself, symbolically configured by clouds, as previously mentioned. Without being able to avoid the memory that this brings, of the metallic “swarms” that act as a railing on the balconies of the Casa Milà (La Pedrera) of Gaudí himself. Counting also as important antecedents to the project exposed here, and in Barcelona itself, the work Núvol i cadira by Antoni Tàpies, and the structures of the Parc Diagonal Mar by Enric Miralles and Benedetta Tagliabue (Figure 35). And in line with all this, a free-line design will also appear, which, as railings and benches, follow the edges of the ramps.

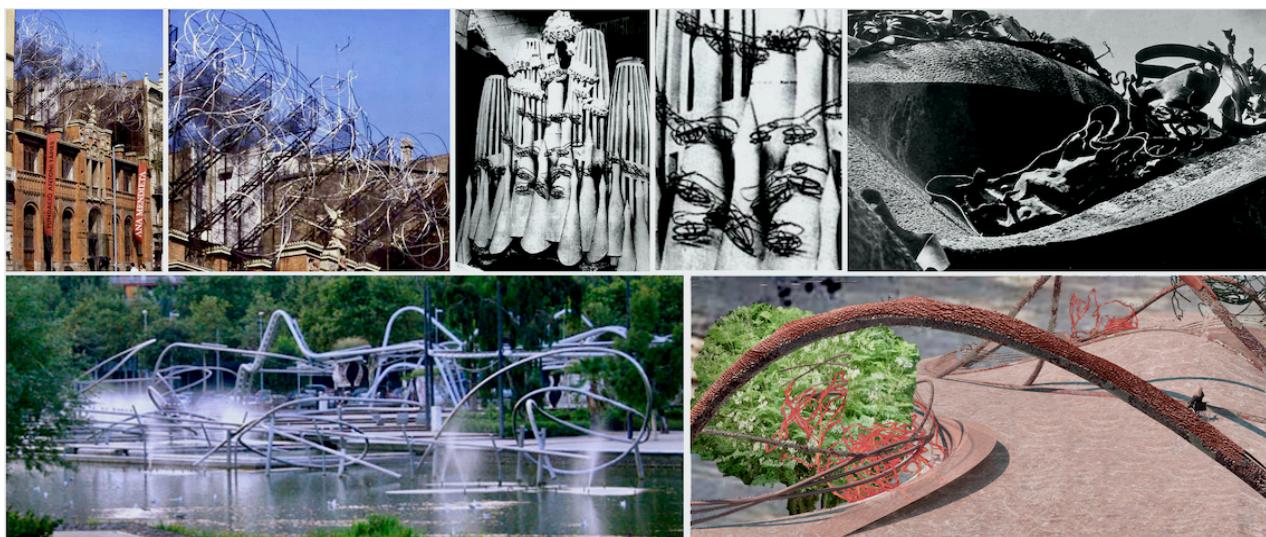


Figure 35. Top left, “cloud” framework, in the Fundació Antoni Tàpies building: Núvol i cadira, by Antoni Tàpies (Barcelona, 1988). Up to the center, frame of “clouds”, in Gaudí’s original model for the Glory facade (photo: Bonet, 2000, p. 121). Above right, similar framework for the balconies of Gaudí’s Casa Milà (Barcelona, 1906-11). Bottom left, framework of “clouds”, supports for vegetation, light and water, in the Parc Diagonal Mar, by EMBT - Enric Miralles and Benedetta Tagliabue (Barcelona, 1995-2002). Bottom right, frame of “clouds” in this access project to the Sagrada Família. The design of free lines of railings and benches following the edge of the ramps is also appreciated here.

4. Harmonizing with the architectural context of the city (Figure 35)

The original Gaudí model of the facade of Glory employed wrought iron as a structural base for the clouds that adorn the facade. Although these wrought iron shapes are to be covered with other sculpted cloudy shapes: this does not blot out its formal value. As it could be seen obviously that Gaudí, the master of geometrical precision, did use the “chaotic” wrought iron shapes before in the fences of balconies of La Pedrera (casa Milà, 1906-11).

As Gaudí almost knew nature secrets of mathematical complexity forming, he mastered the complex calculation of emergent precise “chaotic” shapes of nature as well. Aside from the wrought iron cloud model and La Pedrera fences, another more modern architectural contribution to the uniqueness of Barcelona is the Fundació Tàpies. It could be recognized easily, the harmony of the “chaotic” indefinite iron cloudy shapes of the Fundació Tàpies with the wrought iron model of Gaudí’s clouds and fences.

The ultimate brilliance of these “chaotic” forms emerges from the ultimate freedom in form generation and expression as well, through manipulating and playing with solid and void at the very same time and through the very same line. In Fundació Tàpies a further parameter was added by the lighting of the curves giving it a morphogenesis in time that generate different conception of it between day and night.

Another supporting example is found in Parc Diagonal Mar, of Enric Miralles and Benedetta Tagliabue, which utilized the same concept of playing curves to generate forms, and once again more parameters were added to the successful spatial and volumetric maneuver through curves, by employing these curves as fountains, fences, paths, etc.

In the current work, the authors utilized the same formal concept of indefinite shapes resulting from continuously and freely moving curves, adding a new aspect in this case which is scale. The proposed design employed main 7 curves for their symbolic meaning as mentioned before. These 7 main curves were functioning as load bearing veins of the broad space of the bridge. These 7 curves were also employed as the main paths of the biased random walk equation developed by the authors to resemble the pedestrians’ movement pattern along the main paths of the bridge. The resulting cloudy shapes of the biased random walk pattern of visitors was employed as a torch of fire, fences, and structures for light and vegetation, to obey Gaudí’s model of the facade of Glory.

5. Materiality

In turn, the effect of translucent concrete (Figure 36) allows the set of ramps to create a special atmosphere both during the day, below the ramps, in the covered atrium, and at night, thanks to the installation of led lights in the concrete interior. All this allows for a spacious and easily accessible space, which leaves the public like a “jasper” tray in front of the main facade, like “a sea”: “In front of the throne was something that resembled a sea of glass like crystal” (Ap. 4, 6), “It gleamed with the splendor of God. Its radiance was like that of a precious stone, like jasper, clear as crystal” (Ap. 21, 11).



Figure 36. Examples of translucent concrete to be applied in the construction of the ramps of this project.

Of course, as an alternative you can think of solving the structure with bamboo (Figure 37), as it is proliferating today throughout the world, more and more, due to its special ecological conditions. Or with fiberglass from recycled glass. Both, structures of great lightness compared to their high resistance. But it is not the current work that should be devoted to such versions, since it would imply a separate and specific study. Here, only one door is left open so that alternatives can be glimpsed.



Figure 37. Examples of possible alternatives: fiberglass, recycled, and bamboo structures.

6. Gaudí's geometries (geometry of nature)

As exhibited in all his previous work and most prominently in his masterpiece Sagrada Familia, Gaudí's geometries were the ultimate emergence of functional forms that are learned from nature. These geometries were flowing in morphogenetic shapes with naturally inherited optimum structural functioning, and aesthetical integration and consistency with itself and surroundings, to emerge in a complex architectural case, that demonstrates itself; as a whole, in its' parts, in relation and integration between its parts, and in its endless symbols and metaphors.

On top of all Gaudí's work that enjoyed this delicate rich complexity and structural supremacy came the Sagrada Familia, to enjoy the architectural coherence of the infinitely emerging and regenerating symbolic alphabet made from nature-learned forms. This architectural coherence exhibit emergence, continuity, organicism and functionality.

To highlight the relevance between the proposed design of ramps for the Sagrada Familia and the Gaudi learned from nature geometries, it is to specify and analyze the used geometrical forms in the Facade of Glory according to the model of Gaudi that were regenerated and presented in the current work.

6.1. Catenary arches, hyperbolic paraboloids

As cited by Po-Hung and Chin-Wei (2015), catenaries have a long history as optimum bearing structural elements. This could be traced back to Galileo, who claimed in his *Two New Sciences* (1638) that the curve of a chain hanging under gravity would be a parabola. In 1671, Robert Hooke claimed that he found the ideal shape for an arch and how much thrust does it impose on its buttresses. As he suggested that hanging a flexible line, and inverting it will generate the standing rigid arch. Few years later, Gregory (1697) also endorsed that the ideal arch is an inverted catenary. The Catenary Curve equation was obtained in 1691 by Huygens and Bernoulli. The shape of a catenary is defined by the hyperbolic cosine which is constituted by the natural exponential functions. (Po-Hung and Chin-Wei, 2015).

The reason that catenary is the ideal shape for an arch is that normally in an arch, the line of thrust is the line of compressive stress. It is ideal that the line of thrust is close to the center; otherwise, a tensile stress will occur on the opposite side of the eccentricity of the line of thrust. It happens that the line of thrust of a catenary arch is centered in the arch. Therefore, the arch only bears pure compression and no significant torsional moments occur inside the material. Besides, no shear forces are present at the contact, so a buttress is not required (Po-Hung and Chin-Wei, 2015; Conversano, et al., 2011).

Gaudí revealed his interest in nature's mathematical relations by employing these catenary curves as the form finding method and the structural optimization of his designs: in this case also of his design for Sagrada Familia. Gaudí studied and developed a new method of structural calculation based on models involving ropes and small sacks of lead shot or sand. The plan of his designs was traced on wood and placed on a ceiling, with ropes hanging from the points where columns had to be placed. Sacks were hung from each arch formed by the ropes. These were in fact catenary arches. He would take photographs of the resulting plastic model, shot from various angles and then turned them upside-down, so that the lines of tension formed by the ropes and weights would now indicate the pressure lines of the structure envisaged (Estévez, 2002). In this way Gaudí obtained many "natural" forms in his work (see Figures 31-33).

6.2. Hyperboloids

In geometry, a hyperboloid is a surface that is generated by rotating a hyperbola around one of its principal axes, or a surface that may be obtained from a paraboloid of revolution by deforming it by means of directional scaling (Bektaş, 2017). It also could be defined as a geometric surface consisting of one sheet, or of two sheets separated by a finite distance who sections parallel to the three coordinate planes are hyperbolas or ellipses. The hyperboloid of one sheet is almost the most complicated of all the quadric surfaces. (Bektaş, 2017).

Hyperboloids can be found in Sagrada Familia. Gaudí was the first architect to make a conscious use of such kind of quadrics. Realized again as ruled surfaces, they were used

to design and construct some openings between the columns and the vault, with the purpose of giving more light to the interior (Estévez, 2002). This was to capture a lot of light and diffuse it in the interior both because of its negative curvature in one direction at the saddle points and because of them being formed by two families of straight lines revolving in two different senses around the circular section of the surface (Lorenzi and Francaviglia, 2010).

When Gaudí discovered that all this ruffled ruled geometry is what precisely shapes the forms of nature, it leads him to be the pioneer who will apply it to architecture. And it is therefore the one that appears going through all its design for the Sagrada Família. It will be convenient, then, that all of this also be applied to the design of this specific bridge and ramps, proposed in these pages, and facilitated by the application of advanced digital technology that is characteristic of our 21st century.

7. Digital design proposal study for the bridge (Figures 38)

7.1. Form generation (algorithmic design)

The model is built using Rhinoceros 3D software + Grasshopper 3D, Biods plugin. The design is based on 7 main curves, to obey the symbolic meaning of the number 7 in the Apocalypses as mentioned previously. A biased random walk equation was designed to mimic random walking agents (pedestrians) biased motion towards and around the seven main curves (paths) (Abdallah, et al., 2020). This biased random walk simulation resulted in certain points of attraction that resembles the 7 points of repentance. These points of attraction have a cloudy indefinite appearance due to the simulated biased random walk of visitors towards these points on the 7 main curves.

- Biased random walk model parameters:

The “agents” parameter standing for visitors’ average intensity at each point on a divided curve. (Each curve of the 7 curves is divided to 33 points resembling the age of Jesus Christ). The agents’ movement is estimated along each point on each curve of the 7 curves x 33 points in total, thus the agents count was assigned to 10, which would be the maximum capacity of visitors’ density at one point of the curve.

Point attraction domain: each point on the curve is candidate to be an attraction (or point of gathering of Sagrada Família visitors); the domain was assigned to 360, as it is the maximum spatial domain around a point in all vectors.

Attraction intensity is the parameter controlling the biased behavior of the agents towards a certain point, this was assigned to the approximate value of $1/7 = 0.14 \approx 0.15$, as it is the divided share of the attraction of the main 7 curves.

- The biased random walk forces:

To mimic the biased random walk pattern of movement of the visitors of Sagrada Familia from the south facade, two different forces are affecting this pattern of motion; these two forces are contradictory in direction, but not equal in value. These forces are Random Walk (repulsion), and adherence (attraction).

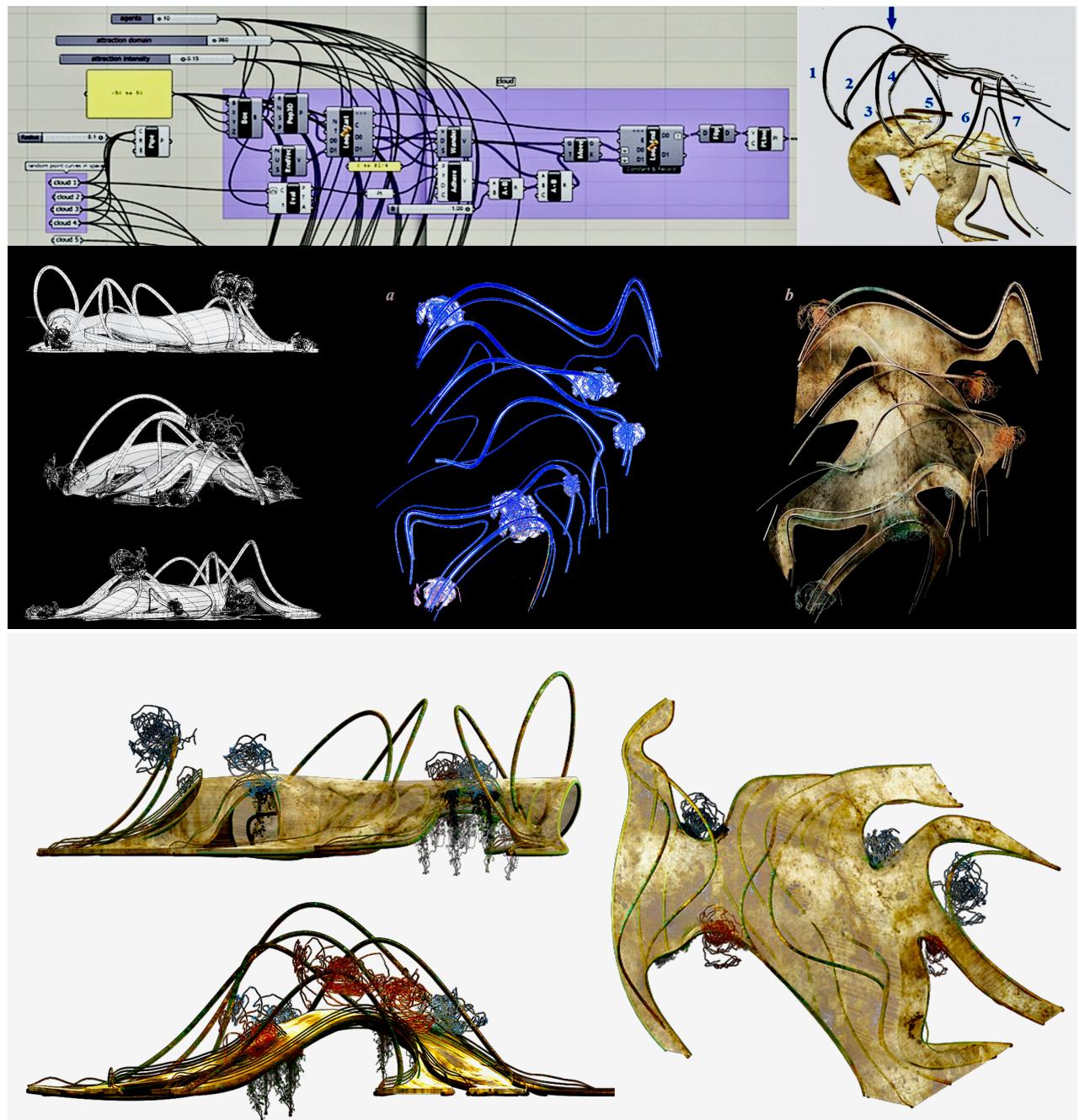


Figure 38. Top, the biased random walk model calculating the visitors' pattern along the 7 paths of the 7 main curves of the bridge. Bottom, the different elevations and plans of previous versions of the ramps.

7.2. Form geometrical analysis

- Following ruled surfaces.
- Following continuity and morphogenesis in hyperbolic paraboloids, (growth and transition).

7.3. Design functionality (seating, and ramps)

The model has been digitally optimized to fit the functional requirements and the urban context. To fit functional requirements of absorbing Sagrada Familia visitors' density, the model was adjusted to provide a bridge that connects Mallorca street with visitors coming from the southern, east and west southern parts heading towards the facade of Glory of the Sagrada Familia. This bridge included a smooth fluid path that provides a smooth transition in altitude, ample width in ramps and pedestrian zones, seating benches, and fences. This functional digital optimization process implied the build of doubly ruled surfaces (hyperbolic paraboloids) that provided double functioning as the main surface of the bridge and the smooth ramps as well.

8. Conclusions

Understanding that the results and discussion place this work within the context of computational design, a possible good way to write about the conclusions of these pages could be to introduce here the words that the author had with the current Director-Architect of the Sagrada Familia, Jordi Faulí, presenting him the architectural design for this bridge.

The day chosen to present this project to him was November 24 (2019). It was the day of the celebration of the Solemnity of Christ the King, as the ideal day for such a presentation, symbolically linking everything in a special way.

(Notice that the Solemnity of Christ the King, also called Solemnity of Lord Jesus Christ, King of the Universe, is in the Roman Catholic Church on the last Sunday of the Liturgical Calendar. This is symbolized as the feast of the end of times, as inscribed in the book of the Apocalypse (VV.AA., 2002), that is the last book of the Christian Bible. Thus, everything is endowed with a deep symbolic sense in saying and doing.)

The Director-Architect of the Sagrada Familia thanked the proposal, and kindly acknowledged the much work behind it. At the same time, he commented that precisely at those moments he was working on the columns of the narthex of the main facade of the Sagrada Familia and reading the Apocalypse: one of those coincidences that polished our action in a special and symbolic way. Then again, he commented that he had not realized that, according to the author of this project, the planned date for finishing the temple (the year 2026, the centenary of Gaudí's death) coincided precisely with the 144 years of the laying of the first stone of the Sagrada Familia temple (in year 1882): $144 = 12 \times 12$, favorite numbers of the book of the Apocalypse.

His words were sufficient reward for the effort made: he commented that with this proposal it can be given dynamism to the access of the facade, with an adapted access, with universal accessibility. And proving that it is an architectural theme that can give rise to many creative and diverse proposals. He is pleased to see the proposal presented here as a creative, organic, beautiful, youthful, and certainly risky proposal. All epithets that fill anyone with satisfaction.

In conclusion, it must be said that it would be very presumptuous for the authors to think that this work was taken into account for the final design of those responsible for the work of the Sagrada Familia. But it was far from being the objective of this work to create an executive project to be built immediately, thus interfering in a way that perhaps bothers current architects. Although it is clear that it opens a door and offers itself freely “to what could be”. At the very least it is simply about creating a stimulus, or a challenge. If only as a moral support to the extraordinary task that is being carried out in the construction of the Sagrada Familia. This is not without massive international admiration. But, also, with insidious local criticism, whether it comes from pure envy or recalcitrant ignorance.

“I love the way Sagrada Familia Bridge seems like a liquid flowing from the Gaudí’s morphology”, said to the author Dennis Dollens, seeing the first drafts of this project, without still knowing that the main inspiration was the sentence of the book of Apocalypse “the river of life-giving water, sparkling like crystal, flowing from the throne of God and of the Lamb” (Ap. 22, 1) [1].

In the end, one has enough reward seeing that the work that one projects is in line with the words spoken by Benedict XVI on the occasion of the consecration of the Basilica of the Sagrada Familia, in Barcelona, on Sunday, November 7, 2010: “The beauty of things leads us to Beauty. This was done by Antoni Gaudí not with words but with stones, lines, plans and peaks. And is that beauty is the great need of man; it is the root from which sprouts the trunk of our peace and the fruits of our hope. The beautiful work is pure gratuitousness, invites freedom and uproot from selfishness”. This is really the grain of sand that architects and designers must bring to this the most gigantic anthill in the entire known universe.

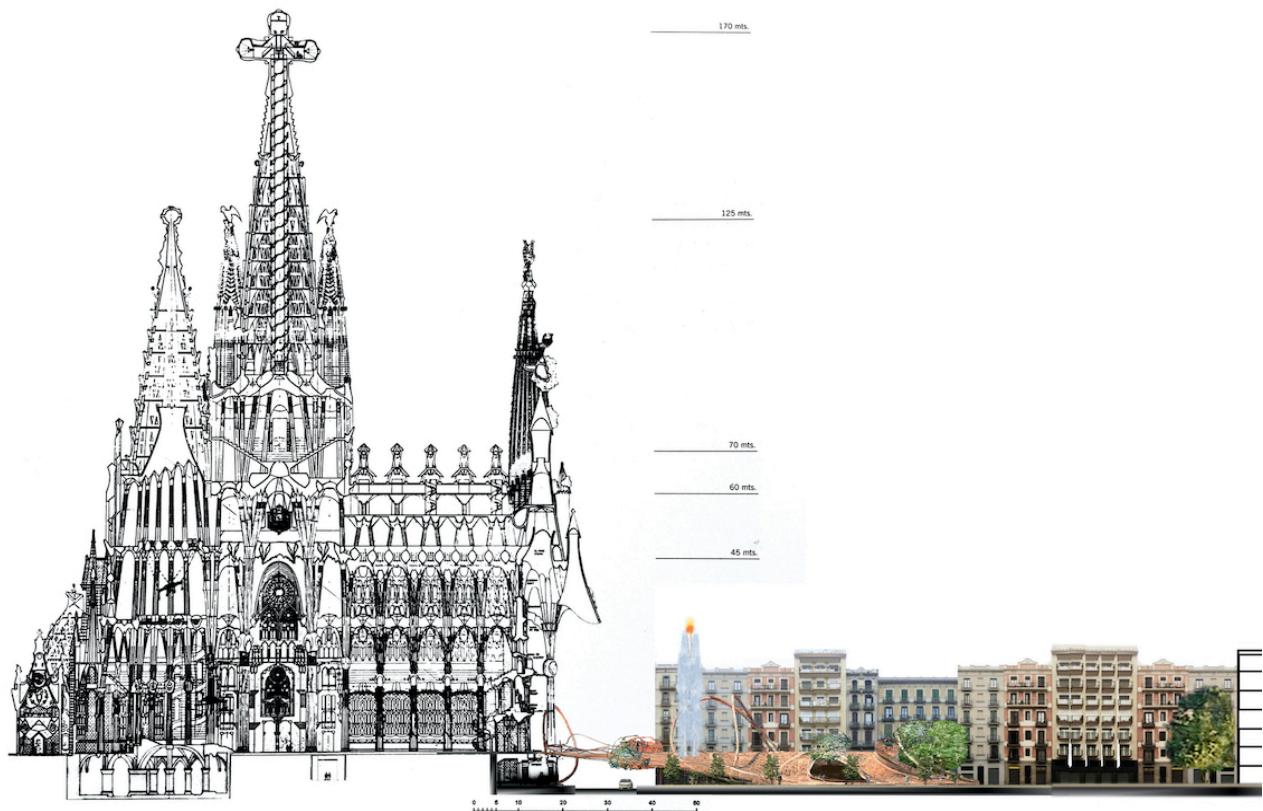


Figure 39-40. View from southwest of the bridge and ramps to the facade of Glory, introducing functional accessibility, symbolic meanings and employing ruled surfaces. (Section drawing of the Sagrada Família: Faulí, 2006, p. 21).



Footnote

[1] Sentence of the book of Revelation, also called Apocalypse: attributed to Sankt John, apostle and evangelist, in VV.AA., *The New American Bible*, United States Conference of Catholic Bishops, Washington, 2002. Especially suitable, furthermore, the quote of *Apocalypse*, 22, 1, heads the first chapter of the *Final Document of the Amazon Synod*, Rome, October 26, 2019. Yes, especially suitable, for the concern that the authors of this article have about planetary sustainability, which is the underlying reason for all the research that they carry out from their Institute for Biodigital Architecture & Genetics.

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