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Architectural Concepts of Religious Buildings: Comparing Le Corbusier's Notre Dame and Meier's Jubilee Church

Duha J. Al-Olaimat*, Isra M. Al-Shdaifat, Sukinah H. Al-Khazaleh, Tala S. Hussainat

Faculty of Engineering- Al al-Bayt University, Mafraq 25110, Jordan

Corresponding Author Email: arch-duha@aabu.edu.jo

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ABSTRACT

Using architectural technology in religious building design can enhance the spiritual senses. However, it can distract us from prayer. This study aims to explain the role of technological tools in translating architectural concepts related to religious buildings, compared with the use of conventional techniques. Meanwhile, this study identifies certain principles that can help architects design religious buildings. The methodology involves a comparison between —Notre Dame church in France, designed by Le Corbusier in 1950—and Jubilee Church in Rome, designed by Richard Meier and built in 2003. The two churches are related to each other. Meier architecture has been recognized as a late modernism owing to the influence of Le Corbusier's visual approach. However, there are certain differences between them. The results demonstrate the role of technology in contributing towards making it easy to reflect spiritual concept. Furthermore, the study reveals how an architect can express spiritual concepts, even when there is no technological assistance, by utilising lighting, colour, space, form, and site forces. This study emphasizes that the prudent utilization of technological techniques can make it easier to produce a comfortable religious space. By contrast, the use of only traditional materials requires huge efforts and a long time.

1. INTRODUCTION

The two churches—Notre Dame church and Jubilee Church—are related to each other. Meier architecture has been recognised as a late modernism owing to the influence of Le Corbusier's visual approach [1]. However, there are certain differences between them: Notre Dame in France, designed in 1950 and finished in 1954. It is a pilgrimage site and probably the most significant building designed by Le Corbusier. In addition to the chapel, the complex includes a pilgrim's house, a modest priest's residence, and a war memorial [2]. The activities that the church includes within its area are simply limited to a quadrangular nave, two side entrances, a central altar and three rooms below the towers. In addition, the construction of the church is simple and consists of rough concrete walls and a beton roof. Nevertheless, the site of the church atop a hill gives it a complex and symbolic design [3]. Meanwhile, Jubilee Church was built in 2003 by Meier. It is one of the 50 churches designed in Rome, Italy, to celebrate the Roman Catholic Jubilee (2000). In response to Vatican's request, a new design language for worship buildings was proposed: more welcoming and more open to the city and having cultural, recreational and social activities, besides religious events. In contrast to the Modernist architecture, many innovative materials used in architecture today make it easy to apply architectural concepts. They are manufactured in large units in massive quantities and assembled on-site [4]. Additionally, the research results show that despite using traditional materials the practices of Le Corbusier's architectural studio are rationally characterized as being both mechanically careful and systemically practical. The resultant design is described as being dependent on a careful examination of the site area and built of shapes with an analytical foundation that serves as supple, nuanced, precise, and practical acoustics [5]. Meanwhile, the concept of Meier's Jubilee Church is based on geometrical development by experimenting with structure, position, and aspects of formal perfection. Therefore, Meier presents Le Corbusier's ideas of a free facade, an open layout, and fully glass windows in his Church in a novel way [6]. The structure of the paper follows this layout "2. Literature Review 3. Methodology, 4. Result and Discussion, 5. Conclusion".

2. LITERATURE REVIEW

"The growth of technology is a prerequisite for nanotechnology innovations in the construction industry. Halicioglu [7] has explained that buildings might undergo significant transformation thanks to nanotechnology. Materials are the construction industry's main source of revenue, therefore to significantly benefit from nanomaterials" [7]. Meanwhile, Parthenopoulou and Malindretos [8] has confirmed that technology contributed to the architectural field through computer-aided design and the production of 3D models (CAD, modeling, 3D rendering, and 3D printing [8]. Moreover, by combining nanotechnology with genetic architecture, the next stage is made possible. Accordingly, the cross-disciplinary relationship between the sciences and architecture is strengthened through the usage of computer design approaches. Additionally, new building techniques and methods have also sped up and improved the efficiency of

project execution. Digital technology made it easy to construct new organic forms inspired by nature [8]. Similarly, Johansen [9] has illustrated that as a result of the application of nanotechnology in architecture, Nano architecture has been developed. In addition to using nanoparticles and manipulating them. Nano architecture re-examines forms and design processes to produce ultra-high-performance structures.

Regarding what architects can produce without new techniques, Monteaguda [10] has mentioned that, in the design of Notre Dame church, as an example of traditional architecture without using new technology, Le Corbusier has created a significant design that was not easy without the assistance of technology. He has chosen suitable loci for the building, including the studying and analysing of the hill's long history as a site of prayer and the visible horizon from all four sides. Le Corbusier has also perceived a holy connection between the hill and its environment, namely the summit's dominance of the surroundings and the distant Jura Mountains [10]. However, Din [11] has clarified that Richard Meier is regarded as a late modernist because of his expansion of Le Corbusier's aesthetic language. His Jubilee Church in Rome, Italy (2003), in particular, features abstraction, projection, weight, and layering elements in its design [11]. In addition, Furuto [12] has stated that Meier was greatly influenced by Le Corbusier, mentioning Meier "refines his concepts of geometrical development by accurately manipulating with structure and space. On the other hand, Parthenopoulou and Malindretos have assured that Meier has used several Nano-techniques which helps to create the unique design of Jubilee Church including self-cleaning windows, 'smog-eating' concrete, and titanium dioxide nanoparticles (TiO_2). These nanomaterials are the main factors of this successful design [8].

This research explains the differences and similarities between the use of both traditional materials and processes, and technological materials and techniques, in translating architectural spiritual themes associated with religious buildings. By comparing the concepts, forms, materials, constructions, light, colour, space, place, and the contexts of the two buildings: Meier's Jubilee Church and Le Corbusier's Notre Dame.

3. METHODOLOGY

The methodology involves a comparison between the two churches: Notre Dame church by Le Corbusier and Meier's Jubilee Church, addressing the concepts, forms, materials and structures, light, colour, space and the contexts of the two building designs. These factors are chosen to be compared due to that both architects depend on these elements to clarify their concepts [2, 6].

3.1 Notre Dame Church by Le Corbusier

3.1.1 Concept

The concept of Notre Dame church highlights the ethereal and spiritual essence of the building. Using traditional materials and methods include colored glasses, concrete, and geometrical shapes. The roof is perhaps the only indication of mechanical advancement, where the curves simulate an airplane wing. Le Corbusier employed aerodynamics in the construction, and all massive and heavyweight attributes appeared weightless [10]. Le Corbusier generated an organic design of a white-walled space, presenting an ethereal appearance of his architecture. The features of the church include the entrance of light, small coloured glass apertures, directly changing axis within the internal area, life sense, symbolism and the organic and functionalism architecture, the elevated walls, which serve as acoustic amplifiers and sound distributors to the entire space [13]. See Figures 1 (a) and (b).

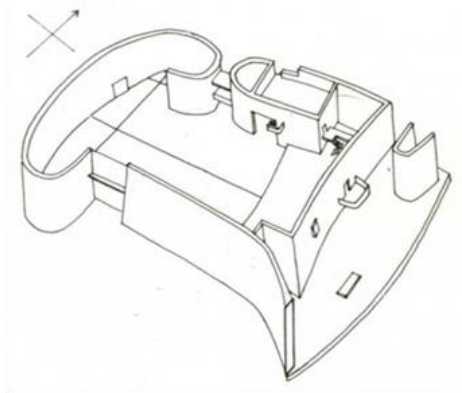
(a)

(b)

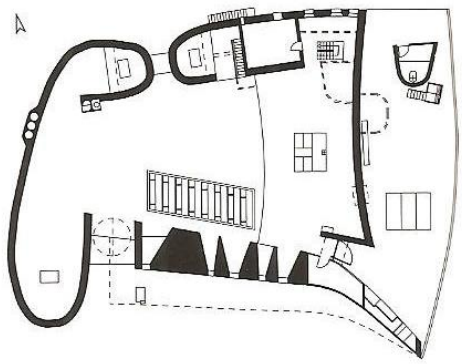
Figure 1. Notre Dame church's roof concept [14]

3.1.2 Form

Architecturally, the Ronchamp chapel is a series of convex and concave concrete structures shielded by a shell. The east wall's altar has small openings, and the roof floats above the walls to produce a slice of light around the chapel. The embrasures on the south wall are intricately carved, and when viewed from the dim nave, the confined glow of each chapel captivates human attention [5]. See Figures 2 (a) and (b).



(a)



(b)

Figure 2. Ronchamp chapel's form [14]

3.1.3 Materials and structure

The roof is made from typical materials used in that period such as a concrete shell that raised above the salvaged stone walls. Seven molded concrete beams, 17 cm thick, prop the rooftop [14]. Roof framing includes: (a) a 6 cm concrete shell, (b) lower girders, 10 x 30 cm, cast in place, (c) 17 cm thick beams, (d) 0.5 x 0.27 m precast upper top roof girders, (e) ceiling 4 cm thick, and (f) scupper for water drainage [14]. Furthermore, the roof is supported by (g) 15 cm concrete pillars and 0.40 × 0.15 m girders, (h) reinforced concrete column distributed along the wall, (i) a bearing-beam, (g) stonework walls, and (k) the only uncovered column [15]. See Figure 3.

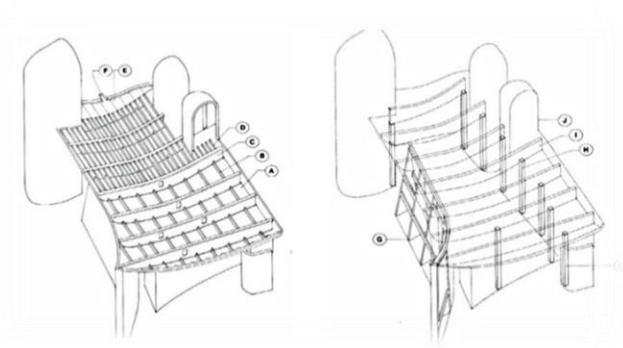
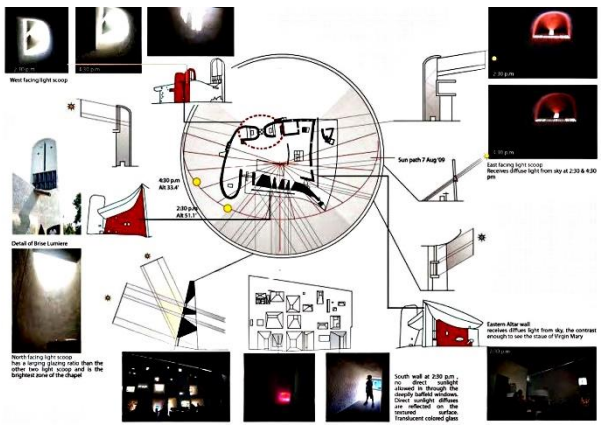


Figure 3. Notre Dame du Haut's structure [5]

3.1.4 Light, colour and space

The Ronchamp chapel is a timeless piece of architecture; it serves as an environment for capturing the sunlight at the whole times of the day [8]. The church's interior space makes expressive use of natural light more than artificial lighting, resulting in a dynamic form that commands the top of Ronchamp hill [8]. See Figures 4 (a), (b) and (c).



(a)

(b)

(c)

Figure 4. Solar penetration, daylight distribution and surface reflection [2]

The luminous milieu in the church generates an exclusive balance of light and adapts brightness in the visual field. Light has been used to highlight the forms and colour [16]. Light passes the space through light shafts in the southwest side, orthogonal apertures in the northeast, light shafts in the northern elevation (which mark the chapel's entrance) and the south elevation, which is punctuated with deeply splayed openings of varying sizes and, some of which fitted with coloured glass [5].

The cavities within the thick wall were spread and shaped to trap the passing light, causing each chamber glow interiorly. Illumination is filtered through perforations and baffles before it is diffused by a series of reflections towards the chapel floor, creating a vertical gradation of light. The lighting strategy depends on the attraction of light and the creation of a contemplative luminous environment [5].

The south wall of the chapel with deeply engraved openings plays an important role; the brightness of sunlight is reduced to a more perceptible level by a relatively large depth with a highly rough surface [14]. In contrast, the space is not disturbingly bright because of the architectural solution of using the light shaft [16]. Accordingly, various light sources eliminate the contrast of brightness [2]. In addition, the axial nave has supply the light unevenly with bright and dark spaces. In ascending order, the brightest spaces are the light shaft that faces east, the orthogonal openings in the northeast elevation, the entries in the north and southeast, the west lightscape, the spaces along the south elevation, and the zones below the north lightscape. The tower has the same lighting system as the other two lightscapes. Moreover, the interior sides of the tower are painted red with a reflection that is approximately one-fourth that of the other faces. The main space of the church is characterised by an even distribution of texture and colour for the materials. Therefore, the brightness is dispersed quite evenly, except at the east end of the church. This creates a really lively effect as the visitor approaches the altar [6].

3.1.5 Context

Le Corbusier was out of his philosophy of standardisation and aesthetic mechanism, resulting in a specific relationship with context. He intentionally chose a location that supplied the loci needed for the response, the visibility of horizon from all four elevations of the hill and its history as a place of worship. Furthermore, he experienced a sacred connection between the hill and the surrounding environment, the context of the Jura Mountains and the hill itself capture the landscape. As a result of the site's characteristics, the ensemble shares numerous resemblances to the Acropolis. Observing the structure till it reaches almost totally the hilltop, from bottom

to the top of the hill, where the architectural and natural activities along the way [10]. See Figure 5.

Figure 5. Left, plan of Notre Dame church, Right, the relationship with the context, 1961 [16]

3.2 Richard Meier's Jubilee Church

3.2.1 Concept

In 2003, Jubilee Church was established in Rome, Italy, as a Catholic Church and communal centre. According to Meier, the design concept is to highlight the contrast between the spherical and cubic shapes, the pure division, and connection points to create the main area of the church [1]'. See Figure 6.

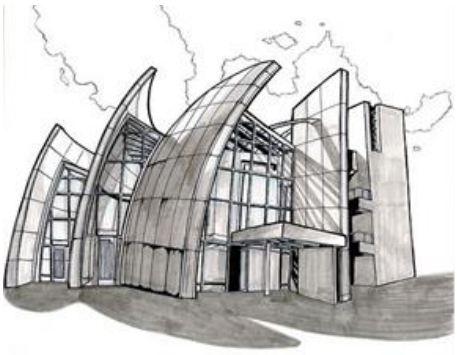


Figure 6. Jubilee Church sketch, Rome, Italy, 2003 [6]

The three structural, curved shell layers, represented the concept of the Holy Trinity—God in three characters as the Holy Spirit, Father, and Son. Their design concept is abstracted from a spherical shape being split in half [1]. In addition, the crucifix, which is traditionally centred in the church sanctuary, is designed as a symbolic illusion of a cross by creating a suspended vertical window that projects its light on the central wall [1].

3.2.2 Form

Meier produced this symbolic computer-aided form that illustrates the processes of abstraction, weighting, projection, and layering as an extension of Le Corbusier's concepts of a free elevation, an open area, and ample natural lighting [6].

The interior architectural design was an abstraction of the circle, square and grid. The pews were ordered in a traditional arrangement, while the occupant developed a movement sense at the connection point between the walls of curved shell layers and the inclined glass ceiling slabs [17]. Accordingly, the exterior of the church was occupied by the projection of geometric shapes. The three layers of curving shells were split and projected into the sky. A single horizontal plane wall is located on the opposite side of the three walls. All of these structural characteristics are not limited to physical churches [2].

Moreover, the form of the church depends on the layering, which appears on the elevations, with the three curved layers. These shell walls give the sense that their surfaces can be flattened to be compatible with each other [6]. The layering of the elevations was also reflected in the internal space. Furthermore, the exterior of the sanctuary is a glass elevation from the ground to the ceiling, which is placed one upon another. Smaller references to layering can also be spotted in the windows behind the crucifix [17]. See Figure 7.

Figure 7. Jubilee Church form, layering, projection and abstraction [18]

3.2.3 Materials and structure

The construction industry has the potential to be revolutionized by nanotechnology. Dozens of nanomaterials are available in the architectural marketplace. In Meier's Jubilee Church, contrary to Le Corbusier's Notre Dame, self-cleaning windows and 'smog-eating' concrete were used, applying titanium dioxide nanoparticles (TiO2) to significantly improve insulation, eliminate bacteria, preclude mildew, and decrease maintenance and environmental impact [18]. The concrete pieces are produced by blending high-performance concrete with white Carrara marble, metakaolin and white Portland-type cement [16].

This church is made up of 256 precast concrete parts that have been assembled into curved white layers of 25m [16]. A three-dimensional extension of a gridded glazed elevations forms the structure. Despite the fact that the organ pulpit incorporates aspects of its surroundings, it stands out among the timber panels, stone, and glass [1]. The pipe organs were raised above the windows, panels and adjacent walls. The single piloti on the right provides the sense of lightness, if it is the only structural part maintaining this prominent element [1].

(a) [17]

(b) [18]

Figure 8. Jubilee Church structure; the single piloti on the right provides the sense of lightness

The three concrete walls are the heaviest parts of the structure. This suggests a heavy structure as there are no voids or openings; however, this structure is broken up by the curved glass that encloses between the walls, leaving a sense of airiness in the overall structure [1]. See Figures 8 (a) and (b).

3.2.4 Light, colour and space

The three most important concepts of Meier's architecture are light, colour and space. As he was affected by Le Corbusier's architecture, his design displays how basic geometry, Spaces with layered definitions and light and shade effects can produce vivid and comprehensible zones. The key part that Meier focuses on as a designer is what he called placeness: What is it that turns a space into a place [7]?

(a) [18]

(b) [6]

Figure 9. Jubilee Church structure, light, colour and place

Simultaneously, in the pipe organ pulpit, natural light flows through the gaps between the solid structural elements, similar to the main axis in Notre Dame church. Light weaves through geometrical elements, highlighting the area with illumination and giving the illusion that it expands with more lighting [17]. In addition, zenithal sidelights illuminate glazed skylights are created between the shells, and the nave is enlivened by a constantly shifting style of lighting and shading. The light is dispersed throughout the church's inner space and varies depending on the time of day, weather, and season, giving a characteristic feature to the interior elevations [8].

According to Meier, "White is the most magnificent colour since it contains all of the rainbow's colours. The whiteness of this colour is almost always modified by light and the sky, the moon, the sun, and the clouds are all in flux." [6]. See Figures 9 (a) and (b).

3.2.5 Context

Meier has the same concern of context as Le Corbusier, he confirmed that a building and its environment can be connected using ten determinants, one or more of which must be serve to turn a space to a place: determinants of the Mode of Being; those that emphasize the building's presence as a separate entity; components that underline the building's presence in its surroundings; those which accentuate imagination and drama; ecstatic exuberance-related attributes; characteristics that preserve a spirit of excitement and mystery; qualities that make us feel like we're in touch with reality; elements that connect the building to its history; characteristics that encourage spontaneous interactions; and characteristics that affirm a person's sense of self-identity [7]. Accordingly, the materials used in the portico, pavement, wall, and ceremonial decors are all inspired by the body of Christ's church, and similarly, it references the surrounding residential area's fabric [8].

4. RESULT AND DISCUSSION

Table 1 shows the results of the comparison between the two churches in terms of concept, form, materials and structure, light and colour, place and context.

Essentially, the design concept makes a significant difference between the two churches. Le Corbusier depended on the analogical concept of designing the form of the building, manipulating light and colours to create a venerable space in the church, and employed organic architecture to relate the church with its surroundings. Moreover, Le Corbusier controls acoustic frequencies using high walls as amplifiers, acting as acoustic amplifiers. Contrarily, Mier used metaphor in his concept as he abstracted the three concrete walls from the idea of the Holy Trinity—Father, Son and Holy Spirit—creating a symbolic illusion of the crucifix from the light through the window. Furthermore, Mier exploited the connection point between the two contrasting shapes—sphere and cube—to create the main space in the church.

With regard to form, Le Corbusier used organic form in his church, creating convex and concave lines, which shaped the entire design of the building. Meanwhile, the composition of Jubilee Church contains geometric shapes joined with each other using methods of abstraction, projection, weighing and layering. Furthermore, the structural features play an essential role in the Jubilee Church design, while the structure in Notre Dame du Haut is designed to be concealed.

Additionally, the materials used significantly differ between the two churches, a quantum leap from tradition to high technology. Notre Dame du Haut was built from existing

materials, such as concrete shells, stone and coloured glass, which were deliberated to be simple materials that do not draw attention, to help the worshipers to pray with such passion. Meanwhile, "Jubilee Church was constructed using high-technological materials, including nanomaterials, self-cleaning windows and 'smog-eating' concrete, alongside the regular materials of glass and concrete, which also serve the same spiritual purpose of ensuring that the worshipers are not distracted, where these materials are white and clean." [18].

Table 1. The results of the comparison between the two churches

	Notre Dame du Haut	Jubilee Church
Concept	Form and function, space and circulation relating to surroundings, organic lines with symbolism and analogy concept, and acoustic control.	The overlapping between the cubic and the spherical shapes, metaphor, symbolic illusion by light.
Form	Organic form, convex and concave	Symbolic and geometric form depending on abstraction, projection, weighing and layering and structural features highlighted by a grid.
Materials and Structure	A concrete shell, stone walls, windows of variable sizes, and coloured glass.	Nanomaterials, self-cleaning windows, 'smog-eating' concrete, glass and concrete walls.
Light, Color, and Place	A contemplative luminous environment, the light is used to highlight space and color by applying: a vertical gradation of light, a deeply recessed opening in the south wall, a very uneven distribution of light in the central nave, and the red-painted internal walls with the reflective surfaces.	Exploiting of effects of light and shade by using white walls, glazed skylights, the projecting natural light through the gap between the massive structural parts in the pipe organ pulpit, and changing style of lighting and shading in the nave where the light is diffused over the internal space of the church and changes based on the day time, the weather and the season.
Context	Respect the context by the visibility of the horizon at all elevations of the hill and choosing the hill that is historically a place of worship, relationship of the hill with its surroundings, similarities with the Acropolis, ability to see the church from the bottom of the hill until it reaches almost entirely the hilltop.	Respect the context by connecting us to reality and the past, and affirming people's identity and materials related to the fabric of the surrounding neighbourhoods.

The light, colour and place of the two churches also play a significant role in supporting the spiritual concepts of the two buildings, although both have a different system of lighting and colour. Le Corbusier created an architectural light-capturing piece. He employed the expressive use of lighting to create a contemplative luminous environment. Light is used to highlight space and colour by applying the following: a vertical gradation of light, a deeply recessed opening in the south wall, a very uneven distribution of light in the central nave and red-painted internal walls with reflective surfaces. Conversely, Meier used light to create vivid and comprehensible spaces employing white walls, natural light projection through geometric shapes, giving the impression of expansion, glazed skylights between the shells, a continuously changing style of lighting and shading in the nave, and varying light diffusion over the external space according to the day-time, weather and season.

As a matter of fact, the participation of the components of the permanent environment, including climate and topography, contributes to highlighting the architectural identity of the urban city [19]. Subsequently, Le Corbusier and Meier respect the context of their architectural designs. In Notre Dame church, the reverence of the surroundings is clear through the capability of seeing the horizon at all elevations of the hill, choosing the hill that is historically a place of worship, the relationship of the hill with adjacent areas, similarities with the Acropolis, and visibility of the church from the bottom of the hill until one almost completely reaches the top of the hill. Likewise, in Jubilee Church, the veneration of the context is manifested by connecting users to reality and the past and confirming human identity by employing materials relating to the cultural and architectural theme of the neighbouring residential area. Accordingly, sustainable context may be understood in two different ways: as continuity and as maintaining natural equilibrium [20].

Further, the procedures of Le Corbusier's architectural atelier have been described pragmatically, as both systematically practical and mechanically prudent. The resulting design, which is unconventional, has been characterised as a debtor to prudent analysis of the site area, and constructed of forms with analytical basis 'as supple, subtle, accurate and practical acoustics' [5]. Meanwhile, extremely influenced by Le Corbusier, Meier 'refined his ideas of geometrical progression by experimenting with structure, place and elements of formal perfection'. Therefore, in his Church, Meier employs the concepts of a free facade, open plan and fully glazed windows in a new light [6].

Finally, Architecture has been described as a type of artificial life. It is subject to morphogenesis, genetic coding, replication and selection, just like the natural environment. Consequently, contemporary architecture aims to produce symbiotic behaviours and metabolic balance within the built environment, which is characteristic of the natural world. Furthermore, Nanotechnology is a new 'language' for expressing architectural concepts. Accordingly, new potentials have evolved, allowing us to produce biomimicking and responsive architecture. A house, according to Le Corbusier, is a machine to live in; similarly, architects now can defined a house as a machine that is alive or even an organism [8].

5. CONCLUSION

From my point of view, the use of nanomaterials in Jubilee Church has helped to easily highlight liturgical and spiritual features in the church, and it has contributed to reflecting the architect's ideas, using the self-cleaning windows and 'smog-eating' concrete, which helps to maintain the building bright white and clean. The use of nanomaterials creates an ideal worship environment. Moreover, nanomaterials reduce the

maintenance of buildings and environmental harm. With Notre Dame du Haut, Le Corbusier achieved great success in creating a perfect spiritual space, using simple material that was not easy. The use of only conventional materials has required an intensive study of solar penetration, daylight distribution and surface reflection, and this has taken a long time to achieve compared to what can be achieved readily today and in a short time.

To conclude, Le Corbusier and Meier, both respected the context; Le Corbusier focused on the site forces to reinforce his ideas and to highlight the church's dominance, while Meier depended on the construction materials to reinforce the church's power. In Notre Dame church, the architect has taken advantage of the site that supported the loci required for the response, exploiting the advantage that the horizon is visible on all four views of the hill, and its history as an area of worship. Meanwhile, Meier focused on the materials used in the portico, the pavement, wall and ceremonial decors, which are all inspired by the body of Christ's church, and the fabric of the surrounding neighbourhoods simultaneously. Finally, I believe that the prudent use of advanced technology can make it easier to create an ideal spiritual space, using liturgical features and architect ideas, while respecting the context.

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