Design of Machines and Structures, Vol. 13, No. 2 (2023), pp. 60–70.
https://doi.org/10.32972/dms.2023.018

DESIGN METHODOLOGY IN THE FRENCH ARCHITECTURE

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Abstract: In this paper the authors are focusing on Jean Nouvel, a significant member of the French architect society. The aim of this research was to analyse the most remarkable elements of the architect's life's work: what kind of notable results he created, what ideas did he apply, etc. The authors tried to make a comparison between the design ways of architecture and mechanical engineering.

Keywords: *design methodology, design process, mechanical engineering, architecture*

1. INTRODUCTION

Design methodology is a structured approach to solving problems that are related to design in any discipline or field. It involves a range of methods, techniques, and tools that are customized to suit the specific needs of a particular design project.

The goal of design methodology is to ensure that the design process is integrated with the broader context of the problem, taking into consideration the needs of users, the feasibility of manufacturing and production, cost, and the constraints of resources. It focuses on a systematic, iterative approach that involves multiple stages, such as research, ideation, prototyping, testing, evaluation, and refinement. Design methodology is relevant in all fields, such as product design, architecture, graphic design, fashion design, engineering, and web design. It is an essential tool for designers to develop innovative and effective solutions that can meet the needs of the users and stakeholders. (Mahmoodi, 2001)

Design methodology is not a new concept, and it has been used by designers for centuries, even before we had a name for it. In fact, throughout history, designers have used a structured approach to solve design problems. For example, architects in ancient Rome used a method for designing buildings that included studying the site, sketching initial designs, testing the design, and ultimately building the structure.

In this paper we will be focusing on France where designers have a rich history of using design methodology to create innovative and effective solutions. So one of the notable French designers of the 21st century Jean Nouvel will be introduced. Nouvel's approach involves extensive research, investigation, and analysis of the site and

context of a project. He then creates several design concepts, tests them, and refines them until he arrives at the best solution.

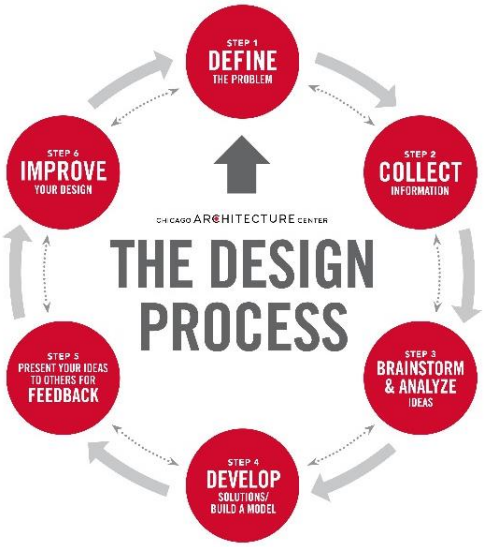


Figure 1. *Design process*
https://discoverdesign.org/handbook

2. JEAN NOUVEL

Jean Nouvel is a celebrated French architect renowned for his avant-garde and innovative architectural designs. Born in Fumel, France, in 1945, he has had a profound impact on the world of architecture with his distinctive and futuristic creations.

His work is characterized by a relentless pursuit of originality, incorporating elements such as light, transparency, and complex geometries. Nouvel's architectural designs have received widespread recognition and numerous awards, solidifying his reputation as a visionary in the field. Thanks to his work he won the Pritzker Architectural Prize in 2008 and has also a place in the pantheon of architectural superstars. His career spans several decades and has left an indelible mark on the global architectural landscape.

2.1. Playing with the light

Artists usually really like to play with the light. In many artistic masterpieces we can see, how the author applied the perfect light. Of course, when we admire these significant works of art amazed, we cannot even imagine how and how long did it take until the artist found the proper solution. Maybe we can have a slight idea of it when we start to study the light space modulator of László Moholy-Nagy. Watching the modulator during its operation it came clear that the changing of the shades is continuous, and every shade can be strange and individual even in an unexpected

moment. Nouvel does not make an exception to the rule: he played a lot with the light in his creations. In the next paragraph two significant buildings are introduced, on which a play of light and shadow with motifs from the Arab world appears. In case of the third example playing with the light is also in the focus, but from an other point of view. In this case, Nouvel uses an idea of the theory that ancient Egyptians would use some kind of mirrors for letting the sunlight into the pyramids. According to scientists these were just ideas on how the ancient people could illuminate the interior of the pyramids, as they could not have such a good quality of mirror that would made it possible to forward the sunlight.

2.1.1. The Louvre Abu Dhabi

Let us begin with one of Nouvel's most notorious works. Born out of an intergovernmental agreement signed between France and the United Arab Emirates on the 6th of March 2007, the Louvre Abu Dhabi is the first universal museum in the Arab world. It brings the Louvre name to Abu Dhabi and presents both ancient and contemporary works of historic, cultural, and sociological interest from around the world. The Louvre Abu Dhabi is one of his most internationally recognized and celebrated projects because of its complexity and its innovative design.

The particularity of this building is its vast, seemingly floating dome as we can see in *Figure 2*. This dome is an intricate lattice structure made of eight different layers of stainless steel and aluminium, with patterns inspired by traditional Arabic geometric designs. The design of the dome is a reference to the interplay of light and shadow in traditional Islamic architecture.



Figure 2. *The Louvre Abu Dhabi*
https://medias-distribution.lab.arte.tv/photos/0914434-cropped.jpg

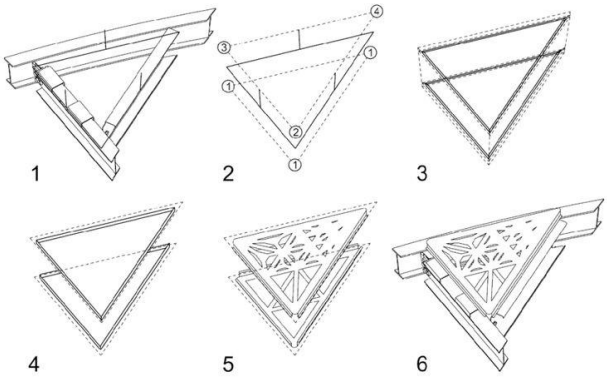


Figure 3. *Different layers of the dome* (Wortmann & Tuncer, 2017)
1 – centre lines and orientations for a single triangle with the substructure, 2 – the panels' bounding planes and density values, 3 – the panel's mounting strips, 4 – the panel's flanges, 5 – the completed panel, 6 – the panel on the substructure

The innovative design of the dome allows dappled sunlight to filter through the intricate pattern, creating a "rain of light" effect inside the museum. (Imbert et al., 2012) (Tourre & Miguet, 2009) This unique play of light and shadow throughout the day provides a constantly changing and dynamic experience for visitors. The interlocking geometric patterns in the dome create a mesmerizing effect, resembling rays of sunlight passing through palm leaves. It's as if you are walking under a forest canopy while exploring the museum's interior.

2.1.2. Institute of the Arab World

Another very well-known of Nouvel's work is in Paris and is called the Institute of the Arab World. Its construction lasts 3 years and the building opened in 1987 for a purpose of representations about Arab world, art, and culture.

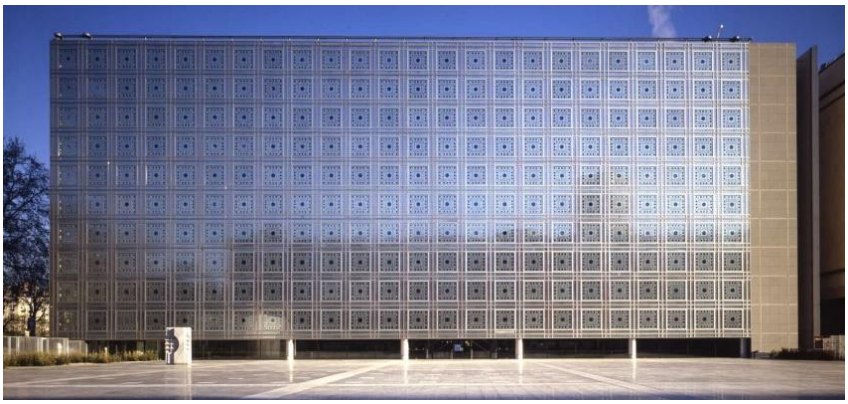


Figure 4. *Arab World Institute south facade*
https://architizer-prod.imgix.net/mediadata/projects/272010/c85761a2.jpg

The most distinctive feature of the Arab World Institute is its innovative mechanical facade. The building's southern facade is covered in a complex system of mechanical diaphragms called ***Moucharabieh***, which automatically adjust to control the amount of sunlight entering the building.

This dynamic feature was inspired by traditional Islamic latticework, but it adds a contemporary and functional element to the structure. The mechanical diaphragms on the building's exterior open and close to regulate the interior light levels. This design is not only a functional response to the intense sunlight in Paris but also a symbolic representation of the merging of technology and traditional Arabic architectural elements. The building's innovative design and cultural significance have earned it recognition in the architectural world. It has received several architectural awards and is often cited as one of Jean Nouvel's most iconic works.



Figure 5. *Moucharabieh representation*
https://wikiarquitectura.com

2.1.3. One Central Park in Sydney

One Central Park is a landmark mixed-use development located in Sydney, Australia, known for its innovative and environmentally conscious design. Designed by Jean Nouvel in collaboration with the Australian firm PTW Architects, the complex features a striking and unique design characterized by its incorporation of extensive vertical gardens, cantilevered ***heliostat***, and innovative sustainability features.

The mixed-use of this building means that it encompasses a variety of functions and purposes within the same complex. It promotes a sense of community and convenience, as residents have access to a wide range of services and facilities without walking a long distance from their homes.

The particularity of One Central Park in Sydney lies in its innovative and groundbreaking approach to incorporating greenery and sustainable features into urban architecture. In our approach of Nouvel's work, one feature of this building is interesting for us, the Heliostat System. In Nouvel's way to play with the light, here is an

innovative concept again. The cantilevered heliostat, the floating square that we can see in *Figure 6*, on the apartment tower is a unique feature. This system uses a series of pivoting mirrors to track the sun's movement and reflect sunlight into the park and public spaces below. It's an innovative way to harness natural light and reduce the need for artificial lighting, promoting energy efficiency. The mirrors were included to alleviate concerns of overshadowing the site's own and the city's public domain.



Figure 6. *One Central Park in Sydney*
https://www.archdaily.com

2.2. Complexity of architecture

Architects should work together with the experts of other areas, like acousticians in case of music halls like theatres and opera houses. In case of Nouvel two significant buildings are introduced in the following: the Philharmonic of Paris, and the Opera House of Lyon. Both buildings were created to enjoy musical performances, so the acoustics of the performance hall are the most important part of the building from the point of view of engineering. But as these buildings are the homes of art, the appearance must be also very important, and the building itself should represent the highest level of art. So, Nouvel, as an architect, had a hard mission to find the balance among the limits of the acoustics, the art, and of course the limits of the architecture. (Venturi, 1977)

2.2.1. Philharmonic of Paris

As it was said before, an example to represent Nouvel's work in collaboration with acousticians is the Philharmonic of Paris which is mainly a concert hall in Paris. The design of this concert hall is to provide the best sound experience for listeners and emphasize the sounds of each instrument.

The Philharmonic of Paris is known for its bold and dynamic architectural design. The building features a series of irregularly shaped, aluminium-clad volumes that appear to jut out at various angles, giving it a sense of movement and contemporary flair. This design was created to express the energy and dynamism of the music performed within.



Figure 7. *Philharmonic of Paris' outside*
https://philharmoniedeparis.fr/themes/custom/pdp_theme/images/discover/philharmonie/carousel-intro/01_VUE-EXTERIEURE-FACADE-W-BEAUCARDET-08.jpg



Figure 8. *Balconies inside the Philharmonic of Paris*
https://i.pinimg.com/564x/f3/7c/97/f37c97bdaee1b5ede347bce99eacb4a0.jpg

The concert hall inside the Philharmonic is renowned for its exceptional acoustics, making it a world-class venue for classical and contemporary music performances. The Philharmonic of Paris is not only a concert hall but also serves as a cultural centre, housing exhibition spaces, educational facilities, and rehearsal studios. The Philharmonic of Paris represents a fusion of architecture and music, with its striking design and emphasis on acoustic excellence. It's a significant cultural and architectural landmark in Paris and is often considered one of Jean Nouvel's prominent works.

Sir Harold Marshall was the principal acoustics consultant for the Philharmonic of Paris. His contribution was essential for the design of the concert hall. As a world-renowned expert in musical acoustics, he worked with Jean Nouvel to ensure that the concert hall provided exceptional acoustics for musicians and the audience. Marshall was tasked with designing the acoustical features of the hall, including the seating and balcony layout, the height and position of the ceiling, the shape of the walls, and the reverberation of the hall. His work helped create a world-class concert hall with top-quality acoustics.

2.2.2. Opera Nouvel

Jean Nouvel's work on the Opera Nouvel in Lyon in France, is a significant architectural project that transformed the city's opera house. Completed in 1993, the Opera Nouvel represents a modern and innovative approach to the renovation and expansion of a historic cultural institution. Jean Nouvel's design involved the addition of a contemporary structure to the existing historical opera house, blending the old and the new as we can see in *Figure 9*. This juxtaposition of modern architecture with a historic building is a signature aspect of Nouvel's approach.



Figure 9. *Opera of Lyon*
https://www.rue89lyon.fr/2014/02/24/lopera-de-lyon-architecture-hybride-entre-rouge-noir/

The exterior of the new addition is characterized by a striking glass and metal facade. The glass surfaces allow natural light to flood into the building and create a sense of transparency, providing a contrast to the solid, historical structure. The interior of the Opera Nouvel features a modern and minimalist design. It includes a grand entrance hall, a large auditorium, and various public spaces. The design aims to create a sense of openness and contemporary elegance. Nouvel also kept the previous style for corridors and main rooms of the building as we can see in *Figure 10*.

Jean Nouvel paid careful attention to the acoustics of the opera house. The design incorporates state-of-the-art acoustic features to ensure that the space is suitable for world-class musical and theatrical performances. And by this, he worked with Victor Peutz, a Dutch acoustician. Peutz was tasked with improving the acoustics of the opera house, which had been criticized for its poor sound quality. Peutz's contributions to the project were significant and he made several changes to the design of the opera house to enhance its acoustics.

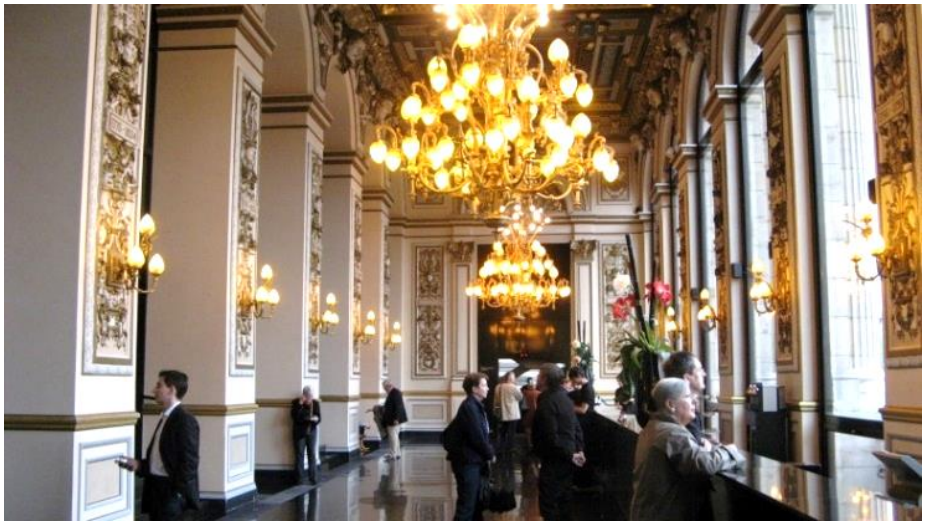


Figure 10. *Inside the Opera*
https://i0.wp.com/operasandcycling.com/wp-content/uploads/2017/10/b_7040.jpg?w=780&ssl=1

He revised the shape of the stage and the orchestra pit to improve sound projection and clarity. He also made changes to the seating arrangement and the shape of the hall to reduce echo and reverberation, which further improved the sound quality. Additionally, Peutz used his innovative computer simulation techniques to create a 3D model of the entire hall, which allowed him to test different acoustic solutions virtually before applying them for real.

Peutz's contributions to the Lyon Opera House were highly praised, and the opera house has since become known for its excellent acoustics. His work established a new standard for opera house acoustics, and he has been recognized as one of the pioneers of modern acoustic design.



Figure 11. *Concert room inside the Opera*
https://assets.classicfm.com/2015/28/opra-nouvel-lyon-france-2014--1436882456-view-1.jpg

The Opera Nouvel has received recognition and awards for its architectural excellence, particularly in its ability to successfully blend historical and modern elements. This building is an example of Jean Nouvel's ability to transform and revitalize cultural institutions through innovative architectural design. His work on the opera house is characterized by a commitment to preserving the historical character of the building while infusing it with a sense of modernity and functionality, creating a space that continues to be a hub for cultural performances and events.

2.3. Nouvel as a world-famous architect

Jean Nouvel is renowned all around the globe. He created a lot of buildings in many different countries. Each building comes with a unique design and functions. Nouvel, thanks to his work, has implanted a few of his art or a few of his approach in a lot of buildings that are famous nowadays. We can find some of his work in Australia, France or the United Arab Emirates as we've seen but also in Spain, the USA, Denmark, the UK, China, Quatar, Austria and even more.

3. SUMMARY

In this paper some of the significant buildings of Nouvel were shown. In the paragraph Playing with the light, some of those buildings were introduced, in which Nouvel used special elements for creating an interior that has got special shades of the sunlight. He used traditional Arabic patterns, which give organic shades on the inner surfaces, of course besides shading of the building. Through the examples of the Philharmonic of Paris, and Opera of Lyon it was proven that the interrelationship among architecture, space and acoustics make Nouvel's buildings as complex as a machine, or a product can be. The main concept of this paper was to find points in

the architectural design that could have got a similar pair in mechanical engineering design. This is not an easy task, because of the two types of design are much different. The work of Nouvel could be a very good source for this, as it is extremely rich, as he designed so many significant buildings all around the word. He also applies the latest results of the CAD as well, which also could be a connection point between the architectural design and the mechanical engineering design. In further research on the basis of the here presented results a precise list of engineering applications should be defined.

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