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POWER OF CANTILEVER DESIGN IN THE CONTEMPORARY ARCHITECTURE

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POWER OF CANTILEVER DESIGN IN THE CONTEMPORARY ARCHITECTURE

Abstract
Cantilever is a structural form that extends horizontally and is supported by one end and free on the other while the load is distributed equally, initiated by the use of bridges and balconies in the buildings. The power of Cantilevers with its different designs is spreading throughout the world via various perspectives since it increases the ability of design creativity and gives proper solutions. However, from that point forward, a research gap that has been found missing relating the structural challenges and how it affects the design and the decisions taken by the clients/ owners paying budgets on such type of structural additions that may not achieve the 100% building safety. Lack of knowing the proper building technologies may lead to reduce limits of innovation, that resulted in building repetitive traditional prototype without remarkable decisions. This paper therefore aims to detect the new building technologies that enable architects to design a cantilever in their projects, helping the design and the load carrying problems and highlight the exceptional designs that challenges the attractive force and establish a flying structure. In order to achieve the mentioned aim, the paper will start presenting a literature review based on a desk research theories and methods of construction were used to clearly explains our topic "the power of cantilevers in contemporary arch." Supported with diverse analysis of Frank Lloyd Wright, Zaha Hadid, and Knight Architects.

Keywords
Cantilever, Contemporary Architecture, Structural Design, Load Carrying, Flying Structures

1. INTRODUCTION

Cantilevers, as a definition, are structural elements made of a beam that is attached to a structure at only one end, and is used in architecture and construction in a way to increase the capability of creativity and capability of load carrying, and they are considered as main elements in contemporary architecture which is known as the architecture of today. Contemporary architecture, known as modern architecture, revolves around a rule that's shared by all those who honor and practice it: it's the thirst and the motivation to plan and manufacture things that are distinct from that was done in the past and what is usually done nowadays. It's the concept of designing and building something new and diverse. Based on the demand and craving to create advanced and unique design solutions, an increase in a creative work of architects took place. *According to the Russian code, a building is considered unique if it achieved at least one of these characteristics: Height over 100m; Span over 100m; cantilever of over 20m; The substructure of over 15m below ground level*. (E.D, V.G, A.K, 2017)

In history, cantilevers firstly were used in ancient China. Cantilever structures began in the 19th century when the architects and engineers started to think about how to build stronger and longer bridges and found out that by supporting the structure with many supports and distributing the load equally, longer and stronger structures could be built. Many engineers such as Fowler, Baker and Watanabe helped in thinking and pushing the construction forward. (J.Bradbury, 2018) Throughout many developments, the first cantilever bridge was built in the late 1800s by Heinrich Gerber in Germany who used the concept of cantilevers with no middle supports and a great span across rivers. Later in 1906, Frank Lloyd Wright used also cantilevers with the construction of Robie house in Chicago. (CENGAGE, 2021)

Cantilevers have a strong impact on the design process and outcome of any project, thus by constructing any type of cantilevered designs we will be reflecting the image that the project will obtain. relating the structural challenges and how it affects the design and the decisions taken by the clients/ owners paying budgets on such type of structural additions that may not achieve the 100% building safety. Lack of knowing the proper building technologies may lead to reduce limits of innovation, that resulted in building repetitive traditional prototype without remarkable decisions. As stated, this shows that new building technologies enable architects to design a cantilever in their projects, we have various basic technologies that enables us to choose the appropriate type of a structural system, from different materials and elements, in addition to size, placement, form, and height. For all these different factors have an impact on the resulting product.

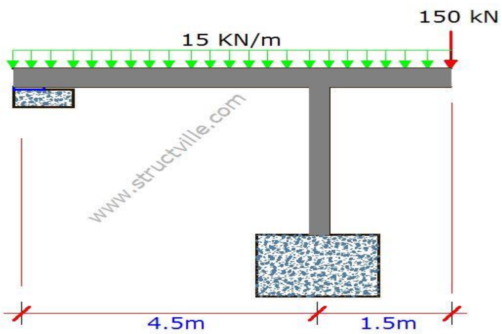

Fig.1: Cantiliver support by structville

Fig.2 Real structure of cantilever by structville

The main hypothesis of this research lies on the ability of cantilever design in effecting the outcome of contemporary architecture by showing the structural challenges and technologies and how it conveys through the design physical possibilities and owner's decisions.

This research is a qualitative type of work. The theoretical study will depend on scientific methods, starting, begin with literature review giving methods, approaches and similar examples. This data will be supported by previous readings, office work, extracting from updated references and then the study will analyze this data in a scientific framework.

2. METHODOLOGY

This research is based on 3 research methods: the inductive method, the analytical method, and the comparative analytical method. The inductive method is used in order to collect the needed data in order to support the topic of the research based on the selected 3 case studies. The second research method, the analytical method, was used in order to analyze the collected data, and providing all the necessary figures, drawings, diagrams and graphs in order to give proper explanations. The comparative analytical method, compared the chosen three case studies by comparing the parameters of analysis stated in table 1, and they're analyzed based on selected criteria:

- Structural challenges
- Diverse design approaches
- Completed projects
- Different functions, locations, and target users

This research is a qualitative type of work. This study will depend on scientific methods, starting, begin with literature review giving methods, approaches and similar examples.

Qualitative research method is decided to use for approaching new conceptual building projects perspective incorporating cantilever designs, which for the matter of act sometimes are considered to be design approach, and will spread creativity related to the conceptual approach to such kind of interest. The hypothetical paper material is collected from authorized sources, for instance, Premier Search, Google scholar, and books relevant to sustainable architecture and construction, materials, books and handbooks of regulations that are found both in the library of architecture found in Beirut Arab University and online. And it is aimed that the report includes the most suitable examples that could be applied in real life situation and have precise data, supporting them with professional opinions.

3. CANTILEVERS IN CONTEMPORARY ARCHITECTURE

3.1 Definition of Cantilevers and Contemporary Architecture

In simple terms:

"*A cantilever is a beam that is supported at only one end and carries a load at the other end.*"

Definition mentioned in (Cantilever: Definition & Terminology, 2017)

From wall signs to balconies, or from airplane wings to seemingly flying structures, one thing that they all have in common, is that they are supported from one end while simultaneously free from the other, and these elements are also known as cantilevers. Cantilever architecture helps integrate designs of buildings from conceptions, helping create a support-free structure without relying on walls or columns, whether from balconies or stairs. (Cantilever architecture 1st edition, 2019)

3.1.1 Definition of Cantilevers

Cantilevers are defined as a rigid structural element that is extended horizontally or in an oblique manner and only supported in only one end. Like most other structural elements, a cantilever may be formed as slabs, trusses, plates, or beams. When a cantilever is subjected to a certain load in its free-end side the load is carried and transferred through shear stress and bending moment. (Refer to fig.3 & fig.4)

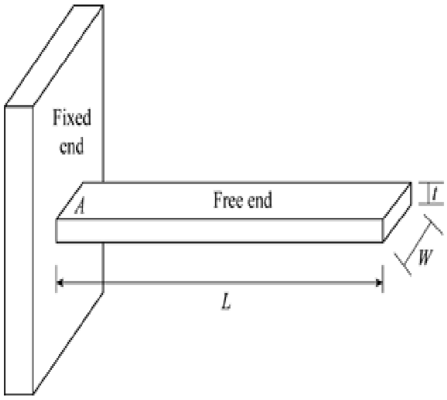

Fig.3: image showing cantilever fixed and free ends source: Chegg study, chegg.com

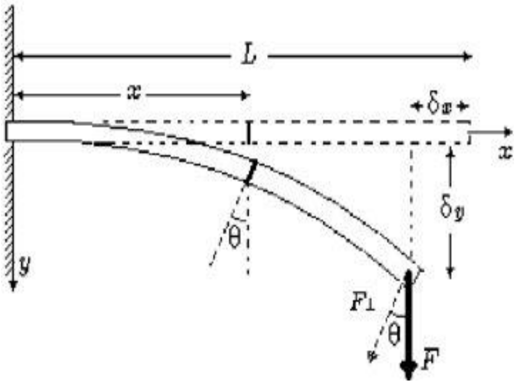

Fig.4: load bending moment on beam by: Edgardo Solano. Source: research gate

3.1.2 An Eye on Contemporary Architecture

As for Contemporary architecture, it is a form construction that shapes and symbolizes multiple styles of building designs, from varies influences. Contemporary architecture differs from modern architecture of the 20th century by including eco-friendly features and embracing all types of creativity. It uses the latest of technological techniques and materials, one of these techniques is the tube structure that helps in designing high-tech, strong, and high-rise structures. (world atlas, 2019)

3.2 Types of Cantilever Designs In Contemporary Architecture

There are 3 main Types that reflect cantilevered designs and help in achieving certain functional and aesthetic tasks.

-Type 1: Through the roof, that is considered as an element of the building (can be walkable) (fig.5)
-Type 2: Through a part of the building's volumes could be 1 or more floors (fig. 6)
-Type 3: Through open sides from the façade, for example: (balconies, terraces) (fig.7)

Type 1

Fig.5: Busan Cinema Center, South Korea by: Coop Himmelb(l)au Source: arch daily

Type 2

Fig.6: Innsbruck Trade Fair A by: ARGE CNBZ Architects, source: arch daily

Typ e 3

Fig.7: the "TORRE ABS tower" by: archimeccanica, Source: Divisare

Each one of these types impacts directly on the design that will be reflected, and the use of varies materials and innovative technologies also help in finding solutions that can even further enhance the desired design goal. (E.D, V.G, A.K, 2017)

3.3 Historical Background of "Cantilevers"

The invention of steel, that was in mid 1800s, made a great impact on making cantilevers famous in the architectural field, due to the effective cantilever system that is only shaped by combining steel with cement.

To begin with, the concept of cantilevers originated in ancient china, with the creation of the dugong that allows the distribution of the weight of the roof along the supports and permit the roof to extend beyond the columns (shown in fig.8). This was based on a bracket joining the top of the post and horizontal roof beam.

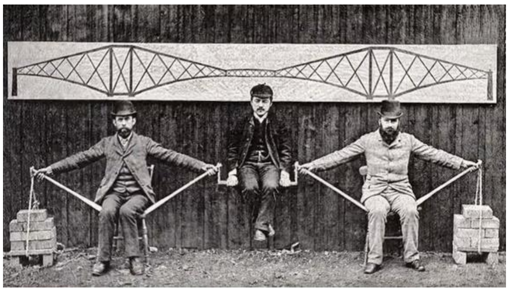

Fig.8: Benjamin baker along with Kaichi watanabe and fowler explaining the cantilever system in bridges. Source: theb1m.com

Cantilevers were used in the late 1800s while constructing bridges to solve the problem of length. The first cantilevered bridge was Hassfurt Bridge in Germany by Heinrich Gerber who adopted his ideas based on the ancient Chinese concepts. By using these ideas, no more middle supports were needed in supporting steel bridges; therefore, longer spans could be produced. Then, cantilevers were used in the building of Robie House (fig. 9), Chicago in 1906, by the famous architect, Frank Lloyd Wright; who prolonged the roof 6m beyond its supports. (Joe Bradbury, 2018), (CENGAGE, 2021)

Fig.9: Robie House and the cantilevered roof. Source: archdaily.com

3.4 Previous Readings:

Several researchers and engineers have studied before the structural type and the basic technologies that enables us to choose the appropriate type of a structural system that is convenient with both the design and the load carrying problems. In order to increase the application of cantilever structure in buildings and other facilities, innovative technologies should be used that permits us in choosing the best solution that solve different risks. Researchers have studied and highlighted the use and the capabilities of steel and reinforced concrete cantilever structures in many buildings.

Fig.10 Figure3:(a) Lucerne Culture and Congress Centre (KKL), architect – Jean Nouvel, 2000, (b) BMW Welt, Munich, Germany, architects – Coop Himmelb(l)au, 2007, (c) 28 Social Housing, Paris, France, KOZ Architectes, 2010, (d) UNASUR General Secretary Headquarters in Quito, Ecuador, architect –Diego Guayasamin, 2014

Elena Generalova stated that a high and innovative level of functional and architectural planning of a building and economic and efficient use of different resources, can be reached by using advanced technologies, materials and constructive systems. (E.D, V.G, A.K, 2017) such innovative technology is the use of cobiax technology (fig.11), and the use of spatial metal structure consisting of mega trusses.

Fig.11: Cobiax technology

Cobiax technology is the technology where the use of concrete is reduced in slabs. This technology aims to reduce the weight of the slab by 35% but retain strength properties by using plastic hollow void formers to fill the slab. Such technology is considered to be an innovative solution for cantilevered structures. It decreases the number of columns up to 40% and the span by 20% (Mehran Shalmani, 2012)

Several publications were directed to study the different types of cantilevered structures and types. Kyoung Sun Moon wrote a book in 2018 titled "cantilever architecture" shown in figure 12, shedding the light on the difference in the use of different materials that can limit the production of large cantilevers and focusing on the lightness that it is considered an important aspect to achieve.

The approach of cantilever design started at first with structural designs such as bridges, and after in houses and public buildings. In order to support the topic of cantilever, real life examples on the power of cantilever design in the contemporary architecture.

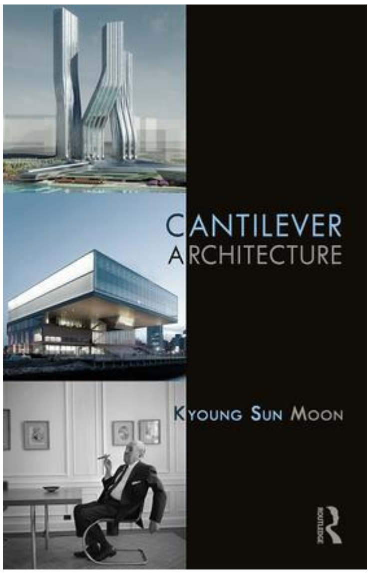

Fig.12: book of cantilever architecture by sun moon, 2018

3.5 International Examples

A) Guest House Rivendell / IDMM Architects

Guest house Rivendell (figure.13, 14 15), located in Gapyeong-gun, South Korea, and designed by IDMM Architects using cantilever design to shed light on main concept of the building depending on the structure as a main feature. The main challenge was in the site parcel that is too big for a residential building, so the architect choses to spread the spaces in the site to not look too small for the site, in addition, he stated that the possibility to design a house is to find a relationship between the spaces integrating together. The structure of cantilever design was used in order to increase the spread of the design along the land *"Perhaps the way its body spreads out like limbs in every direction"* (Archdaily,2014). The structural challenges appear in the use of concrete and leaving it in its natural form to show the body of the building and to determine the sequence of the concept made for the building.

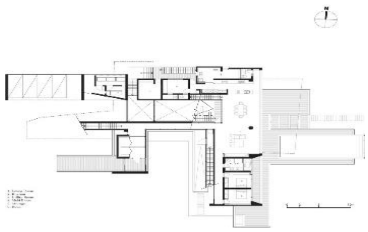

Fig.13: top view of guest house

Fig.14: first floor plan

Fig.15; perspective of cantilever

By IDMM, 2012

B) The Seattle Central Library

Seattle central library (fig.16,17,18) located in Seattle, USA in 2004 by architect Rem Koolhaas and Joshua Prince-Ramus, due to the geometrical composition designed by the architects, that includes an overhang connected on the edge of the top of the building, that's how it appears to the eyes.

Fig.16: Real picture of library by archdaily

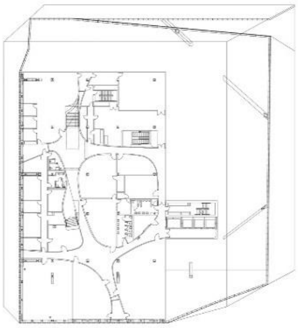

Fig.17: Plan of Library by archdaily

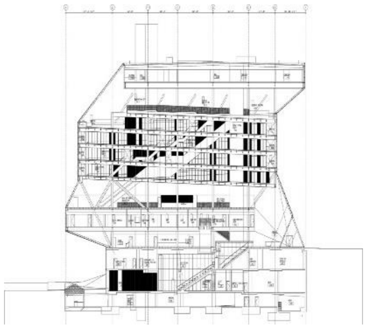

Fig.18: Section of Seattle By Koolhaas. 2004

The structural challenges that appeared in order to design such form, the assistance of professional engineering used the structure of cantilevers to design the edges of the building, this clever style is that the results of the architects decide to let the building's interior floorplan inform the outside form. (Archdaily, 2009)

Based on the preceding research, some of the dedicated parameters of cantilever design and contemporary architecture and the 3 other keywords are analyzed in this table:

Table.1 Parameters of Analysis- Cantilevers in Contemporary Architecture

Cantilever	Contemporary Architecture	Structural Design	Load carrying Capacity	Flying Structures
Horizontal extension	Expressive forms	Strength	Slabs-on grade (SOS)	PV Cells
One-end	High concept	Stability	Shear	Minimal Footprint
Beam	Enormous scale	Rigidity	Discrete loads	Dynamicity

These parameters shall be referred to when investigating about Cantilevers in Contemporary Architecture.

4. CASE STUDIES

4.1 Case Study One: Issam Fares Institute for Public Policy and International Affairs

- Location: Beirut, Lebanon
- Architect: Zaha Hadid
- Area: 3000 m^2
- Year: 2014

The architect was assigned by the American University of Beirut to produce a project that is part of a continuous redevelopment and extended facilities. The Architect, Zaha Hadid has developed a half-cantilevered building over a public courtyard and a sequence of raised pathways.

4.1.1. Study of Cantilever

The architect Zaha Hadid's concept was to allow integration with the landscape and the building design, therefore, she developed a 21-meter cantilever floating above an open courtyard, lifting the functions vertically not interrupting the visual aspects of the user In figure 19, we can see a sectional drawing that shows the various functions, reading and conference room, that are above the cantilevered arm along with the double height courtyard that the cantilever is elevated above.

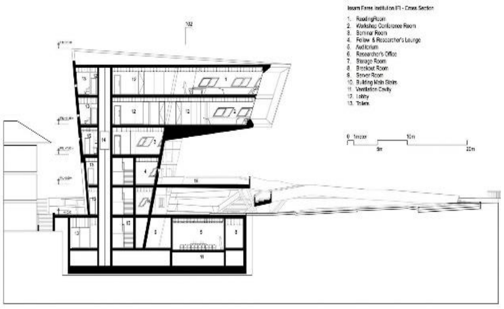

Fig.19: a sectional drawing showing the cantilever arm and the various functions above it

Fig.20: cantilever arm of 21m long floating above an open courtyard of double height Photographed by: Luke Hayes

4.1.2 Contemporary Architecture

The architect worked with in-situ concrete (as shown in fig.21,22) that harmonizes with the other existing building to achieve a lighter appearance, while using specific style of cladding and rendering with a high-quality rhomboidal window, distributed randomly along each concrete wall and concaved in it, integrated with a grey façade. Such elements achieve a modernist type of contemporary architecture

"The building takes full advantage of the region's tradition and expertise of working with in-situ concrete" stated by Zaha's team.

"The building emerges from the geometries of intersecting routes as a series of interlocking platforms and spaces for research, engagement and discourse" stated by Zaha's team.

The design was innovative and very respecting for the campus heritage which is the nature and that is seen scared at AUB and it is considered a part of the institute identity (Barbara Hoidn, 2014)

Fig.21: a photograph that shows the rhomboidal windows and the façade Photographed by: Hufton and Crow

Fig.22: a perspective view that shows the rhomboidal windows and the Ficus and Cyprus trees that are preserved Photographed by: Hufton and Crow

4.1.3 Structural Design

A six-storey building with a small base of 245 m^2 which grows in size on the last two storerys and hold a cantilever of 350m^2 and 21 meters long. Issam Fares Institute is constructed from in-situ reinforced concrete of an amount of 4,200 m^3 and a total of 800 kg of steel and a high standard of construction and material work which makes the lifespan of the building longer.

project info:

total site area: 7,000 sqm
new exterior spaces: 4,000 sqm
total floor area: 3,000 sqm
auditorium capacity: 100 seats
floors: 6
maximum height: 22 m
length of cantilever: 21 m
program: research and administration offices, seminar rooms and workshops, conference room / auditorium, reading room, recreational lounge, roof terrace
total surface of fair-faced concrete: 6,000 sqm
total surface area of glazing: 800 sqm
concrete cast-in-place: 4,200 cbm
total steel used for structure: 800 kg
employees on site: 90 (builders & technicians) for 1,100 days
total working hours: 500,000 hours

Fig.23: Issam Fares Institute project info published on design boom, having all the structural details and specifications.

4.1.4 Load carrying capacity of the cantilever

The building provides an extremely powerful volumetric cantilevered structure (fig.23) that hold 2 floors above it, supported by a base of 245 m^2

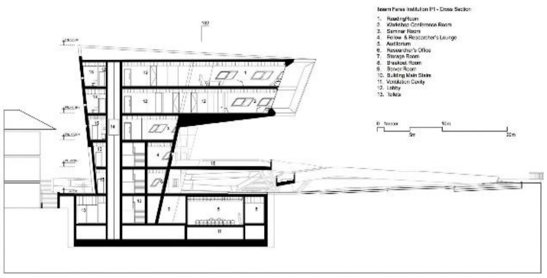

Fig.23: a sectional drawing showing the cantilever arm and the load above it

4.1.5 Flying Structures

The cantilever of Issam Fares Institute is described as a flying structure that aims to reduce the building’s foot print of the building to preserve the existing landscape. In order to achieve the “flying structure” and to reduce the total built-up area, a 600m^2 is concealed underground and a total of 350m^2 is elevated upward which it transforms into a gravity defying cantilever.

table 2 highlights the parameters used in the analysis of “Issam Fares Institute”. the shaded cells represent the achieved parameters

Table 2: Parameters of analysis of Case Study 1

Cantilever	Contemporary Architecture	Structural Design	Load carrying Capacity	Flying Structures	Material
Horizontal extension	Deconstructivism	Strength	Slabs-on grade (SOS)	PV Cells	Wood
One-end		Stability	Shear	Minimal Footprint	Steel
Beam		Rigidity	Discrete loads	Dynamicity	Concrete
					Polymer

4.2 Case study 2: Deichman Library

After multiple delays due to covid-19, and more than a decade after its design competition in 2009, The Deichman library finally opened in 2020, with uniquely designed cantilevers that extend into the waterfront and reaching the public space.

- Location: Sentrum, Norway
- Architects: Atelier Oslo and Lund Hagem
- Date of opening: 16 July 2020
- Area: 19600 m^2
- Structure: Bolinger and Grohmann

Fig.24: View of Deichman Library picture by: Elinar Aslaksen

The library has been set over the Oslo waterfront, set across the grand Opera house. Deichman library is considered as a marvel hosting 450,000 books. With and interior that is considered as a dream for readers, full of skylights, huge windows, and a maze of bookshelves that users would get lost within. (Allie Shiell,2020)

4.2.1 Cantilever study

In order to avoid building too many floors, and due to the relatively small site, a cantilevered structure was designed above its footprint. The Cantilevers are placed in the first floor above the street in the east, in addition to the fourth floor that is 20 meters out, above the urban plaza, forming a horizontal extension to the floor at one side and providing a shading and protective element

Fig. 25: the large cantilevered structure of the building picture by: Elinar Aslaksen

4.2.2 Contemporary architectural concept

The librarians wanted a structure that would give inspiration and push the users to explore all the facilities and try out varies activities that the library would offer, creating a vibrant space where knowledge and learning meet. In order to avoid building too many floors, and due to the relatively small site, a cantilevered structure was designed above its footprint.

4.2.3 Structural design

The structural features of the shell construction in the project are the folded concrete structure with the ramp below, the roof has a folded geometry that provides structural strength that aid the cantilevered floors which are suspended into the roof by tension rods, giving a stable output. (Bollinger and Grohmann, 2019).

Fig.26: section of the Deichman library showing the folded concrete structure and the tension rods source: arch daily

Fig.27: picture showing interior of project and part of concept picture by: Elinar Aslaksen

4.2.4 Load carrying capacity of the cantilever

The loads carried out in the cantilevered part of the project are well managed due to the folded concrete structure and can withstand an adequate shear force that are reflected on the tension wires

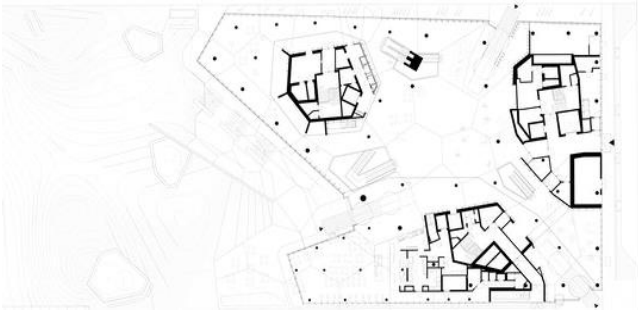

Fig.28: one of the plans of Deichman library
source: lundhagem.no

4.2.5 Flying Structures

The large cantilevered element above the fourth floor of the project seems as if it's a flying structure above the waterfront with unique form, and reduced footprint.

one the reasons for this flying structure was due to the relatively small site at hand, thus allowing for a wider space with less height.

Fig.29: picture showing the flying structure
picture by Elinar Aslaksen

Table 3: Parameters of analysis of Case Study 2

Cantilever	Contemporary Architecture	Structural Design	Load carrying Capacity	Flying Structures
Horizontal extension	Expressive forms	Strength	Slabs-on grade (SOS)	PV Cells
One-end	High concept	Stability	Shear	Minimal Footprint
Beam	Enormous scale	Rigidity	Discrete loads	Dynamicity

4.3 Case Study 3: House of Wisdom Library and Cultural Center

- Location: Sharjah, United Arab Emirates
- Architect: Foster + Partners
- Year: 2020
- Area: 42,000 m2

The house of wisdom library and cultural hub is considered to be one the latest projects that were signed to foster and partners to be completed in 2020 after the declaration of UNESCO of choosing the city of Sharjah to be the 2019 World Book Capital. (Archdaily,2021)

Fig.30: showing the house of wisdom library and cultural hub by Chris Goldstraw

Fig.31: showing the floating structure of the house of wisdom library by Chris Goldstraw

4.3.1 Cantilever Study

The building has an overhang floating roof with a cantilever of 15 m long constructed from steel and concrete in order to give strength to the roof. The building is designed to create large floors with free columns and to hold a 15 m long cantilever. For that reason, the architects and structural engineers tend to design four cores that were considered as main supports to the building.

4.3.2. Contemporary Architecture

The building is functioning two storey floors and a parking basement that embodies sense of lightness and clarity and reflecting the outdoor landscape, adding to the large floating cantilevered on all sides of a transparent rectilinear volume. Moreover, shading facades are added to provide sun blocking and adding the touch of modernism and high-tech.

4.3.3. Structural Design

Four cores are supporting the structure of the library in addition to servicing the library and cultural hub, including the support of floating roof and provide a wide, column-free floorboard. The two cores next to the entrance have staircases leading to the upper floor and also have load carrying capability. (Audrey Wachs, 2021)

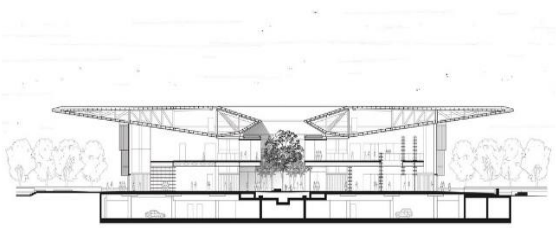

Fig.32: showing the section and the roof structure by the architects

4.3.4. Load Carrying Capacity of the Cantilever

In the height of a framework successive bars may be coupled to develop a framed cantilever device with vertical elements. Frame activity in spring models is formulated and economic performance is contrasted with the traditional approach using optimization procedures.

4.3.5. Flying Structures

The cantilevered roof also shades the Library's big clear facades from the city's hot sun, characterizing the concrete and steel building, and using frames and concrete beams in the structural roof in order to make it a as floating roof or in another words, a flying structure.(Lizzie Crook 2021)

Table 4: Parameters of analysis of Case Study 2

Cantilever	Contemporary Architecture	Structural Design	Load carrying Capacity	Flying Structures	Material
Horizontal extension	Expressive forms	Strength	Slabs-on grade (SOS)	PV Cells	Wood
One-end	High concept	Stability	Shear	Minimal Footprint	Steel
Beam	Enormous scale	Rigidity	Discrete loads	Dynamicity	Concrete Polymer

4.4 Comparison between the 3 Case Studies

Case Study		**Deichman Library** (International)	**House of Wisdom Library and Cultural Center** (Regional)	**Issam Fares Institute for Public Policy and International Affairs** (Local)
Parameter of Analysis				
Location		Sentrum, Norway	Sharjah, UAE	Beirut, Lebanon
Date of opening		July 2020	2020	2014
Architect		Atelier Oslo and Lund Hagem	Foster+ Partners	Zaha Hadid Architects
Power of Cantilevers	**Cantilever Design**	20m out	15 m out	21m out
	Contemporary architecture	Creating a wide-open space that inspires users to explore	Sense of clarity and lightness	Harmony with surrounding
	Structural Design	folded concrete structure aided by tension rods	4 cores holding the roof structure	Small base of 245m2 holding the cantilever arm
	Load Carrying	Holding the load of the top floor	Holding 2 storey and roof	Holding the load of 2 floors
	Flying Structures	Expanding space by extending outside the building site with reduced footprint	Steel and concrete beams carrying the flying roof	Reduction of built-up areas and elevated functions

5. FINDINGS

A survey under the title of the power of cantilever in contemporary architecture has been conducted to answer our questions that serve our aim in finding new technologies and knowing the problems that faces the architects, owners and students while designing cantilevers.
the questions that are stated for the survey are:

1- Do you consider cantilevers to be one of the manifestations that reflects the development in architecture?
2- Do you consider structures that include cantilever design an interesting design?
3- Would you consider doing a project that include a cantilevered structure?
4- Would you consider using some new technologies while constructing a cantilever?
5- As a client, is it convenient to build a cantilever structure and raise the budget of the project?

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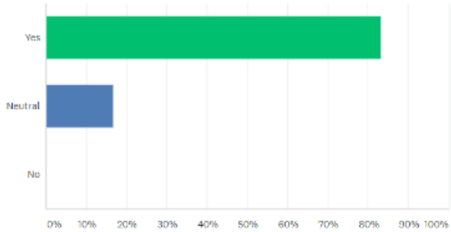
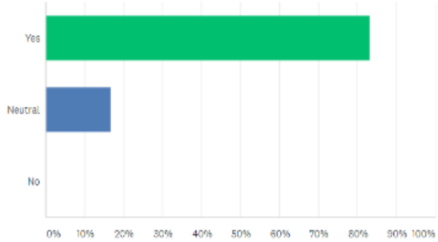
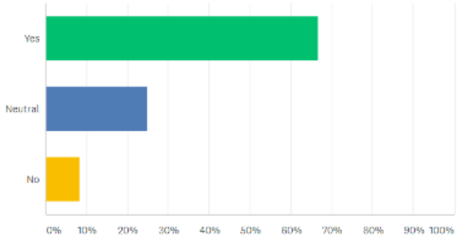
The answers came in the below bar graphs in order to discuss them and give certain conclusions.



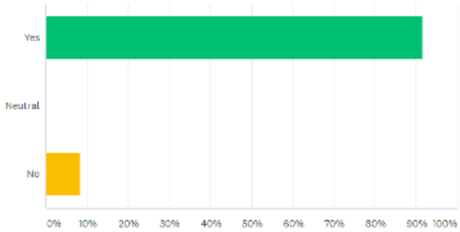
Question 1: Do you consider cantilevers to be one of the manifestations that reflects the development in architecture?



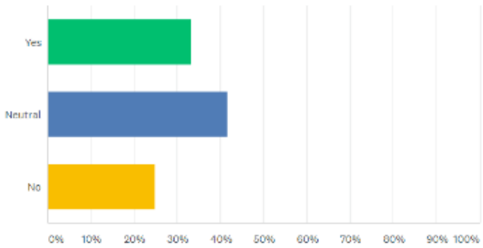
Question 2: Do you consider structures that include cantilever design an interesting design?



Question 3: Would you consider doing a project that include a cantilevered structure?



Question 4: Would you consider using some new technologies while constructing a cantilever?



Question 5: As a client, is it convenient to build a cantilever structure and raise the budget of the project?

6. DISCUSSION

According to the survey that was conducted above, multiple dimensions regarding the topic and aim can be interpreted. The first chart of question 1 concerning cantilevers to be one of the manifestations that reflects the development in architecture, and question 2 which considers structures that include cantilever design an interesting design. most gave positive feedback while non gave a negative one and this shows importance in reflecting the identity of the project on structural challenges. This shows that undeniably the cantilever structural and architectural design elements have a great impact through their aesthetic and symbolic traits that are also innovative solutions to some projects. And that much said is also reflected in the findings of question 3, where the highest number of answers where positive, stating that regardless of external attributes most people would rather consider a cantilever in their project. As for question 4 concerning the new technologies being used in cantilever construction most feedback was aiding that idea, but some might still prefer a mainstream approach. Even though new technologies have aided the construction time speed, and created better more impressive appearances with providing multi-functionality, from weather, light and wind exposure, and creating a shaded urban environment. To finalize the findings with the analysis of question 5 concerning the budget over the construction of the structure, most were hesitant and different opinions have been noted, creating a cantilevered structure might also be financially beneficial by increasing the number of visitors, and users. It will also most definitely be a unique element in the project, but sometimes the balance of some decisions are weighed through conditions and limitations, and therefore to answer the main aim in this discussion. Cantilevered structures have an undeniable power in contemporary architecture and are clearly reflected in the urban fabric that it creates, detecting new building technologies that enable architects to design a cantilever in their projects are now more often considered, most users, clients, and architects aid and support the construction of cantilevers and to be able to reflect the contemporary vision of the client and architect new technologies work on making that idea into reality. Therefore, the main aim that was first stated in the research paper was emphasised and assured in the end by using real live diagrams and facts.

7. CONCLUSION

Based on the preceding research, the study can reach to certain conclusion points:

a. The Cantilever design is considered a structural challenge that needs courage from both architects and owners
b. Contemporary architecture trends surprise societies with awkward compositions due to the innovation of building technology. Cantilever is one of the manifestations that reflects the development happened in architecture
c. Momentum forces (moment of inertia) became easy to be resisted through the power of Cantilever building technology

8. RECOMMENDATIONS

a. Owners and Clients shouldn’t be afraid anymore. Once the financial budget is available, architects can release their innovative solutions to produce remarkable structures veering far away from traditional prototypes.
b. Architects should be very sensitive and keen in the design of cantilevers achieving maximum of panoramic view, structural aesthetics and fully integrated with the site context and climate
c. Architectural Students who seek to design cantilevers in their projects should be aware of dimensions, building technologies and limitations to achieve the best utility.

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