Parametric Design for Large Span Structure

Abhinav Dnyaneshwar Sayam[1*], Chinmay Burange[2]

[1]*Student, P. R. Patil College of Architecture, Sant Gadge Baba Amravati University, Amravati, India*
[2]*Assistant Professor, P. R. Patil College of Architecture, Sant Gadge Baba Amravati University, Amravati, India*

***Abstract*:** **There has been immense growth seems in few years in large span structures in architecture, because of its own positive characteristics. But while designing, the designers face much problem and have to deal with its aesthetic values and technical problems like loads, forces, materials. Architects or designers restrict their thoughts, imaginations because of mentioned above limitations. Now, a question rises – How can we solve the issues and find a best solution while designing a large span structure? Parametric design became an inseparable term of architecture day by day in this new era of architecture. Parametric is not only aesthetically pleasing but also helps to solve the visual, perspective materials and structural errors. To solve the large span structure error and problems we can go through parametric design process to find a best possible solution. In this paper discussed about parametric design and large span structure, parametric design process and how computer technology helps to reach the aimed goal.**

***Keywords*:** **Architects, large span, parametric, rhinoceros, structure.**

1. Introduction

"Parametric design enables architects to push their boundaries of what they do with present available technology."

Parametric is the new and experimental computer aided style of architecture in which the functions are considered parametrically variables rather than static.

The term parametric originates in mathematics, but there is debate as to when designers initially began using the word. Parametric has long history in mathematics.

David Garber (2007) in his doctoral thesis Parametric Practice, he gives the credits to 'Maurice Ruiter' for first using term in paper from 1988 entitled Parametric Design.

But, Robert Stiles argues that the real provenance of parametric was few decades earlier, in the 1940's writings of architect 'Luigi Moretti'. A model of stadium by Luigi Moretti Exhibited in 1960 at the Parametric architecture exhibition at the 12th Milan Triennial. The stadium derives from a parametric model consisting of nineteen parameters.

But as long as gone in past in research found that 'Antoni Gaudi' who was the using term for first time in architecture, he began to designing architecture with parametric catenary curves and parametric hyperbolic paraboloids at the end of the 19th century. He made a first hanging model.

Till date Top Buildings by Parametric –
1) Walt Disney Concert Hall by Frank O Gehry & Partners, USA.
2) BMW welt by COOP HIMMELB (L) AU, Germany.
3) Beijing National Stadium by Herzog & de Meuron, China.
4) Bunham Pavillion by UN Studios USA.
5) Gunagzhou Opera by Zaha Hadid Architects, China.

Long Span Structure – Long span structures are larger than 20 meters. Span is unable to be achieved with ordinary R.C.C. construction. The most common types of long span structures are trusses, folded plates, shell structures. Generally long spans result in flexible, column free internal spaces, reduces substructure costs and to erect the structure.

The initial long span structure was developed as early as the first decade of the previous century by the Alexander Graham. He was even responsible for using space frames for a building a Watch Tower Canada 1907. From 1943 these structures are used in public construction.

Till date Top Long Span Structures –
1) Leige–Guillemins TGV Railway Station by Santiago Calatrava, Belgium.
2) Taoyuan International by ARUP, Taiwan.
3) Palazzetto Dello Sport in Rome by Pier Luigi Nervi
4) Sports Centre in Medellin by Giancarlo Mazzanti.
5) Tarino Espozione by Pier Nervi.

Though long span has its own positive characteristic but also has some drawbacks. Long span structures impose various problems on architects when they design them. Usually there is technical problem, but some time aesthetic also one, tensile forces. But it can be solve by Parametric Design method.

In this paper discussed about Parametric Design, Long Span Structure and how can achieve the problem solution, technical errors and aesthetic values.

2. Methodology of Research

Parametric become a popular style in architecture. It helps in contemporary and futuristic architecture. It optimized the imagination of a designer. It solves a problem face by designer during designing the project.

In this study approach towards the how parametric works and helps the designing large span structure without compromising any kind of value. In the first stage find the origin of the parametric through related research paper and thesis. In next step study about parametric, top architects and top architecture firm who works on parametric architecture and their thoughts and top parametric projects in India and in World as well

*Corresponding author: abhinavsayam66@gmail.com

through websites and published articles and blogs. Then find parametric related news on present and future. In next step study about long span structure and how will parametric helps in resolve the problem in it.

This paper explained about parametric by studying, analyzing research papers, thesis and published articles and visiting related websites. Then represent the thoughts on parametric and explained thoroughly.

3. Parametric

- In order to find the meaning of Parametric, we have to go into the origin of the word itself. How the word came and what is the original thought behind it.
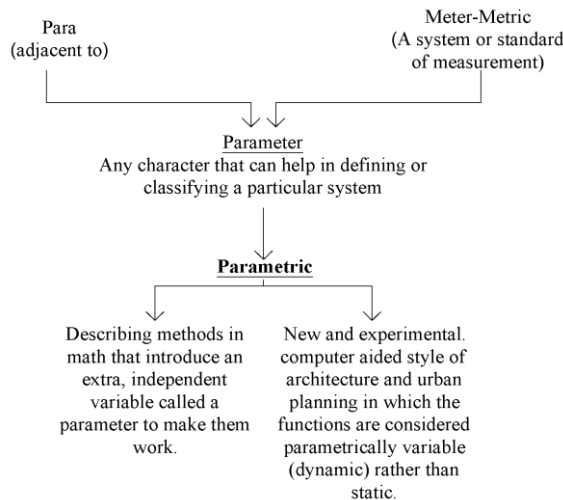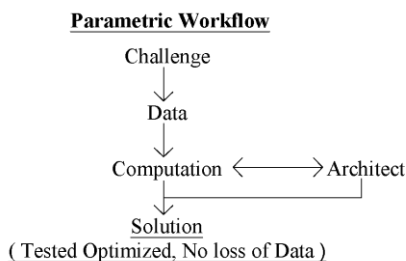
Fig. 1. Parametric meaning
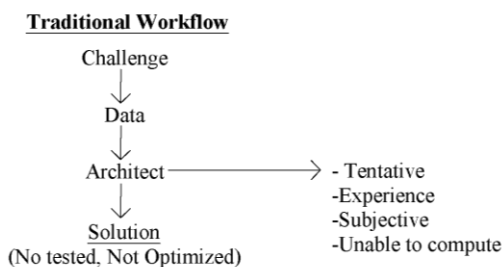
Fig. 2. Parametric workflow

Fig. 3. Traditional workflow

- Parametric design is a design method where features (such as building elements and building components) are shaped according to algorithmic process in contrast to being designed directly.
- Finding the simplest and fast solution to a challenge

/problem with objective evolution of set of different data and parameters like wind, sunlight, weather condition, load, forces, error and many more that gives the most optimized result.

4. Large Span Structure

By case studies and site visit of warehouse, industrial projects, long span structure. It is observed that the form of the building, facades of the building, structural elements and materials of the structure or building was compromised and typical.

In architecture firm by working on different industrial projects came to know, understand and realized that the fact is because of the considering the factor of strength and availability of less time the designer compromise the aesthetic value of the building. Also not use the available present technology. Thus, they design typical design.

If they have to design pleasing, attractive structure it takes time by traditional method and at the same it is difficult to work on strength simultaneously. If they approach towards aesthetic they lack in strength and project completion on time. And if they approach towards the sustainable structure there is lack in aesthetic of the structure.

Because of the client pressure and limited time, various factors consideration, working by traditional method, not using the present computer technology and having not experience of parametric method they design typical long span structure with compromising with aesthetic values.

Only the top architectural firms, architects in India and in World who work on parametric and designing the beautiful large span structures with the consideration of all the factors and parameters just because they go through parametric work process and using available technology.

5. How does the Parametric Works and Help the Optimizing the Project?

1) First, Designer enter the geometrical parameters into a design tool. Then, the tool uses computer processing to design relations between these parameters.

This complex process creates a hierarchy of possible variables. And it is all because of geometrical and mathematical relations.

After that, the designer uses these variables to explore design possibilities. It allows the architects and designers to play the digital fabric of the structure. At the same time, they can be certain that they can replicate the construction in real life.

Key points to remember:
- You don't have to waste time and money on trial and error.
- Since you will be doing everything with tool, you can take human error out of the equation and minimize manual repetition.

2) In this method, parameters and rules determine the relationships between design and response.
- Parametric modeling can be divided into two main types:

a) Propagation based systems, in which final constraints are set and algorithms is final shapes that are unknown based on initial parametric inputs, through a dataflow model.

b) Constrains systems, in which final constraints are set and algorithms are used to define fundamentals (structure, materials use, etc.) that satisfy these constraints.

So called "form-finding" process are implemented through propagation-based systems. Form-finding optimize certain design goals against a set of design constraints, meaning the final form of the design object is "found" based on constraints.

6. Top Parametric Software and Plugins

A. Software

1. Rhinoceros 3D
2. CATIA
3. Free Cad
4. Creo Parametric
5. Siemens NX
6. Autodesk Maya
7. Autodesk Revit

B. Plugins

1. Grasshopper 3D
2. Ladybug (Environmental analysis)
3. Honeybee (Environmental analysis)
4. Geco (Environmental analysis)
5. Heliotrope-Solar (Environmental analysis)
6. Kangaroo Physics (Structural analysis)
7. Karamba (Structural analysis)
8. Bull Ant (Structural analysis)
9. Humming Bird (Structural analysis)
10. Mantis (Structural analysis)

7. Challenges Faced by the Architects while Developing Parametric Architecture

- It is complex process compared to any designing method. It is combination of mathematical operation, data analysis, computer science, and design strategies to be thought about all at once. Therefore, about architects take a longer time to learn parametric software than they take any software to learn.
- They design the process more than final form.
- Parametric architecture results in ample variety in the design

elements, for example for example of a façade or the fluidity of the form. Therefore, it costs a lot of money to manufacture and assemble process.
- The construction phase is also more complicated, it required experience.

8. The Reason why we use Parametric Design in Architecture

- Parametric design brings advantages in both aesthetic and functionality.
- The industrial Revolution.
- Parametric design is a philosophy and methodology that is replacing traditional architecture.
- It allows you to manage complexity.
- Effective management of the process.
- Many alternatives for same design.
- Financially well defined.
- An opportunity to improve the design.

9. Conclusion

Parametric design is the future of upcoming architecture era. Various architects and scientist have worked on it since 19th century. Later on, after computer age it is easy to work on parametric design. It is computer-based style of architecture in which we have to put different parameters into the computer using software like Rhinoceros + Grasshopper and it process on algorithms, equations, make relations between parameters and yields with optimize solution. We can design structure aesthetically and functionally as well. It is possible to design large span structure without compromising aesthetic value and functionality, we can design complex geometrical structure. We have to learn about parametric modeling software and have to work in architectural firm which work on parametric to adopt knowledge about parametric.

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