

Role of Parametric Design in Converting Concept into Reality through Fluid Architecture

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ABSTRACT - This paper explains how parametric architecture has evolved through contemporary architectural style and how the change from Euclidean to non-Euclidean geometries has helped to develop fluid forms and complex geometries in Architecture. It also explains what fluid architecture is, and how it has evolved from history. In history important forms used during Egyptian, Greek and roman architecture were cylinder, pyramid, prism, cube, sphere. But as we observe today these are common geometries used in solid modeling software. Starting from basic geometries, intricate and complicated structures are designed. There are different parameters which can be considered in parametric design. In this research, FLUIDITY is one of the parameter consider in this study. Parametric tools or generative tools helped to visualize these forms and its transformation. The main idea or aim is to understand how a building behaves like fluids and what are the Elements or Fluid Characters that can be used to achieve a free flowing behavior. This behavior can affect the building typology and build environment, which is achieved through software tools.

Keywords: Fluidity, History, Parameter, Parametric, Software, Tools

I. INTRODUCTION

Parametric architecture has helped to develop a new style in architecture i.e. fluidity in architecture. Thus due to this new concept irregular n intricate forms are now possible to design, manipulate and implement very easily in Architecture. Fluidity is something that is already present in architectural history and is now emerging with new trends with the help of new technologies. Parametric design tools help to create fluid designs. In this research paper, Fluidity in architecture is explained with the help of examples and its comparisons. Finally a conclusion is made that fluid inspired buildings are possible due to advance digital computation through parametric tools and digital technologies.

II. OBJECTIVES

1. To understand what is Parametric architecture and its design tools used for Fluid Designs.
2. To understand the concept of fluidity and how it has evolved from history.
3. To study how an architect or a designer implement this concept in his building. (by comparative study of different projects).

III. PARAMETRIC DESIGN

Parametric design is a process based on algorithmic thinking that enables the expression of parameters and rules that, together, define, encode and clarify the

relationship between design intent and design response. The design that is governed by certain logic which includes algorithm (to device the logic) and these algorithm further includes certain parameters which can be varied to see multiple outcome.

Parametric architecture runs on parametric software's which works on parametric modelling, which can be easily manipulated to generate various options of designs and multiples solutions of 3D. There are various modelling software which can create complex geometries by feeding a specific statistics. Number of possibilities is generated in parametric modelling software's of one design. Feature based design tools, surface and solid modelling are used to control structure characteristics. Parametric architecture plays very important role in designing intricate and difficult curvilinear forms. In parametric architecture, interesting, eye catching and distinctive forms are created by using same components in the design. They are possible due to various parametric tools. There are different variables and constant parameters used for designing complex geometries. And by changing these parameters number of design solutions are obtained, from which we can choose the best possible option according to site context, need of designer etc. Traditionally designing of building structure was like "Function-Follows-Forms" but due to parametric architecture building structure can be designed as "Form Follows Functions".so parametric

architecture consists of different parameters but in this research the parameter is **FLUIDITY**.

IV. PARAMETRIC DESIGN TOOLS USED FOR FLUID DESIGNS

Modern designers and architects use certain logic which includes algorithm and this algorithm further includes certain parameters which can be changed, manipulated, controlled. This can be achieved through different tools from different software's. An Algorithm is a set of rules and directions given in a step by step method to calculate, manipulate data and to get a desire solution for design. When an input is given in a form of data, these algorithms determines its result and provides a design output. If the inputs given are appropriate, required results are obtained.

Traditionally during the process of design, parameters used were Site, its location, historical background, site context, Area program, building type, building heights, neighbourhood etc. while in algorithmic design these same parameters (input info) are feeded in the software in the form of algorithms to obtained design solution. By changing these parameters different design options are generated which can manipulate easily. This is something called as parametric or generative or Algorithmic architecture. Software's plays very important role in designing irregular and complex geometries. Software take in data set by the designer and process it to form various shapes. Such flexibility is not possible through all design software.

Rhinoceros is the 3D modelling software used in parametric designs, with the help of grasshopper plug-in. Grasshopper contains different components that contain information. First component contains input information which is connected to second component via connecting wires. And this process continues till a desire output is obtained. (Fig.1) 3D modelling in grasshopper is based on algorithms, which allows the freedom of changing features of any design by modifying the data in any given parameter.

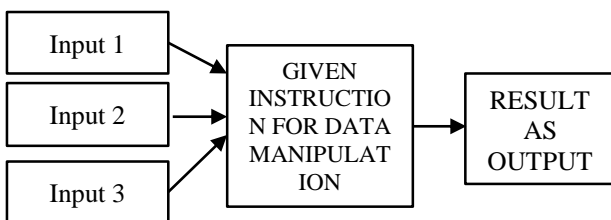


Fig.1 Basic illustration of an algorithm

V. WHAT IS FLUIDITY, FLOW AND FLUID?

Anything that flow is a fluid. Or which simply depicts the behavior of fluids is fluidity. It is different in different ways. Whirlpools which are formed in sea give us circular pattern and if we observe on other hand, sand dunes give us straight pattern. Both are fluidic in manner but through

different means. The ambience that is created by water or a flow of water is very pleasing and visually attractive; hence this concept of fluidity is started developing in Architecture. Initially “function where following the form” for example in charles correa building Kanchan ganga is a very good example of Function follows form, where sections were derived first and form was eventually derived according to function and now, “ Form follows functions” were form is derived first and functions are incorporated into it. Form play vital role in development of fluidic structure so the concept automatically became focused on the form experimentation and manipulation.

VI. HISTORY OF FLUIDITY

Fluid concept was existing ever since the architecture came into existence. If we observe the History of architecture, the designers who constructed the great pyramids of Egypt, they always use the movement of water in their interior parts of pyramids and their palaces, so that the water can be used for domestic purpose and also for keeping the inside of the building cool. Eventually as time passed, this form of water was taken inside the building in different ways as per the need of designers or users. One can use this concept in planning, facades, interiors, urban planning, and landscape. Creative idea of using water in structure for chilling was observed in B.V Doshi office in Ahmadabad. Second very good example is Fallingwater by Frank Lloyd Wright were architecture is connected with man and nature, here water is an integral part of house.

Modern Architecture recommends that Fluidity in building architecture can be used beyond its functional aspects of the building. So up till now in case of fluidity, only the visual outcome of water or its physical effect was taken into a building. But what if the structure is designed in such a way that it acts like water or performs like water. What if we design the building according to its aesthetics, functions, planning, landscape etc which behaves like water or different fluids? Due to all these questions this new style of architecture came into focus that was:

Fluidity in architecture

VII. HOW FLUIDITY DEVELOPED IN ARCHITECTURE

Various questions came into existence about this style and how this concept can be applied in architecture, How a building can look like a fluid, and how they can be constructed. This style started developing in field of architecture in search of uniqueness in designs which created individuality in plan, form, and aesthetics etc. A thought was to get inspire by something advanced and to be original, creative, and inventive. A key experiment of this concept was how the functions be integrated in the form. Traditionally for designers, functions plays very important role than comes form, so thought was given to

function first. i.e. organisation of spaces (Function follows Form). But in case of fluidity, form is established first.(Form follows Functions) after that planning of all spaces. So functional requirement changed as form changes. So building in this case should consider as one combined block with all spaces placed inside it. And to design such kind of structures, software's are the perfect tools. Because of software's one can create irregular forms and spaces, and also help to visualize its 3D model efficiently and modify them before implementing. **This new concept helped architects to jump from concept into reality through parametric modelling tools.**

VIII. WHERE IS FLUIDITY?

When thought of fluidity started evolving, architects and designers thought how this concept can be applied in building structure other than form. So that different parameters can be used in this concept apart from just FORM. From that time onwards designers looked into more fields and done various trials and experiments to integrate this style. Fluidity is used in various fields like in urban design, planning, landscaping, interiors, product designs, fashion design and more. Fluid architects who work on the principle of fluidity are Feri otta, Antoni Gaudi, Zaha hadid, Frank Ghery, Psatrik Schumacher, Santiago Calatrava.

Antoni Gaudi's Casa Mila in barcelona is one of the example from our history which show fluidity in building profile and its planning. While in Zaha Hadid's Heydar Aliyev Centre, fluidity can be observed in Form and building Profile. Fluidity can also be seen in urban design, urban planning and product design.

IX. FLUIDITY EXAMPLES

Different examples of fluidity are explained further and how fluidity is incorporated in building structure and building forms. Main aim is to study the building and observe how Fluid concept is applied in the structure.

1. HEYDAR ALIYEV CENTER

Architect: Zaha Hadid

Location: Baku, Azerbaijan



Fig.2 Heydar Aliyev Center showing landscape and structure

Concept:- It was to appear the Structure like wave which fades as it moves away from building. Concept was also to develop a continuous and fluid relationship between structure, interior and its surroundings landscape.

Building Typology:- Mixed used structure. It has culture centre featuring a conference hall, library, and museum. Front space of the center was Cultural Plaza, a space open for public use.

Fluid character:- Fluid character can be seen in entire site along with structure. Landscape looks like it has emerged from ground and merge with the building. **No right angles in the structure landscape and interiors (Fig.2)**

Material:- Glass Fibre Reinforced Concrete(GFRC) and Glass Fibre Reinforced Polyester (GFRP) used for cladding the steel frame structure that allow flexibility in designing building.

Software used:- Modelling software was Revit and Rhino grasshopper. Rendering done in 3d max,V-Ray,Photoshop.

Structure:- Internal structure of the Heydar Aliyev Cultural Centre is of reinforced concrete . Outer structure is composed of steel space frame .

2. AQUA TOWER, CHICAGO

Architect: Loewenberg & Associates (Studio Gang)

Location: Chicago, USA



Fig.3 Undulating slabs

Concept:- Concept was to create a ripple in façade which is coming out of glass in vertical direction. Architect also got inspired by limestone outcroppings found in lake area.

Building Typology:- Mixed used high rise tower. It includes hotel, apartments, parking and offices.

Fluid character:- In Aqua tower, fluidity is incorporated in the façade of building. It is in the linear fashion all around the tower. **Here its observed that designed is evolved from continues lines. (Fig 3)**

Material and Environmental factor:- They have used concrete material for creating ripple like effect to all the balconies of the apartment.

Apart from good aesthetics, a thought is also given on environmental factors, like green design and energy-efficient features. Part of façade which was shaded due to

slab was fitted with low thermal emissivity glass and part which was not shaded was covered with higher performing glass, because of which series of pools were created on façade.

Software used:- Rhino software with grasshopper plug-in was used to obtain fluidity in the building façade. Number of solutions are achieved by changing the parameters.

Structure:- Construction of Aqua tower is concrete structure.

3. AIRPORT - DESIGNED BY THOMAS BUSECK,

Architect: Thomas buseck,

Location: Innsbruck, Austria.

Concept:- Concept was to design a roof structure very interestingly which will give the fluidic effect. So concept was to give a wave effect to the roof structure. Plan was kept very simple and focus was given to outer structural part to create a fluidic appearance

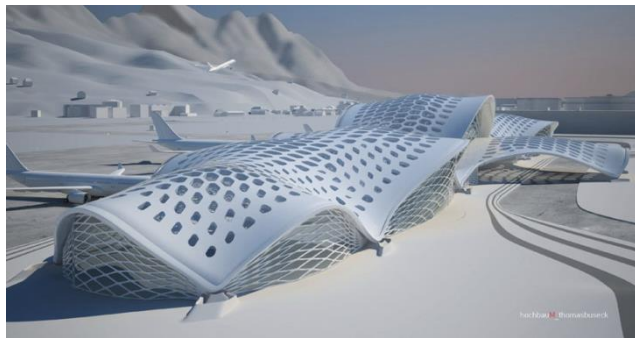


Fig.4 Entrance of terminal

Fluid character:- Fluid character is observed in roof and façade of building. Both the elements merge with each other to form one integrated block. This is very important feature of fluid architecture where two different designs become one at the end.

Material: - FRP was used in roof structure with steel framework and glass panels

Software used:- Lattice structure consisting of small shells was designed in Rhino + geometry gym+ grasshopper. Maya software was also used for form findings.

Structure:- Roof of the terminal contains three layers, first shell cladding, second shell structure and third glazing shell. These 3 layers were arranged in such a manner that the gaps formed due to grid provide natural light inside the building. In this project roof and the façade are two different elements which finally become one at the end.

X. COMPARATIVE ANALYSIS

Comparative study of three projects is done to understand the building dynamics as these projects are designed by different architects by using various softwares.

PARAMETER	HEYDAR ALIYEV CENTER	AQUA TOWER	AIRPORT
BUILDING LOCATION	Baku, Azerbaijan	Chicago, U.S.A	Innsbruck, Austria
BUILDING TYPOLOGY	Mixed used	Residential building + commercial	Expo Building
IDEA/CONCEPT	To develop a continuous and fluid relationship between structure, interior and its surroundings landscape	To make ripple in effect on façade and incorporate fluidity in high rise building.	Concept was to give a wave effect to the roof structure with merges with facades.
SOFTWARE USED	Modelling software Revit and Rhino grasshopper. Rendering in 3dmax, V-ray, Photoshop	Mathematica, Excel sheet Stimulation, Grasshopper Scripting	Grasshopper, Geometry gym
BUILDING AREA	Builtup Area : 57,500 m ² (619,000 sq ft)	Builtup Area : 184,936 sq.mts Height : 261.8 mts	-

FLUIDITY OBSERVED	Fluidity observed in structure as well as landscape. Structure appears like wave which fades as it moves away from building.	Fluidity can be observed in the façade of building, in the linear fashion all around the tower.	Fluid character is observed in roof and façade of building.
FLUID CHARACTERISTICS	No right angles in the structure, landscape and interior.	Here its observed that designed is evolved from continues lines .	Both the elements merge with each other to form one integrated block.
MATERIAL USED	GFRC and GFRP, also concrete and steel	R.C.C for structure	FRP for roof structure with steel framework and glass panels

Table. No. 1

XI. FINDINGS

From the above comparative study, its been observed that, there are different fluid elements or characteristics present in different fluidic buildings. Fluid Characer/Element will play very important role in designing irregular geometries. These types of buildings are visually prominent and exceptional to observe. By using simple lines and curves, fluid architectural designs showcase a beautiful flowing appearance into the interior as well as exterior of the building. These elements will differ from project to project. By using different fluidic elements, These types of structures are now possible to design efficiently and also to implement because of different modelling software's.

XII. CONCLUSION

Architecture has evolved, by changing the parameter constantly from time to time. Right for Egyptian to Mesopotamian, modern to post-modern and now contemporary to dynamism and parametricism, there is a change in Architectural style and methods. Different parameters are considered for designing, in this research Fluidity is considered one of the parameter for study. Now a days designer are adopting this concept in their designs due its aesthetic looks. In this research paper it is observed that, fluidity has some connection with architectural history, likely it has emerged from our history. Parametric design tools and 3D modelling software's help to create fluid designs. Parametric design tools have intense software stimulation, which help to generate complex geometries and irregular forms. It is all based on inputs which are connected to algorithms. And by changing these algorithms or parameters, number of solutions and iteration can be obtained. Designers can easily visualize the complexity in their design and get a proper understanding of their own designs. Each and every curve, point, line or geometry has an equation or mathematical calculations which can be manipulated and altered with the help of solid modelling soft wars which ultimately gives complex design solutions.

Thus fluid inspired buildings are possible due to advance digital computation through parametric tools and digital technologies.

Fluid characteristics derived are : -

- Geometry should be an integrated block.
- There should be no right angles in the design.
- Designed should be evolved from a continues lines.
- Entire building can be considered as fluidic or patterns from which building is evolved should consider Fluidic.

Fluidity is not a method but it's a style in architecture. Architects and designers are exploring this concept to attempt new innovative ideas. Fluidity is one of the parameter which opens new horizon in the field of Architecture.

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