

Understanding the Principle of Aesthetics in Bridges with reference to the Structural Principles

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Abstract: Vitruvius has defined architecture as a combination of *firmitas* (firmness), *Venustas* (beauty) and *utilitas* (utility). *Firmitas* concerns the durability which is the product of structural decisions. *Venustas* is about visual appearance. The concept of beauty in architecture is often justified by the principle of aesthetics. *Utilitas* addresses the issues that are of importance to the functionality of architecture. Architecture is a spatial art. The aesthetic experience of architecture cannot be separated from its practicality and ultimately the utility. Bridge design involves a combination of the scientific and technical principles along with aesthetic consideration for a universal purpose of all the bridges- to cover a span. This paper aims at identifying the linkages of structural principles of bridges to principles of aesthetics.

Keywords: Aesthetic, Structural, bridges.

Introduction

Architecture is always perceived, taught, and analyzed as a composition. The elements of composition like point, line, volume, color and texture. Further, the notions of whether ugly or beautiful, good or bad are formed by the principles of aesthetics. Aesthetics is a branch of philosophy which deals with the formulation of standards which defines the judgments for an art form.

The aesthetic meaning of the object depends upon the practical meaning. (Henry Cowan and Forrest Wilson) Some people consider that a correctly designed structure is essential for a beautiful building and some hold that a correctly designed structure automatically produces beauty. Any Architectural Composition is a structure which basically encloses or defines a space.

Methodology

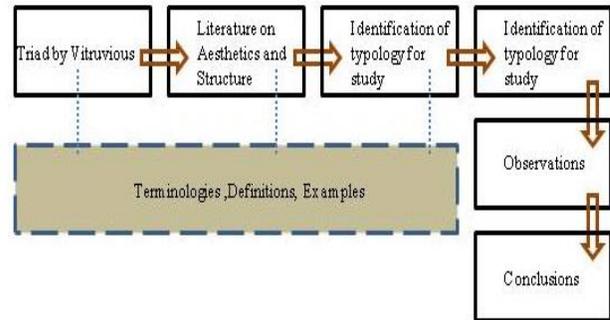


Fig.1 showing Methodology

Literature Review and Comprehension

From leaves and twigs composed as dwellings to concrete of today, architecture has always strived for durability and its quests for spanning. Span dominates the design, as the choice of structural system is dependent on it. Spans can be narrowed down to as simply vertical and horizontal. In case of vertical span the horizontal loads act at right angles to the height of building. In second case where the span is horizontal the vertical loads act at right angles to the span. Both these load systems produce bending moments. The structural system is selected so as it resists these bending moments most effectively.

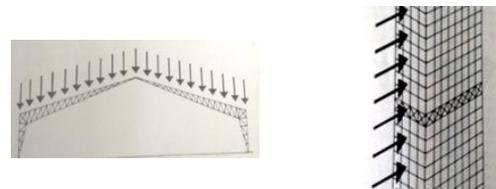


Fig.2 showing horizontal and vertical spans (Source: The design of structural Elements)

The connection in form of bridge is an art symbolizing techniques and skills of construction. Thus, it is a combination of Principles of Structures (*firmitas*) and Aesthetics Principles (*Venustas*). The most fundamental concepts to suit the requirement are derived from both of these to form a unified theme. Bridge design has one and primary aim of connection spanning a gap.

The span determines the shape, the structural assembly of the bridge which ultimately affects the appearance. The types of bridges are of following types according to structure are as follows:

Structural Type	Bridge Type
Beam	
Arch	
Tied Arch	
Truss	
Suspension	
Cable-stayed	

Table .1 showing different types of bridges (Source: Internet)

In Structure : An architect's approach, Howards divides the structure into four categories with respect to relation between structure and form. These are Minimal, Adequate, formal or sculptural and pretentious.

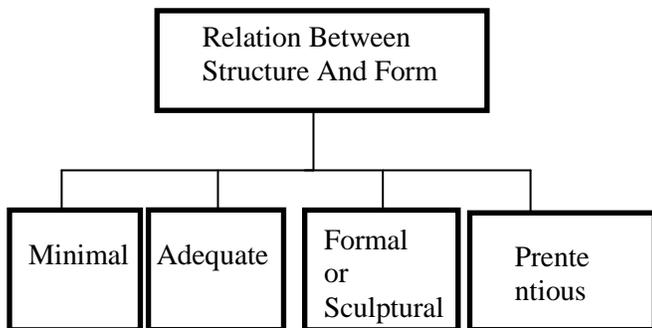


Fig.3(Source: Author)

Minimal Structure corresponds roughly to the engineer's ideal of optimization of weight in the efficient and direct transmission of forces.

A. Minimal through **Science**

B. Minimal through **Form /Arbitrary /Intuition**

Adequate Structure is defined by Howards in two sub categories i.e. visible adequate and hidden adequate.

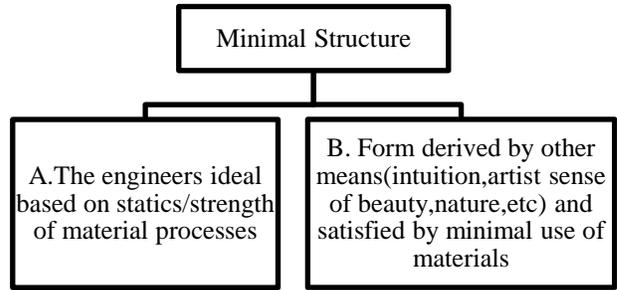


Fig.4 (Source: Author)

Visible Adequate is a structure in which columns, arches etc. can be used to provide scale and interest or to demarcate space. Hidden adequate structure gives the architect a wide freedom to choose surface materials, makes it hard to achieve that unity of material, structural principle, and form so helpful to good architecture.

Formal or Sculptural Structure has the elements exaggerated, or the forms reflect non-efficient use of material just for the sake of emotional impact. The structure is often chosen in spite of the limitations of materials, skills etc.

Pretentious Structure is defined as structure for structure's sake when aesthetic sensitivity is lacking and when novelty of form is the only claim for attention.

	Structure Type	Example	Statement
1A	Minimal through Science		Here, the main purpose is just to connect the two edges and the log becomes the only solution.
1B	Minimal through Form /Arbitrary /Intuition		The form remains structurally same, certain elements are added.

2A	Visible Adequate (Exposed)		The composition of the structure can be divided into parts and analyzed as a whole.
2B	Hidden Adequate		
3	Formal or Sculptural		The railing is molded so as to create an interest.
4	Pretentious Structure		This novel form in arch bridge was a point of attraction.

Line	The Arch lines give a sense of continuity.
Plane/Shape	 The shape operates as an independent identity.
Form	The stability principal and of spanning is expressed truly.
Structural Principals and Aesthetics	 A sense of rhythm is created with the series of arches.

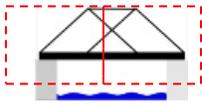
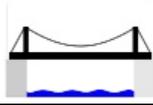
Table.2 showing different types of structures and their examples (Source: Author)

The bridges are considered as manufactured unit, hence their harmony with the surrounding and context has to be established. However, the bridges for this paper are studied as silhouettes, ignoring the color to texture experience.

Line	The horizontal line of the bridge makes a parallel line with the water level; the curve of the arch creates a dynamic effect.
Plane/Shape	The tied arch becomes a dominant shape.
Form	 The form of the bridge can be separated.
Structural Principals and Aesthetics	The Vertical bars from the tie arch give a idea of proportion.

Bridge	
Line	The vertical and horizontal lines direct the movement in a very sequential manner. This gives a very formal character to the bridge.
Plane/Shape	 A basic portal frame assembly, true to its structural functions.
Form	The form is the product of geometry.
Structural Principals and Aesthetics	 The beam bridges give a monotonous effect. However Portal Frame Assembly gives a surety of balance, visually and structurally also.

Bridge	
Line	The inclined lines landing at the horizontal makes a clear statement of structural logic: Truss.
Plane/Shape	 A direct representation of truss.
Form	The form and shape together ties up to a trapezoid.

Structural Principals and Aesthetics	 Balance through shape.
Bridge	
Line	The dominant lines here become the vertical and horizontal assembly above the piers.
Plane/Shape	 The high to low travel of the sag ensures the rear view.
Form	 The sag of the cable creates an informal effect
Structural Principals and Aesthetics	The sag gives a sense of unity.

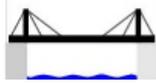
Bridge	
Line	The lines from the cables direct the movement and add dynamics.
Plane/Shape	The triangles become a prominent shape
Form	The interest is concentrated at the starting and end.
Structural Principals and Aesthetics	The cables make a contrast with the vertical support with respect to thickness.

Table 3 Showing comparative Analysis (Source: Author)

Conclusion

The bridges: Architectural marvels, are a combination of Principles of structures and aesthetics. If looked passively, it can be considered that the structural members from the bridges contribute to the aesthetical experiences. So, the structure and aesthetics cannot be separated in case of bridges.

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