

An Overview of Advent of Steel and Evolution of its Applications in India

Beena Kumari¹, Pappal Suneja²

¹Research Scholar, Department of Civil Engineering, Thapar University, Patiala, India

²Lecturer, Department of Architecture, NIT Hamirpur

Abstract : *Steel, as a building material, dates back its advent in our nation India when the East India Company drew its voyage to set up their trade and livelihood while exploiting our resources and people. The vivid applications of that time can be seen in the buildings of Kolkata. For instance, Howrah Bridge is one of the prime examples that may be reminiscent of the evolutionary phase of steel usage witnessed by India as the count of such structures increased with due course of time. Besides this, steel was used as a structural member at Heritage administrative offices like High Court, Raj Bhavan, Town Hall and Writers Building in Kolkata. This paper shall primarily focus on the evolution in usage of steel as a building material ; mainly related to the structural stability considerations and state of the art to cover up maximum applications of ancient as well as present contemporary structures that is in short the revolution brought by steel as time has turned its unique phases with advancement of technology.*

Keywords- *advent ; vivid ; reminiscent ; applications ; revolution.*

I. INTRODUCTION

According to published literature, iron was mostly used for making weapons in ancient times. The great Indian epics, Ramayana, and Mahabharata contain evidence that our forefathers knew about the usage of iron long before many other countries knew about it! Iron is thus very native to India! Not only during Vedic times but also in medieval times, our country has been an epitome of iron wonders. A review in the subsequent sections shows that in modern times too, our country has good examples of construction in steel.

Possibly because our country was under the colonial rule at that time and also due to a mood of complacency, our country failed to catch up with the western industrial revolution. Soon after independence, our country had to gear itself to meet the demands for development and industrial growth and in the first few Five-Year plans made reasonable strides in the area of production and usage of iron and steel.

In this chapter, the historical development of iron and steel in the world and India will be discussed first. The metallurgical aspect of structural steels will be reviewed first and then be proceeded to discuss, the mechanical properties of steel, which are very relevant to structural designers. Later, the different structural steels being produced will be reviewed in brief along with the special variety of steels (such as stainless steels and cold rolled steels).

II. EVOLUTION OF STEEL IN INDIA

2.1 Historical development of Iron and Steel in India

As mentioned earlier, there are numerous examples of usage of iron in our country in the great epics Ramayana and Mahabharata. However, the archaeological evidence of usage of iron in our country is from the Indus valley civilization. There is evidence of iron being used as weapons and even some instruments. The iron pillar made in the 5th century standing till today in Mehrauli Village, Delhi, within a few yards from Qutub-Minar is one of the oldest constructions made of wrought iron, was built at least 1600 years ago, and surviving to this day with very little sign of corrosion. It has been argued that the pillar, standing nearly 7m tall, was one of the pillars supporting a temple structure, which would make it the oldest of its kind. It is made of 98% wrought iron of pure quality and is a testimony to Indian ironworking skills [6]. Scientists describe this as a "Rustless Wonder". Another example in south India is the Iron post in Kodachadri Village in Karnataka, which has 14 meters tall "Dwajha Stambha" reported to have remained without rusting for nearly 1½ millennia. The exciting aspects of these structures are not merely the obvious fact of technological advances in India at that time, but in the developments of techniques for handling, lifting, erecting and securing such obviously heavy articles. These two are merely examples besides several others. The usage of iron in wars during Moghul era of the history is well documented.

2.2 Growth of steel in the Colonial period

India under the British rule experienced growth of iron and steel possibly because of the fallout of technological development of steel in the U.K. The vivid applications of iron and steel can be seen in the buildings of Kolkata that time. We can see several steel structures in public buildings, railway stations, and bridges, which testify the growth of steel in the colonial past. The "Rabindra Setu" Howrah Bridge in Kolkata stands testimony to a wonder in steel. Even after its service life, Howrah Bridge today stands as a monument. The Howrah Bridge is a cantilever bridge with a length of 705 m. The count of such structures increased with due course of time. Besides this, steel was used as structural members in many heritage buildings like High Court, Raj Bhavan, Town Hall and Writers Building in Kolkata. The three-storeyed building of the Currency Building (1867) at Dalhousie Square East became a landmark of the old city. Its roof was arched on iron joists and the floors with a wrought-iron gate of florid design.



Figure1 Howrah Bridge "Ravindra Setu"



Figure2. Second Hooghly Cable Stayed Bridge



Figure3 Use of structural steel in Church at Dalhousie Square



Figure4 Use of wrought iron posts and facia in porch of a Heritage building at Dalhousie square

The recent example is the Second Hooghly cable-stayed bridge at Kolkata (Fig. 2), which involves 13,200 tonnes of steel. Similarly, the Jogighopa rail-cum-road bridge across the river Brahmaputra is an example of steel-intensive construction, which used 20,000 tonnes of steel. There are numerous bridges, especially for railways built, exclusively using steel.

2.3 Production of steel in India

As far as production of steel in India is concerned, as early as in 1907, Jamsetji Nusserwanji Tata set up the first steel manufacturing plant at Jamshedpur. Later Pandit Jawaharlal Nehru realized the potential for the usage of steel in India and authorized the setting up of major steel plants at Bhilai, Rourkela, and Durgapur in the first two five-year plans. In Karnataka Sir Mokshakundam Visweswarayya established the Bhadravati Steel

Plant. Today we also have a number of private sector steel plants in India. The annual production of steel in 1999-2000 has touched about 25 million tonnes and this is expected to grow at a faster rate. However, when compared to countries like USA, UK, Japan, China and South Korea the per capita consumption of steel in India is extremely low at 27.5 kg/person/year. By way of comparison, rapidly growing economies like China consume about 80 kg/person/year.

III. ADVANTAGES & DISADVANTAGES OF STEEL STRUCTURES

Amongst numerous advantages of steel structures, few are listed below:

- **High strength:** The steel structure has high strength and ductility hence; steel member can resist high load with comparatively light weight. The steel members are gas and water tight because of high-density steel with choice of coatings. Due to the high strength of steel, the strength of these buildings is unmatched compared to other building materials.
- **Design and usage flexibility:** Steel members can be readily replaced or re-assembled. Steel offers design flexibility. Steel structures are easy to install and can be used in different types. It is essential when one desires to have a building with a strong foundation for use with long life.
- **Cost effective:** Steel is cost effective and rarely fluctuates in price. Steel allows for improved quality of construction, durability, less maintenance and Lower Life Cycle Cost. While offering improved safety and resistance. Steel buildings save time and money as compared to conventional building systems.
- **Exterior facades:** Façade design using louver was investigated for adapting climates, effective to renew the design of the building. Particularly well suited for the facades of buildings, steel is a functional, practical, and long-lasting material with a universal aesthetic appeal.
- **Large spaces and beams usage:** Thin floor systems allow appreciable gains in vertical space. Using steel columns instead of concrete ones could deliver around 40 square meters of additional floor area on 1000 square meter. The use of long span sections for buildings creates large, open and flexible spaces.
- **Steel Usage:** Facades, Bridges, Roofing, Entrances, Windows and Doors, Interiors, exteriors, Railings, cladding and aesthetic embellishments. Interior usages, false ceilings, trims and decorative furnishings and other embellishments involving less draw in non-corrosive environment steel buildings have evolved into various specific types which can be storage, places of work, living accommodation, and others.
- **Steel frame construction:** The evolution of steel frame construction in the 20th century entirely changed the concept of the Wall and the support. Steel is typical because of high tensile and compressive strengths steel is used for buildings for both practical and aesthetic reasons

Disadvantages:

Faulty design leads to the corrosion of steel in buildings. Steel is weaker in fire resistance. It loses its strength and deforms at a higher temperature (at 600°C or above).

IV. STEEL IN CONTEMPORARY ARCHITECTURE

Steel Buildings are symbol of Modern Architecture. Carbon Steel since 1920- to date is third most popular material after Concrete and Timber. Steel is crucial in the development of the economy and is considered as the backbone of human civilization. Development of iron and steel in construction is an important milestone in Architecture. Steel buildings and bridges were being built in the latter part of the 19th century and early 20th century during the British era, In the post-independence era, in the 1950s, steel traditionally used to set up public and private factories, plants, ports, railways, etc. And the structures in which architecture plays an insignificant role and projects largely managed by engineering professionals from design to construction. This usage pattern continued up to the 1990s its inherent properties ensured that it commanded a high level of comfort with engineers. These days' steel buildings are best known for the diversity of their shapes and their architectural expressiveness which make them more reliable than any other types of structures. Few examples are discussed in proceeding paragraphs.

'Volvo-Eicher' headquarters Gurgaon, NCR: Volvo Eicher Building, India by Ar. Romi Khoslais a building with long spans, open plan commercial office space and the building is World Architecture Award Winner, designed to be a state of the art steel building which uses the least amount of energy and resources possible in its day to day functioning. The building uses a large proportion of re-used material and an extremely high percentage of easily renewable materials. The building is defined by a unique span free steel structure which is set outside of the main building envelope and designed on the principle of a stabilized cube which is diagonally braced



Figure5 Volvo Eicher Building



Figure6 Restello apartments

Living Steel Restello the steel apartment Kolkata, India: The Restello project represent the highest standards in steel design and construction, designed by UK architects Piercy Conner Winner of the Living Steel International Architecture Competition in 2006. The steel structure is of a high grade and manufactured to international standards with Tata Blue Scope Steel and Tata Steel. Galvanized and painted steels are used for corrosion protection and to ensure a long life for the apartments. The steel used in this building fits the climate Of Kolkata Dampness is the major factor. Skin of the building comprises one permeable outer layer of perforated steel screens and a second inner skin of floor to ceiling glazing. The scheme won not only because of its bold, elegant design but because of the strong concept of cross-ventilation and solar-shading

S.I.A. Mumbai Jawaharlal Nehru Stadium is amongst some recent works done in steel. It has an innovative design for a roof over seating tier provided with one of the largest membrane roof systems in the world. Other examples of prominent steel buildings are Hotel Natraj, Mumbai; Kush Building, Ahmedabad; KTI building, Noida; EQ resistant PEB schools in Nepal and Houses in Latur, By Pennar Industries and Oswald Overseas Building, Gurgaon. This building has Column Grid—10X8.3 m with secondary beams castellated, metal deck roofing and entire roof were constructed in 30 days.

V. PEB STRUCTURES AS MODERN BUILDING SOLUTIONS

Pre-Engineered Building (PEB) structures have emerged as a promising solution for eco-friendly construction, which is a very much on demand technology. PEB buildings are inherently green products and have a very negligible impact on the environment as compared to traditional brick masonry and reinforced concrete structures. The only byproduct of such construction is metal scrap which is fully recyclable. The magnificence of pre-engineered building solution is its vast range and usefulness. Many recent commercial and corporate buildings are also now opting to pre-engineered metal structures. Even housing construction spaces are also getting captivated by PEB solutions. The precision and cost effective timelines for delivery of PEB structures rendered by construction companies has led to a higher level of demand over the past few years. In India, PEB market is growing very fast having a huge opportunity in automobile, power, and infrastructure. Being a quicker system to build infrastructure, PEB systems are getting the feasible edge in the industry and are

being adopted by more and more companies. Experts anticipate demand in the manufacturing and commercial sectors to increase by 50 percent in existing as well as some new sectors like power, bridges, and highways, railways, metros, stadiums etc. In coming years, a considerable shift of site fabrication work to the shop fabrication will happen as the former consumes much time and quality. Hence, pre-engineered buildings in India will have a great future as it has in other developed countries.

VI. COCLUSIONS

It is very common to see buildings with structural steel in the U.S. and Europe. But in India, we hardly see steel buildings with the exceptions of industries and temporary shelters, despite being the third biggest producer of steel in the world. Structural steel selectively used in the construction of high-rise buildings with 2-4 projects per year in India, mainly in metropolitan cities those are constrained by limited land availability. The building segment has been slow to adopt. The building's in India is presently dominated by concrete. The industry and infrastructure are currently the main contributing to the overall demand of steel structures in India. Usage of structural steel is currently driven by exception rather than practice. In the construction process, we employ steel in reinforced concrete but the whole structure is not prepared with structural steel in which all the components like columns, beams, floor plates and staircases. are of steel. Building with steel is at its infancy stage in India today.

SCOPE: The developing infrastructure can be anticipated to remain the foundation of Economic growth. Industry and infrastructure segments are expected to be the key demand drivers for steel structures in India over the next 5 years. Presently, structural steel industry employs the on-site model of fabrication for industry and infrastructure segments. Workshop delivery model is popular in PEB and buildings segment. On the whole, there is good prospective for steel structures in India owing to strong economic growth, enhanced government spending on infrastructure and change in approach regarding the utilization of structural steel in building.

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