Future Steel Buildings

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Introduction

Steel buildings are metal structures made of steel. These metal structures can be used to build offices, hospitals, homes, schools, warehouse and workshops. These steel buildings have gained popularity worldwide. The use of computer aided design technology has given a new dimension to building designs.

Steel has become the leading choice as construction material due to its numerous advantages over other building materials. The steel functions as a skeleton for the building. It performs all the functions a human skeleton does. Steel helps keep the building standing tall. It provides strength to the structure. In addition, steel provides resistance against harsh climatic conditions and gives a sleek appearance to the structure. Maintenance of the steel structure is easier compared to if concrete is used for the same purpose.

Steel buildings can be assembled easily as most of the steel components are pre-engineered. Nuts and bolts can be fixed in the specified holes and the structure can be made in minimum time with less labor. Personalized commercial and industrial buildings can also be made, as steel is now available in different colors and shapes.

1 | Basics of Steel

Steel is an alloy that consists of iron and carbon. Carbon content added to steel depends on the grade of steel and typically ranges from 0.2 to 2.1 %. Carbon is mostly used for alloying with iron but a number of other alloying elements have also been used such as manganese, chromium, vanadium and tungsten.

Carbon and other elements function as hardening agents preventing deformations of iron atom crystal lattice.

The invention of Bessemer process in the mid 19th century improved steel production methods. Further modifications were made in the process to make it cost effective and produce steel of better quality.

Modern processes make steel with different combinations of metal alloys to produce steel with different properties for various purposes.

- Carbon steel is composed of mainly carbon and iron. It makes up 90 % of steel production.
- High Strength low alloy steel (HSLA) has small additions of other elements such as manganese to increase steel strength.
- Low Alloy steel uses alloys of manganese, chromium, nickel or molybdenum to improve the hardness of thick sections.
- Stainless Steel uses 11 % chromium usually combined with nickel to resist rust formation (corrosion).

2 | History of Steel

History of Steel Making

History of steel making goes back to 4th century BC. Steel weapons were produced in Iberian Peninsula. Roman military used Noric Steel (high quality steel from Noricum). Chinese of Han Dynasty created carbon intermediate steel by melting wrought iron together with cast iron.

People of East Africa discovered high heat blast furnace which allowed them to forge carbon steel. This technique was duplicated during Industrial Revolution in Europe.

Evidences of carbon steel production in the Subcontinent was found in Sri Lanka. Unique wind furnace blown by monsoon winds was used to produce high carbon steel. Also known as Wootz steel, it is famous for its durability. Trace elements were also used in production of this steel.

Wootz steel was also produced in India and China. It was a complicated alloy containing Iron as the major component. Steel possessed legendary qualities.

Crucible steel was produced in Merv by slow heating and cooling of pure iron and carbon (typically charcoal) in the 9th -10th century.

History of Steel Buildings

Steel buildings are very popular choice for commercial and residential purposes. They can be used as storage units for business or temporary shelters.

Early 20th century saw a great rise in demand of steel buildings. After World War II, their use became more prevalent. Steel frame shelters were built for the army to provide housing during the War.

After the War army shelters were used as living accommodation. Easy availability of steel then allowed more constructions of steel buildings.
The use of steel buildings became more diverse as the people came to know about the strength and durability of steel.

Prefabricated steel buildings came in to use in 1960. These metal buildings had components premade including roof, floor, frame, walls and bracing. The parts just needed to be put together to make a building stand. This allowed to create buildings in various designs and made construction easier.

First computer aided design steel building was seen in 1960's. This allowed steel buildings to have more designs, features, shapes and sizes.

Wide varieties of steel buildings are available now including Arch Steel Buildings, Clear span Buildings and Straight walled buildings. The Arch Steel buildings are used as storage units for agricultural business. They are structurally very strong and durable.

Straight walled buildings are less sturdy compared to Arch steel buildings but have more usable space inside.

Clear span buildings use big overhead beams in place of inside support columns. It offers wide open interior spaces to be used for commercial and industrial buildings. It is a great choice for warehouses, factories and storage space. As beams are not included in the structure, you can easily rearrange floor plans according to your needs.

Clear Span buildings are ideal for use as aircraft storage space and maintenance hangers.

3 | Steel in Construction Industry

Using steel as construction material is not only limited to industrial buildings or temporary shelters. Steel has established itself as one of the most versatile construction materials available for use. It has become a popular choice due to its durability, strength and resilience.

Steel is also called as a green product. Concrete and wood cannot be reused, steel can be recycled thus is more cost effective.

Advantages of Using Steel

Steel buildings can be produced and engineered faster than conventional buildings. Pre-engineered steel has cut down the cost and labor. Construction does not require long times. The material can be shipped to the location and joined together to make a strong structure.

Steel buildings are able to withstand the natural disasters. Earthquakes, cyclones, hurricanes, sudden climatic changes can strike anytime. Use of concrete can cause a number of causalities. Also damages caused to the concrete structure need a lot of money to be repaired. Steel is cost effective and resilient.

Termites, rodents and insects cannot house in steel. This will reduce the sufferings of many people who spend loads of money on fumigations.

Steel is lighter but has more tensile strength. It can be used with other construction materials if needed.

Steel structures have more flexibility as compared to other building materials. Components can be shifted from one place to the other without difficulties. You can even add space by extending the structure.

Grades of Steel

Classification of steel in different grades is based on their chemical composition and physical properties. It has been developed by many standard organizations.

- Society of Automotive Engineers (SAE) steel grades.
- British Standards.
- International Organization for Standardization (ISO)
- ASTM International
- Japanese steel grades JIS standard
- Germany steel grades DIN standard
- China steel grades GB standard

Structural Steel

Structural steel is used to produce shapes, structural bars and plates which are used for building and bridge construction. Structural steel has high strength and is flexible.

Structural steel is made from high strength low-alloy (HSLA) steel. HSLA steels are different from other steels in the way that they are made according to specific mechanical properties not chemical composition.

Typical carbon content of HSLA steel is 0.05-0.25%. Carbon is included for steel to retain its weld ability. Other alloy elements include up to 2 % Manganese and small quantities of copper, nickel, calcium, chromium, vanadium and titanium. These

elements are added to strengthen steel and increase resistance to corrosion. Structural steel is formed using heat analysis.

Structural steel shape, composition, size, strength and storage are regulated in most industrialized countries. Steels used for building construction in the US are identified and specified by ASTM International.

4 | Properties of Structural Steel

Following properties of structural steel are considered before using them for a construction. These properties are useful for determining the quality of steel. High quality steel is used so that dependable and long lasting construction is possible.

1. Density

Density of a material is defined as mass per unit volume. Structural steel has density of 7.75 to 8.1 g/cm^3.

2. Elastic Modulus

Elastic modulus or modulus of elasticity is the measurement of tendency of an object to be deformed when force or stress is applied to it. Typical values for structural steel range from 190-210 gigapascals.

3. Poisson's Ratio

It is the ratio between contraction and elongation of the material. Lower the value, lesser the object will shrink in thickness when stretched. Acceptable values for structural steel are 0.27 to 0.3.

4. Tensile Strength

Tensile strength of an object is the determination of limit up to which an object can be stretched without breaking. Fracture point is the point at which an object breaks after application of stress. Structural steel has high tensile strength so is preferred over other materials for construction.

5. Yield strength

Yield strength or yield point is the stress at which an object deforms permanently. It cannot return to its original shape when stress is removed. Structural steel made of carbon has

yield strengths of 187 to 758 megapascals. Structural steel made of alloys has values from 366 to 1793 megapascals.

6. Melting point

There is no defined value for melting point due to the wide variations in types of structural steel. Melting point is the temperature at which object starts to melt when heated.

7. Specific heat

Specific heat or heat capacity is the amount of heat which needs to be applied to the object to raise its temperature by a given amount. A higher value of specific heat denotes greater insulation ability of the object. Values are measured in Joules per Kilogram Kelvin. Structural steel made of carbon has values from 450 to 2081 and that made from alloys has values ranging from 452 to 1499.

8. Hardness

Hardness is the resistance of an object to shape change when force is applied. There are 3 types of hardness measurements. Scratch, indentation and rebound. Structural steel made by using alloys has hardness value between 149-627 Kg. Structural steels made of carbon has value of 86 to 388 Kg.

5 | Components of Steel Buildings

Modern steel buildings are made of many individual components that have evolved over time. With the benefit of CAD manufacturers are able to produce more variations in dimensions and format of steel buildings.

Building construction is done using different steel shapes and pieces. In most of the developed countries, standard approved shapes are available.
Small steel buildings are prefabricated and are simple to assemble. The larger steel buildings require skilled workers so that safe assembly of the structure is ensured.

There are five main components of structural steel. They are tension members, compression members, bending members, combined force members and their connections.

Tension members can be found as web and chord in trusses and open web steel joints. They carry tensile and pulling forces preventing force to be applied on the other members used in construction.

Columns, Struts or posts make up the compression members. They are the vertical members in trusses and joists that are in compression.

Beams, joists, girders, spandrels, lintels are known as bending members. Each member has its own application but typically bending members carry moments and shear forces.

Combined force members are also known as beam-columns and are subjected to bending compression. Connecting members bring the entire building together.

Steel beam forms basic skeleton of the building and provides great support and strength. These beams usually hold the floor or the roof. I beams are widely used and come in different sizes. I beam can be used both as a beam and a column.

The girder or I beam is used in construction of nearly all metal buildings. It gives strength in all directions. Every structural component of a steel building can be made by varying sizes of I beam.

Reinforced Bars is a type of steel rod which is used to create reinforced concrete. Steel rods are inserted into concrete to add strength and give flexibility to concrete.

These bars are important in buildings made of concrete or which have substantial amounts of concrete used in construction. Steel joists are used to support floors or ceilings. These are laid in rows across girders. They are attached using joist hangers.

6 | Development of Steel Buildings

Construction Basics

Before proceeding with the building design, figure out the exact purpose of construction. Most of the time greater attention is paid to the final look of the building, not the purpose for which it has to be built. It is important to consider how big and tall a structure needs to stand. The time for which building needs to be used is also an important factor.

If the building needs to be used for long periods, steel is a good choice. It will give greater strength and durability. Steel does not bend, break or twist with increasing load. Changes can be made very easily to the steel structure.

Pre-engineered steel used for construction these days has pre defined points at which bolts need to be fixed.

The most impressive feature of steel is that it is recyclable and is very environmentally friendly.

Most steel buildings used for offices or even apartments are located on busy streets of the city. It becomes more important to consider the safety of the residents and people waking around these structures. Structural flaws need to be avoided at all costs.

Building Design

The design of a modern building involves a team of experts from different disciplines. The team needs to communicate clearly to avoid any undesired outcome at the end of the procedure.

The concept of the final design of the building starts with a drawing. Here the architecture comes into action. Designers (architects) start making new drawings and sketches.

A rough design is made initially. Any problems in the design need to be corrected in the early stages. With support from the structural engineer, the complex procedure of drawing a building structure can become easier.

There are two basic parts of a building design. First is the aesthetic and second is practical. The physical and visual appearance of the building needs to be attractive. It will influence the perception people have of the building.

The practical aspect of the building design is mainly concerned with the space allotment for different activities. It includes entry and exit of people, lighting, acoustics, legal matters and building codes.

Computer Aided Design (CAD) is widely used computer software to create technical drawings. There is no need to make the drawing on paper. A 3D model of the building can be made using CAD. Visuals can be added to the model. Different colors and textures can also be applied. Most appropriate settings can then be finalized.

After the architecture is decided it is important to work out the design of the framework. Beams, columns, bracing are decided by engineering calculations. It is the job of the structural engineer to give a shape to the architect's idea.

Steel Frame

A steel frame refers to the building technique with a steel skeleton. Vertical steel columns and horizontal I beams are constructed in a rectangular grid. This grid frame supports the attached walls, floors and roof of the building. The development of the steel frame technique has made the construction of sky scrapers possible.

The cross section of steel columns has a shape similar to the letter H. the two flanges of the column are thicker and wider as compared to the flanges on a beam. This makes it better to withstand compression stress on the building structure.

Square or round steel tubules can be also used. They are often filled with concrete. Steel beams are connected to the columns with fasteners and bolts. The steel web in I beam is wider than column web to resist higher bending stress and moments that occur in beams.

7 | Future of Steel Buildings

Talking about skyscrapers automatically brings in mind images of tall buildings steering through the clouds and reaching the stars. The term sky scraper was first applied to steel frame buildings constructed up to 10 floors in the late 19th century.

Today skyscrapers are becoming common in cities where land is expensive. They provide high ratio of floor space per unit area of land. They not only give utilization of space but also are a symbol of a city's economic power.

The list of super tall towers is headed by Burj Al Khalifa (Dubai). This 160 floored building stands over 828m. Empire State Building was the first to have over 100 storeys.

Other tall towers include PETRONAS Twin Towers (Kuala Lumpur), Taipei 101 and Willis Tower in Chicago.

The Idea of skyscrapers dates back to the first iron frame glass curtain walled office building in 1864. It was only 5 floors. Towards the end of 19th century, skyscrapers began to emerge in Chicago, London and Melbourne.

In the early 1960's, structural engineer Fazlur Khan realized that rigid steel frame is not the only system for tall buildings. This gave the innovation in skyscraper design and construction.

The tube structural system including framed tube trussed tube and bundled tube systems were introduced. This technique allowed skyscrapers to have different shapes from the traditional box shape.

Framed tubes allow fewer interior columns therefore more floor space is available.

The tube structural system is a three dimensional structure composed of 3, 4 or more braced frames or shear walls joined to form a vertical tube system. This system can be constructed using steel, concrete or composite material. This type of construction is used for both office and residential buildings.

Tall buildings due to their height are affected by lateral forces of strong winds and earthquakes. Structural design should be such that it resists these forces.

Design requirements of a building can be divided in to 3 classes:

1. Serviceability
2. Resistance to damage
3. Prevention of collapse

Ancient tall buildings used wood, concrete and bricks. Drawbacks associated with these materials led to the use of wrought iron and subsequently steel.

Steel frames are faster to erect compared to other materials. This gives economic advantages. In addition to cost savings, steel frames if used in tall buildings are lighter and result in considerably reduced loads on the foundation. Multiple storey buildings occupy less floor area.

Framed tube structures consist of closely spaced columns joined by deep girders. Resistance to lateral forces is provided by stiff frames that form a tube around the perimeter of the building.

Joints in framed tube structures are welded for providing rigidity and stability. The internal core of the building has concentrated facilities including elevators and stairs.

The use of a prefabricated framed tube system made construction more practical and efficient. All welding requirements can be done in a horizontal position.

The bundled tube was developed by variation in the tubular structure. It was based on bundling of smaller sized tubes. Each tube rises to a different height. Tubes can be used to create different shapes. Triangular and hexagonal shapes have been used for a few buildings.

For very high buildings super frames and super trussed tubes have been developed. In super frames, structural efficiency is obtained from the concentration of material close to the corners. Super trussed tubes have the advantage that they do not require closely spaced columns of a framed tube.

8 | Conclusion

Steel used in modern construction is completely recyclable. Recycling steel saves natural resources and landfill space. When a steel framed building is no longer needed, it can be recycled into new steel.

As the steel frames and bars are made according to the dimensions desired, there is minimum wastage of construction material. Effective recycling procedures guarantee saving the world's natural resources and are a positive step towards saving the environment.

Green steel homes as they are called are environment friendly. In addition these are resistant to fire, hurricanes, storms, mold and termites. Quick construction saves time and maintenance costs are lower.

These engineered homes are professionally designed and constructed. They have complete wiring and plumbing systems.

Construction has come a long way from its early days. Now humans rely on tougher and more durable steel to construct buildings. With the rate of advancement we are going through currently, the future has a lot more in store in terms of the construction of steel buildings.

About The Author

Lisa Rogers is an independent writer who specializes in academic reports on emergent business industries, such as Future Steel Buildings. Please contact her via e-mail if you have any inquiries on her analysis.