# AN ANALYSIS OF PRE-ENGINEERED STEEL BUILDING

**[1]Sourav Uppal, [2]Dheeraj Kumar**

[1]M. Tech. Scholar, [2]Assistant Professor
Department of Civil Engineering
CBS Group of Institution, Jhajjar, Haryana 124103

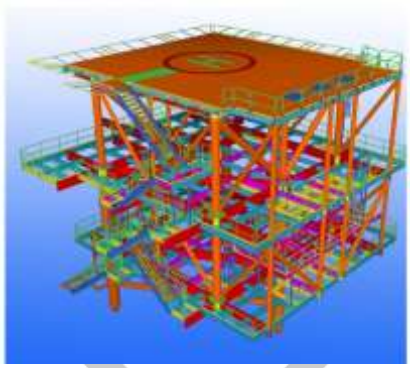
***Abstract*: Steel is the material of choice for the project because it is completely ductile and flexible. It activates under extreme loads rather than crashing and collapsing. The low cost, strength, stability, design flexibility, adaptability and recyclability of structural steel continue to make it the material of choice in construction. Quick build reduces overhead costs for building management services. Steel is widely used in the construction of large span industrial buildings with or without cranes (medium and heavy construction) where concrete construction is not feasible." In structural engineering, a prefabricated building (PEB) is designed by a manufacturer to be manufactured using a predetermined inventory of raw materials and manufacturing methods that can effectively meet a wide range of structural and artistic design requirements. Prefabricated steel buildings can be equipped with different structural accessories, including mezzanines, pantries, partitions, internal partitions, etc. and the building is waterproofed using special caulking cords, infill strips and trim. In the prefab construction concept, the entire project is carried out in the factory and the building components are brought to the site in a state of demolition. A prefabricated building with an efficient design can be up to 30% lighter than conventional steel buildings. Lighter weight means less steel and potential price savings on the structural frame."**

***Keywords*: Prefabricated Building (PEB), Structural Engineering, Lighter Weight**

## STEPS INVOLVED IN CONSTRUCTION OF PEB STRUCTURE

### STEP-1: DESIGN OF PEB STRUCTURE

Steel frames intended for use in a specific structure are extensively designed and manufactured in-house. This project involves the use of careful design software that does not cause errors or changes to structures. Therefore, design is a key element in building an PEB.



### TEKLA MODEL

Tekla Software Structures is used in the construction industry for steel, precast and cast-in-place elements. The software allows customers to create and manage 3D steel or concrete structural models and guides them through the process, from design to fabrication.

### STEP-2: CONSTRUCTION OF FOUNDATION

This next stage calls for standard site clearance, followed by pouring concrete foundations. PEBs tend to be built on shallow insulated foundations since the superstructure's self-weight is considerably smaller.

In severely introduced areas, such as coastal areas, pile foundations are laid, but the depth of the piles is less than that of conventional concrete structures. They generally choose to place a PCC-based flat slab below the deck (shallow insulated base) to avoid its direct contact with the ground. The superstructure pillars are bolted to the platform.

**BOLTED FOUNDATION**

**STEP-3. ERECTION OF STEEL FRAMES**

The type of steel used differs depending on the condition of the structure, for example, if it is a one-story building, the thickness of the steel supplied may be smaller (0.9 mm to 1.2 mm), but for a huge structure, the frame thickness increases (4 mm up to 50 mm). Steel beams and posts are fixed. Steel is also used in the piping of a one-story building and in floors and ceilings in buildings with two or more floors.

**STEP-4. CONSTRUCTION OF WALLS ON ALL SIDES**

The last step in building an ILL is building walls. Typically, for a PEB, the walls are constructed with a variety of materials such as granite, fiber cement insulated panels, steel or aluminum insulated panels, conventional bricks, stone cladding, etc., the choice is up to the user. But generally insulated steel panels are chosen because of their structural strength.

**Advantages of Pre-Engineered Building**

Reduced construction time: When the foundation is built on site, the structural elements are manufactured simultaneously in industries. As assembly time is also shorter, it results in quick completion of the structure.

- Less on-site labor: Most of the work on a PEB construction is done in industries, so the on-site labor requirements are comparatively smaller.
- Reduced cost: As ingredients and labor are reduced, the total construction cost is reduced.
- Design Flexibility: Structural steel members are designed in software and machined so that the desired shape can be achieved without any upsetting. Therefore, PEB can be architecturally versatile.
- Possibility of future expansion: since only bolted connections are used, the longitudinal development in a PEB becomes more pronounced
- Low maintenance: Modern steel finishes and coatings will help steel panels to contain corrosion, chemical attack, etc., and steel surfaces can also be easily repaired if damaged.
- Seismic Encounter: The steel superstructure is light and flexible enough to offer greater resistance to seismic waves compared to conventional concrete structures.

**Disadvantages of A PEB Structure**

Susceptible to Corrosion - If not properly maintained, steel structures are vulnerable to corrosion, so special coatings are needed to repel corrosion from steel.

- Low thermal resistivity: steel, as it is steel, is good for keeping up with heat, reducing thermal comfort in the building.
- Low exposure to fire: During a fire, this type of building becomes more susceptible to damage due to its conductivity.

**ERECTION**

Building with steel is thought to be a complicated undertaking, including many different procedures. Structural steel (PEB) components must be installed in a particular order because of safety and logic constraints. However, the sequence of assembly in the congregation is not reflected in the shipment, transit, unloading, and on-site storage. Because of this, steel components are difficult to locate, to sort, and to identify, thus time is wasted. A range of technologies, including radio frequency identification (RFID), mobile computing devices, and wireless technology, may contribute to the efficiency and simplicity of information flow in development projects by providing options for disaggregating and implementing these advances. Automated procedures and the assemblage of several structural foundations are necessary for prefabricated structures. Steel structural components must be placed in a particular sequence owing to safety and assembly concerns.

**Erection Drawings:**
After field assembly teams have received steel assemblies, assembly drawings offer a step-by-step process on how to assemble them. It's really a guide for assembling the puzzle components. Each box delivered to the field is labelled with a delivery component number for easy identification. This specific number is imprinted on the metal set, along with the other well-known design number. The field connections are shown in the assembly drawings.

**CONSTRUCTION OVERVIEW:**
Prior to the arrival of the PEB components, the site and foundations must be prepared. This insert levels the ground and builds the foundation.

- Remove trees, debris and other objects from the construction site.
- Smooth and level the ground where the foundation will be made.
- Build the foundation using recommended materials according to design parameters.

Foundations are installed without issues; trenches are dug into the concrete base. Anchor bolts are used to secure the foundation.

**Anchor bolt adjustment:**
Precise anchor bolt placement is essential to ensure the safety of everyone on board. Anchor bolts should be secured by a jig or some other method so that they stay perfectly vertical and in position while the concrete is being placed. Before pouring the concrete, double-check the locations of the forms and anchor bolts. The steel construction should not begin until after the completion of the concrete work is verified. It's time to get things right before the equipment and personnel cost a fortune.

**Unloading and preparation of assembled parts**
The truck that delivers your construction materials should be able to access the site from the road or from a neighbouring pathway. The access must be examined and arranged in advance of arrival. As soon as the truck is complete, unload the steel components and arrange them into blocks for easy transport. Protect them from the elements. Unloading and setting up the building's steel components in the most convenient places will save assembly time and make the process more efficient.
During unloading, the dowel plates and slabs are protected from harm thanks to locking the columns and beams. During the unloading process, special care must be taken to avoid accidents caused by mishandling the steel and to prevent damage to goods.
Long-term storage of primed components, such as beams, purlins, etc., can lead to pigment fade and paint softening, which will greatly decrease the paint's adherence to the surface. It is critical to gather all of the components in a work order at an angle, allowing trapped water to escape and air circulation for drying. It's inadvisable to keep puddles un columns or beams since they shouldn't collect and stay there.

**Location of Building Parts:**

Everything is in an ideal spot for being put in. Bolts and nuts are strategically positioned in locations where they will be accessible to the components. Depending on the amount of packages being handled, the handles and spacers are often kept next to the side walls, out of the way of other boxes and components. Leaf bundles may be found on each side of the soil and are angled to keep leaves in place during a downpour. Armatures are often unloaded at a corner of a plate or outside the plate at an end of the structure to keep them away from busy areas during construction of steel.

**COMPONENTSERECTION**

The most important components are those that include a rigid frame, columns and beams, eave supports, purlins, beams, flange supports, end wall columns, and bracing systems, among others. Everything needed to build the first ship is in place. When raising a beam, gather its required pieces as near as feasible. In the reinforced bay, the first four columns are lifted, and the location of the anchor bolts is determined. Once the piece is lifted, you'll need to place the crane for the following phase.

**Survey of rigid frames:**
Structures on the main bearing often connect to the outside wall of the inner bearing. The transverse reinforcement is often located in this area. It is critical that the initial span be done well and channelled correctly so that the job may be completed successfully. Although many approaches are used to raise stiff buildings, it has been shown that initially erecting the columns, connecting them with a belt, and tightening the anchor bolts was more gratifying. Columns may be installed without the need of lifting equipment in

short spans and modest overhang heights. Any reinforcing materials placed immediately after the pieces are removed should be left in situ.

**Completion and plumbing of the first span:**
After the initial intermediate or internal frames are installed, all purels, beams and struts are placed in the reinforced compartment and the opening compartment is aligned and latched before continuing. Correctly piped and strengthened, surplus components will be much reduced when fitted.
The floor beams are joined to the columns once they have been elevated. Assembling a beam securely relies on the available equipment and the foreman's previous expertise. The connections are often done on the ground.
To save time, the clamp must be fastened to the beam before it is lifted. You should not remove any lifting equipment from its beam until the structure is strengthened, in which case it will be impossible for the equipment to buckle or tilt in the longitudinal direction of the building. The erection methods used for clear span and multiple span frames are the same.

It is important to stress that constructing too stiff buildings may be dangerous. It is critical that one avoid leaving any stiff, free-end or cantilever frame elements in a locked or locked condition overnight. Due to the wind, this exercise resulted in the complete loss of a considerable quantity of raised steel. The second cautionary note about constructing multi-span frames vs free span frames involves additional attention. Frames that include internal columns because of their tighter brackets have more weighty areas. Light frames are more prone to crack during construction, thus these modules need extra care when they are assembled and moved.

**Assembled on the column end wall:**

A short column or beam wall may be hoisted into place and anchored with bolts to the ground. Everything, from beams and columns to door headers, door jambs, clips, and diagonal rebar, must be raised from the ground with the screws on the left side being tightened. In order to raise the end wall frame, a spacer bar should be used. The frames and beams are similar, so be careful not to bend on the short axis when you set the cable distribution locations and move the frames.

In cases where spans are more than 60 feet, the columns are put up first, followed by the end wall beam. After that, diagonal steel beams, reinforced with steel headers, cross-jamb braces, and reinforcing steel rebar are inserted in between the last column supports. When releasing the lifting lines, the structure must be strengthened or lashed first. The screws should be tightened one last time once the frame is vertical and square.

**Erecting the remaining frames:**
As seen below, the original design had just a few purlins placed in each span, and these were installed between the frames. In order to provide overall stiffness to the frame, use flange gussets at specified places on the purlins. The whole building is closed and sealed up without making any unwanted connections. The remaining strips may be used to attach the beam in each span, allowing for the roof construction to be finished.

**Installation of Bracing:**
Bracing along a diagonal axis is critical in steel structures. They're capable of handling weights like those that are lifted by an overhead crane on the building's top floors. It is often overstressed beyond what is required to support the building while it is being erected. Some tiny structures do not need diagonal reinforcement to ensure stability, therefore the builder must ensure that such reinforcement is included.
To create a "X" shape, build and attach the next clamp to the next column in the same manner. To secure the structure, measure the diagonal cables and adjust the tensioner / eyebolt to equalise the lengths. To get an X-clip on each side, put a bracket on each side of the sidewall. The column anchor bolts should be adjusted when the building is level.
Cable braces are diagonal braces. The construction should be placed as directed in the construction drawings, and it should be tightened so that the structure does not lean or sway in the wind. However, caution must be taken to ensure that the structural components are not over-stiffened or bent. When tightening the clamp, the worker must carefully monitor the structural components. The installation of a wall reinforcement in a structure cannot be done in the given space in cases where there are complicated door layouts. It is generally possible to relocate them without compromising the building's structure.

**Bolting Procedure in steel structures:**
Steel constructions, such as steel building, may be fixed permanently using this technique. To ensure the quality of construction, it is essential that construction plans clearly specify the diameter and thread count of all bolts, nuts, and washers. A “Friction Type” or “Bearing Type” connection should be shown in the drawing. The screw holes' nominal size (with the exception of the base plate's holes) must be 2 mm bigger than the nominal screw diameter, which is 24 mm for the maximum screw diameter, and 3 mm for higher screw diameters.
**Alignment and assembly**
To insert the screw, the individual components will be aligned, enabling a hole the size of the screw's head to pass through. To avoid damaging components or widening the screw holes, alignment should be accomplished in three methods. It will be necessary to provide packaging in order to make sure that the components make complete contact with the mating surfaces. It's important to run the nut through the threads before attaching screws, as this may help avoid thread flaws that will impede the tightening process. After alignment, the screws will be put in the holes with the nuts having easy access to tighten them.

**Screw tightening (comfortable tightening)**
All bearing-type connections and friction-type connections need bolt tightening as a precondition. Tightening the bolt follows a strict pattern that starts with the end of the connection that is the most rigid and progresses to the ends that are free. It is a good idea to tighten reinforced tension bolts when assembling the car to make picking up the vehicle easier, but the bolts should not be tensioned until all are completely tightened. A tight fit is also known as tightening the screws. You may tighten bolts by hitting the nuts with an impact wrench after using a normal force with a Podger wrench or by using a full force with a Podger wrench and exerting one person's strength. Once the standard nut torque is applied, torque it up with a standard or impact wrench.

**Wall insulation**
Fibreglass roof insulation is the primary kind of roof insulation utilised, and this type is exclusive to it. For heating or cooling purposes, insulating blanket insulation should have a vapour barrier that faces the building. Trim the insulation's length by 6 inches or more to make it easier to handle. The wall panel serves as a signpost. To ensure a good seal around the panel's front edge, the initial piece of wall insulation should be positioned to end where the front edge of the panel begins. It supports the insulation in front of the wall panel so that the following insulation blanket may be glued in place.

**RoofIInsulation:**
A built-in 2-foot-long cutting edge is created by pre-cutting the eaves-to-eaves roof insulation. Leave the insulation on the outside wall's sides, while installing the insulation on the purlins with the building's interior vapour barrier. To have a solid, smooth surface, lengthen the insulation. When attaching the roof sheet, double-sided tape or contact adhesives may be used to keep the insulation in place. If using fibreglass, cut it 4 inches from the end, but leave a layer of insulation on the border of the eave trim. Fold the blanket's insulation edge over the edge of the liner to seal it.

**Align The Straps**
Roofs are typically constructed after walls are built. The eaves and joists must be perfectly aligned before beginning the wall construction. The number of components required may be reduced by moving this lock from compartment to compartment. A single blocking line per bay is often enough. Wind also tends to be vertical and straight when bands are employed.

**Screw alignment**
Professional-looking wall panels may be obtained with proper alignment of the particleboard. Pre-drilling holes in the panels at the same spots may be useful. One template panel may be used to punch up to 15 additional panels layered on top of each other. The panel fasteners in a frame are secured with a 1/8" or 5/32" drill bit, while the side clearance holes need a 1/4" drill bit. Removing metal filings is crucial. The steel panel's surface area after piercing to avoid discoloration.

**Installation of wall Panels:**
The overlapping rib on each panel is positioned towards the panel above it. Set the panel on the frame and attach the cover rib with the screws. Make sure your coverage is comprehensive and accurate as needed. Complete the installation by attaching the remaining fasteners.

Fastener Installation:
To ensure proper installation of ceiling panels, it is vital to use the right fasteners. Insert the loop and tighten it tightly before securing the washer in place. Make sure to use neoprene to prevent bras from getting overloaded - this will provide a quick visual assessment for whether the bra is tight. When you install fasteners, use the proper tool for the job. Speed: 1700-2500.

**Preparing the Eave:**

To fix the eaves to the first roof panel, attach the eaves using waterproof tape. Leave the protective paper on until after you've installed the insulation. Use sealant in a straight line with no gaps, and be sure to scrape off any excess sealant from the nozzle before applying it. Then, apply the sealer at the top of the eave, as well as where the final closing will be attached. To avoid having your roof leak, you must put caulk over the closing strip on the roof's seam, sealing it, and cover it with top eave sealer. A caulk is needed to protect against weather if the roof has ice and snow buildup.

**Installation of the first roofpanel:**
To start, prepare the gutters, and then install the first roof panel. The roof panel's ribs fit snuggly into the inner enclosure because of the roof panel's snapping connection to the inner enclosure. Place the middle of the primary rib along the edge of the panel at the edge of the end wall's roof line. You may attach the panel in position and secure it with the correct force on the frame.

**Roof laminate sequence:**
It is suggested to construct the roof of a structure in a single session, finishing both sides of the ridge. The panel ribs will be kept in place on the ridge panel using this method, and the coated insulation will stay put for longer.

**Final installation**
Some people may think that a ceiling with a back panel overlay is a necessary feature, however the overlapping of the panels may retain moisture and may cause warping of the ceiling. The dampness in this atmosphere may, over time, expose steel and iron to corrosion and failure. The manufacturer recommends that the final panel be cut to the appropriate length in the field to ensure that the desired panel width is obtained for the construction to be completed. To ensure that panels are installed properly, panels should have the cut edge on the outside rather than the edge of the flap. It is vital to move the “narrow” panel with caution and ensure that pedestrians avoid it until the last panel is put in place.

**Skylight Installation:**
To install skylight panels, you'll use the same procedure as with a steel panel. Lock installation on skylights should be done carefully to avoid breaking materials. When installing ceiling panels, be sure to use the light transmitting panel. Unless the light transmitting panel is for the lower option, of course. Overlap the panel sides with the sealing tape as normal, and extend it beyond the panel

width. Position the light transmission panel in place by setting the 12" lower steel panel into the space between it and the light transmission panel. Apply a double layer of sealant to the middle and bottom strips. The sealing tape must be aligned with the top flange's leading and trailing edges.

## TESTING OF MATERIAL

NDT is often used to inspect the straightness of welds. Actually, military personnel are found all over the globe in important industrial applications. An capacity to carefully check welds without causing damage is important, since doing so needs a replacement weld that has not been properly tested. Due to this, major technical advances have been made in the area of safe welding testing techniques.

Numerous NDT techniques may be used to assess the welds. The technique employs a broad variety of technologies that starts with basic visual and somatic testing and gradually improves in speed and efficiency. Fluid levels, electromagnetic waves, the acoustic technique, and the radiation waves offer the tools to investigate the welds' interior structures. But some techniques are better than others.

### Nondestructive Testing Methods Used for Welding

To spot internal defects that may cause a weld to fail, the objective of each END technique used for welding is the same. The significance of testing depends on the severity of the fallout from any misfires. Welding tests are only performed on a high level of competence when dropped welding tools are avoided, since they may cause significant harm. Simultaneously, the need for effective testing procedures is there in contemporary industrial society since soldiers are omnipresent.

Non-destructive weld testing, the standard methods of which include liquid penetrants, x-rays, eddy currents, and ultrasonic testing, also involves removing basic sensory testing.

### Liquid Penetrant Testing

Though easy in theory, it is challenging to perform liquid leakage testing successfully. This method tries to send fluid through the test region by isolating it. The solder is protected from the fluid's refusal to flow through it. If the solder breaks or fails, however, the fluid will break with it. The device tells technicians both that a problem exists and where to find it. Even though this technique is successful, the testing sectional areas, transport and fluid content, make it difficult.

### Radiography

X-ray testing is used to analyse the inner structure of welds (and other objects). Internal voids, ruptures, and failures may all be found using this method. Faster than liquid penetration, this method does not need fluid containment. Nonetheless, the radioactivity used in this process is a major concern. Your team deserves loyalty. Employees must always follow strict safety protocols. Workers who are not needed for testing should stay away from the test location during testing. Logistical challenges caused by security concerns greatly impede the X-ray evidence's production.

### Magnetic Particle Testing

Magnetic particle tests are done on the internal structures of magnetic materials, such as carbon steel welds, to investigate how magnetic fields may affect them. The magnetic field travels through the item, noting any irregularities or defects it comes across along the way. However, the ink is not ferromagnetic, so it must be removed before being reinspected. Another surface irregularity may potentially cause inaccuracies. These drawbacks have a strong negative effect on the productivity of magnetic particle testing, which only further solidifies its cost as unaffordable for large-scale testing regimens.

### Eddy Current Testing

A test known as eddy current testing is similar to magnetic particle testing in that it uses electromagnetic to identify flaws in welds. Eddy current testing does not usually need surface preparation, unlike magnetic particle testing. The efficacy of eddy current testing is improved. Unfortunately, eddy current technique is not effective in finding deep surface flaws in bigger welds, therefore a different approach is required.

### Ultrasonic Testing

The instrument can detect this change on the same side of the weld as the wave was injected, which makes the translation of the reflectance possible for the ultrasonic instrument. The other side of the weld is likewise capable of detecting sound waves and analysing their transmittance. An array method called phase scanning can rapidly and effectively scan the interior of a weld. The strong software can rapidly identify and evaluate pictures, which technicians may use to take action.

## PRE ENGINEERED FOR SUCCESS AND SCOPE FOR FUTURE STUDY

### TRACKING GROWTH OFPEB

Until recently, steel structures have been employed primarily for foundations. But today, construction projects use steel structures to provide solutions for various structural requirements because of the impressive levels of speed, economy, safety, strength, and artistry with which infrastructure construction is occurring. India's prefabricated construction (PEB) industry is booming as the country's infrastructure sector booms. The style and life cycle of both PEB and structural steel buildings are impacted by product modernisation and technical development.more than 8.5% of China's GDP “The total market demand is set at 425,000 TPA with a 15 percent yearly growth rate” (Kirby). The present market is valued at about Rs 3.5 billion and is projected to expand at a rate of 10-15% each year."

### Strength Building:

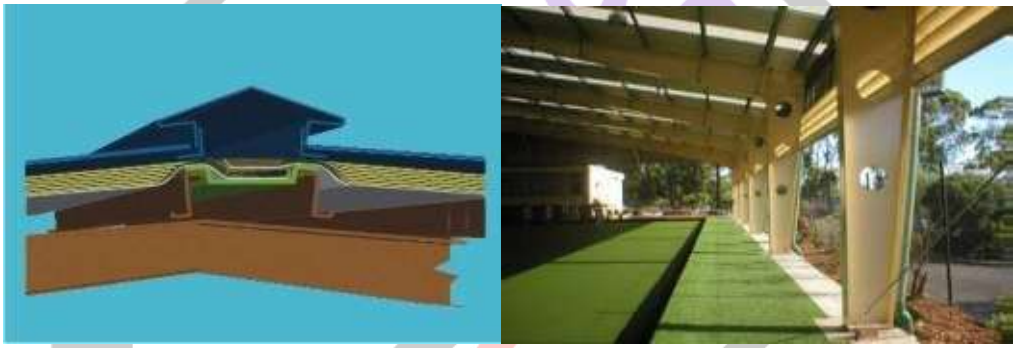
The five-year plan for infrastructure in the nation, which includes the development of airports, subways, and bridges, will give way to sector-specific differences in building materials and construction methods. It includes the aforementioned sectors of design, engineering, manufacture, and construction and erection. This pattern of restructuring reveals an industry in which PEBs are starting to thrive due to an exponential increase in their involvement in many sectors and segments.

**Preferred Alternative:**
In India nowadays, PEB is properly acknowledged as a valuable building method. More benefits are available with steel than with brick and mortar. The global market has an enormous need for steel/steel structures. "Various building sectors, including warehouses, infrastructure, oil and gas refineries, and communal housing, are all believed to benefit from its use" (Kirby).
One of the benefits of using steel over concrete is the durability of the material. The two primary benefits are speed and quality of construction. Steel structures are resistant to fire, earthquakes, and cyclones, thus they are less likely to catch fire, collapse, or blow away, making them long-lasting and safe."

## SCOPE FOR FUTURE STUDY

**Multi-story buildings:**
Multi-story structures in India benefitted from PEB. Patio sheets that are covered in concrete may be used as a tent and stretched to cover an area of over 40 metres. Their Western nation follow-up rate is 80%.
**Glass wool insulation for PEB:**
Thermal and acoustic insulation is a crucial and essential part of the PEB system. Reducing heat gain (or energy loss, for a cooled structure) as well as providing acoustic insulation from outside noise is crucial to offer protection from heavy rain and other weather elements. Typically, the roof of a PEB building contributes 40-50% of the overall heat gain, whereas the walls account for about 15-20% of the heat gain.
All PEB globally are separated due to the following factors.
About 99% of PEBs throughout the globe are insulated for these reasons.

- Minimize heatgain
- Maximize thermalcomfort
- Minimize energy loss, cooling load and operating cost for air conditionedbuildings
- Provide acoustic isolation
- Prevent unwanted moisture condensation



**Honeycomb columns or beams:**
Cellular beams, like solid I-beams, may have the same strength as beams of the same depth, but with much less steel used. This means less weight. Designers may use the variety of beam options to adjust the beam depth and include tapering portions.
**Standard Ridge Roof:**
A standard ridge roof that is particularly used for tarpaulins. The sheets are not perforated or rolled over each other to protect water leakage during rains.

## CONCLUSION

Because steel is so versatile, every item we encounter in our day-to-day existence is either made from steel directly or utilises steel in some other way. Steel is very essential in the building industry. The steel industry will continue to make building projects and the environment better since most of the steel gets recycled. Individual and traditional designs may be achieved using steel structure. The design is not constrained by the requirement for walls to separate supports, because of its strength and wide spans. Over the years, the building may be recycled, re-purposed, and modified to fit your changing requirements. The prefabricated steel construction idea is well adapted to the contemporary engineering sector and has a unique position in the construction industry. This would be the only option for industrial additions that need to be both acoustically and thermally insulated. Steel structures have numerous advantages over other types of construction. One of the most notable advantages is its fast construction.

## REFERENCES:

[1] A explanatory handbook on proposed IS 875 (part3) Wind Loads on Buildings and structures by Department of Civil Engineering IITRoorkee
[2] Design of Steel Structures by R.Sathish Kumar and A.R.Santhakumar
[3] Design Concept of Pre Engineered Building by Syed Firoz, Sarath Chandra kumar, S. kanakambarao International Journal of Engineering Research and Applications, vol2 pp 267- 272.

[4] Design Flexibility of steel by Rajesh Maheshwari, Head Technical Marketing (Coated Steel) at Tata BlueScope SteelLimited.
[5] Pre Engineered Steel Buildings a promising Future by Dr. Abhay Gupta, Vice President (Engineering) Era Building SystemsLtd.
[6] Unicon Pre Engineered Buildingsbrochure
[7] PEB a boon for Building Industry by Steel building systemsIndia.
[8] Fiberglass Wool Isolation for PEB's and SteelRoofs.
[9] Design of Long span structures and Hangars by AmitBharana ERA buildings Ltd.
[10] Pre Engineered for Success: Tracking Growth of PEB Steel buildings inIndia.
[11] Pre Engineered Steel Buildings < The Latest Trend in Building Construction. By K.K. MitraLlyodsIsolationsLimited.12.
[12] Contour the world of steel BuildingsBrochure
[13] PEB VS Conventional the Zamil SteelLimited.
[14] CMAA A Pre Engineered Building ProcessUpdated.
[15] Kit Buildings Manufacturers, Big Country Buildings Pvt.Ltd. Brochure.
[16] Pre Engineered Steel Buildings Section 13121, Bloomington.
[17] PEB Steel Buildings Solutions Product Brochures.