International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

Study and Analysis of Steel, RCC, and Composite Structure Comparison

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Abstract
In India, plain concrete is a common building material, especially for medium- and low-rise buildings. Even while steel is still widely used in high-rise structures and composite construction is less frequent, it's possible that composite construction could prove more beneficial in these projects. Reinforced concrete is often used in construction projects. Steel beams are put into concrete to make reinforced concrete, an efficient composite material. The distinguishing feature of composite construction is the secure joining and bending of two load-bearing structural elements into a single piece. When compared to RCC most steel frames, composite constructions are considered to be some of the least expensive and transient building materials. The main component of a composite construction is an I-section column embedded or encased in building materials, or a tube of steel filled with steel and concrete. Composed of cold steel plates plus mortar, Part I consists of a beam plus a plate for the deck. The beams are connected to the top slab using fire-resistant and robust shear connections.
Keywords— Steel Concrete Composite Building, RCC building, Seismic Analysis etc.

1. Introduction

Plain concrete is a widely used building material in India, particularly for medium- and low-rise structures. Although composite construction is less common and steel is also frequently utilised in high-rise buildings, it is probable that composite construction will be more advantageous in medium- and high-rise buildings.

To maximise the use of steel and concrete and create effective and affordable buildings, steel concrete composite structures can be developed in place of RC structures. The type of material can be chosen to produce the greatest results depending on the characteristics of the building and the materials employed. When two heterogeneous materials are successfully bonded together to act as a single structural element, the result is a composite structure. A novel approach called composite construction is frequently employed to reduce construction costs and expenses.

Steel and concrete are two elements that are frequently and unavoidably utilised in construction, from buildings to bridges, in the modern technological age. Although these materials might have various qualities and traits, they tend to work well together in many ways. Steel has great tensile load resistance but a poor weight-to-strength ratio, therefore thin pieces that are vulnerable to bending are employed. Concrete, on the other hand, has a high resistance to compressive pressures. Concrete can be used for corrosion protection and thermal insulation, whereas steel can be utilised to boost durability, a crucial factor for a tall building. In line with this, the bending of steel in concrete can also be controlled. To have the best of both worlds, composite construction is widely favoured.

A suitable building type must be selected in accordance with the needs of the owner and the construction site. India uses a fairly little amount of steel in building compared to other developing nations. Local and lateral bending is common in steel structural members. The structural components made of concrete are often thicker and less prone to shrinkage over time. Steel can withstand higher shocks and shock loads because it is a tougher material. In doing so, a composite construction using both materials is produced. It has been demonstrated that a structure's response to an earthquake depends on a number of elements, including stiffness, ductility, lateral strength, and straightforward and proper assembly. In order to reach a final comparison decision, it is necessary to evaluate all three building types based on displacement, base movement, floor deflection, and lateral force.

2. Proposed System

In this project, we examine the analytical comparison between a composite structure and a steel RCC. Therefore, we refer to this project as a comparison of a steel RCC and a composite structure. When comparing steel, RCC, and composite buildings, cost is a crucial element. Because when a cheaper alternative is available, expensive projects are frequently overlooked in construction.

What if we discover a building that offers greater strength while costing less? We can evaluate the structure's cost and strength thanks to this comparison.

Saving natural resources is a difficult assignment for a good engineer. Cement's primary components are scarce and extremely expensive. Finding a substitute material with pertinent qualities like strength, cost, and time is therefore crucial. Because the analysis and design are unknown, engineers are also hesitant to accept composite constructions made of steel and concrete. Materials made of structural steel, such as I-profiles, C-profiles, Z-shapes, L-angles, rail profiles, sheets, or plates, are readily available on the market.

Steel offers a composite concrete steel framework that is lightweight. Use of lightweight materials, such as aerated concrete walls, panels, etc., can help minimise the structure's dead weight. if necessary, easily enlarged and rebuilt.

Offers from Steel Structure Construction is quick, materials are strong right away, they are recyclable and biodegradable, and they have a long service life.

In low- and high-rise buildings, this reduces health risks, waste, energy use, emissions, and improves environmental performance.

- **RCC Structures**

"Reinforced cement concrete" is referred to by the term RCC. Concrete responds more appropriately to compression than to anxiety. As a result, steel reinforcing bars are used in conjunction with concrete to increase the tensile resistance capability of the construction. Because steel and concrete have excellent bonding properties, this is the most prevalent notion for building construction and is frequently employed by engineers. RCC is regarded as a superior fabric for construction of structures with lower tops. In India, all design cues for RCC systems are based on the IS:456 Codebook.

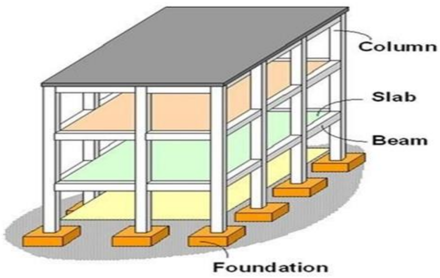

Fig.1.RCC building.

Advantages of RCC structure

1. Compared to other materials used in construction, reinforced concrete has an excessive amount of compressive energy.
2. Because of the reinforcement that has been added, reinforced concrete can also withstand a huge amount of tensile strain.
3. Reinforced concrete is weather and fire resistant.
4. The reinforced concrete construction component is more durable than other building components.
5. Since reinforced concrete is initially a fluid material, it is inexpensive to mould it into a virtually limitless number of shapes.
6. The cost of maintenance for reinforced concrete could be quite low.
7. In buildings such as piers, dams, and footings. The most economically advantageous construction material is reinforced concrete.
8. It exhibits little deflection and behaves like a rigid part.
9. Reinforced concrete is widely used in precast structural components because it can be moulded into any shape that is needed. With the least amount of visible deflection, it produces stiff contributions.
10. For the construction of the structure, reinforced concrete requires less skilled labour than using metal in shape.

Disadvantages of RCC structure

1. Reinforced concrete's tensile strength is around one-tenth that of its compressive strength.
2. Blending, casting, and curing are the three main processes involved in using reinforced concrete. All of this has an impact on the very last steps.
3. The price of the RC casting forms is noticeably greater.
4. RCC column sections are larger than steel segments in multi-story construction because RCC has a lower compressive strength.
5. Shrinkage results in the growth of cracks and a loss of strength.

- **Steel Structures**

It is referred to as "steel structures" when the structural or manufactured metal is employed as a production material for buildings. Unique steel shapes, such as I-section, angle section, channel sections, etc., are employed in steel buildings in accordance with Indian specifications. It is especially helpful in locations that are prone to earthquakes because it is a lightweight material. According to the requirements at the location, the contributors are made inside the factories in unusual shapes and sizes. Additionally, it leads to quicker creation. Industrial sheds and roofs are made of steel structures. But using structural steel as the only material for beams and columns in structures has a number of disadvantages.

Fig 2. Steel Structure

Advantages of Steel structure

1. One of the most adaptable building materials is structural steel. Numerous home, commercial, and company creation packages are compatible with it.
2. Because structural metal is so strong and durable, it is a great material to use for constructing homes and other structures. It is also resistant to earthquakes, wind, and fire.
3. Structural steel is a well-known material for manufacturing projects since it is simple to work with. It may be drilled, reduced, and welded into a variety of shapes and sizes.
4. After its initial usage, structural steel may be recycled or used again, making it environmentally friendly.
5. Because structural steel is a less expensive building material, it is a wise decision for construction projects.

Disadvantages of Steel structure

1. The torsion moment is small.
2. Along with reinforced concrete, it isn't provided or created on the site of the building because it is largely produced inside the manufacturing facility.
3. Corrosion is a significant threat to steel. It needs to be painted with anti-rust paints on a regular basis.
4. Once an incorrect calculation has been made in the layout of a steel structure, it cannot be corrected inside the structure's website. Therefore, 5. Must be duplicated.
6. The heat conductivity is high. Compared to reinforced concrete, it resists fire.

- **Composite Structures**

When a concrete member and a steel component, such as an I-section or steel plate, are combined, the member is referred to as composite. are applied together in a manner that allows them to experience the change of pressures and moments within them, in order to fully exploit the advantages of steel in compression and concrete in tension. This is also reasonably priced. Structural engineers were compelled to carefully consider the issue and offer some better alternatives (such as hybrid use of materials based on one's particular and appropriate hobby and engineering judgement) for the construction of these types of extremely tall buildings in order to improve average performance by making the best changes to manufacturing technology because of failure of many conventional low-rise buildings and multi-storey RCC system.

Fig. 3. Composite structure

Because the best two construction methods existed previously and, needless to say, the decision was frequently made between the two methods—concrete shape or masonry structure. In taller buildings, composite systems are frequently utilised.

Advantages of composite structure

1. Fuel savings result from higher overall performance for a given weight. With composite materials, excellent force-to-weight and stiffness-to-weight ratios can be achieved. Strength divided with the aid of density and stiffness (modulus) divided with the aid of density are two typical ways to describe this. These properties are referred to as "precise" strength and "specific" modulus.
2. Smooth aerodynamic profiles for reducing drag are easier to get. It is possible to produce complicated double-curvature elements with a simple surface end in a single production step.
3. Production expenses are decreased. There are several different ways to make composites.
4. Composites offer excellent resistance to corrosion, chemical assault, and outdoor elements; nevertheless, some chemicals (such as paint stripper) are hazardous for composites, thus new paint and stripper varieties are being developed to solve this. A few thermoplastics are not highly solvent resistant.

Disadvantages of composite structure

1. Composites are more easily damaged than wrought metals because they are more fragile. Cast metals are also frequently fragile.
2. Repair causes new issues for the following reasons: Materials have limited shelf life and require chilled shipping and storage. In many situations, hot curing is crucial and calls for specialised equipment. Both heat and cold cures require time. While the final rivet has been installed, the process is not yet complete.
3. If rivets were utilised and they need to be removed, this poses removal challenges without resulting in more damage.
4. Tooling and strain are required for the specific therapeutic temperature repair.
5. Before recovering composites, they must be completely free of all infection.
6. Prior to restoration, composites need to be dried because all resin matrices and a few fibers absorb moisture.

3. Methodology

3.1. Flow Chart of Project Process

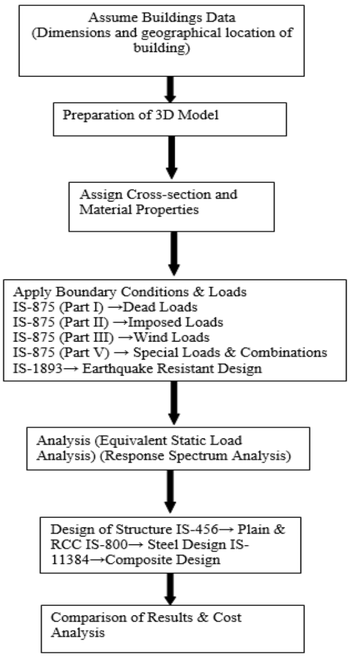

Fig.4. Flow Chart of Project

3.2. Analysis of RCC , Steel and Composite Frames

The current work comprises comparable static load analysis along with the examination of RCC, steel, and composite frameworks. The low-rise building with G+3 was taken into account for the analysis.

The building data detail for these three types of buildings is depicted below:

Table. 1 Building Data For G+3 Building.

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Buildings Dimension in X- Direction	15 m
Buildings Dimension in Y- Direction	13 m
Building Height	12 m
No. Of Story	G+3
Typical Storey Height	3 m
Building Location	Nagpur MH

The following list of material properties considered when analyzing buildings:

Table 2 Material Properties Used

Unit Weight of R.C.C.	25 KN/m³
Unit Weight of Steel	79 KN/m³
Grade Of Concrete	M30
Grade of Reinforcing Steel	HYSD500
Grade Of Structural Steel	Fe 345
Modulus Of Elasticity for R.C.C. (M30)	27.386 KN/m²
Modulus Of Elasticity for Steel	210 KN/m²

After gathering construction data for structures, STAAD uses a variety of modelling methods to create the three-dimensional model. The following illustrates how the building's plan view is shown.

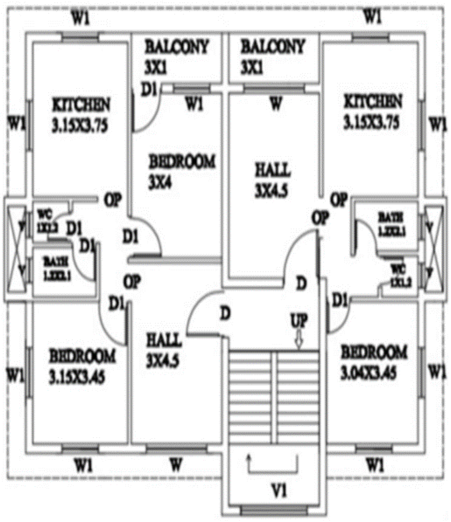

Fig.5. Typical floor plan 1st, 2nd, and 3rd

Table 3. Cross Section Properties Used For G+3 Storey Structure

	CROSS SECTION PROPERTIES		
Member	**RCC**	**Steel**	**Composite**
Beam	350mm x 230mm	ISMB 300	ISMB 300
Column	400mm x 350mm	ISMB 350	I Section 400mmx350mm with
Slab Thickness	150mm	150mm	150mm

The loads taken into consideration in a structure are particularly of two kinds.

1) Basic loads
2) Lateral loads

Basic masses include dead load and live load. While lateral loads are the earthquake loads and wind loads. In this research, seismic load is taken into consideration for region II as in keeping with IS codes, so wind load is taken in step with wind speed 44m/s in that specific location.

The intensities of basic loads and seismic loads parameters are as defined in tables underneath:

Table 4. Basic Loads Considered

Basic loads	
Dead load	self-weight
Flooring + partitions wall +ceiling & load	3KN/m²
Live load	3 KN/m²

Table 5. Seismic Load Parameters Considered

Seismic loads parameters	
Direction	x and y with no eccentricity
Response reduction factor	5
Seismic zone	II
Seismic zone factor	0.24
Site type	II
Importance factor	1

Table 6. Wind Load Parameters Considered

Wind loads parameters		
Wind Speed		44m/s
Terrain Category		3
Structure Class		A
Risk Coefficient (k1 Factor)		1
Topography (k1 Factor)		1

- **RCC Model**

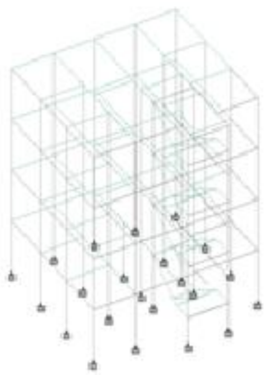

Fig.3.3 Plan on staad

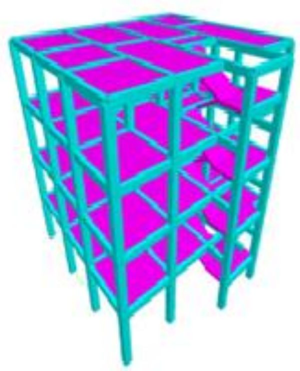

Fig.3.4 Plan with material

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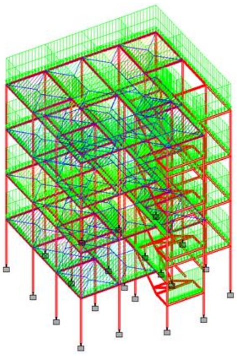

Fig.3.5 Dead load

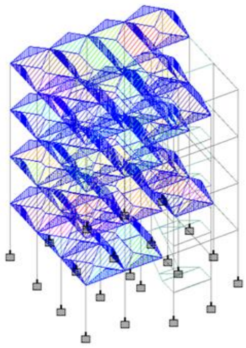

Fig.3.6 Live load

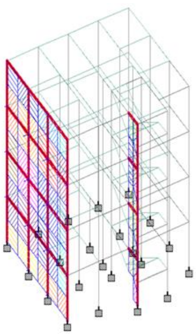

Fig.3.7 Wind load in X direction

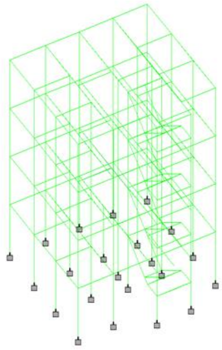

Fig.3.8 Node Displacement

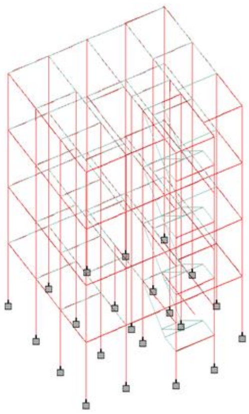

Fig.3.9 Beam end force

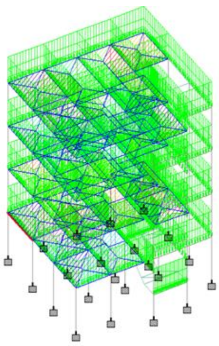

Fig.3.10 Beam Graphs

- **Steel Model**

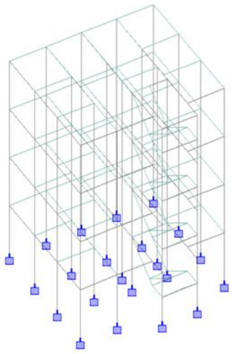

Fig.3.11 Staad model

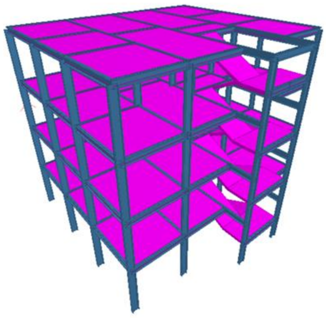

Fig.3.12 Model with property

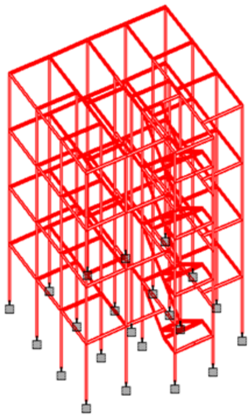

Fig.3.13 Dead load

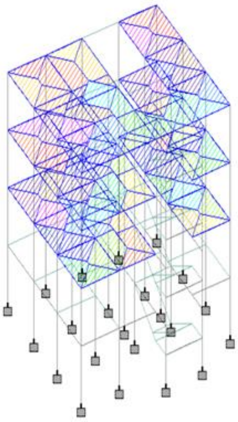

Fig.3.14 Live load

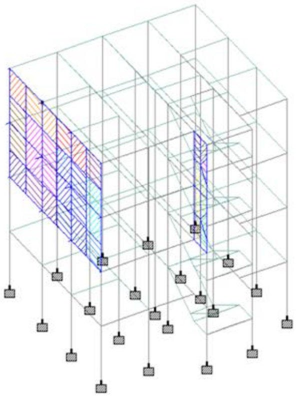

Fig.3.15 Wind load in X direction

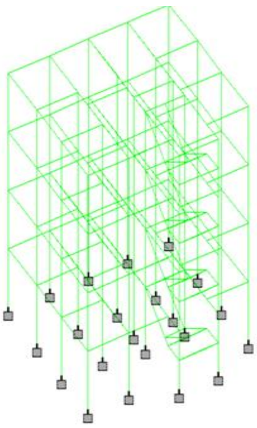

Fig.3.16 Node Displacement

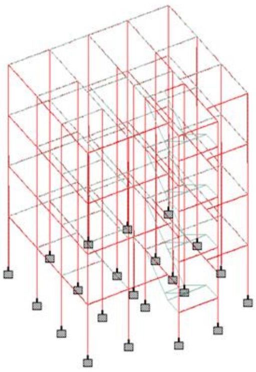

Fig.3.17 Beam end force

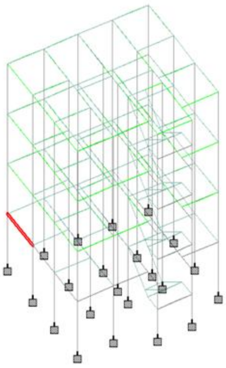

Fig.3.18 Beam Graphs

- **Composite model**

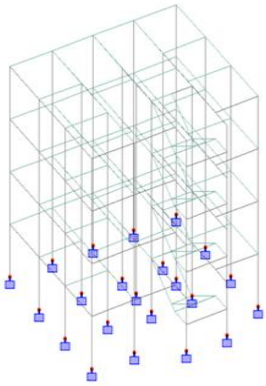

Fig.3.19 Composite model

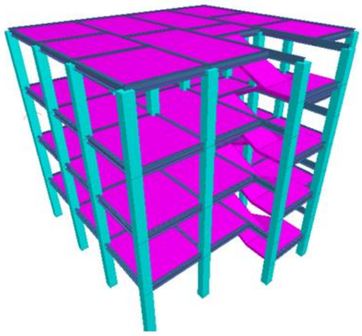

Fig.3.20 Model with property

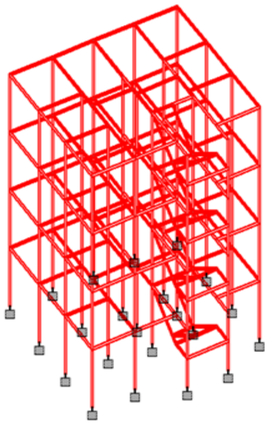

Fig.3.21 Dead load

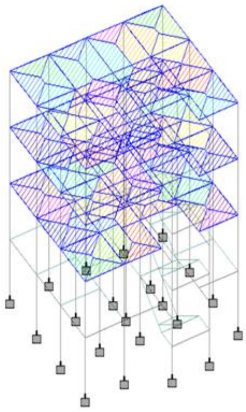

Fig.3.22 Live load

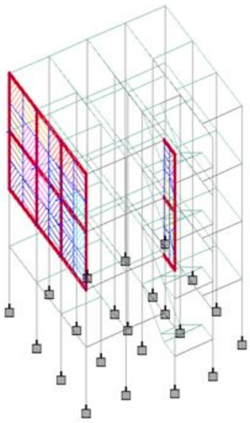

Fig.3.23 Wind load in X direction

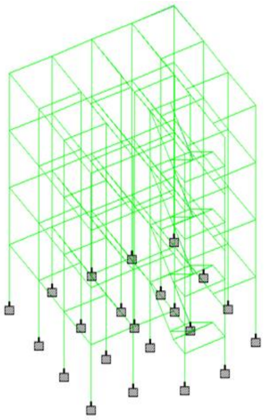

Fig.3.24 Node Displacement

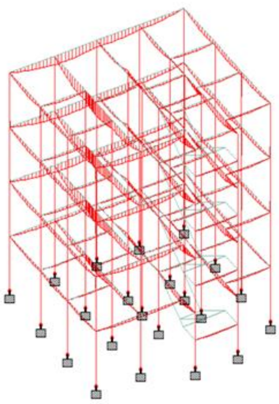

Fig.3.25 Beam end force

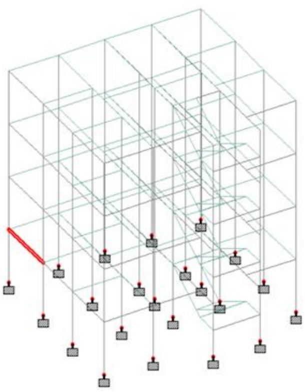

Fig.3.26 Beam Graphs

The results which we get from this research are as follows: -

1. IS 456-2007 is the code used for RCC structures.
2. IS 800-2007 is the code used for steel structures.
3. While building a composite construction, we must apply both IS codes, but we also need to use IS 11384-1985 while creating the composite structure.
4. As indicated in the Chapter methodology, the findings have been analysed for all three structures—RCC, Steel, and Composite—for all types of loadings and loading combinations.
5. The Staad Pro Software was used to construct the geometry for the plan that was created using Auto-CAD and is displayed in the Methodology.
6. Costing, strength, and other factors have been considered in the comparison and time.

7. The suitable design for all type of structure according to need. The suitable way is finalized for the Cost Criteria as well as time Criteria.

4. Conclusion

- In comparison to both steel and composite structures, RCC (Reinforced Cement Concrete) structures are less expensive.
- Steel structures are quicker to build than RCC and composite ones, although they are typically used as temporary structures. So, if we need to build something permanent, a composite structure is better than a steel one.
- If wind load is a big concern in a high-rise building, we won't recommend a steel and RCC construction because the material is best suited for buildings under 15 metres in height. Instead, we'll recommend a steel or composite structure. But because it is so much lighter than RCC and composite structures, it could collapse. Therefore, when their wind load is taken into account, a composite structure for high rise buildings should be suggested.
- RCC structures can be used up to a height of 15 metres and are less expensive than steel and composite structures.
- Steel structures are appropriate for mezzanine floors and warehouses.

The erection of steel structures is quicker, and they are also simple to pull down and reinstall in locations where the other two buildings lack these amenities.

- Composite structures are appropriate for high-rise structures.

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