# Principles and methods of building construction(volume 4)


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**Principles and methods of building construction(4)**

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## Dedicated to my father

**A steadfast mountain and supporter of me throughout my life**

## Dedicated to my mother

**The stone of patience that taught me the alphabet of life**

## Dedicated to my brothers

**Kind companions of my life.**

## Introduction:

For a long time, shelter has played a vital and decisive role in human life and settlement. Due to the extraordinary progress of man in all sciences, the construction industry is no exception to this rule. In order to have strong and safe structures to protect the lives and property of residents, it must be accompanied by up-to-date knowledge to prevent accidents in buildings. Special attention to the principles and methods of building construction from demolition to joinery are basic and very important issues in the construction industry that in this book (Volume 4) I have tried to mention as much as possible, which are:

General principles and methods of construction, execution and reinforcement of various types of steel structures, block work in steel structures, wall posts, types of light structures (LSF) and (CFT) and new systems in the construction of steel structures, composite steel systems and concrete and

industrial structures, all kinds of joints, all kinds of welding and various methods of steel protection. I hope to take a very small step in the development of the construction industry by writing this book.

With respect

Mohammad Tayyebi

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# Chapter 5

# Construction and execution of steel structures

## What is a metal frame?

The metal frame consists of steel, beams and columns. The columns of the steel structure are located vertically and horizontally, and today they cover the bodies of many buildings in the cities of the country. The most basic material used in steel structure is steel, which is currently one of the most important materials in the construction industry.

The use of steel structures in structures and buildings has caused them to benefit from less weight and show more resistance and strength against any impact, pressure and external factors such as earthquakes. Therefore, it can be said that structures with steel structures have more relative balance.

The use of steel structures in structures has a long history. Initially, cast iron was used to make these skeletons. Gradually, cast iron was replaced by low-carbon iron. But over time, the use of steel in the construction of steel structures replaced other materials, so much so that today this structure is also called steel frame.

The best type of joints for steel structures are bolts and nuts, and even in some European countries,

the use of welded joints is not allowed, because welded joints reduce the strength of the structure and the structure is less strong.

## Advantages of using a steel frame

• Steel structure is one of the structures that is considered in different cities, especially large cities, because it can be used in the busiest places.

• The quality of the structure is increased by using steel structure and the amount of material loss is significantly reduced.

• The weight of the steel frame is less compared to the concrete frame, so the weight of the building is reduced by implementing this type of skeleton.

• The properties of this type of skeleton are uniform in all its parts, and due to the close supervision of steel production, we can be sure that its properties are the same in all parts.

• Steel frame buildings will last a long time.

• The speed of execution of steel structure and installation of its parts is higher compared to concrete structure and this structure can be completed in less time.

• The very high strength of steel frame parts has led to its use in high structures and places where the ground is weak.

• The ductility of steel is high and its strength against impact resistance and dynamic forces is excellent.

• One of the prominent features of the steel frame is its retrofitability. For example, if the structure does not have high strength for various reasons, the parts can be strengthened by welding or riveting and new parts can be added.

• Beams and columns of steel frame have a smaller size and volume than concrete frame, so in concrete buildings, the dead space is more than metal structures.

• Using the steel frame can reduce the volume of the foundation.

• The behavior of steel structure against explosion is better compared to concrete structure.

• Structural metal parts can be reused, especially if done with the bolt method.

• Steel has good elasticity and is resistant to high stresses.

• By implementing a metal frame, the substruction of the building can be increased.

• The strength of metal structures against earthquake pressures is high.

• Ductility, welding and flexibility are unique features of steel, so the implementation of steel structures will have more advantages than concrete structures.

• In case of any defect in the metal structure, it can be repaired without any damage.

**Disadvantages of steel frame**

• Steel does not have high resistance to corrosion and rust, so as a result of corrosion of parts may be reduced in size and need maintenance.

• In steel structure, the number of metal parts is large but their dimensions are small, so their tendency to buckle is a major drawback.

• Lack of proper welding of parts and careful supervision of engineers may cause problems with the strength of the structure.

• If the temperature of the steel structure increases to 500 to 600 degrees, the strength and balance of the building will be endangered.

## Metal structural components

## Rebar and its application

Rebar in concrete is very important. Rebar (strip reinforcement) is a steel strip or network of steel wires that is used as a tensile device in reinforced concrete and reinforced masonry structures to reinforce and maintain concrete under pressure. It is generally known as reinforcing steel.

Concrete is strong under compression, but has a weak tensile strength, which significantly increases the tensile strength of the structure. The surface of the rebar is such that it easily engages with the concrete. The most common type of rebar is carbon steel, which usually consists of deformed hot-rolled rods.

Other available types include stainless steel and composite parts made of glass fiber, carbon fiber or basalt fiber. This alternating type is usually more expensive or has less mechanical properties and as a result is often used in special constructions whose physical properties require special performance. (Carbon does not provide it)

In practice, any material with sufficient tensile strength that is significantly compatible with concrete can potentially be used to reinforce

concrete, for example bamboo in areas where steel is not available can be a suitable alternative. Be. Steel and concrete have the same coefficient of thermal expansion, so a structural member of reinforced concrete will experience minimal temperature changes. Due to the great popularity of rebar, it is common to buy rebar in installments.

## Types of rebars mechanically

In terms of mechanical specifications according to the Russian standard, in Iran, there are 4 types of rebars A1, A2, A3, A4, which use the first three types, namely A1, A2, A3 more. In general, rebars are classified based on their tensile strength, which is called the characteristic strength of steel.

## 1.Soft rebar with smooth surface or simple rebar (A1)

These rebars are smooth, simple and without tread, which are characterized by the national standards of Iran S 240. The letter S stands for the simple word in terms of surface shape and the number 240 is the characteristic resistance number of the rebar in megapascals (kg / cm2), which is written after the letter S.

This type of rebar can only be used as a spiral in reinforced concrete structural members or

reinforced concrete buildings, and the use of this type of rebar as thermal rebar or as a structural rebar, except for the cases mentioned above, in All buildings are prohibited. Other categories of rebars are S500, S400, S340, S240.

**Note**: The category of rebars must be included in all technical documents (calculation book, drawings, etc.)

## 2. Semi-rigid rebar with helical ribbed surface (A2)

This type of rebar is usually used to make rectilinear hoop. Their characteristic mark in the national standards of Iran is 340 tread and in terms of surface shape, it has a spiral tread.

## 3.Semi-rigid rebar with ribbed surface (A3)

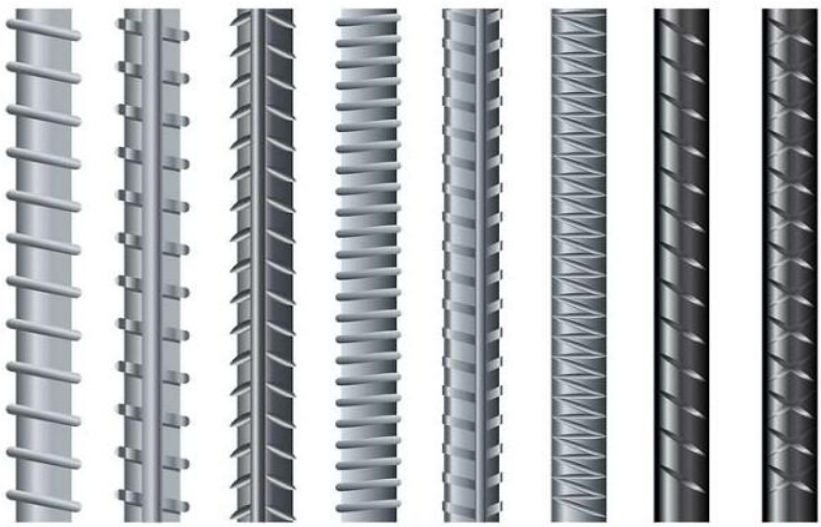
A3 rebars are used as directional rebars for structural components such as beams, columns and.. Their characteristic mark in the national standards of Iran is a 400 tread and in terms of surface shape, they have a gable tread (cross of seven and eight).

## 4. Hard rebar with composite ribbed surface (A4)

These types of rebars have a higher strength than other rebars. Their characteristic mark in the national standards of Iran is 500 tread and in terms of surface shape, it has a composite tread. There were restrictions in the national building regulations for the use of A4 rebars, which in 2014, the National Building Regulations Council approved the use of A4 rebars, except for special shear walls and special bending frames.

## How to distinguish different rebars from each other

Different types of rebars can be identified from their tread. A2 rebars have a single tread in parallel, while the tread on the type A3 rebar is cross-linked (7 and 8).



## Application of different types of rebars in concrete

We have different types of rebars in concrete, each of which we use in a specific place, and each of which has a specific function.

## 1. direction rebar (longitudinal)

As you know, concrete has excellent compressive strength, but its main weakness is low tensile strength, so we use direction (longitudinal) rebars to increase the tensile strength of concrete.

## 2.rectilinear hoop rebar (transverse)

To prevent protrusion of direction (longitudinal) rebars due to buckling, as well as to withstand the

shear force and to prevent the spread of cracks, we use rectilinear hoop or transverse rebars.

## 3.Stirrup rebar

Stirrup rebar is used in wall reinforcement and its task is to place longitudinal or vertical rebars. This type of rebar is similar to the English letter U.


## 4. Vault rebar

It is used in floor and foundation concreting and its task is to place two consecutive horizontal grids (in a row) with a certain distance inside the formwork.

## 5. Adka rebar

We use Adka rebar (Adteka) to withstand negative anchors in the support of single beams and also to withstand shear force. One of the most widely used rebars in the roof is block joists.

## 6. Dragonfly rebar

We use dragonfly rebar to strengthen the shear strength of the rectilinear hoop and also to connect more longitudinal rebars with the rectilinear hoop.

## 7.Composite rebars

Types of steel rebars have many advantages, but when exposed to high humidity, acidic, alkaline, hot and cold environments and the like, they show their weakness.

Researchers have done a lot of research and efforts to solve the problem of corrosion of steel rebars in areas with severe and very severe environmental conditions, which eventually led to the emergence of composite rebars.

Composite rebars are composed of a combination of fibers and a matrix consisting of different resins. The fibers used are carbon, glass and aramid. Also, the resins used in rebars are epoxy, vinyl ester and polyester.

## 8.Epoxy rebar

Epoxy rebars are corrosion resistant rebars and have been replaced by conventional uncoated reinforcing rebars. These rebars have a green appearance and are also known as green rebar.

Epoxy rebars are used to strengthen concrete and protect against corrosion.

Concrete can withstand compressive stresses, but will crack if exposed to high tensile stresses because concrete is brittle. They were able to solve this problem by using steel reinforcements or rebars. Since the rebar is first placed in concrete that is still damp and not completely dry, the possibility of corrosion of the steel rebar is very high. Applying various coatings such as galvanized or epoxy increases the corrosion resistance of the rebar. Epoxy coating prevents oxygen and chlorides from penetrating the steel surface. Epoxy coating is also stable at high pH. Of course, epoxy rebar also has corrosion resistance due to its protective coating against defrosting salts and seawater. Therefore, epoxy rebars can also be used in marine structures.Standard ASTM A775 provides more complete information on epoxy coated steel rebars.

## How to make epoxy rebar

First, the surface of the steel rebar is thoroughly cleaned of contaminants, oils and oxides. It is important to clean the surface of the steel rebar before applying the coating because the presence

of contaminants on the rebar surface makes the epoxy coating not adhere well to the rebar and can be easily removed. In the next step, the clean rebar is heated to 400 to 450 degrees Fahrenheit. It is then placed in an electrostatic spray containing fine epoxy powder. Epoxy powder is absorbed by the rebar through electrostatic force. On the other hand, because the rebar was heated, the powder melted on the surface of the rebar. The molten epoxy powder is crosslinked by chemical reactions to form a thermoset polymer. Thermoset or hard heat polymers have good stability. This method is called fusion-bonded. This method is often used to create epoxy coatings on steel rebars.

The problem with this method is that the coating is non-uniform in thickness. In some parts the coating is thicker and in other parts the coating is thinner. Of course, using the dipping method, a more uniform coating is created, but the coating that is created in the fusion-bonded method is more desirable in terms of adhesion to the steel background.

## Advantages and disadvantages of epoxy steel rebar

Corrosion resistance is the most important advantage of epoxy rebar. Epoxy coating is also a

light and non-toxic coating. The fusion bonded method used to make it is free of harmful substances and does not harm the environment. On the other hand, this coating is economically cheaper than other rebars on the market. These rebars are bendable and in this respect they are better than galvanized rebars. Galvanized rebar is not bendable because the galvanized coating flakes in the area where it is bent. Epoxy rebar can be bent in smooth and wear-free areas. Epoxy rebars are also weldable according to ASTMA706 but should not be preheated.

Epoxy rebar has low resistance to abrasion. Therefore, it needs a lot of care in transportation because any damage makes the rebar vulnerable to corrosion. When using and storing epoxy rebar, care must be taken to avoid friction and contact between the rebars, otherwise wear will occur due to friction between the epoxy coatings, which can lead to damage or even separation of the coating. Epoxy rebar also has little adhesion and bond to concrete.

## Application of epoxy rebar

Epoxy rebar is used in the following structures:

bridges

Parking structures

sea structures

Buildings and structures

Although epoxy rebar has better properties than uncoated rebar, if the coating has holes or cracks, it will cause severe damage to the rebar from the same point. Therefore, it needs a lot of care during transportation, commissioning and storage. Epoxy rebars are banned in some areas, such as Quebec in eastern Canada. Other Canadian provinces and some US states are conducting studies to evaluate their reuse.

## Types of metal structures

Frame steel structure

One of the types of steel structures is frame-shaped structures. Steel frame is a construction technique that uses a steel frame. The skeleton consists of vertical steel columns and I-shaped horizontal beams made of rectangular grids. The work of these rectangular grids will be to support the floors, ceilings and walls, all of which are attached to the frame. In fact, it was the steel frame technique that allowed humans to build the skyscraper, because without this type of structure,

it would be very difficult to build a building of this height.

Rolled steel profiles with intersecting sections of steel columns form the shape of the letter I. Two wide edges in a column are thicker and wider than the edges of a beam. The reason for this is the increase in compressive load tolerance in the structure. Square and tubular steel sections can also be used in frame steel structures. In this case, these sections are filled with concrete.

Steel beams are attached to the columns using screws and bolts. Wide sheets of steel decks can also be used to cover the upper surface of a frame steel structure.

## Applications of frame steel structures

These types of steel structures can be used for high-rise buildings such as multi-storey buildings and skyscrapers, industrial buildings, warehouses, residential buildings and temporary structures.

## Advantages of frame structure

- Very low weight against concrete structures
- More use of the space under the cover and optimal use of materials

- High elastic properties, material cohesion, ductility, easy structural transfer and high installation speed

## Disadvantages of frame structures

- At high temperatures (above 600 ° C) the metal structure of the frame loses its strength and deforms.
- Small parts have been used in the construction of this metal structure and due to the low compressive tension in these structures, the parts tend to buckle.
- Corrosion occurs due to contact of metal structural components with corrosive agents.
- Sometimes, due to the lack of skills of welders on the one hand and the high cost of welding tests on the other hand, the metal structure of the frame does not have a suitable welding frame.

## Shell steel structure

One of the main types of steel structures is shell steel structure. Simply put, a shell steel structure is a structure with a spatial volume such as a sphere or cylinder that is used to build grain depot and fluid storage tanks in factories and so on.

Shell steel structure is a type of metal structure that is known for its special geometric shape. The steel structure is the shell of a three-dimensional rigid body that is thinner than other dimensions. A shell steel structure is necessarily created using two methods.

Advantages of shell structure

- In this type of structure, the weight is significantly low.
- The structure has an eye-catching beauty due to its beautiful design without the need for decoration.
- If the structure is designed and constructed correctly, it will not be damaged by the pressure of the structure.

Disadvantages of shell structure

- Shell metal structures are not resistant to regional bending due to their thin structure.

**Suspended steel structure**

Suspended steel structure is another type of metal structure. Suspended steel structures are structures with horizontal surfaces in which the floors are supported by high-strength parabolic suspended

cables. The strength of a suspended steel structure comes from the shape of strong parabolic cables.

For more efficiency of this type of metal structures, the parabolic form of the species is designed so that its shape is quite close to the exact form of the moment chart. The bent cable is more stable under symmetrical pressure conditions, because the cable has the ability to deform to adjust itself with off-center pressure. This feature in the cable causes secondary pressure on the horizontal surface and further deformation. The reason for the parabolic curvature of the species in the suspended steel structure is the resistance of this structure to off-center or lateral pressures such as wind or vibration pressure and the like.

Application of suspended steel structures

This type of structure uses a variety of metal structures in the construction of bridge decks, suspension bridges and also in the construction of roof structures.

Advantages and disadvantages of suspended structures:

Suspended structures have advantages such as low cost, short execution time and beauty, but due to

the suspended structure, they have a shorter lifespan than concrete structures. They need to be maintained over time, and the joints, especially the traction cable, must be constantly inspected.

## Truss steel structure

Another popular type of metal structure is the truss. To understand the steel structure of a truss, one must first know the truss. Truss is a structure composed of beams and other elements in such a way as to form a lattice structure. In engineering, a truss is a structure consisting of components that create two forces. A two-force component is a structure in which force is applied to only two points. In this type of structure, the components are placed together in such a way that the overall composition acts as a single object.

Trusses usually consist of 5 or more triangular units. These triangles have straight and smooth components whose ends are connected at the joints. These joints are called nodes. In this type of structure, external forces and reactions to these forces are applied only in the area of the joints and lead to the creation of force in the tensile or compressive components.

Advantages and disadvantages of truss structure:

Truss structure can be reused. It has a simple design and does not require special expertise and equipment to run, it can also be used in different situations.

Truss construction speed is slower than other metal structures. They take up a lot of space and must be partially excavated by hand during execution. In the industrial structures section, we fully describe the truss structure.

## Steps of implementation of steel frame foundation

The steps of implementing the steel frame foundation are very precise and each step must be done with great care and accuracy. Because all the weight of the building is divided on the foundation. If for any reason the steel frame foundation is implemented without considering the health standards of the building, the building will face many technical problems and will be dangerous for the occupants of the building. Before implementing the foundation, the soil of that area should be examined and the strength and resistance of the ground to implement the foundation should be ensured. The steps for implementing a steel frame foundation are as follows:

## Step 1: Excavation

The first execution step of a structure is to build its foundation.

Before building the foundation, the foundation plan must be implemented on the ground of the structure with a camera or meter. The land of the place of execution should be free of any plants and roots of plants and the ups and downs should be removed. After leveling the ground at the construction site, we dig the foundation. This depth should be such that the foundation floor is below the freezing depth.

Sometimes, due to the existence of a part of the underground structure, we are forced to dig at a great depth, in which case there is a possibility of wall collapse or emptying under the foundation of the building, to prevent this, the wall must be protected with appropriate shoring equipment.

## Step 2: Execution of megr concrete

The second step in the series of steps of the steel structure foundation is the implementation of megr concrete. As we mentioned in the fourth chapter, megr concrete, like any other type of concrete, is a combination of water, sand and

cement, but it does not have the strength of other concretes and is used only for substructure.

## Step 3:Rebar bimding

Rebar bimding is another step in the implementation of the steel frame foundation, which also has a special sensitivity. Rebar bimding should be placed in the foundation according to the plan and their distance from the concrete is about four centimeters.

## Step 4: Formwork of the steel frame foundation

After rebar binding, the foundation is formed (which is one of the steps in the implementation of the steel frame foundation). The boards used to perform the molding must be sound, flat and without knots, and on the other hand, they must be installed in such a way that excess water can escape from under or around them. The boards must be able to meet the required standards. boards, for example, must be able to hold the concrete formwork in place and protect it from damage and vibration. Formwork boards must be able to protect the concrete formwork from cold and heat and can be removed after drying without damaging the concrete.

## Step 5: Run the BasePlate

The columns of a steel frame building play the role of transmitting the loads applied to the foundation (in the form of compressive, tensile, shear or flexural anchor forces).

In the meantime, the metal column is placed on the foundation with a metal plate that is engaged with the column on one side and concrete on the other. Due to the fact that the metal column can withstand large stresses due to its very high strength and concrete is not able to withstand these stresses; Therefore, the base plate is an intermediary that increases the contact surface of the column with the foundation, causing the distribution of column forces to be tolerable for concrete.

## Base plate bolts

Other components of the base connection of the column are bolts. The connection of the base plate with the concrete is done by the anchor rod. To make the connection, bend the end. In columns that are under pure axial load (compression type), the anchor rod only play a role during the execution of the column and prevent the column from falling.

For example, the diameter of the anchor rod is usually considered to be at least 20 mm (the same as rebar grade 20) and the serrated length of the end of the anchor rod is usually considered to be between 10 and 15 cm, and it depends on the size of forces. It is also recommended that the distance between the center of the anchor rod to the stiffening sheets and the center to the center of the anchor rod be at least 1.5 times the diameter of the anchor rod so that There is enough space to close and adjust the screw.

An important issue in relation to the base plate is the need to use hardeners. If the column, which carries only the axial compressive load, is placed on a low-thickness column plate and no reinforcing sheet is used around it, the column load is spread at an angle to the column plate and moves to the lower side of the plate, and the load It is not distributed all over the surface of the sheet, so parts of the sheet deform and rise around it.

But in conventional designs it is assumed that the base plate sheet is rigid. So this rigidity must be provided somehow. One solution is to increase the thickness of the sheet, which is of course uneconomical and you should look for a way to

use all the available sheet capacity. The use of reinforcement sheets perpendicular to the floor sheet of the column is considered as an economical solution. These reinforcing sheets are usually placed along the sheets forming the cross section of the column and their function is that the axial load of the column starts to spread before reaching the base plate, so that when the load reaches the upper level of the base plate It spreads to a wider area and is less intense. Thus, the compressive stress on the foundation is distributed almost uniformly on the surface of the sheet.

## How to run a base plate

There are two ways to execute a base plate:

Connect the column to the base plate at the factory

In this method, the sheet and the base plate are completely connected to each other by penetration welding. The column with the floor of the column welded to it, is transported from the factory to the site (workshop) and then during the concreting of the foundation, rebars (bolts) are placed in the place of the floor of the columns and concreted and finally, the column set and the column plate are connected to them. The following figure

shows an example of the execution of the base palte with this method.

Connecting the column to the base plate at the workshop: In this method, before concreting the foundation, the base plate with bolts (at least four anchor rod with a diameter of 20 mm in the four corners of the sheet) is fixed in place and then concreting is done. The column is then erected and welded to the column plate.

The important point when installing the column floor, as the pressure distribution plate, is that the end of the column is flat so that all the cross sections of the column sit on the column plate and the power transmission operation is done well.

The following figure shows how the column floor sheet is executed at the execution site.

## Step 6: Execution of concreting

Concreting is almost the last step in the implementation of the steel frame foundation. Concrete should be applied in a coordinated and simultaneous manner. All parts of the reinforcement and foundation must be well covered with concrete. The point to be noted is that before spraying, the concrete must be mixed several times in the mixer truck. Also, the concrete should not be sprayed from a long distance after mixing because there is a possibility of particle separation and damage to the concrete.

For this reason, the concrete must be poured in the desired location by special gutters called shot.

## Step 7: Execution of steel structure

Execution of steel structure is the last step of the implementation of steel structure foundation. The metal structure is done after the execution and completion of the foundation. In the foundation section, the location of the columns is specified, and as soon as the columns are installed, the iron beams are fixed in place and a metal frame is formed. The strength of the steel frame depends primarily on the correct execution of the foundation because it bears the weight of the steel frame and prevents the subsidence of the ground and its consequences by dividing the pressure caused by the steel frame on the ground.

## Types of metal columns

Metal columns are classified into a separate group according to their specific properties.

## Types of metal columns based on cross section

The cross section refers to the geometric shape of the column, which is used in different types and for different applications. Engineers usually choose the cross section of the metal column

according to the amount of load applied by the building.

1.Square column

2. Rectangular column

3. Circular column

4. Column type L.

5. T-type column

6. Type V column

7. Hexagonal column

8. Type Y column