TAMPERE UNIVERSITY OF APPLIED SCIENCES

Evaluation of Iranian Building Codes and Standards Provided for Steel and Concrete Structures in Industrial Buildings in the Case of Making a Contract between Iran and Finland

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Construction Engineering
Building Construction

ABSTRACT

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This research is about the evaluation of standards provided for steel and concrete structures in industrial buildings in the case of making a contract between Iran and Finland. If a contract is made between the two countries, standards are regulated based on the resources existing in the country of destination (country in which the project is conducted) and the country of origin (country which conducts the project) must accept the standards of the country of destination.

In this regard, it is attempted in this project to evaluate the standards of steel and concrete structures in the implementation of industrial buildings which are confirmed in Iran. It should be noted that since the volume of these standards is high, all of them are not included in this research. Some topics of these standards have been selected and introduced.

An important purpose which is pursued in the research is the identification of standards confirmed from Iran to Finland. In this regard, first the steel structures and standards related to it and second the concrete structures and standards related to it are introduced. The fourth chapter summarizes Iranian building codes and standards and introduces the load distribution on buildings, briefly discussing fire protection and fire resistance and climatic issues. The research method is descriptive analysis with a library tool.

Key words: steel structures, concrete structures, Iranian codes, Iranian standards

CONTENTS

1 INTRODUCTION

The purpose of this study is to describe Iranian codes and standards for steel and concrete structures in industrial buildings. This is important when making a contract between Iran and Finland in construction projects. The codes and standards are somewhat different because Iran uses mostly American codes and standards and Finland uses European codes and standards. Also, geographical and climatically different circumstances affect the codes and standards.

The second chapter introduces steel structures in general and the design and foundation for building steel structures. When building foundations several issues have be considered, for example ground water and seismic design.

The third chapter discusses concrete structures in general and the foundation and design for building concrete structure. Also, the effects of an earthquake to concrete structures is discussed.

The fourth chapter discusses Iranian building codes and standards. First the engineering standards for loads are discussed. The environmental loads focus on wind, snow, rain and earthquake loads. Then fire protection and fire resistance are discussed. The last part focuses on corrosion in the climatic circumstances of Iran.

The last chapter is the conclusion. The codes and standards in industrial building are such a vast topic, only a few main issues have been introduced in this study. This study could be helpful in cooperation between Iran and Finland.

2 STEEL STRUCTURES

2.1 Introduction of Steel Structures

This section will try to introduce steel structures. Steel structures are divided into three categories

- Framed structures which are a set of axial, flexural or axial flexural members.
- Shell structures which are storages keeping fluids and gases where the axial force is dominant.
- Suspended structures in which tensile force is dominant.

The purpose of steel structures in civil engineering is usually to have framed structures. The role of the frame in a building is to transfer dead loads and live loads and earthquake and snow charge from a structure to foundation and maintain overall structural stability.

In most cases, rolled profiles are used to build steel structures. If the designed dimensions are other values, the related profile can be provided using plates existing in market. (Article 10 of national regulations 2015.)

2.1.1 Design of Steel Buildings

The selection of the type of section, the method of construction, the method of exploitation and the location of the building create various features and characteristics to build a load-bearing skeleton for a building. Advantages of each structural system and its required materials can be used if characteristics and features of those materials and systems are considered in the designing stage and the designer must correctly judge each one of the materials. This issue is necessary especially in buildings with steel skeletons. Structural criteria in the following have high importance in overall designing and placing pillars:

- Type of section
- Arrangement and method of placing sections
- Anchorage distances
- Size of roof spans
- Type of bracing
- Type of rigid system
- Location of placing rigid system (Interior Spacing System)

2.1.2 Interior Spacing System of Steel Structures

For optimized use of desirable properties of steel buildings, interior spacing system must

- Consist of prefabricated components because more rapid installation and construction of the structure shortens the overall construction time.
- Have lightweight components to minimize overall building weight.
- Have the selected system type to be compatible with the selected system instrument.
- Have fire-resistance with an economic approach.

2.1.3 Interior Spaces of Steel Buildings

Interior spaces of a steel structure usually consist of:

- Ceilings
- Roof
- Exterior walls
- Interior walls
- Walking system (stairs and elevator); by accurate and scientific coordination it is possible to obtain the most economic approach for construction of buildings.

What has been discussed here is a brief description of steel structures, their types and components. Since the relevant standards and principles for steel structures are very detailed, this paper tries to examine the principles of one of the items for industrial buildings.

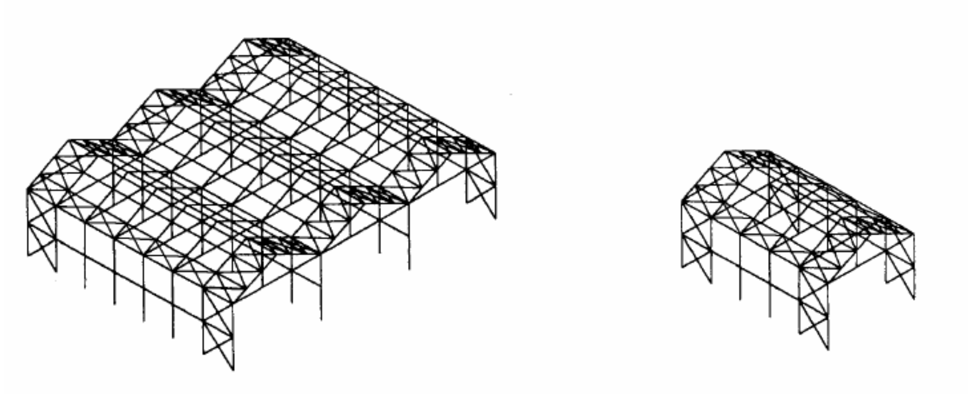
2.1.4 Industrial Buildings

Industrial buildings have various types, for example, one-story buildings with large spans and slope roof that can have overhead or gantry cranes. These buildings, as their name suggests, are used for industrial and productive applications but because such buildings as warehouses, hangars, sports halls and so on have almost the same status in terms of shape and structural system with industrial buildings, the former can be considered in this group as well. The reasons of the similarity of the skeleton of industrial buildings are the common properties from which the most important are

- Due to need for big spaces for exploitation, it is mostly attempted to increase the distance of pillars as much as possible and as a result to reduce their numbers.
- Industrial buildings are often one-story or two-story and rarely built in more than one-story. One-story buildings, in turn, are divided into single-span and multi-spans.

Industrial buildings are classified based on the repeat in compounds of loads determined for various buildings. In fact, this repetition and cycle of the imposed load is considered during exploitation of a building. Usually, assuming a 50-year exploitation period sounds appropriate. (Design and Calculation criteria for Steel Industrial Building 2016.)

a) b)



PICTURE 1. An overview of an industrial building a) with several spans b) with a span (Hamidi & Rahimi Derazkola 2016, 69)

A:

Structural members of buildings in this category during the exploitation period of a building (under the impact of determined loads) will experience a repeat between 500000 and 2000000 or more than 2000000 loading cycles. Designer must analyze the structure by considering position of each one of these loads which is most likely to occur.

B:

Structural members of buildings in this category are under the effect of a repeat over 100000 to 500000 of specified loads during exploitation years of the building.

C:

Structural members of buildings in this category are under the effect of a repeat between 20000 and 100000 periods of determined loads during exploitation years of the building.

D:

Structural members of buildings in this category have the effect of a repeat over 20000 periods of determined loads during exploitation years of the building.

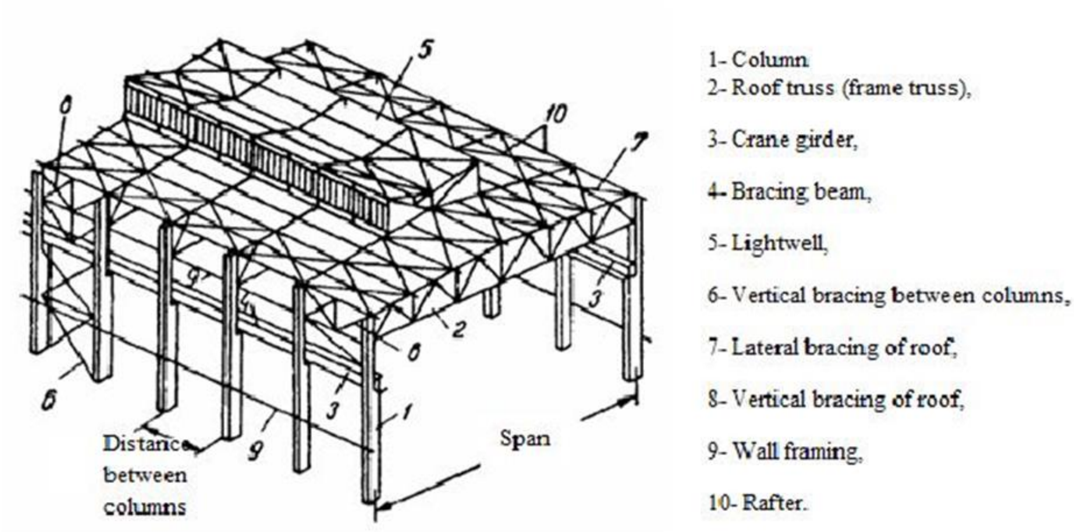
The roof system of these buildings includes a load-bearing structure, structural coating and insulator of moisture and heat. Load-bearing structure of the roof consists of beam or truss in each frame which is in the back of rafters of the roof lining. In the case of using prefabricated slabs with large sizes, it may not be necessary to use load-bearing rafters of the lining and these slabs may be fixed on the main truss or beam. In sloping roofs with a rafter, anchor rods in the middle of the span of the rafters are used to maintain rafters against tangential component with the roof from gravitational force. Roof lining in this mode is usually formed from steel, cement plates or asbestos.

Number of rafters can be reduced, or they can be completely removed in the case of using prefabricated panels.

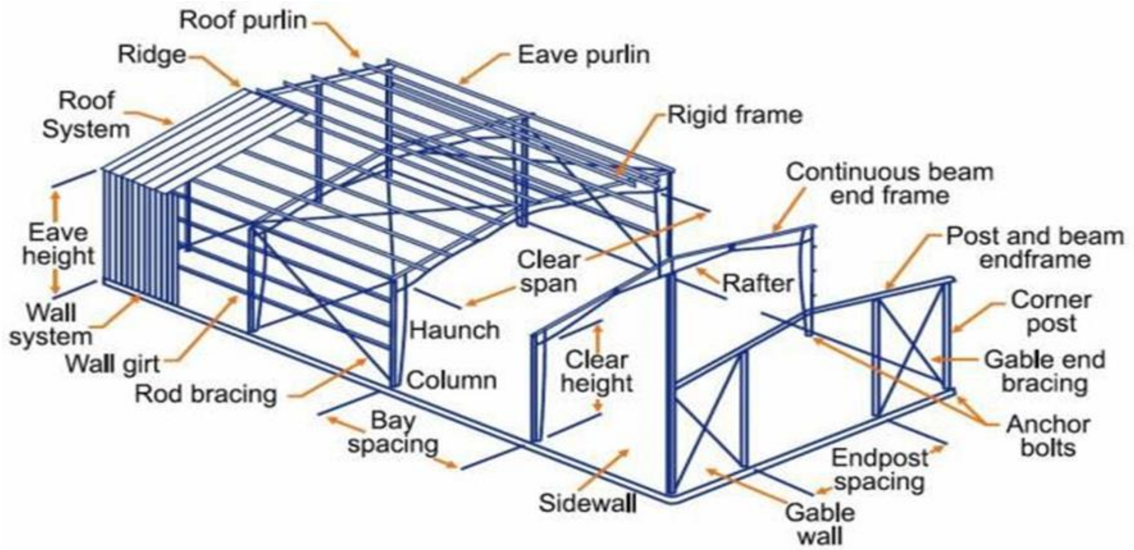
The lining of walls around the building can include steel plates, prefabricated panels or masonry walls. Prefabricated panels generally consist of two layers of metal plate which are connected to each other by an adhesive material of heat insulation. Of course, it is possible to use prefabricated concrete panels as well. Masonry walls can be built using brick, concrete block or clay block. To maintain lateral light lining including steel plates, lateral rafters which are connected to main pillars are used.

Therefore, industrial buildings generally include some large one-story frames of which main load-bearing members consist of some trusses or rigid frames paralleling each other and rafter beams are placed on them in the longitudinal direction and the final lining is placed on the rafter beams (Design and Calculation criteria for Steel Industrial Building 2016).

The main components of framing industrial buildings are shown in the following picture.



PICTURE 2. Main components of framing industrial buildings with rafter roof (Hamidi & Rahimi Derazkola 2016, 71**)**



PICTURE 3. Main components of framing industrial buildings with flat transverse frames (Hamidi & Rahimi Derazkola 2016, 75)

2.2 Some General Points in Analysis and Design of Main Frames of Steel Industrial Buildings

The analysis of the main frames of industrial buildings is like other buildings; it is necessary to pay attention to following points.

Considering the equal conditions of consecutive frames, just one of them can be analyzed in two-dimensional form. In this analysis, frame shift in the direction of perpendicular to the page is ignored. Wind force and gravity forces are calculated based on the surface of the loader of each frame and are included in the analysis. The force caused by earthquake is also divided among frames considering the equal hardness of consecutive frames. Of course, in the case of the presence of a specific condition and inequality of significant number of frames, it is necessary to analyze each type of frame separately and include the effect of difference in the hardness of frames in bearing lateral force in the analysis.

Considering anchoring in a roof and in balance of the load-bearing beam of the crane, usually there is enough three-dimensional rigidity to impose consecutive frames to collaboration of bearing lateral loads and the rigidity can be used to scatter lateral forced caused by the crane.

In modelling the frame for the analysis, it is necessary to pay attention to presence of variable sections. The line passing through the center of the cross section is usually used to form the model. Most of today’s software can accept the variable sections and usually ask the calculating engineer to introduce the degree of function to changes in the moment of inertia of the section to the software. Considering the sever dependency of the moment of inertia to square, the distance between flanges and considering linear changes in the distance between flanges in length of a non-prismatic member, the degree of function of changes in the moment of inertia based on length of the member is usually equal to 2.

It should be noted that the load of the crane is not included in calculating the horizontal force of earthquake if it is suspended by a cable. If the load of the crane is connected to the bridge of the crane by a mechanism which can transfer the horizontal shearing, then the effect of the horizontal acceleration of the earthquake on the load of the crane must be included in calculations of the structure. If required to impose the vertical acceleration in calculations of the structure, the load mass of the crane must be considered as well. Coefficiency of the load in the load compounds is determined by the used regulation.

In terms of buckling out of the flexural frame plate, usually considering common roof bracing the following assumptions can be used:

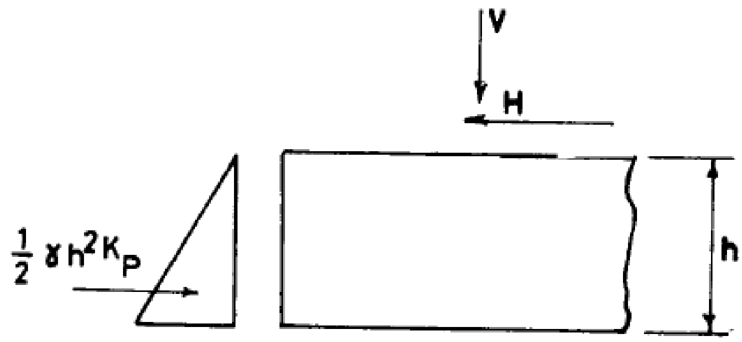
A. It is assumed that the pillar of the frame in supporting points on the foundation, connection to the beam of the frame and the seat of the crane beam are braced against the lateral movement.

B. Compression flange of the frame beam has the tendency of buckling out of the frame plate. In the positive anchor in which the upper flange is compressed, rafters connecting to the flange prevent it from its buckling and the unbraced length of the upper compression flange can be known equal to the distance between the rafters. In the negative anchor which is near to the connection area of the beam and pillar, the lower flange is also placed under the compression and has the tendency to lateral buckling. In these points as well, rafters are used to prevent the lateral buckling of the lower flange of the frame beam. In this method, the lower flange of the beam is connected to rafters by bracing with an angle approximately 45 degrees in the vertical plate. In this mode, the unbraced length of the lower flange can be assumed equal to the distance between the braces of the flange.

2.3 Foundations

The inclined frames of the foundation have a special importance because foundations are usually thrusted horizontally while their vertical load is not too big. For example, a significant force is horizontally imposed to a foundation for single-span frames with short height and low-sloped roof.

The required predictions should be made to prevent thrust in the base of the frame and foundation. In some cases, this thrust can be prevented by placing steel elastics that are buried in concrete or usual building ties. Experiences have shown that in practice this type of measurements are either very expensive or useless when run. Using the passive compression of soil can be effective in these cases without imposing extra costs.



PICTURE 4. Passive source (Amiridalooi; Orangi & Ghaderi 2016, 94)

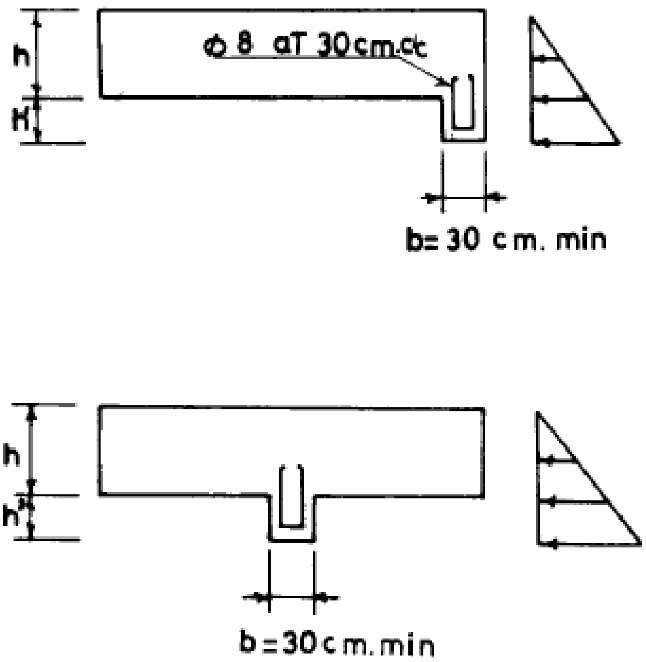
2.3.1 Foundation Classification

Foundations for plant, equipment, structures and buildings are broadly classified as follows:

- Shallow foundations which consists of pad foundations, strip foundations, raft (mat) foundations, etc.
- Deep foundations which consist of deep pad or strip foundation, basement or hollow boxes, caissons, cylinders and piers, piles, peripheral walls or combination of them.
- Storage tank foundations which consist of tank pads, ring walls, etc., - Foundations for machinery.

In the case of fine soils, if concreting is made connecting to the excavation, surface can withstand the imposed force. So, it should be noted that in fine soils wooden framing and separating the concrete from the soil must be avoided; and in soils in which we are forced to framing because of downfall, after getting the concrete and removing the frames must be filled and pummeled with fine soil and appropriate methods to a suitable distance from the foundation which is up to the opinion of a calculating engineer. In addition to the lean concrete width to the edge of the foundation, which is given in most structural maps, in addition to increasing the volume of excavation, eliminates the connection of the soil and the foundation.

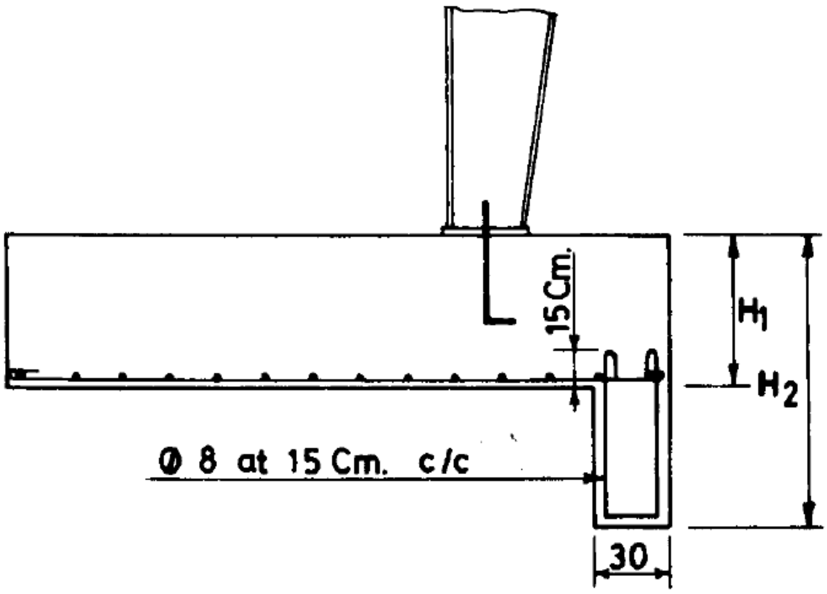
Using a shear lug under the foundation is very effective. Cost of the shear lug is much lower than a transverse tie which is placed among the foundation, but its performance is efficient. Length of the shear lug can be equal to width of the foundation and its concreting can be done at the same time with foundation and if the width of its section is considered more, even placing shear bars can be ignored.



PICTURE 5. Using shear lug under the foundation (Saberi & Parvizi 2007, 52)

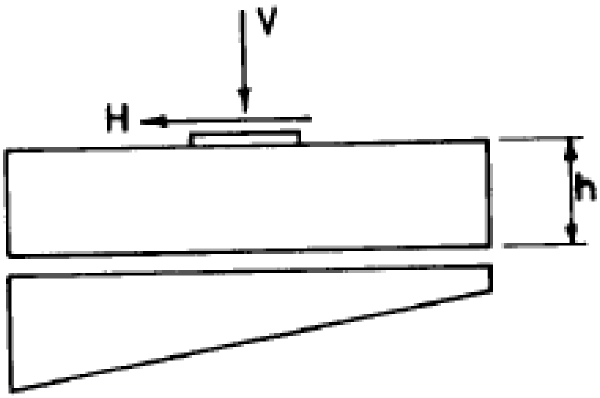
It will be better if the shear lug is in the interior part of the foundation (into span of the frame) so that when the horizontal force affects it, it is to be placed in the tension part not compression and the level of the shear contact of the soil is increased too.

It should be noted that in the case of using passive compression in calculating foundation, soil must not separate from the foundation for any reason. A sample of the practical design of the shear lug stud in the edge of the foundation is shown in the following next picture.

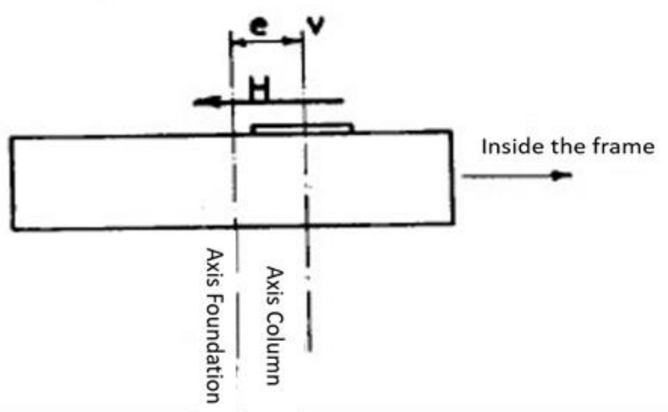


PICTURE 6. Shear lug stud in the edge of the foundation (Sehhat & Shervanitabar 2016, 68)

It should be noted that if excavation is made in the fine soil, framing must not be made. If excavation is made in the loose soil, the behind of the foundation must be pummeled with fine soil. Another issue that, especially in inclined frames, is notable is the vertical resistance of soil under foundation against horizontal and vertical loads. (Article 11 of national regulations 2015.)



PICTRURE 7. Horizontal and vertical loads (Hosseinpour & Javaheritafti 2016, 88)



PICTURE 8. Shifting the column to outer side of the heart (Hosseinpour &Javaheritafti 2016, 89)

However, the effect of wind and earthquake forces in combination with various loadings on such foundation must be evaluated, experiences have shown that such combinations will not be critical to loading. Another issue that should be noted in foundations is the existence of concrete pedestals. Shortness and obesity of these type of members usually make them to be considered as a rigid piece for the pedestal of the frame; and in calculating foundation the forces usually should be known affecting the head of the concrete pedestal. This makes the horizontal force to have a very high effect in calculating the foundation because the value is significantly increased. In this mode, lateral forces caused by the performance of the crane, wind and earthquake are not negligible in determining dimensions and placing steel in the foundation.

What was stated above is related to surface foundations, in the case of weakness of the soil under the foundation or magnitude of the forces imposed from building to foundation, it is necessary to use deep foundations (pile).

2.3.2 Site Investigation

Site investigation consists of an assessment of suitability of the site as well as ground explorations and tests. It may range in scope from a simple examination of the surface soils, with or without trial pits, to a detailed study of the soil and ground water conditions to a considerable depth below the surface by means of boreholes and in-situ laboratory tests. For more detailed information see Code of practice for ground investigations (BS 5930).

For a detailed study, the following information should be obtained:

a) The general topography of the site as it affects foundation design and construction. e.g. surface configuration, adjacent property, the presence of watercourses, ponds, qanats, hedges, trees, rock outcrops, etc.

b) The location of buried services such as electric power and telephone cables, water mains, and sewers.

c) The general geology of the area with particular reference to the main geological formations underlying the site.

d) The previous history and use of the site including information on any defects or failures of existing or former buildings attributable to foundation conditions.

e) Any special features such as the possibility of earthquakes or climatic factors such as flooding, seasonal swelling and shrinkage, permafrost, or soil erosion.

f) The availability and quality of local construction materials such as concrete aggregates, building and road stone, and water for constructional purposes.

2.3.3 Ground Exploration and Tests

Ground exploration should be performed to ascertain the character and variability of the strata underlying the site of the proposed structure. Ground investigations should be carried out generally in accordance with the electrical area classification and extent (IPS-E-CE-110). For additional information refer to Code of practice for foundations clause 2.2 (BS 8004).

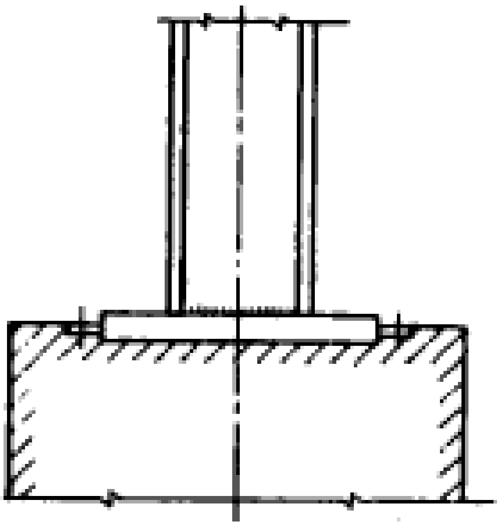
2.3.4 Ground Water

In the design of foundations, the effect of groundwater should always be carefully considered. Substructures should be designed to be stable with any groundwater level that is likely to occur. For more detailed information see BS 5930.

2.3.5 Base of Columns

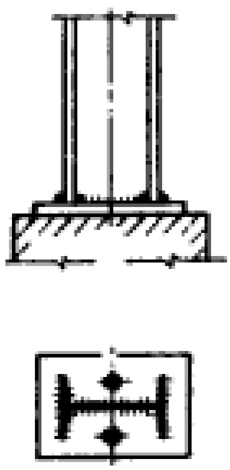
To connect the column to foundation and to distribute its focused force on the foundation surface so that stress in the supporting area does not exceed a certain amount, the lower ends (base) of metal columns are ended up to compression division plates. The main types of support in columns are divided into two types, fixed support and pinned support.

The simplest type of pinned support which is used for columns with great axial force, consists of the division of thick compression on which the end of column is placed.



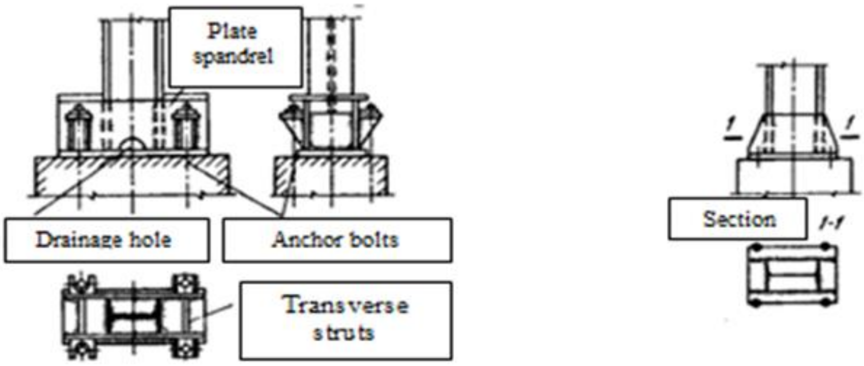
PICTURE 9. Base of column (Hosseinpour & Javaheritafti 2016, 115)

For light columns, the support is designed in a way that all loads in them are transferred to the compression division plate through weld (Design and Calculation criteria for Steel Industrial Building 2016).



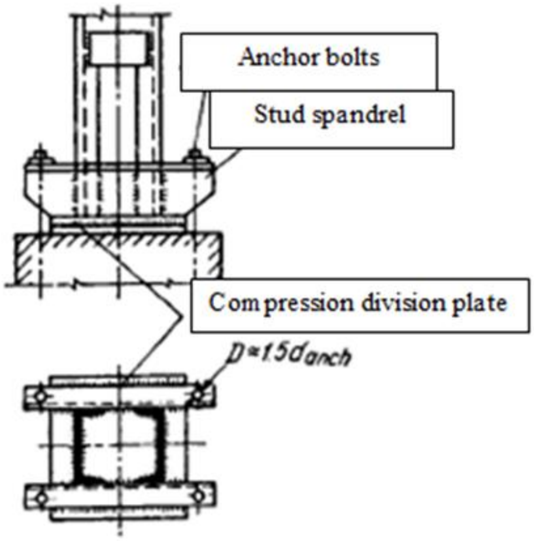
PICTURE 10. Transfer loads through weld (Hosseinpour & Javaheritafti 2016, 117)

If column load and its eccentric is high, connection of column to compression division plate is made using plate pieces or spandrels.



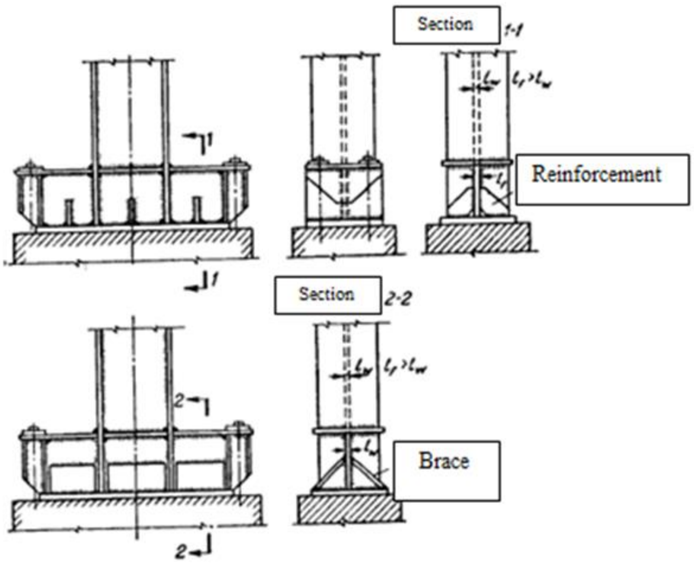
PICTURE 11. Using plate pieces or spandrels (Hosseinpour & Javaheritafti 2016, 120)

If the load and the eccentric is very high, even rolled profiles such as studs can be used to connect column to division plates and for uniform distribution of the load column on the mentioned plate .



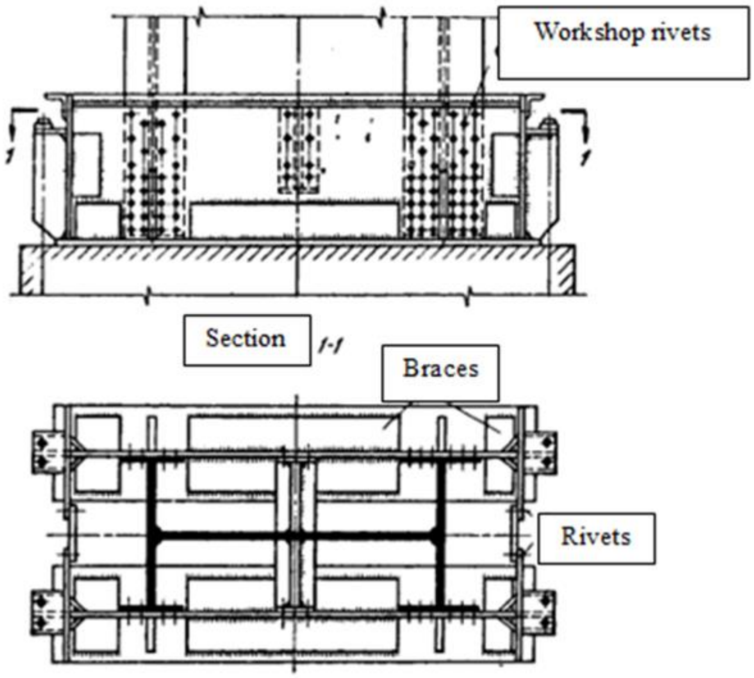
PICTURE 12. Using approximate pieces (Hosseinpour & Javaheritafti 2016, 121)

For easier welding it is better to use pedestals with a web which are reinforced by stiffener or braces. This type of pedestals in vertical direction on the frame plate have low hardness.



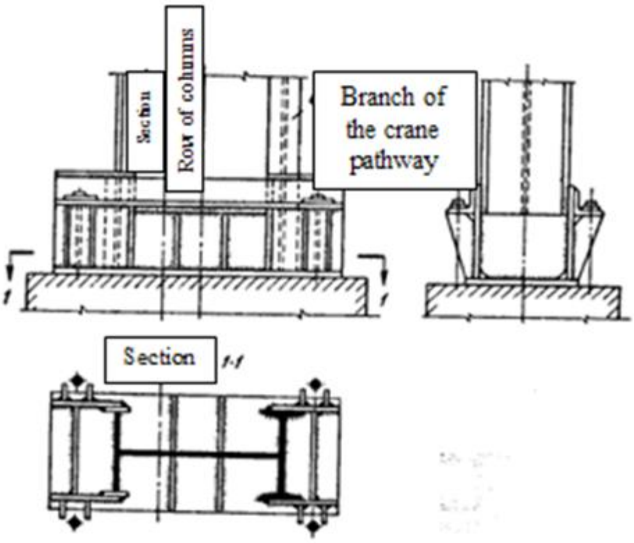
PICTURE 13. Pedestals with open web (Hosseinpour & Javaheritafti 2016, 125)

For heavier columns pedestals with two webs can be used. In this mode, pedestals have large dimensions and due to this they cannot be transferred as a component with the column.



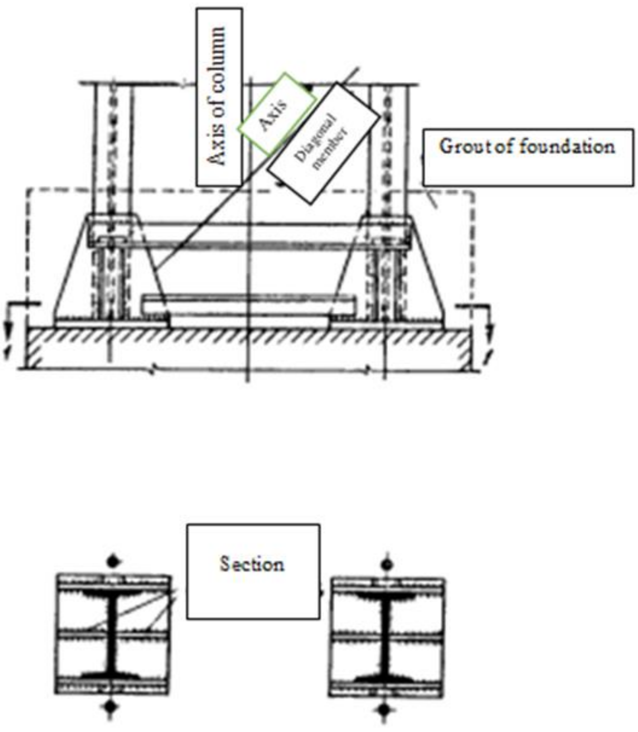
PICTURE 14. Pedestal with two braced webs (Hosseinpour & Javaheritafti 2016, 126)

In integrated columns with a variable section the support shown in the following picture can be used.



PICTURE 15. Pedestal with separated spandrels (Ahadi 2016, 72)

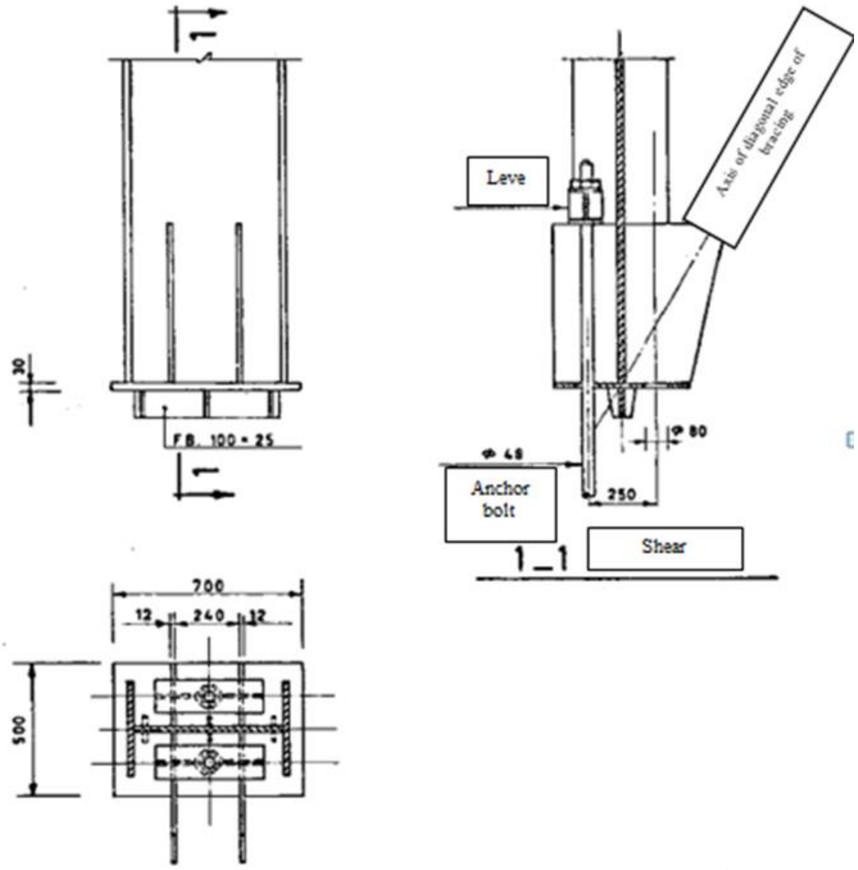
In separated columns (with open web) in industrial buildings, two pedestals separated from each other connected by tensile cornerstone can be used and this is while the distance between two branches of a column of an industrial building is high. This type of pedestal is more economic than the similar integrated type (Design and Calculation criteria for Steel Industrial Building 2016).



PICTURE 16. Pedestal with open web (Ahadi 2016, 75)

2.3.6 Transfer of Shear to Foundation using Tenon

Sometimes due to the high shear force or low axial force of a column, the friction force in the base of the column on a foundation is less than the shear force and cannot withstand it. In this mode according to the following image, a stub is welded under the base of the column that relies on concrete in a relatively wide surface and makes the transfer of the shear force in the base of the column to the foundation possible. This mode mostly happens in the columns of the frames that have been braced and sometimes even their axial force is tensile. In this type of columns, the lower tenon in the base of the column, in addition to the transfer of the shear force to concrete, facilitates working the connecting area of column to foundation in the form of a joint.



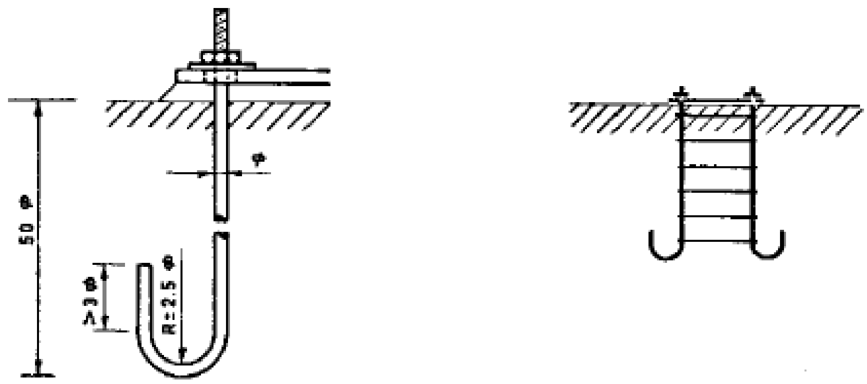
PICTURE 17. Transfer of shear to foundation using tenon (Ahadi 2016, 86)

2.3.7 Determining Length of Anchor Bolts

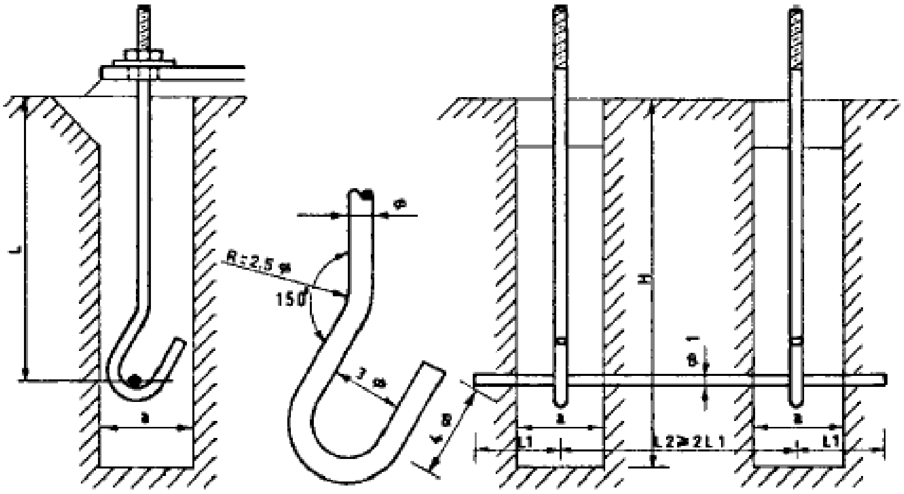
The length of the anchor bolts includes two parts. First part is usually bolted in the length of 10 to 15 centimeters for usual anchor bolts and sometimes up to 30 centimeters for anchor bolts in a large diameter in industrial buildings. This part is left out of the concrete and after regulating the base of the column is fastened on that with bead without mediation of washer.

Second part is placed within the foundation concrete. The length of this part must be in a size that can provide a required brace for transferring the tensile force to the foundation appropriately. The length is dependent on the shape of the anchor bolt and the shape of the anchor bolt depends on the thickness of the foundation, the placing bar of the foundation, the diameter of the anchor bolt.

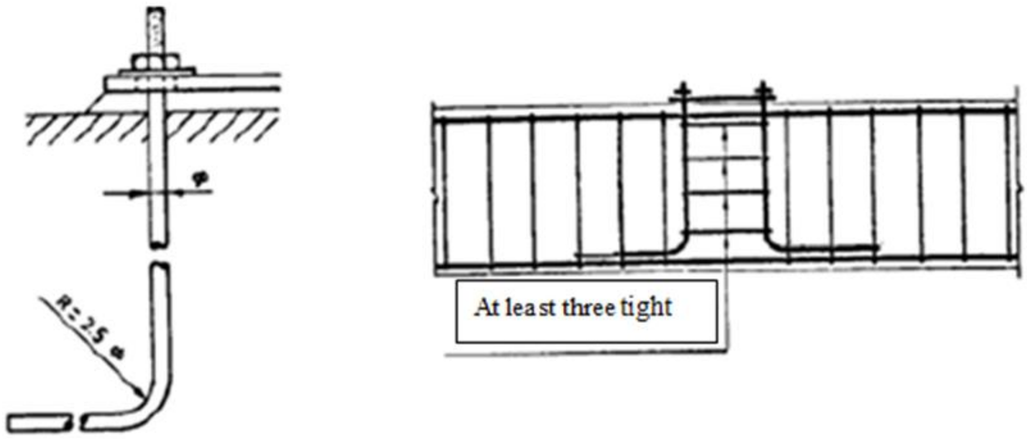
In industrial buildings, depending on the case, the distance between the lower and upper plates of the base of the column or the distance of the upper surface of the foundation to the lever must be added to the above two lengths. Various types of anchor bolts are presented in following images. (Article 11 of National Regulations 2016.)



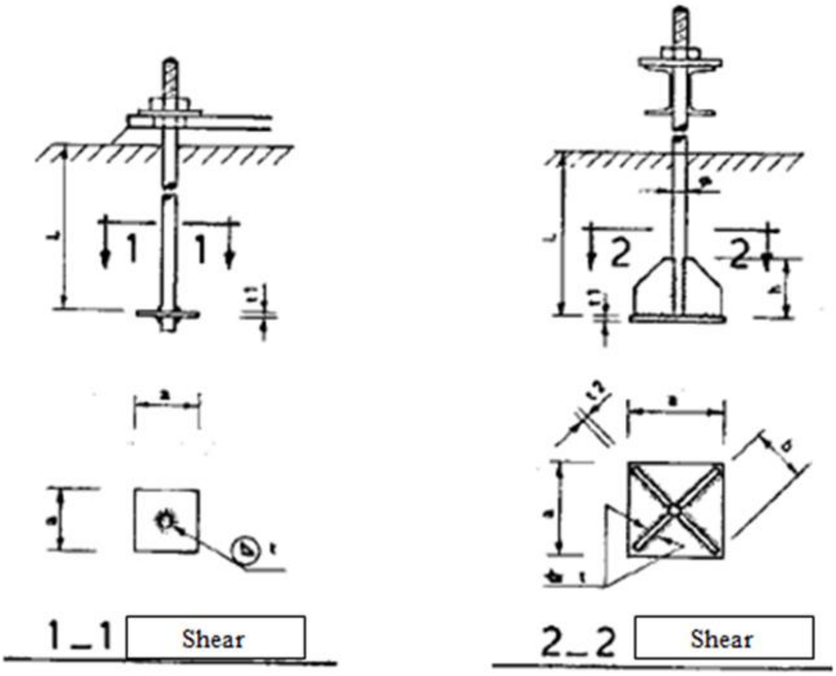
PICTURE 18. Anchor bolt with end hook (Ahadi 2016, 96)



PICTURE 19. Anchor bolt with end hook and shackle (Ahadi 2016, 97)

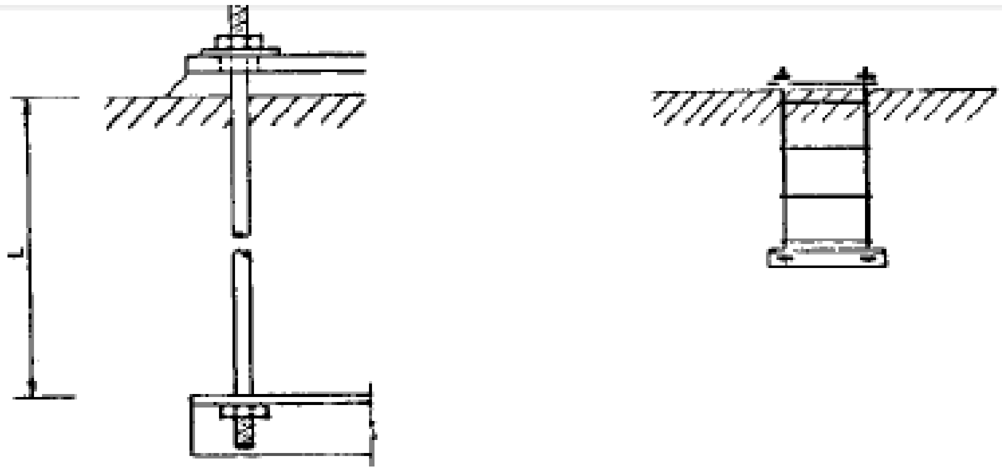


PICTURE 20. Anchor bolt with end hook and shackle (Ahadi 2016, 97)



PICTURE 21. Anchor bolt with end hook and shackle (Ahadi 2016, 98)

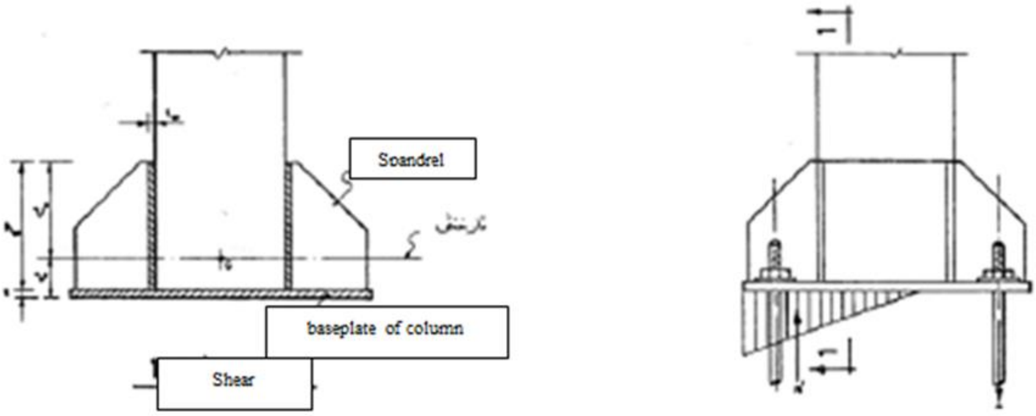
PICTURE 22. Anchor bolt with nut cornerstone (Ahadi 2016, 100)



PICTURE 23. Hack anchor bolt (Ahadi 2016, 99)

2.3.8 Spandrels and Struts

After determining the width, length and thickness of the baseplate of the column, considering the forces imposed on it, the dimensions of the spandrels and structs must be determined. This is made through controlling the stress in the section which passes from the side of the column. The section is under the combined control of the baseplate of the column and spandrels. This sectoin must be calculated and controlled against the combined effect of the flexural moment and shear effort.



PICTURE 24. Spandrels and struts (Design and Calculation Criteria for Steel Industrial building 2016)

2.3.9 Seismic Design Criteria for Steel Structures in Industrial Buildings

The seismic bearing structures are plastic depending on how much they are able to accept extra-elasticity deformations in certain sections of themselves and maintain this feature in reciprocating loadings and to not face significant reduction in resistance and hardness.

The plasticity of the moment frames is usually measured by rotational capacity that they can equip in their nodes. The rotation of a node is defined by the ratio of the relative shift of the upper floor of that node to the height of the floor.

2.3.9.1 Plasticity Limits

In the high plasticity limit, rotation is like the shift of the high floor and a significant part of it is extra-elasticity. In the moment frames, especially included in this category, the amount of rotation is like the rotation relative to the shift of the floor which may be up to 0.04 radian and of that approximately 0.03 radian of which is extra-elasticity.

In the medium plasticity limit, the rotation is like the relative shift of the medium floor so that in the moment frames the amount of rotation of the relative shift of the floor is limited to at least 0.02 radian when its extra-elasticity rotation is approximately 0.01 radian.

In the low elasticity limit, the rotation is like the relative shift of the low floor and the structure practically does not have extra-elasticity deformations.

2.3.9.2 Requirements of Seismic Design for the Base of Column in Metal Structures

Since in this part of the research, the connection of metal structure to foundation is evaluated it is attempted to present requirements of the seismic design of the bases of the columns. The base of all the bearing and non-bearing columns and their connections to column and foundation must separately be able to bear the following forces.

- The most internal forces (including axial force, shear force and flexural moment simultaneously) under the effect of conventional load combinations
- The most axial force (without the presence of shear forces and flexural moment) under the effect of an intensified earthquake load combinations
- In both lengths of the column and separately the flexural moment is equal to total below the flexural moment and without the presence of shear and axial forces.

3 CONCRETE STRUCTURES

In Iranian regulations the basis of designing buildings in concrete structures to obtain safety and exploitation capability is evaluation and control of them in their limit states. The general method for designing is based on probabilistic aspects which are considered in calculation by applying partial factors of safety to specified values of loads and effects on building and specified values of concrete and steel strengths. (ACI 318M "Building Code Requirements for Reinforced Concrete").

3.1 Introduction of Concrete Structures

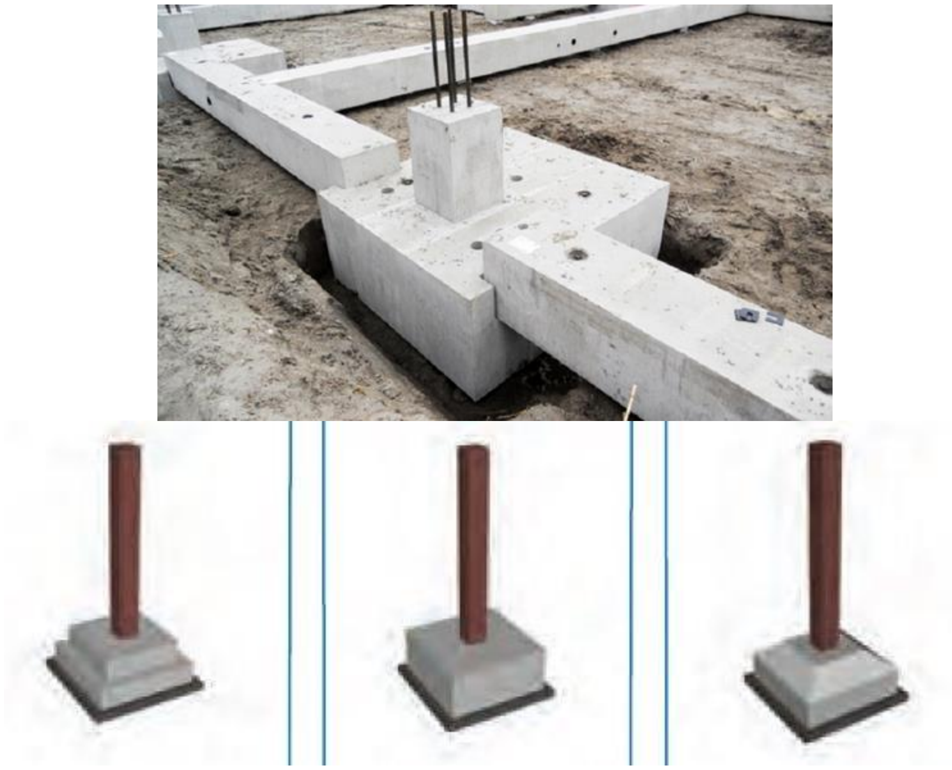
The stability of a building is provided considering their encounter condition with environment through selection of shape of components proportional to this condition, observing executive technical specifications such as quality and minimum amount of cement, quality of water, ratio of water to cement, type and quality of aggregates, maximum amount of harmful materials in materials forming concrete, mixture ratios, condition for pouring and placing concrete, curing and taking care of concrete, covering thickness of concrete and building seams. As it was mentioned in the previous part, since the standard volume of the research is limited so only a part of foundation is presented for evaluation. (Article 9 of National Regulations 2016.)

3.2 Foundation

In the regulation, foundation is referred to as a part of the structure of the building that on the upper surface of that column or wall is placed and its lower space directly relies on the ground or a pile and takes the structure load and transfers it to the ground. Foundation relying on pile is called a pile cap.

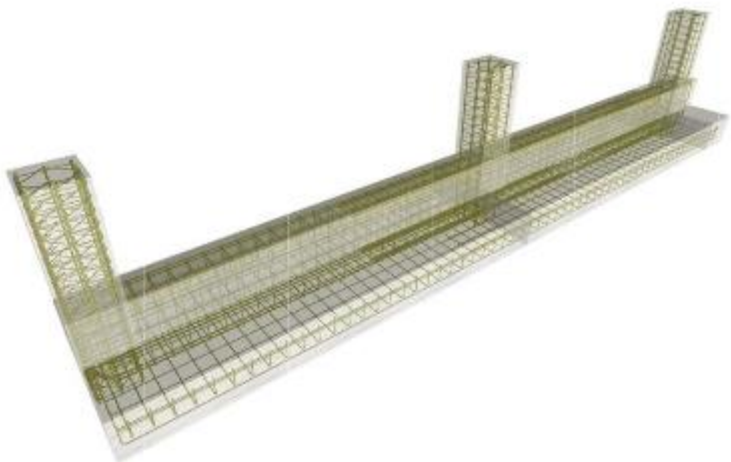
3.3 Types of Foundations

An individual foundation refers to a foundation that transfers the load of one or two columns to the ground in the seam location. Individual foundation can be in the shape of a rectangular square, regular polygon, circle or any other non-regular shape and its section can be in the shape of a rectangular square, trapezius or stairwell. Inidividual foundations which are near to each other can join together and form a combined foundation.



PICTURE 25. Various types of individual foundation schematically (Rahimibirooi et al. 2017)

A Strip foundations refers to a continuous foundation that transfers the load to a wall and with some columns, which are in a row, to the ground. Section of the foundation can be in the shape of a rectangular square, trapezius or reverse T. In a mode in which the strip foundation merely “transfers load of wall to the ground, the foundation is called foundation under wall”.



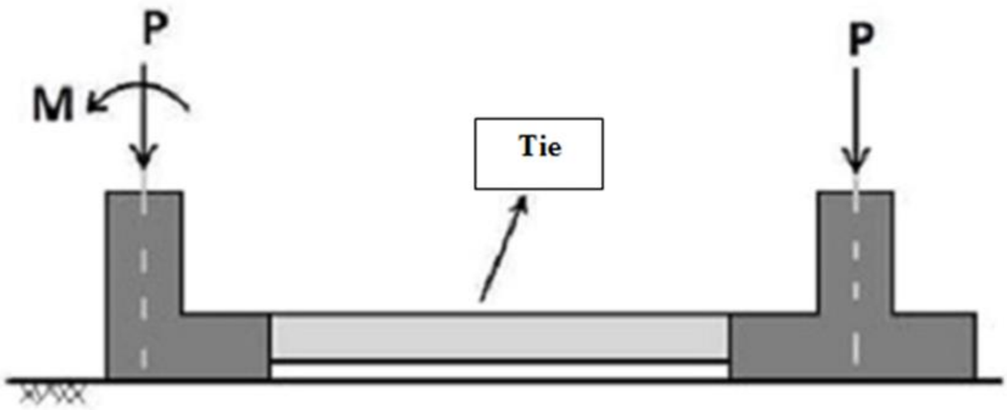
PICTURE 26. Strip foundation schematically (Rahimibirooi et al. 2017)

PICTURE 27. Strip foundation in implementation (Fatehipeykani & Harischian 2016)

A raft foundation refers to a foundation that refers the load of some columns or walls which are in different rows and directions to the ground. Raft foundation mat can be built in the shape of a slab, set of a beam-slab or boxes. (Article 9 of National Regulations 2016.)

PICTURE 28. Raft foundation in implementation (Mortezaei & Fadavi 2016)

A strap foundation refers to a set of two individual foundations that is resultant of loads imposed on one with high eccentric to the center of the foundation and the foundations are connected to each other with a rigid beam. This rigid beam which transfers a part of the load of one of the foundations to another is not assumed to be relied on the soil. (Article 9 of National Regulations 2016.)



PICTURE 29. Strap foundation schematically (Tizfahmfard & Khodayari 2015,77)

3.4 Types of Piles

Piles are components of deep foundation that transfer the loads of the structure to the ground. Piles may be individual or in the form of a group pile. (Instruction of Construction and Implementation of Concrete in Workshop 2006.)

Individual pile refers to a pile which receives the load of a column directly and transfers it to the ground.

Group piles refer to some piles that receive their load from one or some piles through a common pile cap.

- Pile static load tests including axial compression, axial tension, lateral and cyclic loading
- Pile dynamic tests (PDA) and applicable analyses (WEAP, CAPWAP)
- Instrumentation of piles during static tests
- Special loading tests including O-Cell, Rapid Load Tests (RLT) such as STAT-NAMIC
- Pile integrity control tests like CSL and PIT
- Pile design optimization considering the geotechnical conditions, pile group settlement, soil, pile, cap and structure interaction

- “Pile construction specifications” for cast-in-place (bored) and driven piles in various geotechnical and construction conditions

PICTURE 30. Pile design (Pars GeoEnviro 2016)

PICTURE 31. Pile design (Pars GeoEnviro 2016)

PICTURE 32. Pile design (Pars GeoEnviro 2016)

3.5 General Design Criteria

An area of the base of the foundation or number and arrangement of piles must be based on efforts such as the most critical combination of agents without coefficient which are transferred from the foundation to the soil or piles and it must be determined considering the permissible stress of the soil or permissible loads of piles obtained based on studies of soil mechanic.

In cases in which wind or earthquake is one of the agents of the load combinations, the permissible stress of the soil or the permissible load of the pile can be increased up to 33 percent maximally.

The design of the section of the foundation and piles must be made for axial loads, moment, moment and axial loads and shear in the ultimate limit state of strength.

In piles in which their whole length is placed in layers of dense soil, the evaluation of buckle is not necessary but in piles in which the whole or a part of their length is placed in loose or is out of soil, the evaluation of buckle is necessary considering special supporting condition.

The critical sections which must be evaluated for controlling continuity also include those sections in which dimensions of the section or value of reinforcement change. In group piles longitudinal reinforcement of piles must be continued in pile cap and braced appropriately.

The thickness of foundations must not be selected less than 250 millimeter and thickness of pile cap must not be less than 400 mm. (Iran Concrete Regulation 2015.)

3.6 Criteria for Determining Agents in Foundations

Flexural moments and ultimate shear efforts used in designing various sections of foundation must be determined under the effect of ultimate loads and corresponding reactions to them and based on known principles and analysis of structures.

In foundations, instead of using criteria in the above paragraph, flexural moments and ultimate shear efforts in various sections can be obtained approximately from multiplication of values of these agents under the effect of the loads without coefficient in a total safety coefficient of loads. This total safety coefficient must be determined appropriately from division of ultimate loads to exploitation loads.

In foundations on pile, flexural moments and shear efforts in various sections of pile cap can be determined with the assumption that reaction of each pile influences in a focused way in center of that pile.

In foundations, which are placed under column or rear pedestals with circular or regular polygonal sections, for determining position of critical sections in moment and shear the section of column or pedestal can be replaced with a square section with an area equal to the area of the column or pedestal.

Individual foundation, which is built in the form of a slope or stair, must be designed and implemented in a way that function of the foundation is provided uniformly (Instruction for Construction and Implementation of Concrete in Workshop 2006).

3.6.1 Soil Compression Distribution

The soil compression distribution under foundation must be determined considering soil specifications and the way of the effect of the loads on the foundation and based on known principles of soil mechanic.

In individual foundation if the analysis is not made with more accurate details, soil compression distribution can be determined assuming the foundation is rigid.

In an individual foundation the soil compression distribution can be in a way that in a part of that the compression on the soil reaches zero provided that in no direction the length of this part does not exceed a quarter of dimension of the foundation in that direction.

In cases in which forces imposed on foundation are tensile, suitable measures such as using pile or tie bars must be taken to make the foundation not lift off the ground. These measures must be in a way that safety coefficient against lifting forces is 5.1 at least.

In a strap foundation the beam interfacing between foundations must be rigid enough to be able to prevent rotation of the foundation placed under the effect of the eccentric load. If inertial moment is not analyzed more accurately, section of the beam must be considered at least equal to inertial moment of section of the foundation under the effect of the eccentric load. The beam must be designed for moment and shear. In this state soil compression distribution under foundations can be considered uniform. (Iranian Concrete Regulation 2015.)

3.6.2 Flexural Moment

The flexural moment affecting each section of the foundation must be determined by passing a vertical plate through all over the foundation and calculating flexural moments resulted by forces and compressions affecting the whole surfaces of the foundation placed in a side of the plate.

The critical section to determine the maximum flexural moment in foundations beside columns and pedestals and walls must be considered as following:

A. In the side of column, pedestal or wall for foundations placed under column, pedestal or walls.
B. In the middle of distance from edge of the wall to axis of the wall for foundations placed under masonry materials,
C. In the middle of the distance from the side of the column to the edge of the steel baseplate of the column for foundations placed under metal plate of the column.

In individual foundations and those under wall, the possibility to create negative flexural moment and necessity of reinforcement at the top of section of the foundation must be controlled. (Article 9 of National Regulations 2016.)

3.6.3 Shear Effort

The critical section for shear calculations in the distance of d from the following determined locations are considered

A. From the side of the column, pedestal or wall for foundations placed from side of column, pedestal with wall

B. From the middle of the distance from the side of the column to the edge of the steel baseplate of the column for foundations placed from the side of the metal baseplate of the column.

The shear effort in each section of the pile cap must be calculated based on the following criteria:

A. Reaction of each pile with the distance of d/2 or higher than the intended section and placed out of the intended section, makes shear in the section.
B. Reaction of each pile with the distance of d/2 or higher than the intended section and placed within the intended section, makes no shear in the section.
C. In interstitial mode, that part of reaction of the pile that makes shear in the intended section must be calculated by linear interpolation among the absolute value of the reaction for the mode in which center of the pile with distance - and out of the section and zero value for the mode in which center of the pile placed with distance and within the section. (Iranian Concrete Regulation 2015.)

3.7 Restrictions of Reinforcements

In symmetric, spread and strap foundations (except for the interfacing beam) the minimum flexural reinforcement must not be less than the total value of shrinkage and heat reinforcement.

In strip foundation the percentage value of flexural reinforcement must not be less than 15.0 unless the used reinforcement is at least a third higher than the value of the reinforcement determined in calculations. In the last mode, this percentage cannot be less than 1.0.

In foundations the diameter of bars must not be less than 10 mm and their axis-to-axis distance from each other must not be less than 100 mm and higher than 350 mm.
In massive foundations the dimensions and volume of the concrete are considered independent to calculative needs. In these foundations if the control of the surface cracks are considered, volume grid rebar pack must be used. The maximum distance of the volume rebar is 350 mm.

In individual foundations if the function of the foundation is one-sided or its function is two-sided and its shape is square, reinforcements must be distributed uniformly across the width of the foundation. Otherwise, the distribution of the reinforcements must be as following:

A. Longitudinal reinforcements of the foundation are distributed uniformly across the transverse of the foundation.
B. A part of the transverse reinforcements of the foundation, which value is determined by the following equation, is distributed uniformly in the middle strip that in width is equal to smaller dimension of the foundation surface and symmetrically situated to the column and pedestal and the rest of transverse reinforcements are placed uniformly observing the above paragraph in two sides of the middle strip.

Reinforcements of middle strip along the transverse / total transverse reinforcements of foundation = $2/\beta+1$ Transverse reinforcements of piles are considered tight with spiral. (Iranian Concrete Regulation 2015.)

3.8 Earthquake

The seismic risk level of a region is determined by the standard No.2800-05 BHRC-PNS 253. The procedure of the design is in accordance with ACI 318M, Chapter 21 "Special Provisions for Seismic Design".

3.8.1 Definitions

The shrinking components that transfer a part of the inertial force caused by an earthquake within the diaphragm to systems resisting lateral loads.

The executive edge components along the edge of walls or diaphragms are strengthened by longitudinal and transverse reinforcements. These components can have a thickness equal to walls with diaphragms or can be thicker than them. If required, the edge components can also be used in the openings of the edges in walls and diaphragms.

The shell concrete is the concrete of a part of the member section in which the core is situated out of the part enclosed by tie bars.

The base level is a level that the earthquake shakes up to which is transferred from the ground to the building and from that level up the building has its own separate movement to the ground. This level is not necessarily parallel to the ground surface.

A special tight is a closed stirrup consisting of one or some bars that each one then ends to a special hook in two endings. A special tight can be in the form of a spiral and ends in a special hook in the booth endings. (Iranian Concrete Regulation 2016.)

Structural diaphragms are structural components such as slabs of floor roof that make inertial forces caused by earthquake independent against lateral loads.

Structural walls are walls which are designed for resistance against the combined effect of axial forces, flexural moments and shear effort caused by vertical loads of an earth-quake load situated in the middle of their plate. Shear wall is a type of structural wall.

Coupled walls are structural components which consist of two or more individual shear walls which are connected to each other by beams with enough plasticity (coupling beam) with a certain order.

A special hook is a hook with a curve of at least 155 degrees with a straight ending with a length of at least 7 times more than the diameter of the bar and width of 100 mm. This hook must have longitudinal bars and its endings must incline towards the internal part of the stirrup.

A resistant system against lateral loads is a part of the structure which has been calculated for resistance against lateral loads of earthquake.

Plasticity includes the capability of energy depreciation by the inelastic behavior of the whole base structure of its members affected by reciprocating deformations with a large range or important reducing devices in their resistance.

A sewing hook is a bar that in its ending has a hook with the curve angle of at least 135 degrees and with a straight ending part with the length of 8 times more than the diameter of the bar with 100 mm and another ending with a hook with a curve angle of at least 90 degrees and the straight ending part with length of at least 8 times more than the diameter of the bar. These hooks must have longitudinal reinforcements situated in the perimeter of the section of the member. The 90 degrees curve area of hooks must be changed in the alternately in successive sections in length of the member. (Iranian Concrete Regulation 2015.)

Ties are components, usually as the tensile member, transfer inertial forces caused by earthquake and prevent other components of a structure such as the foundations and walls to separate from each other.

The flexural moment of nominal strength is the most flexural moment in a section of flexural members or members under pressure and bending that the member can bear in that section. This moment is considered 15.1 times more than the resistant flexural moment of the section, that is, M, -1, 15 M.

The critical area is an area in which it is possible to create a plastic joint under the effect of the loads of an earthquake.

The core of the compressive member is a part of a cross section of the member surrounded between the back and the back of the surrounding tie bars.

A plastic joint is a part of the member in which plastic rotation is made.

In the analysis of a structure, combined function of all structural and non-structural components that affect its linear and nonlinear reflection must be appropriated for lateral loads.

(Newton per square millimeter) must be appropriated. In addition, the two following criteria must be observed about these steels:

A. The real yield strength of the steel based on test of the factory must not have difference higher than 125 megapascal (Newton per square millimeter) with yield strength of its specification.
B. The ratio of the rupture strength of the steel to yield strength, its specification must not be less than 1.25.

Longitudinal reinforcement in all structures, regardless of their plasticity level, and tie bars must be ribbed (rebar). Welding stirrups and other bars to longitudinal reinforcements must be avoided.

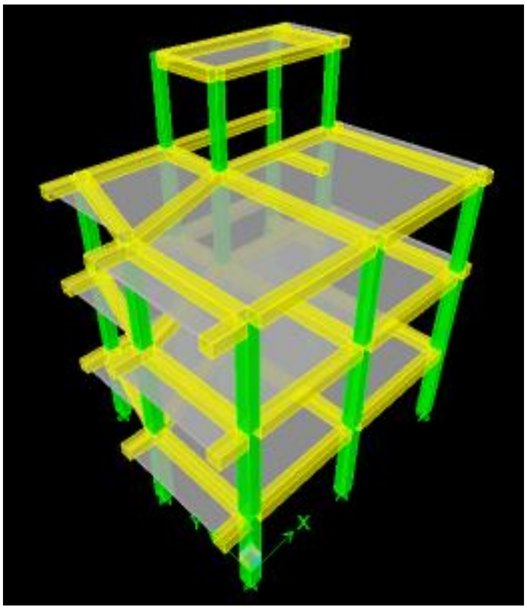
3.8.2 Control of Structure in Limit State of Exploitation

A building as a set consisting of structural and non-structural components must be designed in a way that structural and non-structural component are not damaged as much as possible in limit the state of exploitation under the effect of lateral loads of an earthquake and no limitation happens during the exploitation. For this purpose, usually in buildings, the limitation of lateral shifts caused by an earthquake are to be appropriate for structural and non-structural components and considered enough.

In this research in which industrial buildings are considered since they are important buildings, in addition to limitation of lateral shifts, some measures must be taken to minimize the probability of damages to equipment and machineries. (Instruction of Construction and Implementation of Concrete in Workshop 2016.)

3.8.3 Plasticity Limits of Structure

Strength components must be designed against lateral loads of an earthquake for one of three defined plasticity limits (Article 9 of National Regulations 2016).



PICTURE 33. An overview of the structure of plasticity (National Regulations 2016)

Low plasticity limit is appropriate for structures in which high shift is not expected and only taking certain measures to keep their safety against repetitive and reciprocal loads of an earthquake is considered.

Medium plasticity limit is necessary for structures in which the reflection of the structure facing earthquake forces enters the nonlinear area and the sections of the structure must be designed in a way that adequate safety against fragile ruptures to be provided for them.

High plasticity limit is necessary for structures of which members in certain sections must have high energy depreciation and absorption capacity so that if a mechanism is created in them, total stability and coherence of the structure are maintained, and, in this regard, enough confidence is available.

Structures in which plasticity is provided more considering the more nonlinear behavior and energy absorption capability, less lateral earthquake loads can be designed. Criteria related to the way of reduction of these loads have been determined in the regulation of designing buildings against an earthquake (standard number 2800).

4 IRANIAN BUILDING CODES AND STANDARDS

Introducing regulatory topics of Iranian building. Part of these Codes and Standards can be found on the Internet, and some part should be purchased.

TABLE 1. Discourses of the Iranian national building codes (Iranian National Building Codes 2009)

1	Definitions	11	Prefabricated Construction
2	Administration & Enforcement	12	Precautions During Building Operations
3	Fire Protection	13	Electrical Installations
4	General Building Requirements	14	Air-Conditioning and Heating Installations
5	Building Materials & Products	15	Lifts and Escalators
6	Loads	16	Sanitary Installations
7	Foundation	17	Gas Supply Plumbing
8	Masonry Buildings	18	Acoustics and sound Control
9	Concrete Structures	19	Energy Conservation
10	Steel Structures	20	Signs

Sources of Iranian Building Codes:

- ACI (AMERICAN CONCRETE INSTITUTE)
  318-05 "Building Code Requirements for Structural Concrete"
- API (AMERICAN PETROLEUM INSTITUTE)
  650-05 "Welded Steel Tanks for Oil Storage"
- ASCE (AMERICAN SOCIETY OF CIVIL ENGINEERS) ASCE 7-05 "Minimum Design Loads for Building and other Structures
- IRANIAN NATIONAL BUILDING CODES
  Loads in Buildings Part 6-1385
- BHRC (BUILDING AND HOUSING RESEARCH CENTER)
  BHRC-PNS 253"Iranian Code of Practice for Seismic Resistant Design of Buildings Standard No. 280005 (3rd Edition)
- BSI (BRITISH STANDARDS INSTITUTION)
  6399 Part 2-02 "Code of Practice for Wind Loads"
- IPS (IRANIAN PETROLEUM STANDARDS)
  IPS-E-GN-100 "Engineering Standard for Units"
  IPS-E-CE-200 "Engineering Standard for Concrete Structures"
  IPS-E-CE-500 "Engineering Standard for Loads"
  IPS-E-CE-210 "Engineering Standard for Steel Structures"
- MCA (MANUFACTURING CHEMISTS ASSOCIATION)

Safety Guide, SG-22-1978 "Sitting and Construction of New Control Houses for Chemical Manufacturing Plants"

4.1 Engineering standards for loads in Iran

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies. (Engineering standard for loads, IPS-E-CE-500 2009.)

4.2 Environmental loads

4.2.1 Wind load

For requirements governing the determination of wind loads in the design of buildings and structures, reference is made to the British Standards, BS 6399 part 2 or Iranian National Building code part 6.

For guidance, Table 1. illustrates the velocity and pressure of wind in Iran. (reference: Iranian National Building code part 6.)
For the wind design loads of power plants in Iran, this standard recommends the use of latest statistics gathered by the Iranian Meteorological Bureau, i.e., the Annual Yearbooks, and the Wind Roses.

$$p = I_w q C_e C_g C_p$$

P = External pressure

I_w = Importance factor of wind load

q = Base pressure

C_e = Winding factor

C_g = Factor of wind muzzle

C_p = Factor of external pressure

TABLE 2. Velocity and basic pressure of wind in Iran (Engineering standard for loads, IPS-E-CE-500 2009)

STATION (City) نام ایستگاه (شهر)			VELOCITY OF WIND سرعت باد (V) km/h کیلومتر بر ساعت	BASIC WIND PRESSURE فشار مبناء باد daN/m^2 دکا نیوتن بر مترمربع
1.	Abadan	آبادان	90	40.5
2.	Abadeh	آباده	100	50.0
3.	Abali	آبعلی	110	60.5
4.	ARAK	اراک	90	40.5
5.	ARDABIL	اردبیل	130	84.5
6.	URUMIYEH	ارومیه	90	40.5
7.	Aghajari	آغاجاری	110	60.5
8.	ISFAHAN	اصفهان	110	60.5
9.	Omidiyeh	امیدیه	110	60.5
10.	AHWAZ	اهواز	110	60.5
11.	Iran Shahr	ایرانشهر	110	60.5
12.	Babolsar	بابلسر	100	50.0
13.	Bojnurd	بجنورد	130	84.5
14.	Bam	بم	110	60.5
15.	Bandar Anzali	بندر انزلی	110	60.5
16.	BANDAR ABBAS	بندر عباس	100	50.0
17.	Bandar Langeh	بندر لنگه	90	40.5
18.	BUSHEHR	بوشهر	100	50.0
19.	Birjand	بیرجند	90	40.5
20.	Parsabad Moghan	پارس آباد مغان	100	50.0
21.	TABRIZ	تبریز	110	60.5
22.	Torbat-e-Heydarieh	تربت حیدریه	80	32.0
23.	TEHRAN	تهران	100	50.0
24.	Jask	جاسک	100	50.0
25.	Siri	جزیره سیری	110	60.5
26.	Kish	جزیره کیش	100	50.0
27.	Chabahar	چابهار	90	40.5
28.	KHORAMABAD	خرم آباد	80	32.0
29.	Khoy	خوی	90	40.5
30.	Dezful	دزفول	110	60.5
31.	Ramsar	رامسر	90	40.5
32.	RASHT	رشت	90	40.5
33.	Zabol	زابل	120	72.0
34.	ZAHEDAN	زاهدان	130	84.5
35.	ZANJAN	زنجان	80	32.0
36.	Sabzevar	سبزوار	90	40.5
37.	Serakhs	سرخس	110	60.5
38.	Saqez	سقز	100	50.0
39.	SEMNAN	سمنان	80	32.0
40.	SANANDAJ	سنندج	90	40.5
41.	Shahrud	شاهرود	80	32.0
42.	SHAHR-e-KORD	شهرکرد	80	32.0
43.	SHIRAZ	شیراز	80	32.0
44.	Tabas	طبس	90	40.5
45.	Fasa	فسا	90	40.5
46.	Ghaem Shahr	قائم شهر	90	40.5
47.	QAZVIN	قزوین	100	50.0
48.	QOM	قم	90	40.5
49.	Kashan	کاشان	100	50.0
50.	KERMAN	کرمان	130	84.5
51.	KERMANSHAH	کرمانشاه	90	40.5
52.	GORGAN	گرگان	80	32.0
53.	Maragheh	مراغه	110	60.5
54.	MASHHAD	مشهد	90	40.5
55.	Manjil	منجیل	130	84.5
56.	Noshahr	نوشهر	90	40.5
57.	HAMADAN	همدان	100	50.0
58.	YAZD	یزد	110	60.5

4.3 Snow Loads

This clause gives the minimum imposed roof loads that may be applied by snow accumulation for the use in designing buildings and building components (Engineering standard for loads, IPS-E-CE-500. 2009).

4.3.1 Zoning

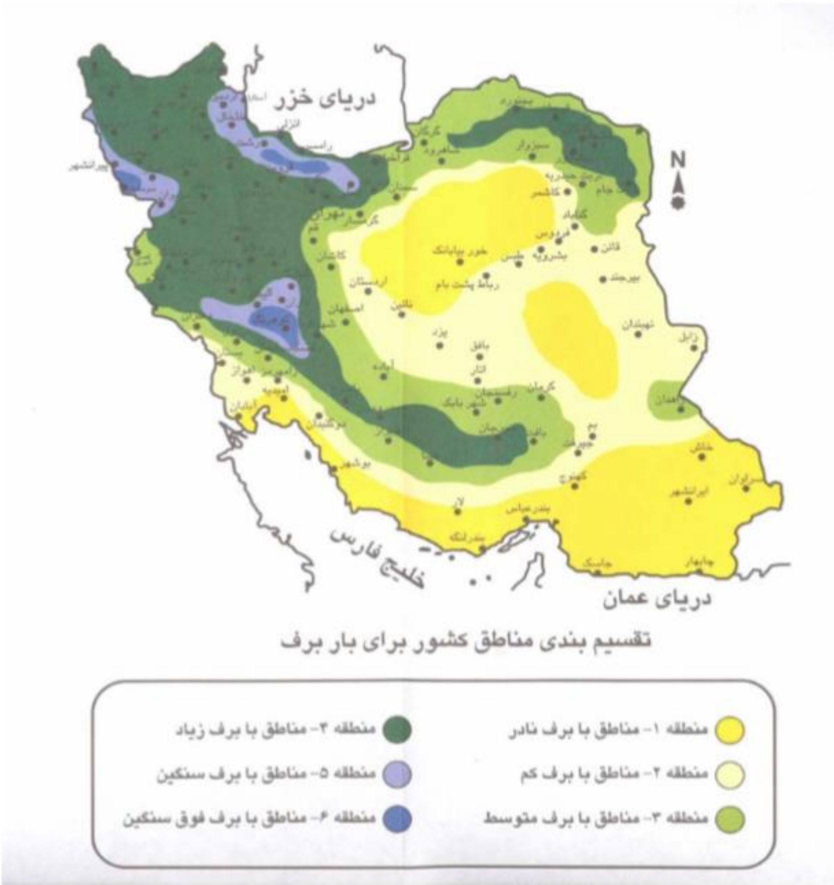
Various parts of the country have been classified into four zones according to the intensity of annual snowfall:

Zone I: Regions with no previous record of snowfall. → 0,25 kN/m^2
Zone II: Regions with low rate of snowfall. → 0,5 kN/m^2
Zone III: Regions with medium rate of snowfall. → 1,0 kN/m^2
Zone IV: Regions with high rate of snowfall. → 1,5 kN/m^2
Zone V: Regions with heavy snowfall. → 2,0 kN/m^2
Zone VI: Regions with ultra-heavy snowfall. → 3,0 kN/m^2

MAP NO.1-GROUND SNOW LOAD, FOR 50-YEAR MEAN RECURRENCE INTERVAL FOR VARIOUS REGIONS OF IRAN (COURTESY OF IRANIAN METEOROLOGICAL BUREAU)

نقشه شماره ۱ – بار برف مناطق مختلف ایران با دوره بازگشت ۵۰ سال

(بر گرفته از سازمان هواشناسی ایران)



PICTURE 34. Ground snow load for 50-year mean recurrence interval for various regions of Iran (Courtesy of Iranian meteorological bureau)

4.3.2 Calculation of snow load

Snow load is determined according to the zoning and slope of the roof, as shown in Table 3 below:

TABLE 3. Snow load in kPa (kN/m^2), as applied on the horizontal projection of the roof (Engineering standard for loads, IPS-E-CE-500 2009)

TABLE 2- SNOW LOAD, IN kPa (kN/m^2), AS APPLIED ON THE HORIZONTAL PROJECTION OF THE ROOF
جدول ۲-بار برف وارده بر تصویر افقی بام ، بر حسب (kN/m^2)

ZONE منطقه	SLOPE OF THE ROOF شیب بام					
	15° OR LESS 15° یا کمتر	20°	25°	35°	45°	60° OR MORE 60° یا بیشتر
I	0.25	0.25	0.25	0.25	0.25	0.25
II	0.50	0.50	0.45	0.35	0.25	0.25
III	1.00	0.95	0.85	0.7	0.50	0.25
IV	1.5	1.40	1.25	1.00	0.75	0.40
V	2.00	1.85	2.00	1.35	1.0	0.5
VI	3.00	2.75	2.50	2.00	1.50	0.75

Note 1:
Figures shown in Table 3 are the least amounts. In regions, with unusual conditions, where snowfall is more intense, loads applicable to that condition should be used.

TABLE 4. Lowest nominal values of uniformly distributed loads (Engineering standard for loads, IPS-E-CE-500 2009)

TABLE 3 - LOWEST NOMINAL VALUES OF UNIFORMLY DISTRIBUTED LOADS
جدول ۳- حداقل مقادیر اسمی بار گسترده یکنواخت

NO.	BUILDINGS AND PREMISES ساختمان‌ها و محوطه ها	Lowest Nominal Values Of Loads. kPa حداقل مقادیر اسمی بارهای زنده (کیلوپاسکال)
1	RESIDENTIAL FLATS, BEDROOMS IN KINDERGARTENS AND SCHOOLS, DWELLINGS, HOTEL ROOMS, HOSPITAL AND SANATORIUM WARDS, ETC. واحدهای مسکونی، اتاقهای خواب در کودکستانها، اتاقهای مدارس، آپارتمانها و اتاقهای هتلها، اتاقهای عمومی در بیمارستانها و آسایشگاهها و غیره	1.5
2	OFFICES FOR ADMINISTRATION, TECHNICAL AND SCIENTIFIC STAFF, CLASSROOMS IN SCHOOLS AND COLLEGES, CLOAK-ROOMS, SHOWER-BATHS, LAVATORIES IN INDUSTRIAL AND PUBLIC BUILDINGS دفاتر کاری امور اداری، فنی و علمی، کلاسهای درس و مدارس و کالج ها، رختکن ها، حمام ها، توالتها در ساختمانهای عمومی و صنعتی	2.0
3	STUDYROOMS AND LABORATORIES IN HEALTH, EDUCATION OR SCIENTIFIC ESTABLISHMENTS, ROOMS WITH DATA PROCESSING EQUIPMENT, KITCHENS IN PUBLIC BUILDINGS, TECHNICAL FLOORS, BASEMENTS, ETC. سالنهای مطالعه و آزمایشگاههای مراکز بهداشتی، مراکز علمی و پژوهشی، مراکز با تجهیزات فرآوری داده ها، آشپزخانه های مراکز عمومی، کفهای صنعتی، زیرزمینها و غیره.	2.0
4	HALLS: سالن ها:	
	A) READING-ROOMS (WITHOUT BOOKSHELVES) الف) سالن های مطالعه (بدون قفسه های کتاب)	2.0
	B) DINING-ROOMS (IN CAFES, RESTAURANTS,ETC.) ب) سالن های غذاخوری (در کافه ها، رستورانها و...)	2.0
	C) CONFERENCE-HALLS, WAITING-ROOMS, THEATRE AND CONCERT HALLS, GYMNASIA, BALL-ROOMS, ETC. ج) سالن های کنفرانس، سالن های انتظار، سالن های تئاتر و کنسرت، سالنهای ورزشی و سالنهای رقص و غیره.	4.0
	D) DEPARTMENT STORES د) فروشگاههای بزرگ	4.0
	E) EXHIBITION HALLS (IN ADDITION TO EQUIPMENT AND MATERIALS) ه) سالن های نمایشگاهی (بهمراه تجهیزات و مواد)	2.5
5	SHELVING IN LIBRARIES, OFFICES WITH FILING STORAGE, STAGES IN THEATRES, ETC. قفسه های کتابخانه ها و دفاتر دارای قفسه های بایگانی، سن های تئاتر و غیره.	5.0
6	STANDS: جایگاه ها:	
	A) WITH FIXED SEATS الف) با صندلی های ثابت	4.0
	B) WITHOUT FIXED SEATS ب) بدون صندلی های ثابت	5.0
7	LOFT SPACE (IN ADDITION TO THE WEIGHT OF EQUIPMENT AND MATERIALS) انباری زیر شیروانی (بهمراه وزن تجهیزات و لوازم)	0.7
8	TERRACES AND ROOFS: تراسها و بامها:	
	A) ZONES FOR REST الف) تراسها و بامهایی که جهت استراحت استفاده می‌شوند	1.5
	B) ZONES CROWDED BY PEOPLE LEAVING HALLS, OFFICES, PRODUCTION BUILDINGS, ETC. ب) تراسها و بامهای پر ازدحام در هنگام ترک سالن ها، دفاتر، ساختمانهای تولیدی و غیره	4.0
9	BALCONIES AND LOGGI بالکنها و ایوانها:	
	A) STRIP UNIFORMLY LOADED IN AN AREA 0,8 m WIDE ALONG THE BARRIER الف) بارگذاری نواری یکنواخت در سطحی به عرض ۰/۸ متر و در امتداد دیوار	4.0
	B) UNIFORMLY LOADED OVER THE WHOLE BALCONY AREA, IF ITS EFFECT IS MORE UNFAVORABLE THAN THAT IN A) ب) بارگذاری یکنواخت بر روی تمام سطح بالکن در صورتی که این بارگذاری منجر به وضع نامناسب تری نسبت به حالت الف شود	2.0
10	LOBBIES, FOYERS, CORRIDORS, STAIRCASES (WITH ADJACENT PASSAGES), ADJOINING PREMISES SPECIFIED IN برای لابی ها، سرسراها، راهروها و پلکانها (در مجاورت معابر) و محوطه مربوطه به توضیحات زیر مراجعه شود:	
	A) No. 1 الف) ردیف ۱	2.5
	B) Nos. 2 AND 3 ب) ردیفهای ۲ و ۳	3.0
	C) Nos. 4 AND 5 ج) ردیفهای ۴ و ۵	4.0
	D) No. 6 د) ردیف ۶	5.0
11	PLATFORMS OF RAILWAY AND SUBWAY STATIONS سکوهای راه آهن و ایستگاههای مترو	4.0
12	GARAGES AND CARPARKS FOR PASSENGER CARS AND LIGHT VEHICLES (NOT FOR TRUCKS) گاراژها و پارکینگ های ماشینهای سواری و وسایل نقلیه سبک (شامل کامیونها نمی‌شود)	2.5

4.3.3 Snow loads on roofs

In the design of roofs, the greater value of either snow load (as given in Table 3) or live load (as given in Table 4) is assumed, and these two need not be considered simultaneously.

$P_r = 0{,}7.\ C_s.\ C_t.\ C_e.\ I_s\ .P_g$

P_r = Snow loads on roof

C_e = Snowflake factor

C_t = Temperature conditions factor

C_s = Slope factor

I_s = Importance factor

4.3.4 Drifts on lower roofs

Roofs are designed to sustain localized loads from snowdrifts that form in the wind shadow of a) higher portions of the same structure and b) adjacent structures and terrain features.

a) Lower roof of a structure. Snow that forms drifts comes from a higher roof or, with the wind from the opposite direction, from the roof on which the drift is located. These two kinds of drifts ("leeward" and "windward respectively) are shown in Figure 1. The geometry of the surcharge load due to snow drifting is approximated by a triangle as shown in Figure 2. Drift loads are superimposed on the balanced snow load. If h_c/h_b, is less than 0.2, drift loads are not required to be applied. (h_b = height of balanced snow load, h_c = clear height from top of balanced snow load to (1) closest point on adjacent upper roof, (2) top of parapet, or (3) top of a projection on the roof)

b) Adjacent structures and terrain features. The requirements in sub-clause “a” are also used to determine drift loads caused by a higher structure or terrain feature within 6.1m (20 ft) of a roof. The separation distance, s, between the roof and adjacent structure or terrain feature is reduced applied drift loads on the lower roof by the factor (6.1-s)/6.1 where s is in m. (Engineering standard for loads, IPS-E-CE-500 2009.)

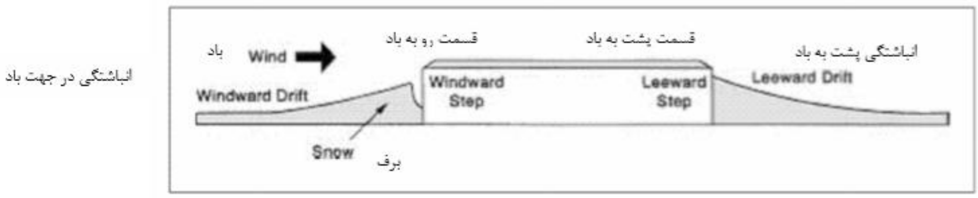


Fig. 1- DRIFTS FORMED AT WINDWARD AND LEEWARD STEPS

شکل ۱- مراحل ایجاد انباشتگی برف بر بام‌های رو به باد و پشت به باد

FIGURE1. Drifts formed at windward and leeward steps (Engineering standard for loads, IPS-E-CE-500 2009)

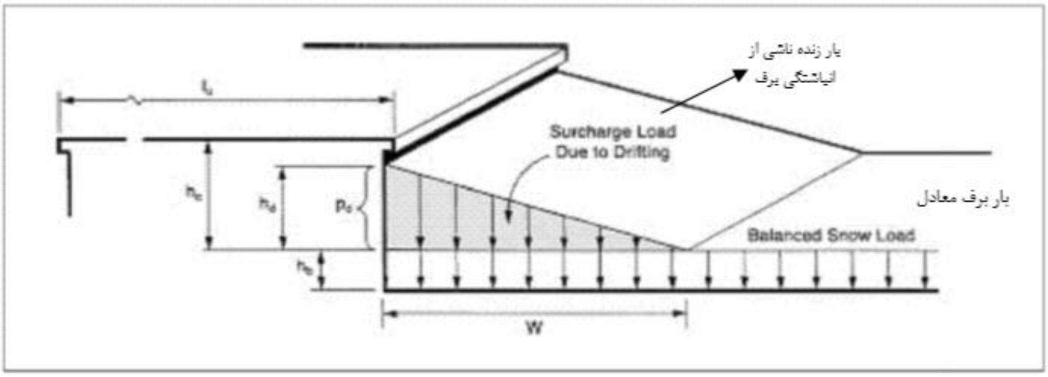


Fig. 2- CONFIGURATION OF SNOW DRIFTS ON LOWER ROOFS
شکل ۲- آرایش انباشتگی برف بر بام‌های پایین دستی

FIGURE 2. Configuration of snow drifts on lower roofs (Engineering standard for loads, IPS-E-CE-500 2009)

4.3.5 Sliding snow

The load caused by snow sliding off a sloped roof onto a lower roof is determined for slippery upper roofs with slopes greater than 1/4 on 12, and for other (i.e., non-slippery) upper roofs with slopes greater than 2 on 12. The total sliding load per unit length of eave is 0.4pfW, where W is the horizontal distance from the eave to the ridge for the sloped upper roof. The sliding load is distributed uniformly on the lower roof over a distance of 4.6 m (15 ft) from the upper roof eave. If the width of the lower roof is less than 4.6 m, the sliding load is reduced proportionally.

The sliding snow load should not be further reduced, unless a portion of the snow on the upper roof is blocked from sliding onto the lower roof by snow already on the lower roof or is expected to slide clear of the lower roof. Sliding loads are superimposed on the balanced snow load.

4.3.6 Extra loads from rain-on-snow

For locations where ground snow load is 0.96 kN/m^2 or less, but not zero, all roofs with slopes (in degrees) less than W/15.2 (where W is the horizontal distance from the eave to ridge in m) should have a 0.24 kN/m^2 rain-on-snow surcharge. This rain-on-snow augmented design load applies only to the balanced load case and need not be used in combination with drift, sliding, unbalanced, or partial loads.

4.4 Rain Loads

A. Roof drainage Roof:

The drainage systems should be designed in accordance with the provisions of the IPS-E-CE-390: " Engineering Standard for Rain and Foul Water Drainage of Buildings". Secondary (overflow) drains should not be smaller than primary drains.

B. Ponding loads:

Roofs should be designed to preclude instability from ponding loads.

C. Blocked drains:

Each portion of a roof should be designed to sustain the load of all rainwater that could accumulate on it if the primary system for that portion is blocked. Ponding instability should be considered in this situation. If the overflow drainage provisions contain drain lines, such lines should be independent of any primary drain lines.

D. Controlled drainage:

Roofs equipped with controlled drainage provisions should be equipped with a secondary drainage system at a higher elevation which prevents ponding on the roof above that elevation. Such roofs should be designed to sustain all rainwater loads on them to the elevation of the secondary drainage system plus 0.24 kPa. Ponding instability should be considered in this situation. (Engineering standard for loads, IPS-E-CE-500 2009.)

4.5 Seismic (Earthquake) Loads

All buildings and structures should be designed to withstand the effects of seismic forces as well as wind effects. Wind and seismic forces are assumed to act separately, and their effects should not be considered simultaneously. Generally, structures and their components should be able to thoroughly withstand the greatest stress caused by wind and earthquake. Structures are designed individually in either one of the principal directions, without considering the other direction. Simultaneous effects of seismic forces in both directions need not be considered. In the seismic design of structures, only the horizontal component of the seismic force should be considered, and the vertical component should not be considered, except for the following cases:

- For cantilevered balconies and projections (particularly those carrying considerable dead load at the tip), and for buildings that house technical instruments or special equipment where the vertical component may cause a malfunction, then the effect of vertical component shall be considered.

The minimum lateral seismic force in each direction of a structure should be calculated according to the provisions of "Iranian National Building Code-part 6" or ASCE-7. (Engineering standard for loads, IPS-E-CE-500 2009.)

4.6 Dead Loads

Dead loads comprise the weight of all permanent construction, including walls, floors, roofs, ceilings, stairways, and fixed service equipment, plus the net effect of prestressing. Moreover, the following complementary items should be considered as dead load (Engineering standard for loads, IPS-E-CE-500 2009):

- fireproofing;
- sprinkler system;
- fixed partitions;
- all fixed equipment with the relevant fluid content;
- the vertical and horizontal pressures due to the stored liquid;
- insulation weight

4.7 Live Loads

Live loads are those loads produced by the use and occupancy of the building or other structure and do not include environmental loads such as wind load, snow load, rain load, earthquake load, or dead load (Engineering standard for loads, IPS-E-CE-500 2009).
Live loads on a roof are those produced:
1. during maintenance by workers, equipment, and materials
2. during the life of the structure by movable objects such as planters and by people.

TABLE 5. Industrial occupancy class (workshops, factories) (Engineering standard for loads, IPS-E-CE-500 2009)

TABLE IB/7 - INDUSTRIAL OCCUPANCY CLASS
(WORKSHOPS, FACTORIES)

جدول I–ب/۷ طبقه بندی فضاهای صنعتی
(کارگاهها، کارخانه ها)

FLOOR AREA USAGE کاربری فضای کف	INTENSITY OF DISTRIBUTED LOAD شدت بار گسترده kN/m²	CONCENTRATED LOAD بار متمرکز kN
FOUNDRIES. ریخته گری ها	20.0	To be determined for specific use جهت مصارف ویژه باید مشخص شود.
TYPE STORAGE AND OTHER AREAS IN PRINTING PLANTS. انبار چاپ و سایر فضا های چاپخانه.	12.5	9.0
BOILER ROOMS, MOTOR ROOMS, FAN ROOMS AND THE LIKE, INCLUDING THE WEIGHT OF MACHINERY. اتاقهای دیگ بخار، موتورخانه ها، اتاقهای هواساز و مشابه آن شامل وزن ماشین آلات	7.5	4.5
FACTORIES, WORKSHOPS AND SIMILAR BUILDINGS. کارخانه ها، کارگاهها و ساختمانهای مشابه	5.0	4.5
CORRIDORS, HALLWAYS, FOOTBRIDGES, ETC. SUBJECT TO LOADS GREATER THAN FOR CROWDS, SUCH AS WHEELED VEHICLES, TROLLEYS AND THE LIKE. راهروها، تالارهای ورودی، پلهای پیاده رو و غیره که بار وارد بر آنها ازمناطق پرازدحام بیشتر میباشد مانند: خودروهای چهارچرخ، چرخ دستیها و موارد مشابه	5.0	4.5
CORRIDORS, HALLWAYS, STAIRS, LANDINGS, FOOTBRIDGES, ETC. راهروها، تالارهای ورودی، پله ها، پاگردها، پلهای پیاده رو و غیره	4.0	4.5
MACHINERY HALLS, CIRCULATION SPACES THEREIN. سالنهای ماشین آلات و مسیرهای گردش در آن سالنها	4.0	4.5
LABORATORIES (INCLUDING EQUIPMENT) KITCHENS, LAUNDRIES. آزمایشگاهها (شامل تجهیزات)، آشپزخانه ها و رختشویخانه ها	3.0	4.5
WORKROOMS, LIGHT INDUSTRIAL WITHOUT STORAGE. کارگاهها، صنایع سبک بدون انبار	2.5	1.8
TOILET ROOMS. توالتها	2.0	—

TABLE 6. Retail occupancy class (shops, department stores, supermarkets) (Engineering standard for loads, IPS-E-CE-500 2009)

TABLE IB/6 - RETAIL OCCUPANCY CLASS
(SHOPS, DEPARTMENTAL STORES, SUPERMARKETS)

جدول I– ب/۶ طبقه بندی فضای خرده فروشی ها
(مغازه ها، فروشگاهها، فروشگاههای بزرگ)

FLOOR AREA USAGE کاربری فضای کف	INTENSITY OF DISTRIBUTED LOAD شدت بارگسترده kN/m²	CONCENTRATED LOAD بار متمرکز kN
COLD STORAGE سردخانه ها	5.0 FOR EACH METER OF STORAGE HEIGHT WITH A MINIMUM OF 15.0 ۵،۰ کیلو نیوتن بر مترمربع به ازاء هر متر ارتفاع انبار و حداقل ۱۵،۰	9.0
STATIONERY STORES فروشگاههای لوازم التحریر	4.0 FOR EACH METER OF STORAGE HEIGHT ۴،۰ کیلو نیوتن بر مترمربع به ازاء هر متر ارتفاع انبار	9.0
STORAGE, OTHER THAN TYPES LISTED SEPARATELY. انبارها، بغیر از انواعی که بطور جداگانه لیست شده اند.	2.4 FOR EACH METER OF STORAGE HEIGHT ۲،۴ کیلو نیوتن بر مترمربع به ازاء هر متر ارتفاع مخزن	7.0
BOILER ROOMS, MOTOR ROOMS, FAN ROOMS AND THE LIKE, INCLUDING THE WEIGHT OF MACHINERY. اتاقهای دیگ بخار، موتورخانه ها، اتاقهای هواساز و سایر موارد شامل وزن ماشین آلات	7.5	4.5
CORRIDORS, HALLWAYS, ETC. SUBJECT TO LOADS GREATER THAN FROM CROWDS, SUCH AS WHEELED VEHICLES, TROLLEYS AND THE LIKE. راهروها، تالارهای ورودی و غیره که بار وارد برآنها از مناطق پرازدحام بیشتر می‌باشد مانند: خودروهای چهارچرخ، چرخ دستی ها و موارد مشابه	5.0	4.5
CORRIDORS, HALLWAYS, STAIRS, LANDINGS, FOOTBRIDGES, ETC. راهروها، تالارهای ورودی، پله ها، پاگردها، پلهای پیاده رو و غیره	4.0	4.5
SHOP FLOORS FOR THE DISPLAY AND SALE OF MERCHANDISE. کف مغازه ها جهت عرضه و فروش اجناس	4.0	3.6
KITCHENS, LAUNDRIES. آشپزخانه ها، رختشویخانه ها	3.0	4.5
TOILET ROOMS توالتها	2.0	—
BALCONIES بالکنها	SAME AS ROOMS TO WHICH THEY GIVE ACCESS BUT WITH A MINIMUM OF 4.0 مشابه اتاقهایی که بالکن به آن دسترسی دارد و حداقل ۴،۰ کیلو نیوتن بر مترمربع در نظر گرفته می‌شود.	1.5 PER METER RUN CONCENTRATES AT THE OUTER EDGE ۱،۵ کیلو نیوتن به ازاء هر متر طول که بصورت متمرکز بر لبه بیرونی اعمال می‌شود.

TABLE 7. Lowest nominal values of uniformly distributed loads (Engineering standard for loads, IPS-E-CE-500 2009)

TABLE 3 - LOWEST NOMINAL VALUES OF UNIFORMLY DISTRIBUTED LOADS
جدول ۳- حداقل مقادیر اسمی بار گسترده یکنواخت

NO.	BUILDINGS AND PREMISES ساختمان‌ها و محوطه ها	Lowest Nominal Values Of Loads. kPa حداقل مقادیر اسمی بارهای زنده (کیلوپاسکال)
1	RESIDENTIAL FLATS, BEDROOMS IN KINDERGARTENS AND SCHOOLS, DWELLINGS, HOTEL ROOMS, HOSPITAL AND SANATORIUM WARDS, ETC. واحدهای مسکونی، اتاقهای خواب در کودکستانها، اتاقهای مدارس، آپارتمانها و اتاقهای هتلها، اتاقهای عمومی در بیمارستانها و آسایشگاهها و غیره	1.5
2	OFFICES FOR ADMINISTRATION, TECHNICAL AND SCIENTIFIC STAFF, CLASSROOMS IN SCHOOLS AND COLLEGES, CLOAK-ROOMS, SHOWER-BATHS, LAVATORIES IN INDUSTRIAL AND PUBLIC BUILDINGS دفاتر کاربری امور اداری، فنی و علمی، کلاسهای درس و مدارس و کالج ها، رختکن ها، حمام ها، توالتها در ساختمانهای عمومی و صنعتی	2.0
3	STUDYROOMS AND LABORATORIES IN HEALTH, EDUCATION OR SCIENTIFIC ESTABLISHMENTS, ROOMS WITH DATA PROCESSING EQUIPMENT, KITCHENS IN PUBLIC BUILDINGS, TECHNICAL FLOORS, BASEMENTS, ETC. سالنهای مطالعه و آزمایشگاههای مراکز بهداشتی، مراکز علمی و پژوهشی، مراکز با تجهیزات فرآوری داده ها، آشپزخانه های مراکز عمومی، کفهای صنعتی، زیرزمینها و غیره.	2.0
4	HALLS: سالن ها:	
	A) READING-ROOMS (WITHOUT BOOKSHELVES) الف) سالن های مطالعه (بدون قفسه های کتاب)	2.0
	B) DINING-ROOMS (IN CAFES, RESTAURANTS,ETC.) ب) سالن های غذاخوری (در کافه ها، رستورانها و...)	2.0
	C) CONFERENCE-HALLS, WAITING-ROOMS, THEATRE AND CONCERT HALLS, GYMNASIA, BALL-ROOMS, ETC. ج) سالن های کنفرانس، سالن های انتظار، سالن های تئاتر و کنسرت، سالنهای ورزشی و سالنهای رقص و غیره.	4.0
	D) DEPARTMENT STORES د) فروشگاههای بزرگ	4.0
	E) EXHIBITION HALLS (IN ADDITION TO EQUIPMENT AND MATERIALS) ه) سالن های نمایشگاهی (بهمراه تجهیزات و مواد)	2.5
5	SHELVING IN LIBRARIES, OFFICES WITH FILING STORAGE, STAGES IN THEATRES, ETC. قفسه های کتابخانه ها و دفاتر دارای قفسه های بایگانی، سن های تئاتر و غیره.	5.0
6	STANDS: جایگاه ها:	
	A) WITH FIXED SEATS الف) با صندلی های ثابت	4.0
	B) WITHOUT FIXED SEATS ب) بدون صندلی های ثابت	5.0
7	LOFT SPACE (IN ADDITION TO THE WEIGHT OF EQUIPMENT AND MATERIALS) انباری زیر شیروانی (بهمراه وزن تجهیزات و لوازم)	0.7
8	TERRACES AND ROOFS: تراسها و بامها:	
	A) ZONES FOR REST الف) تراسها و بامهایی که جهت استراحت استفاده می‌شوند	1.5
	B) ZONES CROWDED BY PEOPLE LEAVING HALLS, OFFICES, PRODUCTION BUILDINGS, ETC. ب) تراسها و بامهای پر ازدحام در هنگام ترک سالن ها، دفاتر، ساختمانهای تولیدی و غیره	4.0
9	BALCONIES AND LOGGI بالکنها و ایوانها:	
	A) STRIP UNIFORMLY LOADED IN AN AREA 0,8 m WIDE ALONG THE BARRIER الف) بارگذاری نواری یکنواخت در سطحی به عرض ۰/۸ متر و در امتداد دیوار	4.0
	B) UNIFORMLY LOADED OVER THE WHOLE BALCONY AREA, IF ITS EFFECT IS MORE UNFAVORABLE THAN THAT IN A) ب) بارگذاری یکنواخت بر روی تمام سطح بالکن در صورتی که این بارگذاری منجر به وضع نامطلوب تری نسبت به حالت الف شود	2.0
10	LOBBIES, FOYERS, CORRIDORS, STAIRCASES (WITH ADJACENT PASSAGES), ADJOINING PREMISES SPECIFIED IN برای لابی ها، سرسراها، راهروها و پلکانها (در مجاورت معابر) و محوطه مربوطه به توضیحات زیر مراجعه شود:	
	A) No. 1 الف) ردیف ۱	2.5
	B) Nos. 2 AND 3 ب) ردیفهای ۲و۳	3.0
	C) Nos. 4 AND 5 ج) ردیفهای ۴و۵	4.0
	D) No. 6 د) ردیف ۶	5.0
11	PLATFORMS OF RAILWAY AND SUBWAY STATIONS سکوهای راه آهن و ایستگاههای مترو	4.0
12	GARAGES AND CARPARKS FOR PASSENGER CARS AND LIGHT VEHICLES (NOT FOR TRUCKS) گاراژها و پارکینگ های ماشینهای سواری و وسایل نقلیه سبک (شامل کامیونها نمی‌شود)	2.5

TABLE 8: Institutional and educational/public assembly occupancy class (hospitals, schools, colleges, halls auditoria, restaurants, museums, libraries, non-residential clubs, theatres, broadcasting studios, grandstands). (Engineering standard for loads, IPS-E-CE-500 2009)

TABLE IB/3/4 - INSTITUTIONAL AND EDUCATIONAL/ PUBLIC ASSEMBLY OCCUPANCY CLASS (Hospitals, Schools, Colleges), (Halls, Auditoria, Restaurants, Museums, Libraries,Non-Residential Clubs,Theatres, Broadcasting Studios, Grandstands)

جدولI– ب/۳/۴ طبقه بندی سازمانها و موسسات آموزشی / فضاهای گردهمایی

(بیمارستانها، مدارس، کالجها) و (سالنها، تالارهای کنفرانس، رستورانها، موزه ها،
کتابخانه ها، باشگاههای غیر مسکونی، تئاترها، استودیوهای رادیویی، جایگاههای سرپوشیده تماشاچیان)

FLOOR AREA USAGE کاربری فضای کف	INTENSITY OF DISTRIBUTED LOAD شدت بار گسترده kN/m^2	CONCENTRATED LOAD بار متمرکز kN
STACK ROOMS (BOOKS). انبارهای کتاب	2.4 FOR EACH METER OF STACK HEIGHT BUT WITH A MINIMUM OF 6.5 ۲٫۴ به ازاء هرمتر ارتفاع قفسه و حداقل ۶٫۵	7.0
STATIONERY STORES. انبارهای لوازم التحریر	4.0 FOR EACH METER OF STORAGE HEIGHT 7.5 ۴ به ازاء هر متر ارتفاع انبار	9.0
BOILER ROOMS, MOTOR ROOMS, FAN-ROOMS AND THE LIKE, INCLUDING THE WEIGHT OF MACHINERY. اتاقهای دیگ بخار، موتورخانه ها، اتاقهای هواساز و سایر موارد مشابه شامل وزن ماشین آلات	7.5	4.5
CORRIDORS, HALLWAY, ETC. SUBJECT TO LOADS GREATER THAN FROM CROWDS, SUCH AS WHEELED VEHICLES, TROLLEYS AND THE LIKE. راهروها، تالارهای ورودی و غیره که بار وارد بر آنها از مناطق پر ازدحام بیشتر می‌باشد مانند: خودروهای چهارچرخ، چرخ دستی ها و موارد مشابه	5.0	4.5
DRILL ROOMS AND DRILL HALLS اتاقهای حفاری و سالنهای حفاری	5.0	9.0
ASSEMBLY AREAS WITHOUT FIXED SEATING, STAGES, GYMNASIA فضاهای گردهمایی بدون نشیمنهای ثابت، سکوها، ورزشگاهها	5.0	3.6
PROJECTION ROOMS اتاقهای جلوآمده	5.0	—
CORRIDORS, HALLWAYS, AISLES, STAIRS, LANDINGS, FOOTBRIDGES, ETC. راهروها، تالارهای ورودی، راهروها، پله ها، پاگردها، پلهای پیاده روها و غیره	4.0	4.5
READING ROOMS WITH BOOK STORAGE, e.g. LIBRARIES. اتاقهای مطالعه باقفسه های کتاب مثل کتابخانه ها	4.0	4.5
ASSEMBLY AREAS WITH FIXED SEATING* فضاهای گردهمایی با نشیمنهای ثابت	4.0	—
MUSEUM FLOORS AND ART GALLERIES FOR EXHIBITION PURPOSES. کفهای موزه و گالریهای هنری جهت مقاصد نمایشگاهی	4.0	4.5
MOSQUES, PRAYING ROOMS مساجد، نمازخانه ها	5.0	4.0
LABORATORIES(INCLUDING EQUIPMENT) KITCHENS, LAUNDRIES, CORRIDORS, HALLWAYS, AISLES, LANDINGS,STAIRS ETC. NOT SUBJECT TO CROWD LOADING آزمایشگاهها (شامل تجهیزات)، آشپزخانه ها، رختشویخانه ها، راهروها، تالارهای ورودی، راهروها، پاگردها، پله ها و غیره که تحت بارهای ناشی از ازدحام قرار نمی‌گیرند.	3.0	4.5
CLASSROOMS, PRAYING ROOMS. کلاسهای درس، نمازخانه ها	3.0	2.7
READING ROOMS WITHOUT BOOK STORAGE. اتاقهای مطالعه بدون انبارش کتاب	2.5	4.5
AREAS FOR EQUIPMENT. فضاهای استقرار تجهیزات	2.0	1.8
X-RAY ROOMS, OPERATING ROOMS, UTILITY ROOMS. اتاقهای پرتوX، اتاقهای بهره برداری، اتاقهای سرویسهای جانبی	2.0	4.5

4.8 Combination of Loads

4.8.1 Combining Nominal Loads Using Allowable Stress Design

Loads listed herein should be considered to act in the following combinations; whichever produces the most unfavorable effect in the building, foundation, or structural member being considered. Effects of one or more loads not acting should be considered. (Engineering standard for loads, IPS-E-CE-500 2009.)

1. D + F
2. D + H + F + L + T
3. D + H + F + (L_r or S or R)
4. D + H + F + 0.75 (L + T) + 0.75(L_r or S or R)
5. D + H + F + (W or 0.7E)
6. D + H + F + 0.75 (W or 0.7E) + 0.75L + 0.75(L_r or S or R)
7. 0.6D+ W + H
8. 0.6D + 0.7E +H

Exception: In combinations (4) and (6), the companion load S should be taken as either the flat roof snow load (p_f) or the sloped roof snow load (p_s).

D = Dead load consisting of:

a) Weight of the structural member itself.

b) Weight of materials of construction incorporated into the building to be permanently supported by the structural member, including built-in partitions.

c) Weight of permanent service utilities.

E = Earthquake (Seismic) load.

F = Loads due to fluids with well-defined pressures and maximum heights.

H = Loads due to the weight and lateral pressure of soil and water in soil.

L = Live loads due to intended use and occupancy, including loads due to movable objects and movable partitions and loads temporarily supported by the structure during maintenance. L includes any permissible reduction. If resistance to impact loads is taken into account in design, such effects should be included with the live load L.

L_r = Roof live loads

P = Loads, forces and effects due to pending.

R = Required dynamic resistance to blast loads, see Appendix IC.

r = Rain load.

S = Snow load

T = Thermal loads = Self-starting forces and effects arising from contraction or expansion resulting from temperature changes, shrinkage, moisture changes, creep in component materials, movement due to differential settlement, or combinations thereof.

W = Wind load

4.8.2 Combinations of Loads Using Strength Design

Structures, components, and foundations should be designed so that their design strength equals or exceeds the effects of the factored loads in the following combinations (Engineering standard for loads, IPS-E-CE-500 2009):

1. 1.4(D + F)
2. 1.2(D+ F +T) + 1.6(L + H) + 0.5(L_r or S or R)
3. 1.2 D + 1.6(L_r or S or R) + (L or 0.8W)
4. 1.2D + 1.6W + L + 0.5(L_r or S or R)
5. 1.2D + 1.0E + L + 0.2S
6. 0.9D + 1.6W + 1.6H
7. 0.9D + 1.0E + 1.6H

Exceptions:

1. The load factor on L in combinations (3), (4), and (5) is permitted to equal 0.5 for all occupancies in which distributed live load is less than or equal to 4.8kN/m2(100psf), except for garages or areas occupied as places of public assembly.
2. The load factor on H shall be set equal to zero in combinations (6) and (7) if the structural action due to H counteracts that due to W or E.
   Where lateral earth pressure provides resistance to structural actions from other forces, it should not be included in H but should be included in the design resistance.
3. In combination (2), (4), and (5), the companion load S should be taken as either the flat roof snow load (p_f) or the sloped roof snow load (p_s).

4.9 Engineering Standards for Fire Protection in Buildings

The Iranian Petroleum Standards (IPS) reflect the views of the Iranian Ministry of Petroleum and are intended for use in the oil and gas production facilities, oil refineries, chemical and petrochemical plants, gas handling and processing installations and other such facilities.
IPS are based on internationally acceptable standards and include selections from the items stipulated in the referenced standards. They are also supplemented by additional requirements and/or modifications based on the experience acquired by the Iranian Petroleum Industry and the local market availability. The options which are not specified in the text of the standards are itemized in data sheet/s, so that, the user can select his appropriate preferences therein.

The IPS standards are therefore expected to be sufficiently flexible so that the users can adapt these standards to their requirements. However, they may not cover every requirement of each project. For such cases, an addendum to IPS Standard should be prepared by the user which elaborates the requirements of the user. This addendum together with the relevant IPS form the job specification for the specific project or work. The IPS is reviewed and up-dated approximately every five years. Each standard is subject to amendment or withdrawal, if required, thus the latest edition of IPS is applicable.

The users of IPS are therefore requested to send their views and comments, including any addendum prepared for cases. These comments and recommendations will be reviewed by the relevant technical committee and in case of approval will be incorporated in the next revision of the standard. (Engineering standard for fire protection in buildings, IPS-E-SF-380 2009.)

REFERENCES:
Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents should, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date should be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

- NFPA (NATIONAL FIRE CODES)
  NFPA 101 “Alternative Approaches to Life Safety” NFPA 220 “Types of Building Construction” NFPA 251 “Standard Method of Tests of Fire Resister of Building Construction and Materials” NFPA A-1 “Fire Code” NFPA A-13 “Standard for the Installation of Sprinkler Systems”
- BSI (BRITISH STANDARD INSTITUTION) BS 9999 “Code of Practice for Fire Safety in the Design Management and Use of Building”
- IPS (IRANIAN PETROLEUM STANDARDS)
  IPS-E-GN-100 “Engineering Standard for Units”
  IPS-E-SF-400 “Engineering Standard for Industrial Stairs, Ladders, Platforms, and Scaffolds”
  Types of construction in fire protection.

Type I (442 or 332)

Type I construction is the type in which the structural members, including walls, columns, beams, floors, and roofs, are of approved noncombustible or limited-combustible materials and have fire resistance ratings not less than those set forth in Table 9.

Type II (222.111.000)

Type II construction is the type not qualifying as Type I construction in which the structural members including walls, columns, beams, floors, and roofs are of approved noncombustible or limited combustible materials and have fire resistance ratings not less than those set forth in Table 9.

Type III (211 or 200)

Type III construction is the type in which exterior walls and structural members which are portions of exterior walls are of approved noncombustible or limited combustible materials, and interior structural members, including walls, columns, beams, floors, and roofs, are wholly or partly of wood of smaller dimensions than required for Type IV construction or of approved noncombustible, limited combustible, or other approved combustible materials. In addition, structural members have fire resistance ratings not less than those set forth in Table 9.

Type IV (2HH)

Type IV construction is the type in which exterior and interior walls and structural members which are portions of such walls are of approved noncombustible or limited-combustible materials. Other interior structural members including columns, beams, arches, floors and roofs are of solid or laminated wood without concealed spaces. In addition, structural members have fire resistance ratings not less than those set forth in Table 9.

Type V (111 or 000)

Type V construction is the type in which exterior walls, bearing walls, and floors and roofs and their supports are wholly or partly of wood or other approved combustible material smaller than required for Type IV construction. In addition, structural members have fire resistance ratings not less than those set forth in Table 9.

TABLE 9: Fire resistance rating (in hours) for type I through type V construction (Engineering standard for fire protection in buildings, IPS-E-SF-380 2009)

TABLE 1 - FIRE RESISTANCE RATINGS (IN HOURS) FOR TYPE I THROUGH TYPE V CONSTRUCTION

	Type I		Type II			Type III		Type IV	Type V	
	442	**332**	**222**	**111**	**000**	**211**	**200**	**2HH**	**111**	**000**
Exterior Bearing Walls[a]										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0[b]	2	2	2	1	0[b]
Supporting one floor only	4	3	2	1	0[b]	2	2	2	1	0[b]
Supporting a roof only	4	3	1	1	0[b]	2	2	2	1	0[b]
Interior Bearing Walls										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	2	1	0
Supporting one floor only	3	2	2	1	0	1	0	1	1	0
Supporting roofs only	3	2	1	1	0	1	0	1	1	0
Columns										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H	1	0
Supporting one floor only	3	2	2	1	0	1	0	H	1	0
Supporting roofs only	3	2	1	1	0	1	0	H	1	0
Beams, Girders, Trusses, and Arches										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H	1	0
Supporting one floor only	2	2	2	1	0	1	0	H	1	0
Supporting roofs only	2	2	1	1	0	1	0	H	1	0
Floor-Ceiling Assemblies	2	2	2	1	0	1	0	H	1	0
Roof-Ceiling Assemblies	2	1½	1	1	0	1	0	H	1	0
Interior Nonbearing Walls	0	0	0	0	0	0	0	0	0	0
Exterior Nonbearing Walls[c]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]	0[b]

H: heavy timber members (see text for requirements).
[a] See NFPA 5000, 7.3.2.1.
[b] See NFPA 5000, Section 7.3.
[c] See 4.3.2.12, 4.4.2.3, and 4.5.6.8.

[5000: Table 7.2.1.1]

4.10 Fire Resistance

Every external wall of a building other than that of the warehouse class should comply with the requirements as to noncombustibility and fire resistance specified as appropriate thereto in Column (2) of the following Table according to the distance of the wall from the nearest boundary of the premises (Column (1)).

Every external wall of a building of the warehouse class intended to be used wholly or predominantly for storage should, if the capacity of the building exceeds 7000 m3, or if its height exceeds 22 m, be noncombustible throughout and have a fire resistance of three hours. (Engineering standard for fireproofing in building, IPS-E-CE-260 2009.)

4.11 Materials for Steel Structures

- **Cold-Rolled Structural Shape (LSF System)**

Steel types:
S340H
S230H
S340L
S340L

- **Hot-Rolled Structural Shape**

ASTM A36/A36M
ASTM A529/A529M
ASTM A572/A572M
ASTM A588/A588M
ASTM A709/A709M
ASTM A913/A913M
ASTM A992/ A992M

- **Structural Tubing**

ASTM A500
ASTM A501
ASTM A618
ASTM A847

- **Pipe**

ASTM A53/A53M, Gr. B

- **Plates**

ASTM A36/A36M

ASTM A242/A242M

ASTM A283/A283M

ASTM A514/A514M

ASTM A529/A529M

ASTM A572/A572M

ASTM A588/A588M

ASTM A709/A709M

ASTM A852/A852M

ASTM A1011/A1011M

- **Bolts**

ASTM A307

ASTM A325

ASTM A325M

ASTM A449

ASTM A490

ASTM A490M

ASTM F1852

- **Nuts**

ASTM A194/A194M

ASTM A563

ASTM A563M

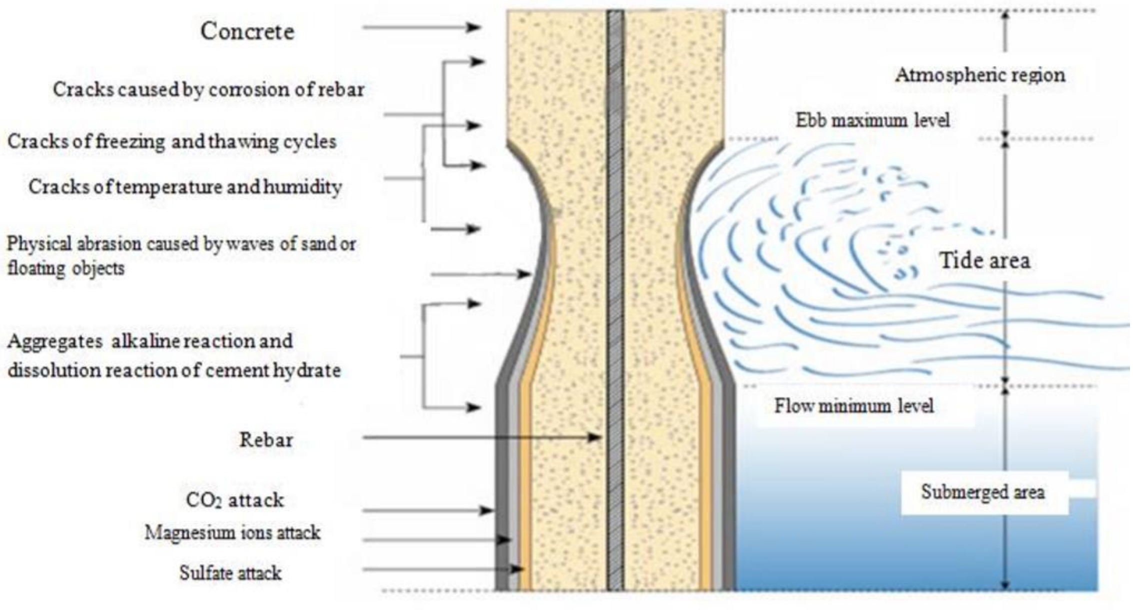
4.12 Building Design Software in Iran

- ETABS
- REVIT
- FEM-DESIGN
- AUTOCAD (CIVIL & LT/2D-3D)
- ARCHICAD

4.13 A Review on Corrosion of Reinforcing Steel in Concrete Structures Located on the Southern Coast of Iran

Coastal Structures in the Middle East are influenced by hydrostatic pressure, impact loading, erosion and continuous cycles of changes in temperatures. As a result, these structures are often made of high strength concrete and reinforcement steel. Therefore, protecting steel embedded in concrete is critical from the point of view of durability. Concrete permeability is the most important determinant of long-term durability. Although concrete is considered as a durable material in the marine environment, many collapses have been reported from concrete structures by the beach. The durability of the material can be resulted from the proper implementation and maintenance. The situation of the Persian Gulf in terms of salts in seawater and in terms of its climatic conditions have made this environment as one of the most aggressive marine environments from the perspective of corrosion of reinforcement in concrete structures. Early collapses due to corrosion of reinforcement in concrete structures in the Persian Gulf region have caused a lot of maintenance costs for countries in this region. Therefore, the increasing tendency to determine the causes of the corruption in concrete, the methods to prevent it, and contributing factors in high resistance and strength, unlike the short life of the concrete, is a sign for the importance of the issue.

Infrastructure structures in the Persian Gulf have been increased in the past decades and many of these structures faced many problems due to corrosion caused by chloride ion penetration. The main problems include weak implementation, inadequate processing, lack of exposure to environmental conditions as well as unsuitable design for corrosive environmental conditions. Therefore, concrete durability is one of the important requirements for the design and execution of concrete structures is in the southern regions. Damage and degradation of concrete structures affected by corrosive fluids, wet gases, etc. are known as concrete corrosion. Concrete corrosion is a physical - chemical process, while the process of reinforced concrete corrosion is electro-chemical. Many marine wharfs, dock facilities and oil platforms in the Persian Gulf that were built with concrete got exposed to the marine environment and thus they were corroded. The interplay between the concrete and the concrete service environment can lead to the destruction of reinforced concrete structures and in many cases makes structures inappropriate for action based on its design purposes. The interplay is often chemical and environmental. For concrete in marine environments, it seems to be a direct relationship between low permeability, high strength, and good durability. The marine structures such as port buildings and coastal platforms are built using high quality concrete. In general, porous concrete with different size is made from a few angstroms to several millimeters. This system of pores is filled by the solution, including different amounts of salt. Problems related to the use of reinforced concrete in marine environments are well known. These problems have led to extensive researches on the metal corrosion of concrete structures. The reinforced concrete rebar protects concrete against corrosion by the severe alkaline environment (PH=11.5). Therefore, this process limits decomposition. This process occurs by the carbon concrete that reduces the alkalinity or by the presence of small amounts of chloride ion in concrete around the metal. Chloride penetration depth depends on the capability of moisture permeability and the level of oxygen near the surface of the metal. Corrosion occurs in the absence of any of these factors. Corrosion causes metal to become oxides and hydroxides of iron compounds in various stages. This process increases the volume. Such damages caused by corrosion can be seen in the form of parallel cracks to the direction of rebar. Finally, cracking and fragmentation of the concrete occur, and the rate of corrosion increases. Progressive collapse can be defined as a chain reaction of collapse. A building undergoes progressive collapse when a primary structural element fails, resulting in the failure of adjoining structural elements, which in turn causes further structural failure. Hence, discussion of resisting progressive collapse for structures arises. In the present study, several samples of the structural steel model with moment frame are designed for seismic requirements. Then, their vulnerability is evaluated for the progressive collapse and it is improved based on a method of retrofitting against the progressive collapse. Finally, the seismic behavior of this system is re-evaluated and the retrofitting effect of progressive collapse on the seismic behavior of the system is evaluated. (The Caspian Sea Journal 2016, 61-66.)



PICTURE 35. Possible collapses and their place in a concrete column in seawater (The Caspian Sea Journal 2016, 62)

4.13.1 Climatic Conditions of the Region

Climatic conditions of the region are hot and dry. Meanwhile, the summers are long and hot and major winds blow from the Arabian Desert. According to the statistics gathered from two weather stations of Dir port and Lengeh port which are the only weather stations and are similar to the aforementioned region in terms of atmospheric characteristics, the average temperature and precipitation in a 25-year period are as follows: The absolute maximum temperature (46 ° C), absolute minimum temperature (7.5 ° C), average annual rainfall (220 mm), maximum daily rainfall (51 mm), maximum wind speed (17 to 18 meters per second). (The Caspian Sea Journal 2016)

4.13.2 Saline Existing in the Persian Gulf Water

The minimum amount of salt in the water is in August and its maximum is in the Strait of Hormuz in February. The average amount of salt in the Persian Gulf water in comparison with the open sea salts in ppm is shown in the following table (The Caspian Sea Journal 2016):

TABLE 10. The average of salt in the Persian Gulf water in comparison with the open sea salts (The Caspian Sea Journal 2016, 63)

Salt	open sea water	Persian Gulf water
Calcium salts (Ca)	50 - 480	480
Magnesium salts (Mg)	360 - 14010	1600
Sodium salts (Na)	2190 - 12200	12600
Potassium salts (K)	70 - 550	470
Epsom salts	580 - 2810	3300
Chlorine salts (CL)	3960 - 20000	23400

It is observed that concentration of salt in the water of the Persian Gulf is equivalent to or higher than of the open seas. Therefore, the design and construction of onshore and offshore structures must be considered. Consulting engineers of metallurgy and corrosion, Morley and Attlee, estimated by 0.14 mm per year the corrosion in sea water in the Persian Gulf using steel candles in the south of the Persian Gulf.

4.13.3 Potentials of Corrosion

When a metal is immersed in a solution, potential difference occurs on the surface of the liquid and solid due to the non-uniform distribution of the load in the liquid and solid phase. It is impossible to determine fixed potential differences in the level of steel and concrete. Therefore, it is necessary to define the other electrodes to complete the electrical circuit. Potential measured between the electrodes is called pili. In fact, it is the total potential of the two half cells. A constant potential difference can always be obtained by referring to a reference electrode which has a half cell potential. As noted earlier, the electrode used to measure the reinforcement potentials is Ag / AgCl.

TABLE 11. Range of corrosion potential and corrosion possibility for a half-cell of Ag/AgCl (The Caspian Sea Journal 2016, 63)

The range of potential	The possibility of corrosion
Lower than -84mv	There is a 90 per cent chance of corrosion activity
Between -84mv and -234mv	The corrosion activity is not definitive, but it is quite possible.
Higher than -234mv	There is a 90 per cent chance of corrosion activity

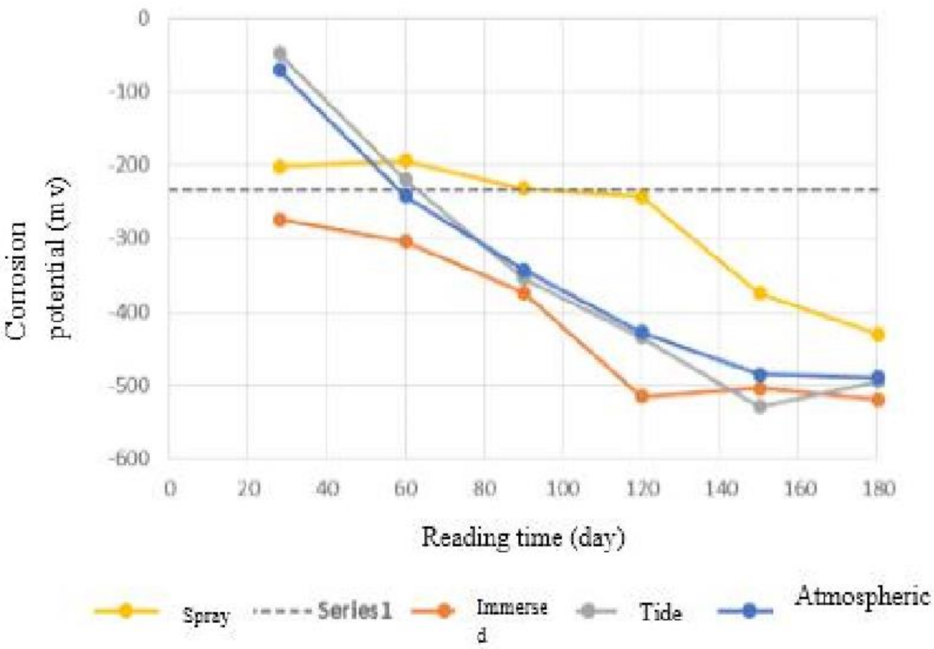


FIGURE 3. The corrosion potential of samples A1 in different circumstances at the age of 28, 60, 90, 120, 150, and 180 days (The Caspian Sea Journal 2016, 65)

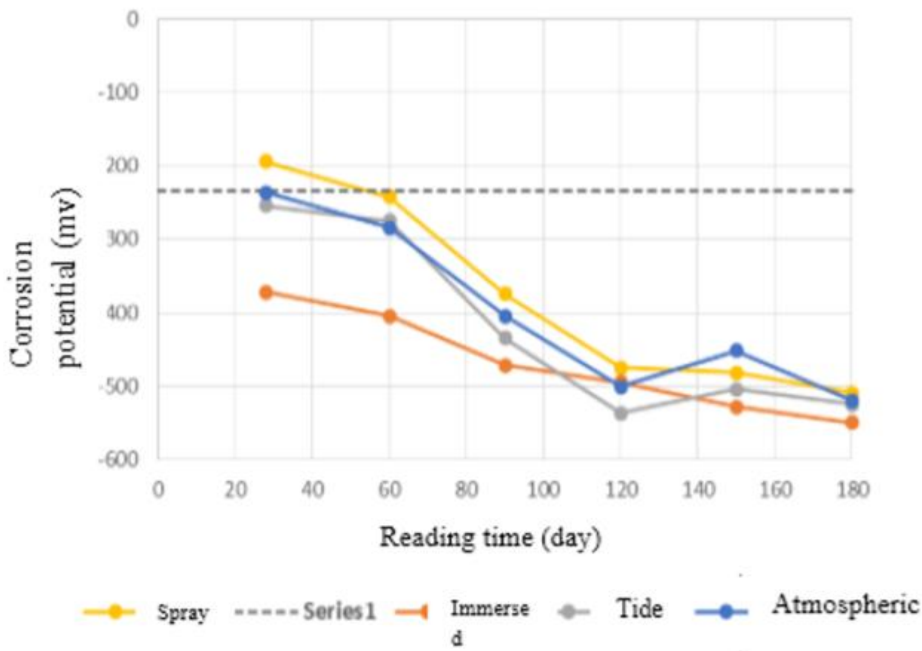


FIGURE 4. The corrosion potential of samples A2 in different circumstances at the age of 28, 60, 90, 120, 150 and 180 days (The Caspian Sea Journal 2016, 65)

4.13.4 Corrosion current

Potentiostat is used to measure the intensity of corrosion and the results are provided in different environmental conditions at the age of 180 days for samples A1 and A2.

TABLE 12. The result of corrosion current density for various environmental samples at the age of 180 days (The Caspian Sea Journal 2016, 66)

Sample	Immersion	tide	Splash	Atmospheric
A1	0.321	0.393	0.416	0.384
A2	0.586	0.826	1.016	0.674

TABLE 13. The range of corrosion intensity (The Caspian Sea Journal 2016, 66)

Level of corrosion	Corrosion current density ($\mu A/cm^2$)
conditions with low impacts	$I_{corr} < 0.1$
Low to moderate corrosion	$0.1 < I_{corr} < 0.5$
medium to high corrosion	$0.5 < I_{corr} < 1$
high corrosion	$I_{corr} > 1$

In the case of all samples placed in different zones, the electrical resistance decreases over time and will probably lead to an increase in corrosion intensity over time. Comparing the results obtained in this study indicate that the intensity of corrosion is reduced in zones of splash, tidal, atmospheric and immersion. Samples placed in severe corrosive marine environment compared to control environment have a dramatic reduction in electrical resistance. Electric resistance value is reduced and consequently the corrosion intensity increases because of the increase in moisture and chloride penetration into concrete. Samples placed in the splash zone has the lowest electrical resistance in comparison with zones of immersion, tides and atmospheric. The reason is the increase in penetration of chloride ions into the concrete pores that further reduces electrical resistance of concrete and increases intensity corrosion of reinforcement. The splash zone is the most difficult situation in terms of corrosion because increasing amount of moisture and the amount of free chlorine in the concrete and the existence of sufficient oxygen increase corrosion intensity. In immersion zone, although the corrosion potential of reinforcement is very high, the intensity corrosion is minimal due to lack of oxygen. Permeability can be minimized by increasing the amount of micro silica and decreasing the water - cementitious materials ratio. The size of coating greater than 5 cm is recommended for concrete structures exposed to tides. (The Caspian Sea Journal 2016.)

5 DISCUSSION

This research evaluates regulations used in Iran for steel and concrete structures in the case of making a contract between Iran and Finland and implementing a project in Iran by a Finnish company. As it was mentioned previously, the volume of these regulations is very high and does not fit into this research, so it was attempted to select and present a part of the regulations.

In this regard, the research has been divided into two parts discussing first metal and second concrete structures. In metal structures, first the structure and systems used in it are introduced and then a part of general points in the analysis of metal structures are provided. The emphasis of this part is on standards of structure-to-foundation connection. In the next step of this part, seismic standards for steel structures are provided.

The next part is standards related to concrete structures. In this regard, seismic standards are considered as well. It should be noted that in these regulation, design requirements and implementation of structures have been evaluated.

For future suggestions it is suggested to evaluate design standards and implantation of the mentioned structures in other usages in future researches and researchers can conduct a comparative evaluation between standards in Iran and Finland to improve the level of interactions between the two countries. These researches can be divided into various usages and structures.

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