DESIGN OF STEEL STRUCTURES

BASIC LECTURES

ON

STRUCTURAL STEEL

FOR

FOURTH STAGE

IN CIVIL ENGINEERING COLLEGE

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FORWARD

THIS IS THE FIRST EDITION OF A SIMPLE TEXT BOOK IN STEEL STRUCTURES WITH MUCH AS POSSIPLE DETAILS IN DESIGN & ANALYSIS OF STEEL STRUCTURES & ERECTION OF SKELETAL OR FRAMED STEEL BUILDINGS.

THIS UNPRETENTIOUS WORK IS DEVOTIED TO GRADUITED STUDENTS OF FINAL ACADEMIC STUDY & ALSO TO DESIGNERS & BUILDERS, TO HAVE A CLOSEST GUIDE WITH SOLVED PRACTICAL EXAMPLES IN ELEMENTS OF STEEL CONSTRUCTION ASSEMPLIES.

THE AUTHOR HOPE THAT THIS WORK WILL BE VERY HELPFUL FOR OUR STUDENTS IN CIVIL ENGINEERING FACOULTY OF AL-MUSTANSIRIAH UNIVERSITY & ALSO FOR WHOLE STUDENTS IN OTHER UNIVERSITIES IN IRAQ.

ACTUALLY, OUR COUNTRY NEED AN OVERTURNING IN THE CONSTRUCTION OF MANY TYPE OF BUILDINGS & BRIDGES USING STEEL FRAMES MATERIALS INSTEAD OF OTHER CLASSICAL MATERIALS.

SO, THE AUTHOR HOPES THAT THIS WORK WILL REALLY HELP WHOME NEED A LITTLE WITH SOME DETAILS IN HIS STUDY & CAREER.

FINALLY, IN THIS WORK, THE ADOPTED STANDARD & SPECIFICATION FOR DESIGN & ERECTION IS THE AISC 14th EDITHION IS FOLLOWED.

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بسم الله الرحمن الرحيم

((لَقَدْ أَرْسَلْنَا رُسُلَنَا بِالْبَيِّنَاتِ وَأَنْزَلْنَا مَعَهُمُ الْكِتَابَ وَالْمِيزَانَ لِيَقُومَ النَّاسُ بِالْقِسْطِ وَأَنْزَلْنَا الْحَدِيدَ فِيهِ بَأْسٌ شَدِيدٌ وَمَنَافِعُ لِلنَّاسِ وَلِيَعْلَمَ اللَّهُ مَنْ يَنْصُرُهُ وَرُسُلَهُ بِالْغَيْبِ إِنَّ اللَّهَ قَوِيٌّ عَزِيزٌ))[٢٥]

صدق الله العظيم

يقول الله تعالى في محكم كتابه أنه انزل الحديد من السماء، اي انه نزل من السماء عند تكوين الارض وانه غير موجود على الكواكب الاخرى في المجموعه الشمسية، و المعجزة في الحديد أن الوزن الذري له تقريبا ٥٧ وهو ترتيب السورة في القرآن، كما وأن عدد سور القرآن هي ١١٤.

In the name of Allah, the Beneficent, the Merciful

"And He revealed iron, wherein is mighty power and (many) uses for mankind"

ما هو الإعجاز في رقم سورة الحديد وعلاقته بالوزن الذري للحديد؟

في سورة الحديد معجزتان: علمية ورقمية، فإذا تلفتنا حولنا نرى للحديد أثراً في كل شيء اخترعه الإنسان في القرن العشرين. فجميع الآلات والأجهزة يدخل في تركيبها الحديد، جميع وسائط النقل ووسائل الاتصال وغيرها حتى الطعام الذي نأكله واللباس الذي نلبسه وحتى الماء الذي نشرب اليوم وغير ذلك... كل هذه الأشياء تم إعدادها بواسطة آلات صُنعت أساساً من الحديد، فما هو سرّ هذا المعدن الذي يُعتبر سيد المعادن في القرن العشرين؟

الملفت للانتباه أننا عندما ندرس جميع المعادن نجد أن للحديد خواصاً ينفرد بها وحده. فهو المعدن الوحيد الذي نستطيع أن نتحكَّم بصلابته ومتانته بحدود واسعة من خلال إضافة بعض العناصر مثل الكربون. ولكن ما الذي يعطي الحديد هذه الخواص الفريدة؟

إنها الطريقة التي تركبت فيها ذرات الحديد، فبين هذه الذرات توجد قوى عظيمة تشدّ هذه الذرات إلى بعضها ضمن مجموعات تسمى جزيئات الحديد. وعندما يضاف عنصر الكربون بنسبة ما فإن ذرات الكربون الأصغر حجماً تتوضع في أماكن محددة بين هذه الذرات لتزيد من قوى الشدّ هذه مما يزيد في مرونة المعدن ومتانته معاً.

ويمكن القول: في ذرات الحديد وجزئياته بأس شديد، لأن كلمة (البأس) تجمع عدة صفات كالمتانة والصلابة والمرونة، وهذه جميعها موجودة داخل الحديد. وهنا تتجلى عظمة القرآن عندما يصف الحديد بأن فيه بأساً شديداً، يقول تعالى: (وأنزلنا الحديد فيه بأس شديد)[الحديد: ٢٥]. ولكن هنالك شيء آخر في هذه الآية وهو كلمة (أنزلنا): فهل نزل الحديد فعلاً إلى الأرض؟

نحن نعلم منذ بداية خلق الكون أن العنصر الأساسي الذي نشأ في بداية الخلق هو الهيدروجين (وهو أخف العناصر في الطبيعة) ثم بدأت العناصر الأثقل بالتشكل نتيجة للاندماجات النووية والحرارة المرتفعة والطاقة الجبارة التي خلَّفها الانفجار الكبير.

وقد كان يُظن سابقاً أن الحديد الذي على الأرض نشأ من تفاعلات تمت على الأرض. ولكن أحد الباحثين قاس كمية الطاقة اللازمة لتشكل الحديد فوجدها كبيرة جداً، مثل هذه الطاقة لا تتوفر إلا في النجوم الضخمة (التي هي أضخم بكثير من الشمس). وقد قاده هذا الأمر إلى التصريح بأن عنصر الحديد لا يمكن أن يتشكل داخل المجموعة الشمسية أو على الأرض، بل تشكل في الفضاء بدرجات حرارة وطاقة عالية جداً ثم قُذِف به إلى الأرض على شكل نيازك، أي نزل إلى الأرض!!

١- ثبت علمياً أن الحديد الموجود في الأرض نزل نزولاً من السماء.

٢- ثبت علمياً أن القوى الموجودة في عنصر الحديد هي قوة شديدة جداً تجمع بين المتانة والمرونة والصلابة وهي ما سماه القرآن بالبأس الشديد.

ولكن الإعجاز لم ينته، لأن هذه السورة العظيمة تحوي معجزة عددية أيضاً!!

٣- فالوزن الذري للحديد هو على التقريب (٥٧) والعجيب أن رقم سورة الحديد في القرآن هو (٥٧) أيضاً!! وهذا الرقم هو نصف عدد سور القرآن، أما عدد الإلكترونات في ذرة الحديد فهو (٢٦) إلكتروناً، وهذا ما يسمى بالعدد الذري وهو عدد ثابت لكل عنصر من عناصر الطبيعة. والعجيب أن الآية التي ذكر فيها الحديد في سورة الحديد، رقم هذه الآية مع البسملة هو (٢٦) نفس العدد الذري للحديد!!! وبالتالي ان سورة الحديد تقع في قلب القرآن مثلما ان الحديد يقع في قلب الأرض.

إن هذه الحقائق العلمية والهندسية والرقمية تثبت أننا كيفما نظرنا إلى آيات الكتاب العظيم نجدها مُحكمة ومعجزة، ولا تناقض العلم الحديث بل تتفوق عليه. وهذا إثبات على أن القرآن كتاب متكامل ومحكم.

وفي هذا المقام نذكِّر بأن الإعجاز القرآني لا يقتصر على علوم الفلك والأرض والطب وغيرها، بل في كل آية من آيات القرآن هنالك معجزة رقمية مبهرة وبناء محكم يدلّ على أن هذا القرآن كتاب من عند الله تعالى، رتب حروفه وكلماته بنظام رقمي لا يمكن لأحد أن يأتي بمثله! وهذا ما برهنا عليه من خلال أبحاث الإعجاز الرقمي والتي تتضمن حقائق رقمية مذهلة تدل على عظمة منَزِّل القرآن سبحانه وتعالى.

الكلام منقول من الموسوعه العلمية للدكتورعبد الدائم الكحيل وهو مهندس وباحث إسلامي في مجال الإعجاز العلمي في القرآن والسنة، ولهُ العديد من الأعمال المنشورة، وهو من مواليد ١٣٨٥هـ/١٩٦٦م في مدينة حمص في سوريا.

الحمد لله على نعمة الإسلام

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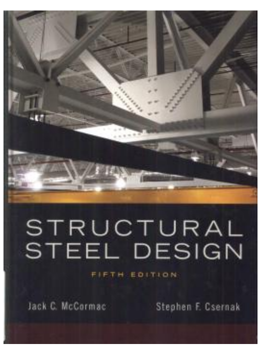
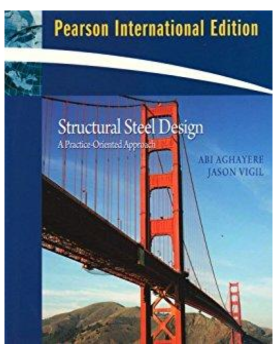
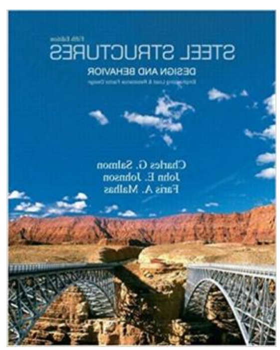
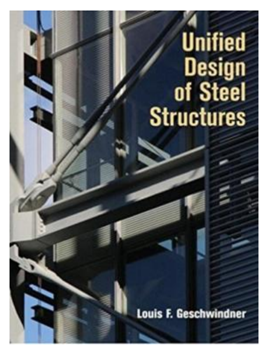
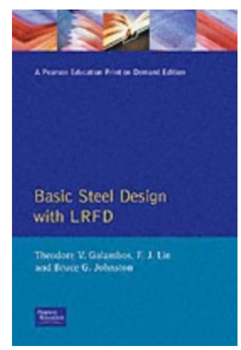






Introduction

On steel structures

Specifications & Properties

Part A

LECTURE # 01

COURSE SUMMARY

- Behavior and design of members subjected to axial forces, and combined bending and compression, and connections.
- Methods of allowable stress design (secondary) and load and resistance factor design (primary).
- Framing & trussing systems and loads for. Public, industrial buildings and bridges.

COURSE GOAL

- To provide student with understanding the steel material and the behavior of steel members and structures.
- To teach the student about structural loading, load combinations, and load paths, about how to design structural steel systems, and how to use the current building codes and design specifications.
- To satisfy ABET requirement with an ability to design a system to meet desired needs, to function on design teams, and to identify, formulate, and solve engineering problems.
- To provide an understanding of professional and ethical responsibilities.

CONSIDERED SUBJECTS

Part A

- Metal.
- Structural Design.
- Structural Designer.
- Type of Steel Structures.
- Types of Loads.
- Specifications for Design of Steel Structures.
- Design Procedure of Construction Project.

Part B

- Structural Steel Elements.
- Grade of Steel.
- Properties of structural Steel.
- Design Philosophy.
- Principals of design.

❖ METAL:

Metal is a Greek word "métallon" .Metals are generally malleable — that is, they can be hammered or pressed permanently out of shape without breaking or cracking — as well as fusible (able to be fused or melted) and ductile (able to be drawn out into a thin wire).[3] About 91 of the 118 elements in the periodic table are metals (some elements appear in both metallic and non-metallic forms).

Astrophysicists use the term "metal" to collectively describe all elements other than hydrogen and helium. Thus, the metallicity of an object is the proportion of its matter made up of chemical elements other than hydrogen and helium.[4]

Many elements and compounds that are not normally classified as metals become metallic under high pressures; these are formed as metallic allotropes of non-metals.

❖ Difference between Iron and Steel

There are many differences between iron and steel. Primarily, iron is an element while steel is an alloy comprising of iron and carbon. However, in this alloy iron is present in a greater quantity. You can add various other metals to steel so as to produce alloys that have different properties. For example, if chromium is added to steel, stainless steel is the product. It is durable and doesn't rust easily. In the construction industry steel is used on a large scale. This is because steel is stronger than iron and it has better tension and compression properties.

So the main differences are:

- Iron is an element while steel is an alloy.
- Iron was known to the humans from the beginning of civilization; however steel was discovered much later.
- Steel is a derivative of iron.

And it's CHEMICAL SYMBOL **(Fe)**, ATOMIC NUMBER **(26)**, ATOMIC MASS **(55.847).**

❖ <u>STRUCTURAL DESIGN:</u>

Structural design of buildings or other structures should be carried out as per the relevant code of practice.

- Structural concrete Design shall conform to ACI 318-14 / IS 456: 2010 / BS 8110: Part 1: 1987 or other whichever code is applicable.
- Structural steel design and fabrication shall conform to AISC-ASD (14th Edition) / IS 800:1984 / BS 5950: Part 1:1990.
- Structural design methods are selected based on the local practices. Working stress method, Limit State Method, Load Resistance Factor Design method. These are the methods used for the design of structural members and are guided by the relevant standard code of practice.

- Following factors to be considered for design of buildings or other structures and shall conform to the standard codes:
- Maximum allowable settlement of foundation / structure.
- Vertical and lateral deflections of buildings, structures as whole and other structural members.
- Sliding and overturning of buildings or structures should be checked and prevented by design.
- Standard detailing guidelines should be followed in drawing.
- All engineering and design shall comply with relevant and applicable codes of practices, local bye-laws, and rules as per directorate of industries and factories & as listed in Project Design Basis.
- Environmental exposure conditions should be considered in design and respective factors must be applied in structural member design.
- Types of construction materials and structural members and their properties should be used during design.
- Special care should be taken to provide easy escape of occupants during emergency situations such as fire.
- These are only few points; many other factors should also be considered which may be relevant for the design. A checklist for different types of structural design should be maintained and followed to prevent any error during design and detailing for buildings and other structures.

❖ STRUCTURAL DESIGNER'S WORK:

The aim of the structural designer is to produce the design and drawings for a safe and economical structure that fulfils its intended purpose. The steps in the design process are as follows:

1. Conceptual design and planning. This involves selecting the most economical structural form and materials to be used. Preliminary designs are often necessary to enable comparisons to be made.

2. Detailed design for a given type and arrangement of structure, which includes:

- Idealization of the structure for analysis and design;

- Estimation of loading;

- Analysis for the various load cases and combinations of loads and identification of the most severe design actions;

- Design of the foundations, structural frames, elements and connections;

- Preparation of the final arrangement and detail drawings.

The materials list, bill of quantities and specification covering welding, fabrication erection corrosion protection and fire protection may then be prepared. Finally the estimates and tender documents can be finalized for submission to contractors. The structural designer uses his/her knowledge of structural mechanics and design, materials, geotechnical and codes of practice and combines this with his/her practical experience to produce a satisfactory design. He/she takes advice from specialists, makes use of codes, design aids, handbooks and computer software to help him/her in making decisions and to carry out complex analysis and design calculations.

❖ <u>Comparative Design and Optimization:</u>

Preliminary designs to enable comparisons and appraisals to be made will often be necessary during the planning stage in order to establish which of the possible structural solutions is the most economical. Information from the site survey is essential because foundation design will affect the type of superstructure selected as well as the overall cost.
Arrangement drawings showing the overall structural system are made for the various proposals. Then preliminary analyses and designs are carried out to establish foundation sizes, member sizes and weights so that costs of materials, fabrication, construction and finishes can be estimated. Fire and corrosion protection and

maintenance costs must also be considered. However, it is often difficult to get true comparative costs and contractors are reluctant to give costs at the planning stage.

By optimization is meant the use of mathematical techniques to obtain the most economical design for a given structure. The aim is usually to determine the topology of the structure, arrangement of floors, spacing of columns or frames or member sizes to give the minimum weight of steel or minimum cost. Though much research has been carried out and sophisticated software written for specific cases, the technique is not of general practical use at present. Many important factors cannot be satisfactorily taken into account.

The design of individual elements may be optimized, e.g. plate girders or trusses.

Again, in optimizing member costs it is essential to rationalize sizes, even if this may lead to some oversized items. Floor layouts and column spacing should be regular and as a consequence, fabrication and erection will be simplified and cost reduced.

❖ Aims and Factors Considered in Design Comparison:

The aim of the design comparison is to enable the designer to ascertain the most economical solution that meets the requirements for the given structure. All factors must be taken into consideration. A misleading result can arise if the comparison is made on a restricted basis.

Factors to be taken into account include:

- Materials to be used;
- Arrangement and structural system and flooring system to be adopted;
- Fabrication and type of jointing;
- Method of erection of the framework to be used;
- Type of construction for floor, walls, cladding and finishes;
- Installation of ventilating/heating plant, lifts, water supply, power etc.;
- Corrosion protection required;
- Fire protection required;

- Operating and maintenance costs.
- Aesthetic considerations are important in many cases and the choice of design may not always be based on cost alone. Most structures can be designed in a variety of ways.

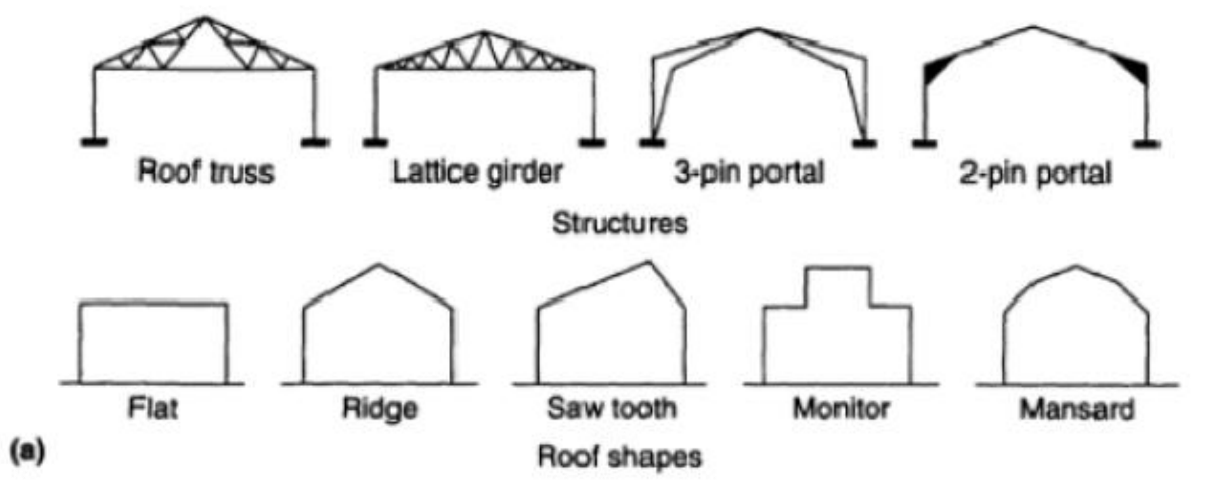
❖ Specific basis of comparisons for common structures:

In the following sections a classification is given on which design comparisons for some general purpose structures may be made.

Type of building and design methods:

(a)Single-storey, single-bay buildings:

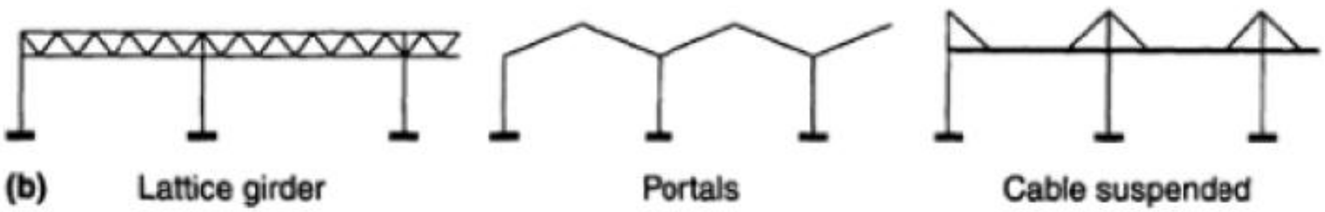
For a given plan size & requirements; the designer can make the following choices.



The design may be fully welded or with rigid joints mode using high-strength bolts.

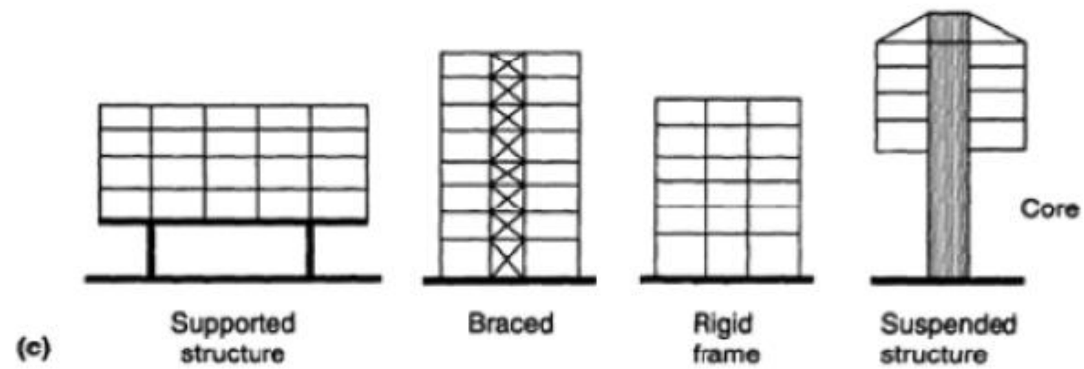
(b)Single-storey, multi-bay buildings

Three common types of single-storey, multi-bay buildings are the lattice girder roof, multi-bay portal and cable suspended roof (Figure (b)). The comments from (a) above apply.



(c)Multi-storey buildings

Many different systems are used and many parameters can be varied in design. Some important aspects of the problem are as follows.



❖ TYPES OF STEEL STRUCTURES:

1- BUILDINGS
- PUBLIC BUILDINGS
- INDUSTRIAL BUILDINGS
- RESIDENTIAL BUILDINGS

2- BRIDGES
- RAIL ROADS
- MONO RAIL (OVERGROUND)
- HIGHWYS & PEDESTRINS

3- OTHER STRUCTURES
- POWER TRNSMISION TOWERS, FOR
- RADARS & T.V INSTALLIATIONS
- WATER SUPPLY TANKS.
- SHIPS & AIR PLANES.

❖ Steel material types:

• **CARBON STEEL [0.2% to 1.5% Carbon] + Fe**
(A36, A53, A500, A501, A529, A570)
- Low Carbon Steel [~ 0.2% carbon] Uses: Sheets, wires, pipes, rebar
- Mild Carbon Steel [0.3% to 0.7% carbon] Uses: Rails, boilers, plates, axles, Structures.
- High Carbon Steel [0.7% to 1.5% carbon] Uses: Surgical instruments, razor blades,
cutlery, spring, construction.

Where carbon Steel is:

• The ideal type for structural applications because of cheap production cost and high ductility.

• High/Mild Carbon Steel: Reinforcement bars

• Low Carbon Steel: Structural Steel

• **STAINLESS STEEL [14% to 28% chromium and 7% to 9% nickel] + Fe**
Uses: Car accessories, watch case, utensils, cutlery.

• **ALLOY STEEL [Depends on % of metals]**
- Mn in Steel [10% to18% Mn]

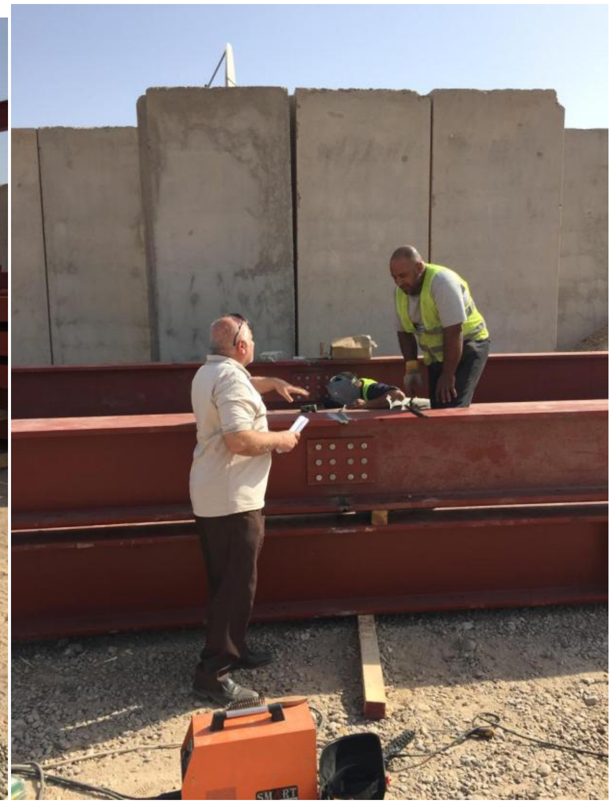
Uses: Rail tracks, armor plate, safe.

- Si in Steel [1% to 5% Si]

Uses: Permanent magnet.

- Ni in Steel [2% to 4% Ni]

Uses: Machine components, Gear, shaft, cable.

❖ TYPES OF LOADS:

- Dead loads.
- Live Loads.
- Wind Loads.
- Impact Loads.
- Fatigue.
- Earthquake Loads.
- Snow Loads.
- Other Loads.

Dead Loads: Dead Loads are loads from the self weight of the structural members in fixed position such as beams, columns, slabs, wall, finishing, plastering etc. Any stationary elements or equipments which may be permanently positioned on the structure shall also be considered as dead load. Dead loads are also called as self weight and are calculated as volume multiplied by its unit weight. Unit of different materials are provided by the standard codes.

Live loads: Live loads also called as imposed loads are probable loads that the structure may be subjected to during occupancy. These are loads which are moving or dynamic in nature and may or may not be present on the structure during intended use of the structure. For example, for an industrial structure, loads from people, maintenance tools etc. can be called as live loads, while loads from equipments which are stationary at a location is considered as the dead load.

Live loads are different for different types of structures and vary with type of occupancy. For example, for a residential building, live load on floor is considered as 3 kN/m^2 while for industrial structures or business centers live loads can be taken as 4 or 5kN/m^2. These loads vary for different structures based on intended use.

Minimum live loads to be considered for design purpose are obtained from respective standard codes based on country or region. ASCE 7 provides minimum live loads for buildings and other structures in USA. While in India, IS875 Part-2 provides guidelines for minimum live loads. At any way live loads are such as:

- Weight of people.
- Furniture.
- Machinery & goods.
- Dynamic forces resulting from moving loads.
- Wind loads.
- Forces resulting from temperature change.
- Pressure of liquids.
- Earthquakes.

SNOW LOADS:

- Freshly fallen dry snow weight is about 5-6 pcf.

Packed snow weight is about 10 pcf.

- Snow loads on roofs < snow weight on grounds.
- Snow & other live loads are taken with respect to the horizontal projection of the inclined roofs or members.
- N.B.C, stipulate that snow loads on roofs = 40-10 psf.

[For flat surface q = 40 psf].
[For inclined surface q = 10 psf].

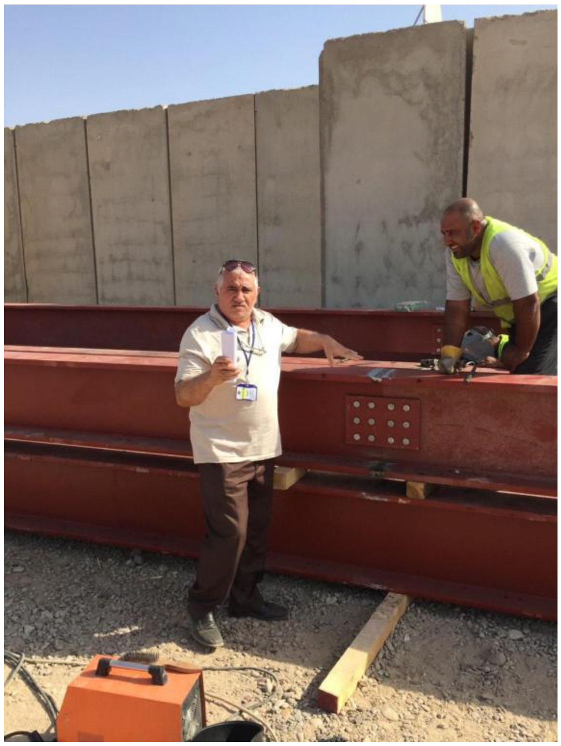


TABLE 4-1 MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS, L_o, AND MINIMUM CONCENTRATED LIVE LOADS

Occupancy or Use	Uniform psf (kN/m²)	Conc. lb (kN)
Apartments (see *Residential*)		
Access floor systems		
Office use	50 (2.4)	2,000 (8.9)
Computer use	100 (4.79)	2,000 (8.9)
Armories and drill rooms	150 (7.18)	
Assembly areas and theaters		
Fixed seats (fastened to floor)	60 (2.87)	
Lobbies	100 (4.79)	
Movable seats	100 (4.79)	
Platforms (assembly)	100 (4.79)	
Stage floors	150 (7.18)	
Balconies (exterior)	100 (4.79)	
On one- and two-family residences only, and not exceeding 100 ft² (9.3 m²)	60 (2.87)	
Bowling alleys, poolrooms, and similar recreational areas	75 (3.59)	
Catwalks for maintenance access	40 (1.92)	300 (1.33)
Corridors		
First floor	100 (4.79)	
Other floors, same as occupancy served except as indicated		
Dance halls and ballrooms	100 (4.79)	
Decks (patio and roof)		
Same as area served, or for the type of occupancy accommodated		
Dining rooms and restaurants	100 (4.79)	
Dwellings (see *Residential*)		
Elevator machine room grating (on area of 4 in.² [2,580 mm²])		300 (1.33)
Finish light floor plate construction (on area of 1 in.² [645 mm²])		200 (0.89)
Fire escapes	100 (4.79)	
On single-family dwellings only	40 (1.92)	
Fixed ladders	See Section 4.4	
Garages (passenger vehicles only)	40 (1.92)[a,b]	
Trucks and buses		
Grandstands (see *Stadiums and arenas, Bleachers*)		
Gymnasiums—main floors and balconies	100 (4.79)	
Handrails, guardrails, and grab bars	See Section 4.4	
Hospitals		
Operating rooms, laboratories	60 (2.87)	1,000 (4.45)
Patient rooms	40 (1.92)	1,000 (4.45)
Corridors above first floor	80 (3.83)	1,000 (4.45)
Hotels (see *Residential*)		
Libraries		
Reading rooms	60 (2.87)	1,000 (4.45)
Stack rooms	150 (7.18)[c]	1,000 (4.45)
Corridors above first floor	80 (3.83)	1,000 (4.45)
Manufacturing		
Light	125 (6.00)	2,000 (8.90)
Heavy	250 (11.97)	3,000 (13.40)
Marquees	75 (3.59)	
Office Buildings		
File and computer rooms shall be designed for heavier loads based on anticipated occupancy		
Lobbies and first-floor corridors	100 (4.79)	2,000 (8.90)
Offices	50 (2.40)	2,000 (8.90)
Corridors above first floor	80 (3.83)	2,000 (8.90)
Penal Institutions		
Cell blocks	40 (1.92)	
Corridors	100 (4.79)	
Residential		
Dwellings (one- and two-family)		
Uninhabitable attics without storage	10 (0.48)	
Uninhabitable attics with storage	20 (0.96)	
Habitable attics and sleeping areas	30 (1.44)	
All other areas except stairs and balconies	40 (1.92)	
Hotels and multifamily houses		
Private rooms and corridors serving them	40 (1.92)	
Public rooms and corridors serving them	100 (4.79)	
Reviewing stands, grandstands, and bleachers	100 (4.79)[d]	

WIND LOAD:

Wind loads are horizontal loads on the building which are exerted on the surface area of the building on windward side. This load is calculated based on the wind zone which provides the maximum wind speed in the given zone. This can be obtained from the wind map of the location. This wind speed is converted into force based on the surface area and orientation of building w.r.t. wind direction. Shape of the building is or structural member is also considered for calculation. Wind loads are considered only on those structural members are exposed to the wind or which resists the wind. The guidelines for calculation of wind force on structure is provided by ASCE 7-95 / UBC -1997 /IS 875 : 1987 (Part 3) / BS CP3 : Chapter V : Part2 : 1972 or whichever applicable codes shall be considered based on the location of the building or structure. The wind load is significant for tall building. The (NBC), stipulate the following wind pressure values to be used for building analysis & design:

Height in ft	Uniform pressure in psf
0 - 29	15
30 - 49	20
50 - 99	25
100 - 499	30

- The analysis & design of building for wind loads computations re affected by the shape of building, so the above values should be multiplied by the following shape factors:

Shape of building	Shape factor
Rec. & Square	1.0
Hexagonal or Octagonal	0.8
Rounded or Elliptical	0.6

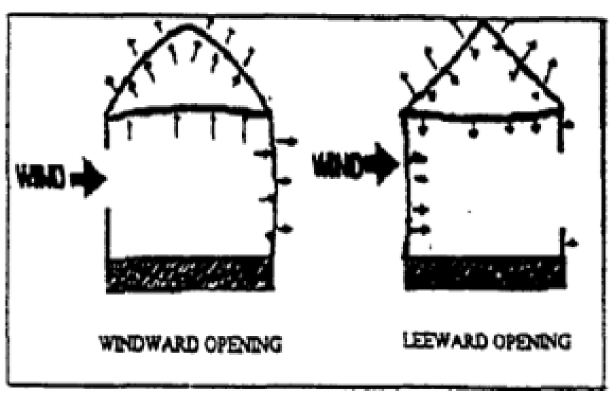
- For building with sloping roofs; aero dynamic effect must be consider as follow:

ROOF PRESSURE = 1.25 x WIND PRESSURE

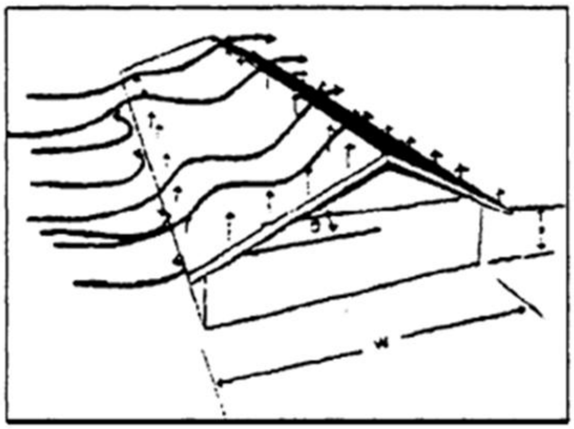
- Wind pressure can be approximately calculated as:

$$q = 0.00256\ Cs\ V^2$$

Where; (v) is speed of air in mile / hour. (q) is pressure per unit area.& Cs = shape factor of structure. (The shape factor, *Cs*, varies with the horizontal angle of incidence of the wind. On vertical surfaces of rectangular buildings, *Cs* may vary between 1.2 and 1.3)



- Opening may led to pressurization or depressurization of the building.



- Wind uplift forces greatest at eaves & along ridges.

IMPACT LOAD:

- The term impact refers to the dynamic effect of a suddenly applied load.

- The impact of moving live load is a complex phenomenon & has significant factors:

- Speed of vehicles.
- Mass of vehicle relative to the mass of a road or bridge.
- Irregularities in the truck or floor.
-

IMPACT LOAD = L impact = L (1 + LF).

The AISC & NBC give the following (LF):

Type	LF
Elevators	1.0
Machineries & other moving loads	≥ 0.25

EARTHQUAKE LOAD:

Design for earthquake or seismic loads shall be carried out as per ASCE 7/UBC/ IS 1893 or whichever standard code is applicable. The guidelines provided by these applicable codes shall be followed for calculation of earthquake forces.

A structure response to an earthquake depends on:

- Location in the affected region.

- Orientation relative to the direction of the most violent motion of the earth.

- Natural period of vibration.

- Dynamic characteristics.

- Physical properties of the structural material.

- Nature of foundation material.

UBC gives the following approach for earthquake analysis:

$$F = m \cdot a$$

Where:

F = force related to acceleration of mass.

a = Acceleration.

m = Mass of building.

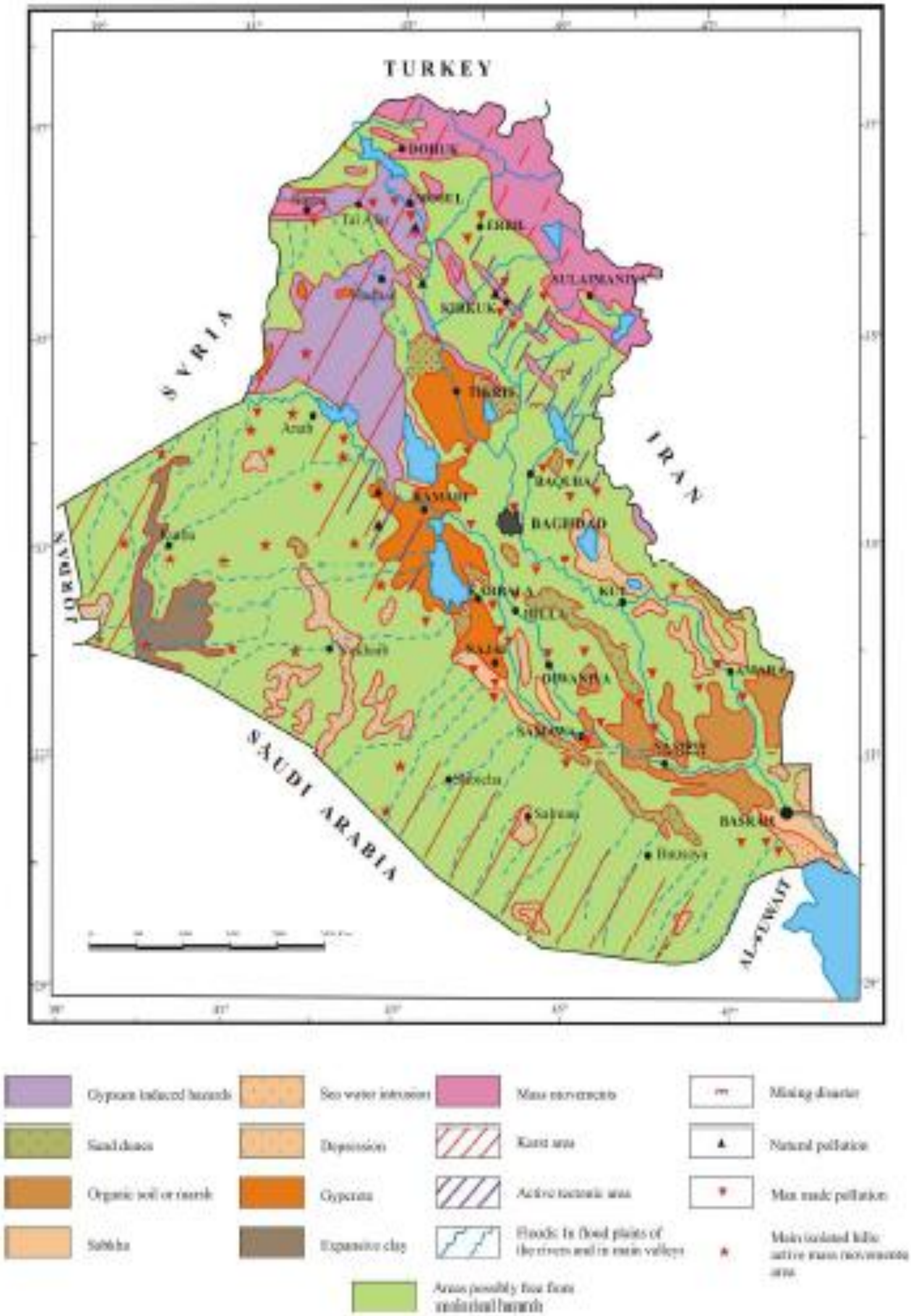


Fig.3: Simplified Geological Hazards Map of Iraq
(modified from Sissakian and Ibrahim, 2005)

Load combination equations:

1- Allowable Stress Design:

For ASD, the required strength, Ra, is determined from the following load combinations (according to the AISC SCM, 13 ed.):

D + F
D + H + F + L + T
D + H + F + (Lr or S or R)
D + H + F + 0.75(L + T) + 0.75(Lr or S or R)
D + H + F ± (W or 0.7E)
D + H + F + (0.75W or 0.7E) + 0.75L + 0.75(Lr or S or R)
0.6D + W + H 0.6D ± (W or 0.7E).

2- Load and Resistance Factor Design:

For LRFD, the required strength, Ru, is determined from the following factored load combinations:

1.4(D + F)
1.2(D + F + T) + 1.6(L + H) + 0.5(Lr or S or R)
1.2D + 1.6(Lr or S or R) + (L or 0.8W)
1.2D + 1.0W + L + 0.5(Lr or S or R)
1.2D ± 1.0E + L + 0.2S + 0.9D + 1.6W + 1.6H
0.9D + 1.6 H ± (1.6W or 1.0E)

For the wind consideration, the ASCE allows a "position correction factor" which turns the coefficient of wind action to 1,36 :

1,2D + 1,36W +.... the same above or 0,9D - 1,36W

Where:

D = dead load,

Di = weight of Ice,

E = earthquake load,

F = load due to fluids with well-defined pressures and maximum heights,

Fa = flood load,

H = load due to lateral earth pressure, ground water pressure, or pressure of bulk materials,

L = live load due to occupancy,

Lr = roof live load,

S = snow load,

R = nominal load due to initial rainwater or ice, exclusive of the ponding contribution,

T = self straining load,

W = wind load,

Wi = wind on ice.

SEISMIC GROUND MOTION VALUES

11.4.1 Mapped Acceleration Parameters. The parameters *SS* and *S*1 shall be determined from the 0.2 and 1.0 s spectral response accelerations shown on Figs. 22-1 through 22-14, respectively. Where *S*1, is less than or equal to 0.04 and *SS* is less than or equal to 0.15, the structure is permitted to be assigned to Seismic Design Category A and is only required to comply with Section 11.7. **11.4.2 Site Class.** Based on the site soil properties, the site shall be classified as Site Class A, B, C, D, E, or F in accordance with Chapter 20. Where the soil properties are not known in sufficient detail to determine the site class, Site Class D shall be used unless the authority having jurisdiction or geotechnical data determines Site Class E or F soils are present at the site.

11.4.3 Site Coefficients and Adjusted Maximum Considered Earthquake (MCE) Spectral Response Acceleration Parameters.

The MCE spectral response acceleration for short periods (*SMS*) and at 1 s (*SM*1), adjusted for Site Class effects, shall be determined by Eqs. 11.4-1 and 11.4-2, respectively.

$$SMS = Fa\ Ss \quad (11.4\text{-}1)$$
$$SM1 = Fv\ S1 \quad (11.4\text{-}2)$$

Where:
SS = the mapped MCE spectral response acceleration at short periods as determined in accordance with Section 11.4.1, and
S1 = the mapped MCEspectral response acceleration at a period of 1 s as determined in accordance with Section 11.4.1
where site coefficients Fa and Fv are defined in Tables 11.4-1 and 11.4-2, respectively. Where the simplified design procedure

TABLE 11.4-1 SITE COEFFICIENT, Fa

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at Short Period				
	$S_S \le 0.25$	$S_S = 0.5$	$S_S = 0.75$	$S_S = 1.0$	$S_S \ge 1.25$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.2	1.2	1.1	1.0	1.0
D	1.6	1.4	1.2	1.1	1.0
E	2.5	1.7	1.2	0.9	0.9
F	See Section 11.4.7				

NOTE: Use straight-line interpolation for intermediate values of SS .

TABLE 11.4-2 SITE COEFFICIENT, Fv

Site Class	Mapped Maximum Considered Earthquake Spectral Response Acceleration Parameter at 1-s Period				
	$S_1 \le 0.1$	$S_1 = 0.2$	$S_1 = 0.3$	$S_1 = 0.4$	$S_1 \ge 0.5$
A	0.8	0.8	0.8	0.8	0.8
B	1.0	1.0	1.0	1.0	1.0
C	1.7	1.6	1.5	1.4	1.3
D	2.4	2.0	1.8	1.6	1.5
E	3.5	3.2	2.8	2.4	2.4
F	See Section 11.4.7				

NOTE: Use straight-line interpolation for intermediate values of S1.

of Section 12.14 is used, the value of Fa shall be determined in accordance with Section 12.14.8.1, and the values for Fv, SMS, and SM1 need not be determined.

11.4.4 Design Spectral Acceleration Parameters. Design earthquake spectral response acceleration parameter at short period, SDS, and at 1 s period, SD1, shall be determined from Eqs. 11.4-3 and 11.4-4, respectively. Where the alternate simplified design procedure of Section 12.14 is used, the value of SDS shall be determined in accordance with Section 12.14.8.1, and the value for SD1 need not be determined.

$S_{DS} = \frac{2}{3} SMS$ ……………………………………………………………………(11.4-3)

$SD1 = \frac{2}{3} S_{M1}$……………………………………………………………………..(11.4-4)

11.4.5 Design Response Spectrum. Where a design response spectrum is required by this standard and site-specific ground motion procedures are not used, the design response spectrum curve shall be developed as indicated in Fig. 11.4-1 and as follows:

1. For periods less than *T*0, the design spectral response acceleration, *Sa*, shall be taken as given by Eq. 11.4-5:

$$Sa = SDS\ (0.4 + 0.6\ \frac{T}{TO}) \quad \text{(11.4-5)}$$

2. For periods greater than or equal to T0 and less than or equal to TS, the design spectral response acceleration, Sa, shall be taken equal to SDS.

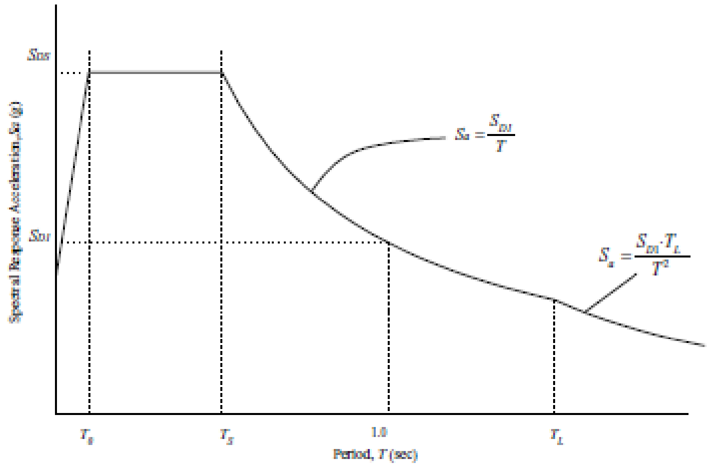


FIGURE 11.4-1 DESIGN RESPONSE SPECTRUM

3. For periods greater than *TS*, and less than or equal to *TL* , the design spectral response acceleration, *Sa*, shall be taken as given by Eq. 11.4-6:

4. For periods greater than TL , Sa shall be taken as given by Eq. 11.4-7:

where
SDS = the design spectral response acceleration parameter at short periods
SD1 = the design spectral response acceleration parameter at 1-s period
T = the fundamental period of the structure, s
T0 = 0.2 $(\frac{SD1}{SDS})$
TS = $(\frac{SD1}{SDS})$
And

TL = long-period transition period (s) shown in Fig. 22-15 (Conterminous United States), Fig. 22-16 (Region 1), Fig. 22-17 (Alaska), Fig. 22-18 (Hawaii), Fig. 22-19 (Puerto Rico, Culebra, Vieques, St. Thomas, St. John, and St. Croix), and Fig. 22-20 (Guam and Tutuila).

11.4.6 MCE Response Spectrum. Where a MCE response spectrum is required, it shall be determined by multiplying the design response spectrum by 1.5.

11.4.7 Site-Specific Ground Motion Procedures. The site specific ground motion procedures set forth in Chapter 21 are permitted to be used to determine ground motions for any structure. A site response analysis shall be performed in accordance with Section 21.1 for structures on Site Class F sites, unless the exception to Section 20.3.1 is applicable. For seismically isolated structures and for structures with damping systems on sites with S1 greater than or equal to 0.6, a ground motion hazard analysis
shall be performed in accordance with Section 21.2.

11.5 IMPORTANCE FACTOR AND OCCUPANCY CATEGORY:

11.5.1 Importance Factor. An importance factor, I , shall be assigned to each structure in accordance with Table 11.5-1 based on the Occupancy Category from Table 1-1.

11.5.2 Protected Access for Occupancy Category IV. Where operational access to an Occupancy Category IV structure is required through an adjacent structure, the adjacent structure shall conform to the requirements for Occupancy Category IV structures. Where operational access is less than 10 ft from an interior lot line or another structure on the same lot, protection from potential falling debris from adjacent structures shall be provided by the owner of the Occupancy Category IV structure.

TABLE 11.5-1 IMPORTANCE FACTORS

Occupancy Category	*I*
I or II	1.0
III	1.25
IV	1.5

TABLE 11.6-1 SEISMIC DESIGN CATEGORY BASED ON SHORT PERIOD RESPONSE ACCELERATION PARAMETER

Value of S_{DS}	Occupancy Category		
	I or II	III	IV
$S_{DS} < 0.167$	A	A	A
$0.167 \leq S_{DS} < 0.33$	B	B	C
$0.33 \leq S_{DS} < 0.50$	C	C	D
$0.50 \leq S_{DS}$	D	D	D

11.6 SEISMIC DESIGN CATEGORY

Structures shall be assigned a Seismic Design Category in accordance with Section 11.6.1.1. Occupancy Category I, II, or III structures located where the mapped spectral response acceleration parameter at 1-s period, S_1, is greater than or equal to 0.75 shall be assigned to Seismic Design Category E. Occupancy Category IV structures located where the mapped spectral response acceleration parameter at 1-s period, S_1, is greater than or equal to 0.75 shall be assigned to Seismic Design Category F. All other structures shall be assigned to a Seismic Design Category based on their Occupancy Category and the design spectral response acceleration parameters, S_{DS} and S_{D1}, determined in accordance with Section 11.4.4. Each building and structure shall be assigned to the more severe Seismic Design Category in accordance with Table 11.6-1 or 11.6-2, irrespective of the fundamental period of vibration of the structure, T.

Where

S_1 is less than 0.75; the Seismic Design Category is permitted to be determined from Table 11.6-1 alone where all of the following apply:

1. In each of the two orthogonal directions, the approximate fundamental period of the structure, T_a, determined in accordance with Section 12.8.2.1 is less than $0.8T_s$, where T_s is determined in accordance with Section 11.4.5.

2. In each of two orthogonal directions, the fundamental period of the structure used to calculate the story drift is less than T_s.

3. Eq. 12.8-2 is used to determine the seismic response coefficient C_s.

4. The diaphragms are rigid as defined in Section 12.3.1 or for diaphragms that are flexible, the distance between vertical elements of the seismic force-resisting system does not exceed 40 ft.

Where the alternate simplified design procedure of Section 12.14 is used, the Seismic Design Category is permitted to be determined from Table 11.6-1 alone, using the value of SDS determined in Section 12.14.8.1.

TABLE 11.6-2 SEISMIC DESIGN CATEGORY BASED ON 1-S PERIOD RESPONSE ACCELERATION PARAMETER

Value of S_{D1}	OCCUPANCY CATEGORY		
	I or II	III	IV
$S_{D1} < 0.067$	A	A	A
$0.067 \le S_{D1} < 0.133$	B	B	C
$0.133 \le S_{D1} < 0.20$	C	C	D
$0.20 \le S_{D1}$	D	D	D

11.7 DESIGN REQUIREMENTS FOR SEISMIC DESIGN CATEGORY A:

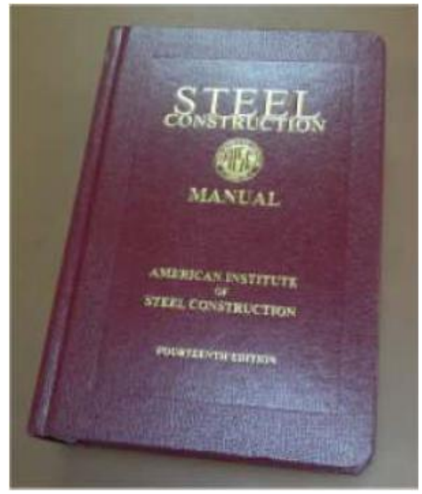
11.7.1 Applicability of Seismic Requirements for Seismic Design Category A Structures. Structures assigned to Seismic Design Category A need only comply with the requirements of Section 11.7. The effects on the structure and its components due to the forces prescribed in this section shall be taken as E and combined with the effects of other loads in accordance with the load combinations of Section 2.3 or 2.4. For structures with damping systems, see Section 18.2.1.

11.7.2 Lateral Forces. Each structure shall be analyzed for the effects of static lateral forces applied independently in each of two orthogonal directions. In each direction, the static lateral forces at all levels shall be applied simultaneously. For purposes of analysis, the force at each level shall be determined using Eq. 11.7-1 as follows:

$F_x = 0.01 w_x$ (11.7-1)

Where:

Fx = the design lateral force applied at story x, and
wx = the portion of the total dead load of the structure, D, located or assigned to Level x



❖ <u>SPECIFICATIONS FOR DESIGN OF STEEL STRUCTURES:</u>

AISCM or ASDM: It is an official manual book which, include dimensions, properties, tables & specifications of standard hot rolled steel sections issued by (AISC).

Many available standards for properties & specifications of steel sections may be followed in design & constructions are published by some institutes & associations such as:

- AISC: American institute of steel construction.
- AASHTO: American association of state highway & transportation officials.
- AISI: American iron & steel institute.
- AREA: American railway engineering association.
- ASTM: American society for testing& material.
- NBC: national building code.
- UBC: Uniform building code.
- BS: British standard.
- DIN: Deutsch international Norma.
- FIP: French international
- EURO: Euro code.

AISC Steel Construction Manual (SCM):

American Institute of Steel Construction (AISC), Inc. publishes the AISC Manual of Steel Construction (Steel construction manual, or SCM), which is currently in its 14th edition. Structural engineers use this manual in analyzing, and designing various steel structures. Some of the chapters of the book are as follows:

- Part1- Dimensions and properties of various types of steel sections available on the market (W, S, C, WT, HSS, etc.).
- Part 2- General design considerations.
- Part 3- Design of flexural members.
- Part 4- Design of compression members.
- Part 5- Design of tension members.
- Part 6- Design of members subject to combined loading.
- Part 7- Design consideration for bolts.
- Part 8- Design considerations for welds.
- Part 9- Design of connecting elements.
- Part 10- Design of simple shear connections.
- Part 11- Design of flexure moment connections.
- Part 12- Design of fully restrained (FR) moment connections.
- Part 13- Design of bracing connections and truss connections.
- Part 14- Design of beam bearing plates, column base plates, anchor rods, and column splices.
- Part 15- Design of hanger connections, bracket plates, and crane-rail connections.
- Part 16- General nomenclature.
- Part 17- Specifications and codes.
- Commentary on specifications and codes.
- Miscellaneous data and mathematical information.

❖ DESIGN METHODS FOR STRENGTH:

1- ASD Method:

In this method, the engineer uses the ASD load combinations (below) to determine the required strength of a member and arranges for the allowable strength to satisfy this equation:

$$R_a \leq \frac{R_n}{\Omega}$$

Where:

Ra = required strength,

Rn = nominal strength, specified in Chapters B through K of the AISC SCM,

Ω = safety factor, specified in Chapters B through K of the AISC SCM,

Rn/Ω = allowable strength.

2- LRFD Method:

In this method, the engineer uses the Load and Resistance Factor Design (LRFD) load combinations (below) to determine the required strength of a member and arranges for the allowable strength to satisfy this equation:

$$R_u \leq \phi * R_n$$

Where:

Ru = Required strength.

Rn = Nominal strength, specified in Chapters B through K of the AISC SCM.

Ø = Resistance factor, specified in Chapters B through K of the AISC SCM.

Ø Rn = Design strength.

Important Note:

ASD versus LRFD:

As per the AISC SCM, 14th ed., either design method is allowed by the AISC SCM 14th edition. A common misconception about the two methods is that ASD gives a more conservative value. In reality, ASD is more conservative in designs with a live to dead load ratio of 3 or lower. With a higher ratio, LRFD is more conservative.

The two design methods are related through the Ω factor of ASD and the φ factor of LRFD. While these factors have different uses, they are always related by the following expression:

$$\Omega = \frac{1.5}{\phi}$$

The values of these factors vary according to the country codes.

❖ DESIGN PROCEDURE FOR PROJECTS:

Any project pass through many studies began with feasibility study to execution.

Our matter in this text book is the design stages, as follow:

1- Architectural design:

Function	Material
Gives L.L such as	To be consulted with structural
School ---- 40 - 60 psf	Engineer (metal, brick, wood, reinf.conc…etc.)

2- Structural design:

Grid	Structural analysis
Columns, beams & slabs	wind loads
	Shear, bending moment & Axial load

3- Mechanical design:

4- Electrical design:

5- Environmental requirements:

THANKS FOR LISTENING & HOPING EVERY WORD & CONCEPT IS UNDERSTOOD